B. Tech.

in

METALLURGICAL AND MATERIALS ENGINEERING

FLEXIBLE CURRICULUM

(For students admitted during 2018-19)

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

TIRUCHIRAPPALLI – 620 015

TAMIL NADU, INDIA

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

	Courses	Credits
General Institute Requirement (GIR) (Institute Formula)	17	68
Programme core (PC) (MME proposal)	20	64
Essential Laboratory Requirement (ELR) (MME proposal)	08	14
Programme Elective + Open Elective + Minor (PE+OE+MI) (MME proposal)	10	30
Total	55	176

CURRICULUM

The total minimum credits for completing the B.Tech. programme in **MME** is 176 [68+108]. The total number of credits can be within **175 to 180** (According to Institute norms).

MINIMUM CREDIT REQUIREMENT FOR THE VARIOUS COURSE CATEGORIES

The structure of B.Tech programmes shall have General Institute Requirements (GIR), Programme Core (PC), Elective Courses (PE, OE and MI) and Essential Programme Laboratory Requirements (ELR) are as follows:

Sl. No.	**COURSE CATEGORY**	**Number of Courses - As in MME** ***(Institute Guidelines listed in brackets)***	**Number of Credits** ***(Institute Guidelines listed in brackets)***
1.	General Institute Requirement (GIR)	17 *(17)*	68 *(68)*
2.	Programme Core (PC)	20 *(16-20)*	64 *(56-65)*
3.	Essential Programme Laboratory Requirement (ELR)	08 *(2 per session)*	14
4.	Elective courses a. Programme Electives (PE) b. Open Electives (OE) c. Minor (MI) A student should be allowed a minimum of 50% of the total electives of a programme from (b) and (c) if so desired by the student.	10 *(10-15)*	30
TOTAL			**176**

	(175 -180)

(I) GENERAL INSTITUTE REQUIREMENTS (Outline)

Sl.No.	**Name of the course**	**Number of Courses**	**Maximum Credits**
1.	Mathematics	4	14
2.	**Physics***	**2**	**7**
3.	**Chemistry***	**2**	**7**
4.	Humanities	1	3
5.	Communication	2	6
6.	Energy and Environmental	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	1	3
12.	**Branch Specific Course****	**1**	**2**
13.	***Summer Internship***	***1***	***2***
14.	***Project work***	***1***	***6***
15.	***Comprehensive Viva***	***1***	***3***
16.	Industrial lecture	-	1
17.	NSS / NCC / NSC	-	0
	TOTAL	**17**	**68**

***including Lab**

**** Commence during Orientation Programme**

I. GENERAL INSTITUTE REQUIREMENTS (Course and Course details)

1. MATHEMATICS

Sl.No.	Course Code	Course Title	Credits
1.	**MAIR11**	**Mathematics I**	**4**
2.	**MAIR12**	**Mathematics II**	**4**
3.	**MAIR32**	**Transforms and Partial Differential Equations**	**3**
4.	**MAIR41**	**Numerical Techniques**	**3**
Total			**14**

2. PHYSICS

Sl.No.	Course Code	Course Title	Credits
1.	**PHIR11**	**Physics I**	**3**
2.	**PHIR12**	**Physics II**	**4**
Total			**7**

3. CHEMISTRY

Sl.No.	Course Code	Course Title	Credits
1.	**CHIR11**	**Chemistry I**	**3**
2.	**CHIR12**	**Chemistry II**	**4**
Total			**7**

4. HUMANITIES

Sl.No.	Course Code	Course Title	Credits
1.	**HSIR13**	**Industrial Economics and Foreign Trade** (January session for MME students)	**3**
Total			**3**

5. COMMUNICATION

Sl.No.	Course Code	Course Title	Credits
1.	**HSIR11**	**English for Communication**	**3**
2.	**HSIR12**	**Professional Communication**	**3**
Total			**6**

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**	**Workshop Practice**	**2**
Total			**2**

10. BASIC ENGINEERING

Sl. No.	Course Code	Course Title	Credits
1.	CEIR 11	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. PC17PROJECT WORK

Sl.No.	Course Code	Course Title	Credits
1.	MTIR17	Project Work	6
Total			6

15. COMPREHENSIVE VIVA

Sl.No.	Course Code	Course Title	Credits
1.	MTIR18	Comprehensive viva	3
Total			3

16. INDUSTRIAL LECTURE

Sl.No.	Course Code	Course Title	Credits
1.	MTIR19	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.

17. NSS /NCC/ NSO

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

(II) PROGRAMME CORE (PC) (Course and Credit details)

[Note: (1) Number of programme core: 16 to 20 (2) Credits: 56 – 65]

Sl. No.	Course Code	Course Title	Credits				Pre requisites	Credits
			L	T	P	C		
1.	MTPC10	Engineering Mechanics	3	0	0	3	Nil	3
2.	MTPC11	Strength of Materials	2	1	0	3	MTPC10	3
3.	MTPC12	Electrical, Electronic and Magnetic Materials	3	0	0	3	MTIR15	3
4.	MTPC13	Metallurgical Thermodynamics	3	1	0	4	Nil	4
5.	MTPC14	Mineral Processing and Metallurgical analysis	3	0	0	3	Nil	3
6.	MTPC15	Physical Metallurgy	3	1	0	4	Nil	4
7.	MTPC16	Instrumentation and Control Engineering	3	0	0	3	Nil	3
8.	MTPC17	Transport Phenomena	2	1	0	3	Nil	3
9.	MTPC18	Phase Transformation and Heat Treatment	3	1	0	4	MTPC15	4
10.	MTPC19	Metal Casting Technology	3	0	0	3	Nil	3
11.	MTPC20	Materials Joining Technology	3	0	0	3	Nil	3
12.	MTPC21	Iron Making and Steel Making	3	1	0	4	MTPC13, MTPC17	4
13.	MTPC22	Non-metallic materials	3	0	0	3	Nil	3
14.	MTPC23	Mechanical Behaviour of Materials	3	0	0	3	MTPC11, MTPC15	3
15.	MTPC24	Metal forming Technology	3	0	0	3	MTPC23	3
16.	MTPC25	Particulate processing	3	0	0	3	MTPC23	3
17.	MTPC26	Non-Ferrous extraction	3	0	0	3	MTPC13, MTPC14	3
18.	MTPC27	Non-Ferrous Physical Metallurgy	3	0	0	3	MTPC15	3
19.	MTPC28	Corrosion Engineering	3	0	0	3	Nil	3
20.	MTPC29	Testing and Characterisation of Materials	3	0	0	3	Nil	3
							Total	64

(III) ELECTIVES

IV. PROGRAMME ELECTIVE (PE) (Course and Credit details)

Students pursuing B.Tech in MME should take total of TEN courses (Total of ten: PE+OE+MI) from the List of Electives indicated below.

Sl.No.	Course Code	Course Title	Prerequisites	Credits
1.	MTPE01	Fatigue, Creep and Fracture Mechanics	MTPC23	3
2.	MTPE02	Special Steels and Cast Irons	MTPC18	3
3.	MTPE03	Special Casting Techniques	MTPC19	3
4.	MTPE04	Special Topics in Metal Forming	MTPC24	3
5.	MTPE05	Ladle Metallurgy and Continuous Casting of steels	MTPC21	3
6.	MTPE06	Welding Metallurgy	MTPC20	3
7.	MTPE07	Processing of Light Alloys	MTPC27	3
8.	MTPE08	Design aspects of Welding and Casting	MTPC19. MTPC20	3
9.	MTPE09	Thermodynamics of Solidification	MTPC13, MTPC19	3
10.	MTPE10	Alloy Development	MTPC18	3
11.	MTPE11	Ceramic Materials	Nil	3
12.	MTPE12	Ceramic Processing	MTPC22	3
13.	MTPE13	High Temperature Materials	MTPC15	3
14.	MTPE14	Emerging Materials	Nil	3
15.	MTPE15	Automotive Materials	MTPC15	3
16.	MTPE16	Physics of Materials	MTPC12	3
17.	MTPE17	Biomaterials	Nil	3
18.	MTPE18	Advanced Characterization Techniques	MTPC29	3
19.	MTPE19	Materials for extreme environments	Nil	3

b. OPEN ELECTIVE (OE) (Offered by Dept. of MME)

MME is offering nine open electives which are listed here. Student of MME can also register for Open Electives offered by other departments.

Sl.No.	Course Code	Course Title	Prerequisites	Credits
1.	MTOE41	Non Destructive Testing and Failure Analysis	Nil	3
2.	MTOE42	Process Modelling and Applications	Nil	3
3.	MTOE43	Computational Techniques	Nil	3
4.	MTOE44	Design and Selection of Materials	Nil	3
5.	MTOE45	New Product Development	Nil	3
6.	MTOE46	Introduction to Quality Management	Nil	3
7.	MTOE47	Surface Engineering	Nil	3
8.	MTOE48	Nanomaterials and Applications	Nil	3
9.	MTOE49	Intellectual Property Rights	Nil	3

Considering the courses covered in Programme Core of BTech (MME), Programme Electives of BTech (MME), and the expectations from the field (industry/ research / service sectors) and possible gaps, IT IS RECOMMENDED THAT every student of BTech (MME) explore studying one or more electives in areas such as – Management, Industrial Relations, Applied Statistics and Probability, Higher Mathematics, Automation, Neural Networks, Artificial Intelligence, Man-Machine Interface, Design of Machine Elements, Design of Reactors and Project Management.

c. MINOR (MI)

Students from other departments who have registered for B.Tech Minor in MME should take minimum FIVE of the listed seven minor courses, in order to earn MINOR in MME. *Students of MME may take five minor courses in chosen discipline outside MME. Student of B.Tech MME is not permitted to register for the following minor courses offered by MME.*

[Note: Number of Minor courses: 5 courses (Minimum)]

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	MTMI81	Materials Technology	Nil	3
2.	MTMI82	Fundamentals of Metallurgy	Nil	3
3.	MTMI83	Physical Metallurgy and Heat Treatment	Nil	3
4.	MTMI84	Deformation Processing	Nil	3
5.	MTMI85	Manufacturing Methods	Nil	3
6.	MTMI86	Testing and Evaluation of materials	Nil	3
7.	MTMI87	Overview of Non-Metallic Materials	Nil	3

Note : Student should be allowed a minimum of 50% of the total electives of a programme from Open electives and Minor, if so desired by the student.

(IV) ESSENTIAL PROGRAMME LABORATORY REQUIREMENT (ELR)

Sl.No.	Course Code	Course Title	Co requisites	Credits
1.	MTLR30	Process Metallurgy lab	MTPC14	1
2.	MTLR31	Ferrous Metallography lab	MTPC18	2
3.	MTLR32	Instrumentation & Control lab	MTPC16	1
4.	MTLR33	Foundry and Welding lab	MTPC19, MTPC20	2
5.	MTLR34	Materials Testing lab	MTPC23	2
6.	MTLR35	Non-Ferrous Metallography and Characterisation lab	MTPC27	2
7.	MTLR36	Particulate Processing and Ceramic Materials lab	MTPC25	2
8.	MTLR37	Corrosion and Surface Engineering lab	MTPC28	2
Total				**14**

NOTE: Students can typically register for 2 laboratory courses during one session along with regular courses (PC / PE / OE / MI).

V. ADVANCED LEVEL COURSES FOR B.Tech. (HONOURS)

A student can obtain B.Tech. (Honours) degree provided the student has;

i. Registered at least for 12 theory courses and 2 ELRs in the second year.
ii. Consistently obtained a minimum GPA of 8.5 in the first four sessions
iii. Continue to maintain the same GPA of 8.5 in the subsequent sessions (including the Honours courses)
iv. Completed 3 additional theory courses specified for the Honours degree of the programme.
v. Completed all the courses registered, in the first attempt and in four years of study.

Sl.No.	Course Code	Course Title	Prerequisites	Credits
1.	MTHO10	Advanced Thermodynamics of Materials	MTPC13	3
2.	MTHO11	Advanced Solidification Processing	MTPC19	3
3.	MTHO12	Crystallography	MTPC15	3
4.	MTHO13	Aerospace Materials	Nil	3
5.	MTHO14	Recent Developments in Welding Processes	MTPC20	3
6.	MTHO15	Recent Developments in Forming Processes	MTPC24	3
7.	MTHO16	Recent Trends in Nano materials	Nil	3
8.	MTHO17	Economics of Metal Production Processes	MTPC14, MTPC21	3
9.	MTHO18	Mathematical Techniques in Materials Research	MAIR 11, MAIR 21, MAIR 32, MAIR 41, MTPC 13, MTPC 15	3

S. 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.

S.No.	**Programme Outcomes (PO)**
1	The Metallurgical and Materials Engineering graduates are capable to apply knowledge of mathematics, science and engineering.
2	The Metallurgical and Materials Engineering graduates are capable to design and conduct experiments, as well as to analyze and interpret data.
3	The Metallurgical and Materials Engineering graduates are capable to design a system, a component, or a process to meet desired needs within realistic constraints such as economic, environmental, social, ethical, health and safety, manufacturability, and sustainability.
4	The Metallurgical and Materials Engineering graduates are capable to function on multi-disciplinary teams.
5	The Metallurgical and Materials Engineering graduates are capable to identify, formulate and solve engineering problems.
6	The Metallurgical and Materials Engineering graduates have the understanding of professional and ethical responsibility.
7	The Metallurgical and Materials Engineering graduates are capable to communicate effectively.
8	The Metallurgical and Materials Engineering graduates have the broad education necessary to understand the impact of engineering solutions in a global, economic and societal context.
9	The Metallurgical and Materials Engineering graduates are capable to engage themselves in life-long learning.
10	The Metallurgical and Materials Engineering graduates have knowledge of contemporary /current issues.
11	The Metallurgical and Materials Engineering graduates are capable to use the techniques, skills, and modern engineering tools necessary for engineering practice.
12	The Metallurgical and Materials Engineering graduates are capable to apply fundamental and practical knowledge of unit operations and processes, principles of management and economics for providing better services to Metallurgical and Materials process industries.

Course Code	**:**	HSIR11
Course Title	**:**	**English for Communication**
Number of Credits	**:**	**3**
LTPC Breakup	**:**	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	**:**	Nil
Course Type	**:**	GIR

Course Learning Objectives
The primary objective is to develop in the under-graduate students of engineering a level of competence in English required for independent and effective communication for academic and social needs.
Course Content
Communication An introduction - Its role and importance in the corporate world – Tools of communication – Barriers – Levels of communication – English for Specific purposes and English for technical purposes. ***Listening*** Listening process & practice – Exposure to recorded & structured talks, class room lectures – Problems in comprehension & retention – Note-taking practice – Listening tests- Importance of listening in the corporate world. ***Reading*** Introduction of different kinds of reading materials: technical & non-technical – Different reading strategies: skimming, scanning, inferring, predicting and responding to content – Guessing from context – Note making – Vocabulary extension. ***Speaking*** Barriers to speaking – Building self-confidence & fluency – Conversation practice- Improving responding capacity - Extempore speech practice – Speech assessment. ***Writing*** Effective writing practice – Vocabulary expansion - Effective sentences: role of acceptability, appropriateness, brevity & clarity in writing – Cohesion & coherence in writing –Writing of definitions, descriptions & instructions - Paragraph writing - Introduction to report writing

Reference Books	
1	*Krishna Mohan and Meenakshi Raman 'Effective English Communication', Tata McGraw Hill, New Delhi, 2000.*
2	*Meenakshi Raman and Sangeetha Sharma 'Technical Communication', Oxford University Press, New Delhi, 2006*
3	*M. Ashraf Rizvi 'Effective Technical Communication', Tata McGraw-Hill, New Delhi, 2005.*
4	*Golding S.R. 'Common Errors in English Language', Macmillan, 1978.*
5	*Christopher Turk 'Effective Speaking', E & FN Spon, London, 1985.*
Course Outcomes	
1	At the end of the course student will be able to express themselves in a meaningful manner to different levels of people in their academic and social domains.

Course Code	MAIR11
Course Title	**MATHEMATICS- I**
Number of Credits	4
LTPC Breakup	L: 3, T: 0, P: 1, C: 4
Prerequisites	-
Course Type	GIR

Course Learning Objectives

Learning Objectives: Objective of the course is to

1. determine canonical form of given quadratic form.
2. discuss the convergence of infinite series.
3. analyze and discuss the extrema of the functions of several variables.
4. evaluate the multiple integrals and apply in solving problems.

Course Content

Characteristic equation of a matrix –Eigen values and Eigen vectors – Properties of Eigen values – Diagonalization of matrix – Cayley-Hamilton Theorem (without proof) verification – Finding Inverse and Power of a matrix using it – Quadratic form – Definite and indefinite forms – Orthogonal reduction of quadratic form to canonical form.

Introduction to sequences, Infinite series-Convergence Tests for positive term series – Comparison, integral test, Root, Ratio test, Raabe's tests, logarithmic test - Alternating series – Leibnitz's rule – Absolute and Conditional Convergence. Riemann rearrangement theorem (without proof).

Functions of several variables – Partial derivatives and Transformation of variables – Jacobian and its Properties- Taylor series-Maxima and Minima of function of two variables.

Double integral – Changing the order of Integration – Change of variables from Cartesian to Polar Coordinates – Area using double integral in Cartesian and Polar Coordinates – Triple integral – Change of Variables from Cartesian to Spherical and Cylindrical Coordinates – Volume using double and triple integrals.

Reference Books

1	*Kreyszig, E., Advanced Engineering Mathematics, 10th edn, John Wiley Sons, 2010.*
2	*Grewal, B.S., Higher Engineering Mathematics, 43rd edition, Khanna Publications, Delhi.*
3	*Greenberg, M.D. Advanced Engineering Mathematics, Second Edition, Pearson Education Inc. 1998*
4	*Strauss. M.J, Bradley, G.L. and Smith, K.J. Calculus, 3rd Edition, Prentice Hall, 2002.*

Course Outcomes

1 After the completion of the course, students would be able to

1. compute eigenvalues and eigenvectors of the given matrix.
2. transform given quadratic form into canonical form.
3. discuss the convergence of infinite series by applying various test.
4. compute partial derivatives of function of several variables
5. write Taylor's series for functions with two variables.
6. evaluate multiple integral and its applications in finding area, volume.

Course Code	:	PHIR11
Course Title	:	**Physics – I (Theory & Lab)**
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	Nil
Course Type	:	GIR

Course Learning Objectives

- To make a bridge between the physics in school and engineering courses.
- To introduce the basic concepts of modern science like Photonics, Engineering applications of acoustics, fundamentals of crystal physics and materials science.

Course Content

Lasers Introduction to Laser-characteristics of Lasers-Spontaneous and stimulated emissions – Einstein's coefficients – population inversion and lasing action – laser systems: Ruby laser, He-Ne Laser, semiconductor laser-applications:–Holography- CD-drive – industrial and medical applications.

Fiber Optics Fermat's principle and Snell's law-optical fiber – principle and construction – acceptance cone - numerical aperture - V-Number - types of fibers, Fabrication: Double Crucible Technique, Vapour phase Oxidation Process – fiber optic communication principle – fiber optic sensors-other applications of optical fibers.

Acoustics Characteristics of musical sound – loudness – Weber-Fechner law – decibel – absorption coefficient – reverberation – reverberation time – Sabine's formula – acoustics of buildings – ultrasonics – production of ultrasonics using piezoelectric method –magnetostriction method-applications.

Crystallography Crystalline and amorphous solids – lattice and unit cell – seven crystal system and Bravais lattices – symmetry operation – Miller indices – atomic radius – coordination number – packing factor calculation for sc, bcc, fcc – Bragg's law of X-ray diffraction –Laue Methodpowder crystal method.

Magnetic materials, conductors and superconductors

Magnetic materials: Definition of terms – classification of magnetic materials and properties – Domain theory of ferromagnetism- hard and soft magnetic materials – applications.

Conductors: classical free electron theory (Lorentz –Drude theory) – electrical conductivity

Superconductors: definition – Meissner effect – type I & II superconductors – BCS theory (qualitative) – high temperature superconductors – Josephson effect – quantum interference (qualitative) – SQUID – applications.

Laboratory Experiments 1.Torsional pendulum 2.Numerical aperture of an optical fiber 3. Temperature measurement - Thermocouple 4. Specific rotation of a liquid – Half Shade Polarimeter 5. Thickness of a thin wire – Air Wedge 6. Conversion of galvanometer into ammeter and voltmeter 7. Dispersive power of a prism – Spectrometer 8. Superconductivity- measurement of transition temperature 9. Absorption spectrometer 10. Brewster's Angle measurement 11. Measurement of Young's modulus

Reference Books

1. *'Engineering Physics', R.K. Gaur and S.L. Gupta, Dhanpat Rai Publications (P) Ltd., 8th edn.New Delhi (2001).*
2. *Laser Fundamentals, William T. Silfvast, 2nd edn, Cambridge University press, NewYork (2004)*
3. *Fundamentals of Physics, 6th Edition, D. Halliday, R. Resnick and J. Walker, John Wileyand Sons, New York (2001).*
4. *Introduction to solid state physics,7th Edn, Charls Kittel, Wiley, Delhi (2007)*

S.1 *'Practical Physics', R.K. Shukla, Anchal Srivastava, New age international {2011)*	
6.1 *B.Sc. Practical Physics', C.L Arora, S. Chand* &Co. *(2012)*	
Course Outcomes	
1	At the end of the course student will be able to understand many modern devices and technologies based on lasers and optical fibres. Student can also appreciate various material properties which are used in engineering applications and devices.

Course Code	:	CHIR11
Course Title	:	**Chemistry – I (Theory & Lab)**
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	Nil
Course Type	:	GIR

Course Learning Objectives

To introduce students to water chemistry, bonding concepts, entropy and basic organic chemistry.

Course Content

Water Sources, hard & soft water, estimation of hardness by EDTA method, 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.

Chemical Bonding Basic concepts, bonding in metals, electron gas theory, physical properties of metals (electrical & thermal conductivity, opaque & lusture, malleability & ductility), Alloy - substitutional alloys, interstitial alloys. Coordinate bond, EAN rule, 16 & 18 electron rule, crystal field theory, splitting of 'd' orbitals in octahedral, tetrahedral and square planar complexes.

Shape & Intermolecular Interactions Shape-Lewis dot structures, formal charge, VSEPR method, consequences of shape, dipole moment, valence bond theory; Intermolecular interactions-ion ion interactions, ion-dipole interactions, hydrogen bonding, dipole-dipole interactions, London / dispersion forces, relative strength of intermolecular forces; Consequences-surface tension.

Thermodynamics Entropy as a thermodynamic quantity, entropy changes in isothermal expansion of an ideal gas, reversible and irreversible processes, physical transformations, work & free energy functions, Helmholtz and Gibbs free energy functions, Gibbs-Helmholtz equation, GibbsDuhem equation, Clapeyron-Clausius equation & its applications, Van't Hoff isotherm and applications.

Fuels & Lubricants Fuels - Classification, examples, relative merits, types of coal, determination of calorific value of solid fuels, Bomb calorimeter, theoretical oxygen requirement for combustion, proximate & ultimate analysis of coal, manufacture of metallurgical coke, flue gas analysis, problems. Lubricants - Definition, theories of lubrication, characteristics of lubricants, viscosity, viscosity index, oiliness, pour point, cloud point, flash point, fire point, additives to lubricants, Solid lubricants.

Laboratory Experiments1. Estimation of total alkalinity in the given water sample. 2. Estimation of carbonate, non-carbonate and total hardness in the given water sample. 3. Estimation of dissolved oxygen in the given water sample. 4. Determination of the percentage of Fe in the given steel sample. 5. Estimation of Ca in limestone. 6. Estimation of Fe^{3+} by spectrophotometer.

Reference Books

1	*Engineering Chemistry', P.C. Jain, M. Jain, Dhanpat Rai Publishing Company, New Delhi, 2005.*
2	*'Physical Chemistry', P. Atkins, J.D. Paula, Oxford University Press, 2002.*
3	*'Modern Inorganic Chemistry', R.D. Madan, S. Chand & Company Ltd., New Delhi, 2012.*
4	*'Engineering Chemistry', M.J. Shultz, Cengage Learning, New Delhi, 2007.*
5	*Laboratory Manual, Department of Chemistry, NITT*
6	*Laboratory Manual on Engineering Chemistry, S.K. Bhasin, S. Rani, Dhanpat Rai Publishing Company, New Delhi, 2011.*

Course Outcomes

1	At the end of the course student will be able to learn about quality of water, bonding theories, entropy change for various processes and basic stereo chemical aspects.

Course Code	:	CSIR11
Course Title	:	**Introduction to Computer Programming (Theory & Lab)**
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	Nil
Course Type	:	GIR

Course Learning Objectives

- To learn the fundamentals of computers.
- To learn the problem solving techniques writing algorithms and procedures.
- To learn the syntax and semantics for C programming language
- To develop the C code for simple logic
- To understand the constructs of structured programming including conditionals and iterations

Course Content

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

Algorithms – Characteristics – Flowcharts - Principles of Structured programming – Sequential, selective structures - Repetitive structures –Bounded , Unbounded and Infinite iterations – Examples for each.

Introduction to C – C character set – Identifiers and Keywords – Datatypes – Constants – Variables – Declarations – Expressions – Statements – Symbolic constants – Operators– Library functions – Data input and output: Single character input and output – Entering input data – Writing output data – gets and puts functions. Control statements – Branching: if-else – Looping: while – do-while – for; Nested control structures – switch statement – break statement – continue statement – comma operator – goto statement.

Modular Programming – Functions and Procedures – Examples – Parameter passing methods.

Arrays – Defining an array – Processing an array – Multidimensional arrays-Pointers – Variable definitions and initialization – Pointer operators – Pointer expressions and arithmetic – Pointers and one-dimensional arrays- Functions – Defining a function – Accessing a function – Function prototypes – Passing arguments to a function –Passing arrays to a function – Passing pointers to a function – Recursion.

Laboratory Experiments1. Programs using sequence construct 2. Programs using selection construct 3. Programs using Iterative construct 4. Programs using nested for loops 5. Programs using functions with Pass by value 6. Programs using functions with Pass by reference 7. Programs using recursive functions 8. Programs using one dimensional Array 9. Programs using two dimensional Arrays 10. Programs using Pointers and functions 11. Programs using Pointers and Arrays

Reference Books

1. *Byron Gottfried, 'Programming with C', Third Edition, Tata McGraw Hill Education, 2010.*
2. *R.G.Dromey, 'How to Solve it By Computers?', Prentice Hall, 2001*
3. *J.R. Hanly and E.B. Koffman, 'Problem Solving and Program Design in C', 6th E, Pearson, 2009.*
4. *Paul Deital and Harvey Deital, 'C How to Program', Seventh Edition, Prentice Hall, 2012.*
5. *Yashavant Kanetkar, 'Let Us C', 12th Edition, BPB Publications, 2012.*

Course Outcomes

1 At the end of the course student will have

1. Ability to write algorithms for problems
2. Knowledge of the syntax and semantics of C programming language
3. Ability to code a given logic in C language
4. Knowledge in using C language for solving problems

Course Code	:	MTIR15
Course Title	:	**Introduction to MME**
Number of Credits	:	**2**
LTPC Breakup	:	L: 2, T: 0, P: 0, C: 2
Prerequisites (Course code)	:	Nil
Course Type	:	GIR

Course Learning Objectives

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

Course Content

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

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

Modern materials – Bio and Nano materials.

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

Reference Books

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

Course Outcomes

1. Define engineering materials technology and understand each stage of the materials cycle, material selection criteria [5, 8, 10]
2. Understand the impact of Metallurgical and Materials Engineering solutions in a global, economic, environmental, and societal context [8]
3. Become familiar with the science behind the development of metals and materials [1]
4. Become familiar with current trends / developments and the prevailing industrial scenario in metals and materials [8,10]

Course Code	:	CEIR11
Course Title	:	**Basics of Civil Engineering**
Number of Credits		**2**
LTPC Breakup	:	L: 2, T: 0, P: 0, C: 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 Mc Graw Hill, 2000.*
5	*Lecture notes prepared by Department of Civil Engineering, NITT*

Course Outcomes

At the end of the course:

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

Course Code	:	EEIR11
Course Title	:	**Basics of Electrical and Electronics Engineering**
Number of Credits		**2**
LTPC Breakup	:	L: 2, T: 0, P: 0, C: 2
Prerequisites(Course code)	:	Nil
Course Type	:	GIR

Course Learning Objectives

This course aims to equip the students with a basic understanding of Electrical circuits and machines for specific types of applications. The course gives a comprehensive exposure to house wiring. This course also equips students with an ability to understand basics of analog 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, Mc Graw Hill, 2012.*
4	*Malvino, A. P., Leach D. P. and Gowtham Sha, 'Digital Principles and Applications', 6th Edition, Tata Mc Graw Hill, 2007.*
5	*Vincent Del Toro, 'Electrical Engineering Fundamental', Prentice Hall India, 2002.*

Course Outcomes

1.	At the end of the course student will be able to 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: 3, T: 0, P: 0, C: 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.
Geometrical constructions dividing a given straight line into any number of equal parts, bisecting a given angle, drawing a regular polygon given one side, special methods of constructing a pentagon and hexagon – conic sections – ellipse – parabola – hyperbola - cycloid – trochoid.
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 or 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.
Computer aided drafting Introduction to computer aided drafting package to make 2-D drawings.
Self-study only, not to be included in examinations. Demonstration purpose only.

Reference Books

1	*Bhatt, N. D. and Panchal, V.M., ‘Engineering Drawing’, Pub.: Charotar Publishing House, 2010.*
2	*Natarajan, K. V., ’A text book of Engineering Graphics’, Pub.: Dhanalakshmi Publishers, Chennai, 2006.*
3	*Venugopal, K. and Prabhu Raja, V., ‘Engineering Drawing and Graphics + AutoCAD’, Pub.: New Age International, 2009.*
4	*Jolhe, D. A., ‘Engineering drawing’, Pub.: Tata McGraw Hill, 2008*
5	*Shah, M. B. and Rana, B. C., ‘Engineering Drawing’, Pub.: Pearson Education, 2009.*
6	*Trymbaka Murthy, S., ‘Computer Aided Engineering Drawing’, Pub.: I.K. International Publishing House, 2009.*

Course Outcomes

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

Course Code	:	SWIR11
Course Title	:	**NSS/ NCC/ NSC**
Number of Credits		**0**
LTPC Breakup	:	L: 0, T: 0, P: 0, C: 0
Prerequisites (Course code)	:	Nil
Course Type	:	GIR

Course Learning Objectives
Course Content
Reference Books
Course Outcomes

Course Code	:	HSIR12				
Course Title	:	**Professional Communication**				
Number of Credits		**3**				
LTPC Breakup	:		L	T	P	C
			3	0	0	3
Prerequisites (Course code)	:	Nil				
Course Type	:	GIR				

Course Learning Objectives

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

Course Content

Listening Barriers to listening: Physical & psychological – Steps to overcome them – Purposive listening practice – Active listening and anticipating the speaker – Use of technology in the professional world.

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

Reading Speed reading practice – Use of extensive readers –Trans-coding: verbal and nonverbal – Eye-reading practice – Analytical and critical reading practice- Introduction to ethics & values through case-study materials.

Writing Professional Correspondence – Formal and informal letters – Argument Writing practice – Perspectives in writing – Narrative writing -Different registers - Tone in formal writing – Summary writing practice- Introduction to reports.

Study Skills Reference Skills - Use of dictionary, thesaurus etc – Importance of contents page, cover & back pages – Bibliography.

Reference Books

1	*Shirley Taylor (1999), 'Communication for Business', Longman, New Delhi.*
2	*Robert Gannon (2000), 'Best Science Writing: Readings and Insights', University Press,Hyderabad*
3	*Richard A. Boning (1990), 'Multiple Reading Skills', McGraw Hill, Singapore.*
4	*Albert J. Harris, Edward R.Sipay (1990), 'How to Increase Reading Ability', Longman.*
5	*David Martin (1994), 'Tough Talking', University press, Hyderabad.*

Course Outcomes

1	At the end of the course student will have knowledge of the various uses of English in their professional environment and they will be able to communicate themselves effectively in their chosen profession.

Course Code	MAIR21				
Course Title	MATHEMATICS – II				
Number of Credits	(3L+1T=)4				
LTPC Breakup	L	T	P	C	
	3	1	0	4	
Prerequisites	MAIR11				
Course Type	GIR				

Course Learning Objectives

1. Introduce the structure vector space and various operations on it.
2. Introduce different method to solve the 2nd order differential equations and its applications in electric circuit problems.
3. Familiarize concepts like differentiations and integration for function of complex variable.
4. Introduce vector differential operator for vector function and important theorems on vector functions to solve engineering problems.

Course Content

Vector space – Subspaces – Linear dependence and independence – Spanning of a subspace – Basis and Dimension. Inner product – Inner product spaces – Orthogonal and orthonormal basis – Gram-Schmidt orthogonalization process.

Basic review of first order differential equation - Higher order linear differential equations with constant coefficients – Particular integrals for $x^n e^{ax}, e^{ax}\cos(bx), e^{ax}\sin(bx)$ – Equation reducible to linear equations with constant coefficients using $x = e^t$ - Simultaneous linear equations with constant coefficients – Method of variation of parameters – Applications – Electric circuit problems.

Gradient, Divergence and Curl – Directional Derivative – Tangent Plane and normal to surfaces – Angle between surfaces –Solenoidal and irrotational fields – Line, surface and volume integrals – Green's Theorem, Stokes' Theorem and Gauss Divergence Theorem (all without proof) – Verification and applications of these theorems.

Analytic functions – Cauchy – Riemann equations (Cartesian and polar) –Properties of analytic functions – Construction of analytic functions given real or imaginary part – Conformal mapping of standard elementary functions $\left(z^2, e^z, \sin z, \cos z, z + \frac{k^2}{z}\right)$ and bilinear transformation.

Cauchy's integral theorem, Cauchy's integral formula and for derivatives– Taylor's and Laurent's expansions (without proof) – Singularities – Residues – Cauchy's residue theorem – Contour integration involving unit circle.

Reference Books

1	*Kreyszig, E., Advanced Engineering Mathematics, 10th edn, John Wiley Sons, 2010.*
2	*Grewal, B.S., Higher Engineering Mathematics, 43rd edition, Khanna Publications, Delhi.*
3	*Gilbert Strang, Linear Algebra and its applications, 4th edn, Cengage Learning, 2006*
4	*James Ward Brown and Ruel V. Churchill, Complex variables and Applications, 9th edn, McGraw-Hill, 2013*

Course Outcomes

1 After the completion of the course, students are able to

1. Perform standard operation in finite dimensional vector spaces
2. Compute the dot product of vectors, lengths of vectors, and angles between vectors.
3. Perform gradient, div, curl operator on vector functions and give physical

	interpretations. 4. Use Green's, Gauss divergence and Stoke's theorems to solve engineering problems. 5. solve higher order ODEs and interpret it geometrically. 6. Compute differentiation of functions of complex variable. 7. Construct analytic function for given real or imaginary part of it. 8. find images of the given region by standard functions of complex variable. 9. compute bilinear map by knowing the images of three points.

Course Code	**:**	PHIR12
Course Title	**:**	**Physics – II (Theory & Lab)**
Number of Credits		**4**
LTPC Breakup	**:**	L: 3, T: 1, P: 0, C: 4
Prerequisites (Course code)	**:**	Nil
Course Type	**:**	GIR

L	T	P	C
3	1	0	4

Course Learning Objectives

- To make a bridge between the physics in school and engineering courses
- To introduce the basic concepts of modern physics like fundamentals of quantum mechanics, nuclear physics and advanced materials.
- To introduce the concepts of NDT and Vacuum Technology.

Course Content

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 – eigenvalues and eigen functions – superposition principle – interpretation of wave function – particle confined in one dimensional infinite square well potential.

Nuclear and Particle Physics Fundamental forces - Nuclear properties and forces - Nuclear models - Shell model - Nuclear reaction - Radioactivity - types and half-lives - application in determining the age of rock and fossils- Neutrons and its applications (neutron diffraction, nuclear reaction etc)- Stellar nucleosynthesis. Particle physics - classification of matter - quark model-neutrino properties and their detection.

Advanced Materials

Nanomaterials - Introduction and properties – synthesis – chemical vapour deposition – ball milling – applications. Carbon nanotubes: structure and properties – synthesis– arc method – pulsed laser deposition- applications.

Liquid Crystal types – nematic, cholesteric, smectic – modes: dynamic scattering, twisted nematic – display systems.

Shape memory alloys-one way and two way memory effect- pseudo elasticity-applications

Non-Destructive Testing Principle of ultrasonic testing – inspection methods – different types of scans – liquid penetrant testing – magnetic particle inspection – principle and types of radiography – exposure factor – attenuation of radiation – real time radiography – principle of thermography – thermographic camera – advantages and limitations of all methods.

Vacuum Technology Introduction-Exhaust pump and their characteristics-different types of pumps-rotary vane pump-roots pump-diffusion pump-turbo-molecular pump-measurement of low pressure pirani gauge-penning guage - applications of vacuum technology - thin film deposition: thermal evaporation-sputtering.

Laboratory Experiments1. Wavelength of sodium light – Newton's rings 2. Thermal conductivity – Lee's Disc 3. Wavelength of mercury spectrum – Spectrometer 4. Calibration of Voltmeter – Potentiometer 5. Wavelength of laser using diffraction grating 6. Field along the axis of a Circular coil 7. Non-destructive testing by ultrasonic flaw detector. 8. GM counter experiment 9. Zeeman Effect experiment 10. Millikan's oil drop experiment 11. Kunds tube experiment

Reference Books

1	*A text book of Engineering Physics', M.N. Avadhanulu and P.G. Kshirsagar, S. Chand and Company, New Delhi 2009.*
2	*'Engineering Physics', R.K. Gaur and S.L. Gupta, Dhanpat Rai Publications (P) Ltd., 8th ed., New Delhi 2001.*

3	*'Concepts of Modern Physics. Arthur Beiser', Tata McGraw-Hill, New Delhi 2010.*
4	*'Hand Book of Non-destructive evaluation', C.J. Hellier, McGraw-Hill, New York 2001.*
5	*'Vacuum Science and Technology', V.V. Rao, T.B. Ghosh, K.L. Chopra, Allied Publishers, New Delhi 2008.*
6	*'Introduction to Nanotechnology', C.P. Poole and F.J. Owens, Wiley, New Delhi 2007.*
7	*'Introduction to Liquid Crystals Chemistry and Physics',* 2nd Ed, *Peter J. Collings, Princeton University Press, New Jersey, 2002.*
8	*D. C. Lagoudas 'Shape memory alloys - modeling and engineering applications', Ed., Springer, New York 2008*
9	*R.K. Shukla, Anchal Srivastava ,'Practical Physics' , New age international 2011.*
10	*C.L Arora 'B.Sc. Practical Physics', S. Chand &Co, 2012.*
Course Outcomes	
1.	At the end of the course student will get an exposure to most modern and advanced concepts in nuclear physics, nanotechnology and advanced materials. Study of basic concept of NDT is very important for a modern engineer.

Course Code	:	CHIR12
Course Title	:	**Chemistry - II (Theory & Lab)**
Number of Credits		**4**
LTPC Breakup	:	L: 3, T: 1, P: 0, C: 4
Prerequisites (Course code)	:	Nil
Course Type	:	GIR

Course Learning Objectives

To introduce the students to basic principles of electrochemistry, importance of corrosion, spectroscopic techniques, metals, alloys polymers and composites.

Course Content

Electrochemistry Conductivity of electrolytes- Specific, molar and equivalent conductivity, Nernst equation for electrode potential, EMF series, hydrogen electrode, calomel electrode, glass electrode, Electrolytic and galvanic cells, cell EMF, its measurement and applications, Weston standard cell, reversible and irreversible cells, concentration cell, electrode (hydrogen gas electrode) and electrolyte concentration cell, concentration cell with and without transference, fuel cells, hydrox fuel cell.

Corrosion Dry corrosion and wet corrosion, mechanisms, types of corrosion, DMC, DAC, stress, inter granular, atmospheric and soil corrosion, Passivity, Polarization, over potential and its significance, Factors affecting corrosion, protection from corrosion by metallic coatings, electroplating, electroless plating and cathodic protection, Chemical conversion coatings and organic coatings- Paints, enamels.

Spectroscopic Techniques Interaction of Electromagnetic radiation with matter- Born–Oppenheimer approximationIR Spectroscopy- Instrumentation and Applications-Franck–Condon Principle - Electronic Spectra-Theory of electronic transitions – Instrumentation- Beers Law- Applications – Woodward-Fieser rules for acyclic dienes and unsaturated ketones – NMR Spectroscopy – Shielding and deshielding-Chemical shift-Applications -Atomic absorption and Atomic Emission Fundamentals

Metals and Alloys Physical Properties of Metals-Theories of Bonding in metals – Free Electron theory – Valance bond theory – MO theory -Metallurgy – different processes involved in isolation and purification of metals from ores-thermodynamics of reduction processes – Isolation of Nickel, Chromium, Tungsten, Uranium, and Iron- Heat Treatment of Steel-Powder metallurgy-Alloy steels – Thermal Analysis-Thermogravimetry-Differential Thermal Analysis-Differential Scanning Calorimetry

Polymers and Composites Concept of macromolecules-Nomenclature of polymers-Tacticity-Polymerization processes- Mechanism-Types of Polymerization-Classification of Polymers-Effect of Polymer structure on properties-Moulding of plastics into articles-Important addition and condensation polymers –synthesis and properties – Molecular mass determination of polymers-Static and dynamic methods, Light scattering and Gel Permeation Chromatography-Rubbers – Vulcanization – Synthetic rubbers – Conducting polymersComposite materials – Reinforced composites and processing.

Laboratory Experiments1. Corrosion rate by polarization technique 2. Conductometric titration 3. Potentiometric titration 4. pH metric titration 5. Percentage purity of bleaching powder 6. Percentage purity of washing soda 7. Determination of molecular weight of polymer by viscometry 8. Demonstration of sophisticated instruments and assignments on them

Reference Books

1	*P. C. Jain & M. Jain, 'Engineering Chemistry', Dhanpat Rai Publishing, New Delhi, 2005.*
2	*B.R. Puri, L.R. Sharma, M.S. Pathania, 'Principles of Physical Chemistry', Vishal Publishing, 2008.*
3	*F.W. Billmayer. 'Textbook of Polymer Science'. 3rd Edn, Wiley. N.Y. 1991.*
4	*C. N. Banwell & E.M. McCash, 'Fundamentals of Molecular Spectroscopy', 4th Edn, Tata Mc Graw-Hill Edition, 1995.*

5	*S. S. Darer, S. S. Umare, 'A Text Book of Engineering Chemistry', S. Chand Publishing, 2011.*
6	*Laboratory Manual, Department of Chemistry, NITT*
7	*S.K. Bhasin, S. Rani, 'Laboratory Manual on Engineering Chemistry', Dhanpat Rai Publishing Company, New Delhi, 2011.*
Course Outcomes	
1	At the end of the course student would become familiar with the importance of electrochemistry, its applications, corrosion, and spectroscopic techniques for characterization, importance of properties of metals, alloys polymers and composites.

Course Code	:	ENIR11				
Course Title	:	**Energy and Environmental Engineering**				
Number of Credits		**2**				
LTPC Breakup	:	L	T	P	C	
		2	0	0	1	
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- Off shore Wind energy- Environmental benefits and impacts.

Biomass resources-Biomass conversion Technologies- Feedstock pre-processing 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. 2004.' Renewable energy: Power for a sustainable future'. Oxford University press.*
2	*B H Khan, 'Non-Conventional Energy Resources'-The McGraw –Hill Second edition.*
3	*G. D. Rai, 'Non-conventional energy sources', Khanna Publishers, New Delhi, 2006.*
4	*Gilbert M. Masters, 'Introduction to Environmental Engineering and Science', 2nd Ed, PH 2003.*
5	*'Unleashing the Potential of Renewable Energy in India' –World bank report.*
6	*Godfrey Boyle, Bob Everett and Janet Ramage.2010.'Energy Systems and Sustainability. Power for a sustainable future'. Oxford University press.*

Course Outcomes

1	At the end of the course student will be introduced to the Principal renewable energy systems and explore the environmental impact of various energy sources and also the effects of different types of pollutants.

Course Code	:	MTPC10
Course Title	:	**Engineering Mechanics**
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	Nil
Course Type	:	PC

Course Learning Objectives

- To explain the importance of mechanics in the context of engineering and conservation equations.
- To explain the significance of centroid, centre of gravity and moment of inertia. To introduce the techniques for analyzing the forces in the bodies.
- To apply the different principles to study the motion of a body, and concept of relative velocity and acceleration.
- To describe the trajectory of a particle under projectile motion.
- To identify the basic elements of a mechanical system and write their constitutive equations.

Course Content

Fundamentals Mechanics and its relevance, concepts of forces, laws of mechanics - parallelogram law, Lami's theorem, law of polygon, concept of free-body diagram, centroids, center of gravity, area moment of inertia, mass moment of inertia – simple and composite planes, Numerical.
Friction Laws of friction, static friction, rolling friction, application of laws of friction, ladder friction, wedge friction, body on inclined planes, simple screw jack – velocity ratio, mechanical advantage, efficiency, Numerical.
Statics Principles of statics, types of forces, concurrent and non-concurrent forces, composition of forces, forces in a plane and space, simple stresses and strains, elastic coefficients, Numerical.
Kinematics Fundamentals of rectilinear and curvilinear motion, application of general equations, concept of relative velocity, analytical and graphical techniques, Numerical.
Dynamics Principles of dynamics, D'Alembert's principle, conservation of momentum and energy, vibrations of simple systems, Numerical.

Reference Books

1	*Kumar, K. L., Kumar, V. 'Engineering Mechanics', Pub.: Tata McGraw Hill, 2011.*
2	*Palanichamy, M. S., and Nagan, S., 'Engineering Mechanics – Statics & Dynamics', Pub.: Tata McGraw Hill, 2002.*
3	*Timoshenko, S. and Young, D. H.,' Engineering Mechanics', Pub.: McGraw Hill, 2006.*
4	*Popov, E. P., 'Engineering Mechanics of Solids', Pub.: Prentice Hall, 1998.*
5	*Shames, I. H. and Rao, G. K. M., 'Engineering Mechanics – Static and Dynamics', Pub.: Pearson Education, 2009.*
6	*Beer, F. P., and Johnson Jr. E. R.,' Vector Mechanics for Engineers', Pub.: McGraw Hill, Year of publication: 2009.*
7	*Rao, J. S. and Gupta, K., 'Introductory Course on Theory and Practice of Mechanical Vibrations', Pub.: New Age International, 1999.*

Course Outcomes

1	At the end of the course student will be able to identify and analyze the problems by applying the fundamental principles of engineering mechanics and to proceed to research, design and development of the mechanical systems.

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

Course Learning Objectives
Introduction to the use of tools and machinery in Carpentry, Welding, Foundry, fitting and Sheet Metal Working
Course Content
Carpentry Wood sizing exercise in planning, marking, sawing, chiselling and grooving to make 1. Half lap joint 2. Cross lap joint **Welding** Exercise in arc welding for making 1. Lap joint 2. Butt joint **Foundry** Preparation of sand mould for the following 1. Flange 2. Anvil **Fitting** Preparation of joints, markings, cutting and filling for making 1. V-joint 2. T-joint **Sheet metal** Making of small parts using sheet metal 1. Tray 2. Funnel

Reference Books	

Course Outcomes	

Course Code	:	MAIR32
Course Title	:	**Transforms and Partial Differential Equations**
Number of Credits		**3**
LTPC Breakup	:	L: 0, T: 0, P: 2, C: 2
Prerequisites (Course code)	:	MAIR11,MAIR21
Course Type	:	GIR

Course Learning Objectives

1. understand the importance of transform techniques to solve engineering problems.
2. apply Laplace and Fourier transform to solve the mathematical equations arising in mechanical engineering.
3. understand Fourier series analysis and its use in solving boundary value problems.
4. understand and solve the partial differential equations.
5. construct mathematical model of some heat transfer problem and vibration of an elastic string.

Course Content

Laplace Transform of Standard functions, derivatives and integrals – Inverse Laplace transform - Convolution theorem-Periodic functions – Application to ordinary differential equations and simultaneous equations with constant coefficients and integral equations.

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

Fourier transforms - Fourier cosine and sine transforms – inverse transforms - convolution theorem and Parseval's identity for Fourier transforms - Finite cosine and sine transforms.

Formation of partial differential equations eliminating arbitrary constants and functions - solution of first order equations - four standard types - Lagrange's equation - homogeneous and non-homogeneous type of second order linear differential equation with constant coefficients.

One-dimensional wave equation and one-dimensional heat flow equation - method of separation of variables - Fourier series solution.

Reference Books

1. Grewal.B.S., Higher Engineering Mathematics, 43rdEdition, Khanna Publisher, Delhi
2. Debnath L., and Dambaru Bhatta, Integral Transforms and Their Applications, 2nd Ed. (Special Indian Ed).Chapman & Hall/CRC, Indian Edtion, 2010
3. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 2010.
4. Haberman R., Applied Partial Differential Equations: With Fourier Series and Boundary Value Problems. Pearson, 2013.
5. K.Sankara Rao, Introduction to Partial Differential Equations, 3rd Edn, PHI Learning Private Ltd. 2012.

Course Outcomes

1. Compute Laplace and inverse Laplace transform of functions.
2. Apply Laplace transform to solve ordinary differential equations.
3. Compute Fourier and inverse Fourier transform of functions.
4. Compute Fourier series of given function and interpret its coefficients.
5. Able to form partial differential equation for given family of surfaces.
6. Compute solution of few types of linear and non-linear first order/second order PDEs.
7. Construct mathematical model of heat transfer problem and its solution by separation of

variable method.

8. Construct mathematical model of vibration of elastic sting (one dimensional) and solution of it.

Course Code	:	HSIR14
Course Title	:	**Professional Ethics**
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	Nil
Course Type	:	GIR

Course Learning Objectives

Identify the core values that shape the ethical behavior of an engineer. To create an awareness on 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 (Indian Reprint now available)*
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	
	Upon completion of this course, students should have
1	Understood the core values that shape the ethical behaviour of an engineer
2	Exposed awareness on professional ethics and human values.
3	Known their role in technological development

Course Code	:	MTPC11
Course Title	:	**Strength of Materials**
Number of Credits		**3**
LTPC Breakup	:	L: 2, T: 1, P: 0, C: 3
Prerequisites (Course code)	:	MTPC10
Course Type	:	PC

Course Learning Objectives

The objective is to determine the stresses, strains on various structural object, displacements in various structures and their components under the specific externalloads such as axial load, bending and shear load as well as torsion.

Course Content

Elastic limit - Hooke's law - Poisson's ratio - Bar of uniform strength - Equivalent area of composites sections - temperature stresses - Hoop stress - Volumetric strain - stresses due to different types of axial loading - Gradually and Impact loads.

Stresses on an incline plane – principle stresses - thin cylinders - Circumferential and longitudinal stresses - Wire bound pipes - Thin spherical shells - Biaxial stresses doubly curved walls of pressure vessels

Beams – types - Shear forces and bending moment diagrams. Bending - Theory of simple bending - Practical application of bending equation - Section modulus - Shear stress distribution on a beam section

Center of gravity - centroid of a uniform lamina - centroids of lamina of various shapes - Moment of an Inertia of a lamina - definition - Parallel axes theorem - Perpendicular axes theorem - Moment of Inertia of lamina of different shapes

Pure torsion - Theory of pure torsion - Torsional moment of resistance - Power transmitted by a shaft - Torsional rigidity - Stepped shafts - Keys - couplings - Shear and Torsional resilience-Shafts of non-circular section - Close coiled helical springs

Reference Books

1	*Rajput R. K., 'Strength of Materials', S. Chand, 1996*
2	*Ramamrutham S., 'Strength of Materials', 8th Edition, Dhanapat Rai, 1992*
3	*Ramamrutham S and R. Narayanan, "Strength of Materials', 7th Edition, 1999*
4	*Strength of Materials, R.K. Bansal, 4th edition, Laxmi Publications, 2010.*

Course Outcomes

At the end of the course student will be able to:

1	Understand the different types of material behaviour such have elastic, plastic, ductile and brittle [1, 2]
2	Study the fundamental mechanics of solid deformable bodies. [1, 5, 11]
3	Use the concept of moment of inertia of lamina for different shapes [1, 5]
4	Able to solve the numerical and practical problems related to real world strength of materials [1, 5, 8]

Course Code	:	MTPC13
Course Title	:	**Metallurgical Thermodynamics**
Number of Credits		**4**
LTPC Breakup	:	L: 3, T: 1, P: 0, C: 4
Prerequisites (Course code)	:	Nil
Course Type	:	PC

Course Learning Objectives

To learn the basic principles and concepts of thermodynamics, in the domain of metallurgy and materials; and to learn about equations and their applications; and to appreciate that metallurgical thermodynamics is a knowledge base with abundant applications

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 1st and 2nd laws - Maxwell's relations, Clausius - Clapeyron equation, Trouton's rule, Gibb's - Helmholtz relations.

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

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

Numerical problems on the concepts mentioned in all the above units.

Reference Books

1	*Tupkary R.H., 'Introduction to Metallurgical Thermodynamics', 1st Edition, TU Publishers, 1995*
2	*Upadhyaya G.S., Dube R.K., 'Problems in Metallurgical Thermodynamics and Kinetics', 1st Edition, Pergamon Press, 1977 Ghosh A, 'Textbook of Materials and Metallurgical Thermodynamics', PHI EEE, 3rd Print, 2009.*
3	*Ahindra Ghosh, 'Textbook of Materials and Metallurgical Thermodynamics', PHI Learning, 2002.*

Course Outcomes

	At the end of the course student will be able to:
1	Understand the basic laws of thermodynamics [1, 2]
2	Understand the multiple approaches to thermodynamics, from the bulk property point of view and from the atomistic point of view [1]
3	Understand concepts such as the theory of solutions, free energy, entropy, criteria for equilibrium and conditions for feasibility [1, 2]
4	Obtain the skill to use metallurgical thermodynamic concepts and equations for understanding phase diagrams, phase transformations, theory of solutions [11, 5]
5	Obtain problem solving skills in order to improve / modify industrial processes, esp. In extraction metallurgy, liquid metal treatment and in heat treatment [1, 2, 11, 8]

Course Code	:	MTPC14
Course Title	:	**Mineral Processing and Metallurgical Analysis**
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	Nil
Course Type	:	PC

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 ; economics of ore processing;
Chemical processing of ores - leaching ,ion-exchange and liquid- solvent extraction; crushing and grinding – types, washing, sorting and hand-picking; laboratory and industrial screening classifiers, mechanical and hydraulic; sedimentation principles

Concentration by jigs, tables, heavy media separation, froth floatation, magnetic and electrostatic separation, thickeners and filters; use of flow sheets (specific examples from metals processing), wet and dry sampling,

Principles of chemical analysis - ores, metals, alloys, non-metallics, details of specific chemical analysis techniques, introduction to common analysis techniques used in metallurgical industries (spectrovac and spot testing)

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. *Gilchrist J.D., 'Extraction Metallurgy', 2nd Edition, Pergamon Press, 1980*
4. *Joseph Newton, 'Extractive Metallurgy', 1st Edition, Wiley Eastern, 1967*
5. *Vogel A.I., 'A TextBook of Quantitative Inorganic Analysis', 3rd Edition, ELBS, Longman, 1978*

Course Outcomes

At the end of the course student will be able to:

1. Understand the mineral processing basic principles [1, 2]
2. Describe the physical and chemical properties of various minerals [1, 2]
3. To know and understand the various separation methods of mineral or gangue particles [2]
4. To know the common analysis techniques used in metallurgical industries [8, 11]
5. Explain the various types of process control in mineral processing [1]
6. To study about the different ores for different materials [1, 11]

Course Code	:	MTPC15
Course Title	:	**Physical Metallurgy**
Number of Credits		**4**
LTPC Breakup	:	L: 3, T: 1, P: 0, C: 4
Prerequisites (Course code)	:	Nil
Course Type	:	PC

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 grain size determination,

Self-diffusion, diffusion in alloy, diffusion mechanisms, activation energy, laws of diffusion- Fick's I law, II law, inter-diffusion and Kirkendall 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	*Reed Hill R.E., 'Physical Metallurgy Principles', 2nd Edition, Affiliated East West Press, 1973*
2	*Derek Hull, 'Introduction to Dislocations', Pergamon, 2nd Edition, 1981*
3	*Raghavan V., 'Physical Metallurgy - Principles and Practice', Prentice - Hall of India, 1993*
4	*Guy A.G., 'Elements of Physical Metallurgy', 3rd Edition, Addison Wesly, 1974.*

Course Outcomes

At the end of the course student will be able to:
Upon completion of this class, students are expected to

1. Understand the geometry and crystallography of crystalline materials [1, 2].
2. Identify planes and directions in hexagonal and other crystal systems
3. Understand the significance of various defects and estimate the grain size in polycrystalline materials.
4. Assess parameters to solve engineering problems involving diffusion
5. Explain the phase transformations based on phase diagrams
6. Apply thermodynamic concepts in the construction of phase diagrams

Course Code	:	MTLR30
Course Title	:	**Process Metallurgy Lab**
Number of Credits		**1**
LTPC Breakup	:	L: 0, T: 0, P: 1, C: 1
Co requisites (Course code)	:	MTPC14
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. Sieve analysis
2. Sedimentation and decantation
3. Determination of size distribution in sample
4. Jaw crusher
5. Bomb Colorimeter
6. Viscosity Measurement
7. Heavy medium separations
8. Froth floatation
9. Observations of mineral samples
10. Observations of furnaces

Course Outcomes

	At the end of the course student will be able to:
1	Obtain the skills for physical observation of minerals/ores [1, 2]
2	Obtain the ability to perform sieve analysis [2]
3	Obtain the ability to observe comminution and to perform related calculations [1, 2, 5]
4	Become familiar with mineral beneficiation operations [2, 8, 10, 11]

Course Code	:	MAIR41			
Course Title	:	**Numerical Techniques**			
Number of Credits		**3**			
LTPC Breakup	:	L	T	P	C
		3	0	0	3
Prerequisites (Course code)	:	Nil			
Course Type	:	GIR			

Course Learning Objectives

To develop the basic understanding of numerical algorithms and skills to implement algorithms to solve mathematical problems on the computer.

Course Content

Solution of linear system - Gaussian elimination and Gauss-Jordan methods - LU - decomposition methods - Crout's method - Jacobi and Gauss-Seidel iterative methods - sufficient conditions for convergence - Power method to find the dominant eigenvalue and eigenvector.

Solution of nonlinear equation - Bisection method - Secant method - Regula falsi method - Newton-Raphson method for f(x) = 0 and for f(x,y) = 0, g(x,y) = 0 - Order of convergence - Horner's method - Graeffe's method - Bairstow's method.

Newton's forward, backward and divided difference interpolation – Lagrange's interpolation – Numerical Differentiation and Integration – Trapezoidal rule – Simpson's 1/3 and 3/8 rules - Curve fitting - Method of least squares and group averages.

Numerical Solution of Ordinary Differential Equations- Euler's method - Euler's modified method - Taylor's method and Runge-Kutta method for simultaneous equations and 2nd order equations - Multistep methods - Milne's and Adams' methods.

Numerical solution of Laplace equation and Poisson equation by Liebmann's method - solution of one dimensional heat flow equation - Bender - Schmidt recurrence relation - Crank - Nicolson method - Solution of one dimensional wave equation.

Reference Books

1. David Kincaid and Ward Cheney, Numerical Analysis, 3rd Ed, American Mathematics Society, (Indian edition) – 2010.
2. Gerald C.F., and Wheatley P.O., Applied Numerical Analysis, Addison-Wesley Publishing Company, 1994
3. Jain, M.K., Iyengar, S.R. and Jain, R.K., Numerical Methods for Scientific and Engineering Computation, New Age international,2003
4. Atkinson, K.E., An Introduction to numerical Analysis, John Wiley & Sons, 2008

Course Outcomes

1. compute numerical solution of given system AX=B by direct and iterative methods.
2. compute largest eigenvalue and its corresponding eigenvector of matrix A.
3. compute numerical solution of f(x)=0 and nonlinear equations with two variables,
4. interpolate function and approximate the function by polynomial.
5. compute numerical differentiation and integration of $f(x)$.
6. compute best curve fit for the given data by curve fitting method.
7. compute numerical solution of ordinary differential equations by finite difference method.
8. compute numerical solution of partial differential equations by finite difference method.

Course Code	:	MTPC16
Course Title	:	**Instrumentation and Control Engineering**
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	Nil
Course Type	:	PC

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 system, classification of variables,
ON/OFF, P, PI, 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 Measurement Systems" 3rd E, 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 8085/8080A", 3rd edition, Penram International Publishing house, 2002*
4	*Patranabis, "Sensors and Transducers", Wheeler Publishing, 1999.*
5	*Doebelin E.O, " Measurement system-applications and design", 4th E McGraw Hill New York,2003*

Course Outcomes

	At the end of the course student will be able to:
1	Differentiate static and dynamic characteristics and calibration standards for measurements. [1]
2	Select the suitable temperature measurement method for the suitable condition. [1, 2]
3	Application of various transducers for direct contact and non-contact measurements. [2, 11]
4	Design and measurements of PC based methods, construction of interface devices. [2, 11]
5	Differentiate loops and variables and their effective applications in various situations. [1, 2, 11]

Course Code	:	MTPC12
Course Title	:	**Electrical, Electronic and Magnetic Materials**
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	MTIR15
Course Type	:	PC

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 - piezo electricity and pyro electricity – $BaTiO_3$ – structure and properties.

Origin of Magnetism - Introduction to dia, para, ferri and ferro magnetism – 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 super conductivity – Types of super conductors –YBCO- structure and properties – specific super conducting 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- - photo detectors – Optical disc and optoelectronic materials –LCD, LED and diode laser materials - electro optic modulators - Kerr and Pockel's effect – $LiNbO_3$.

Reference Books

1	*Kittel C., 'Introduction to Solid State Physics', 7th Edition, Wiley Eastern, New International Publishers, 2004*
2	*Dekker A. J., 'Electrical Engineering materialsPrentic Hall, 1995*
3	*Ed. Kasap and Capper, handbook of electronic and photonic materials, 2006, NY.*
4	*Dekker. A.J, Solid state Physics, Mac Millan India, 1995*
5	*Van Vlack L.H, Elements of Materials Science and Engineering, 6th edition,Addison Wiley, 1989*
6	*Raghavan V, Materials Science and Engineering – A First Course, Prentice Hall India, 2004.*

Course Outcomes

	At the end of the course student will be able to:
1	To understand the band gap theory for conducting, semiconducting and insulating materials.
2	To understand various electrical phenomenon such as ferro electricity, piezo electricity and pyro electricity along with dielectric behaviour of materials [1].
3	To study various kinds of magnetism principles, various types of materials exhibiting magnetism and their day to day applications in industry with recent advancements [1, 2, 5].
4	To study the theory of superconductivity phenomenon and superconducting materials and their

	applications along with recent advancements [5, 8].
5	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 [2, 11]. **To** learn about photoconduction phenomenon, optical materials and various optical devices and their performances **[1].**

Course Code	:	MTPC17
Course Title	:	**Transport Phenomena**
Number of Credits		**3**
LTPC Breakup	:	L: 2, T: 1, P: 0, C: 3
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 – convective heat transfer – concept of heat transfer coefficient – radiative heat transfer

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 modeling

Reaction Kinetics - Basic definitions & concepts – reaction mechanisms – reaction rate theories – slag–metal reaction

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	*Szekely J., Themelis N. J., 'Rate Phenomena in Process Metallurgy', Wiley, 1971*

Course Outcomes

	At the end of the course student will be able to:
1	Understand the scientific aspects related to heat flow, fluid flow and mass transfer [1, 2]
2	Learn about related equations, in the above context [1, 2, 8, 10]
3	Understand how transport concepts and equations are used in the modelling of metallurgical processes [1, 2, 11]
4	Obtain the ability to convert actual (descriptive) processes into appropriate equations and then attempt to solve the same [1, 5, 8, 9, 10, 11]
5	Obtain the basic skills essential for process modeling [1, 11]
6	Obtain the ability to carry out complex process calculations [5, 8]

Course Code	**:**	MTPC18
Course Title	**:**	Phase Transformation and Heat Treatment
Number of Credits		4
LTPC Breakup	**:**	L: 3, T: 1, P: 0, C: 4
Prerequisites (Course code)	**:**	MTPC15
Course Type	**:**	PC

Course Learning Objectives

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

Course Content

Introduction and classification of phase transformations. Diffusion in solids: phenomenological approach and atomistic approach. Nucleation and growth theories of vapour 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, spinoidal 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	*Avner S.H., 'Introduction to Physical Metallurgy', 2nd edition, Tata McGraw Hill, 1984*
2	*Lakhtin Y., 'Engineering Physical Metallurgy', 2nd Edition, MIR Publishers, 1979*
3	*Prabhu Dev K. H., 'Handbook of Heat Treatment of Steel', TMH, 1988*

Course Outcomes

At the end of the course student will be able to:

1.	Describe the mechanisms responsible for atomic and molecular movements in condensed phases [1, 2]
2.	Understand the heat treatment of steels using TTT and CCT [1, 2]
3.	Determine the heat treatment conditions required to obtain a given microstructure using TTT diagrams [1, 2, 8, 11]
4.	Relate solid state atomic mobility to transport phenomena in materials [5, 8, 11]
5.	Understand the different kinds surface hardening of steels [2, 11]

Course Code	:	MTPC22
Course Title	:	**Non-metallic materials**
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	nil
Course Type	:	PC

Course Learning Objectives

To develop the basic knowledge of materials particularly 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 polymerization, 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', Wiley Interscience, 1994*
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

1.	Select different materials other than conventional metals and alloys for specific engineering applications [3, 4]
2.	Solve the materials problems associated with the weight reduction through the appropriate choice of polymers ceramics, and composites [1, 11]
3.	Provide low cost alternative to expensive metals and alloys [8]
4.	Describe the selection criterion for polymers, ceramics and composites for various engineering applications [1, 10, 11]
5.	Analyze different microstructure of polymers, ceramics and composites and alter them according to application requirements [1, 11, 5]
6.	Emphasis the need of modern materials over conventional metal and alloys [8]

Course Code	:	MTLR31				
Course Title	:	**Ferrous Metallography Lab**				
Number of Credits		**2**				
LTPC Breakup	:		L	T	P	C
			0	0	2	2
Prerequisites (Course code)	:					
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
- To develop the knowledge of heat treatment and associated procedure of various engineering materials and apply them to study how it influences the microstructure and results in different mechanical behavior.

Course Content

List of Experiments

1. Specimen preparation for metallographic observation - working of metallurgical microscope
2. Determination of grain size of metallic materials
3. Macro etching - cast, forged and welded components
4. Microstructure cast iron - gray, nodular and malleable iron - unetched
5. Microstructure of gray, nodular and white iron – etched
6. Microstructure of steels (Low C, Medium C and High C steels)
7. Heat treatment of Low, medium and high carbon: Annealing, Normalizing and Hardening & Tempering
8. Heat treatment of tool steels
9. Carburizing of steel
10. Microstructure of heat treated stainless steels
11. Overheated structure and banded structure in steel

Course Outcomes

At the end of the course student will be able

1. After the completion of this laboratory course, the student is able to prepare the specimens for metallographic examination with best practice, can operate the optical microscope and understand, interpret, analyze the microstructures of all ferrous materials. [1, 2, 5, 11]
2. Define various heat treatment procedures for variety of engineering materials and their importance in materials behavior [1, 2]
3. Classify different heat treated microstructure using microscope [1]
4. Provide the practical solution procedure for the betterment of the materials performance based heat treatment [1, 2, 10]

Course Code	:	MTLR32
Course Title	:	**Instrumentation & Control Lab**
Number of Credits		**1**
LTPC Breakup	:	L: 0, T: 0, P: 1, C: 1
Prerequisites (Course code)	:	MTPC16
Course Type	:	ELR

Course Learning Objectives

To measure the basic mechanical parameters like strain, torque, load, displacement, pressure and temperature through the electronic and PC based methods

Course Content

List of Experiments

1. Measurement of strain using strain gauges.
2. Measurement of displacement using LVDT.
3. Measurement of pressure.
4. Measurement of temperature using RTD.
5. Measurement of temperature using TC.
6. Measurement of temperature using Thermistor.
7. Simple exercise on 8085 Microprocessor.
8. Simulation ON/OFF,P, PI, PID controller design using MATLAB.
9. Simple exercise based on PLC instructions.

Course Outcomes

1.	Construct strain gauge to measure the strain and torque and analysis. [1, 2]
2.	Construct a circuit to measure load, displacement using load cells and LVDT, respectively. [1, 2]
3.	Design of pressure measurement device and analysis. [2, 11]
4.	Construction and analysis of temperature measurement devices and their selections. [2, 11]
5.	Construction and analysis of design of PD, PID and PLC control devices. [1, 2, 11]

Course Code	:	MTPC 19
Course Title	:	**Metal casting technology**
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	NIL
Course Type	:	PC

Course Learning Objectives

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

Course Content

Introduction to casting and foundry industry; basic principles of casting processes; sequence in foundry operations; patterns; moulding practice; ingredients of moulding sand and core sand, 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

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 (modeling), 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, Tata McGraw Hill Publishers, 1985*
2. *Jain P. L., ' Principles of Foundry Technology', 3rd Edition, Tata McGraw Hill, 1995*
3. *Srinivasan N. K., 'Foundry Technology', Khanna Publications, 1986*

Course Outcomes

1. Select the appropriate design of the moulds, patterns etc. [1, 3, 11]
2. Design a new pattern or mould for required applications, if needed [1, 8]
3. Choose the appropriate furnace for the production of new materials [3, 8]
4. Distinguish the casting microstructures for different materials [1, 9]
5. Alter the microstructure for different applications [4, 5]

Course Code	:	MTPC20
Course Title	:	**Materials Joining Technology**
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	NIL
Course Type	:	PC

Course Learning Objectives

To know the concepts of different materials joining technology and emphasis on underlying science and engineering principle of every processes.

Course Content

Classification of welding processes, energy sources used in welding, working principle, advantages, 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, pre heat and cooling rate, PWHT. Weldability of carbon steel, stainless steel & aluminum. Hot & cold cracking phenomenon, 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

1.	Understand the working principle, merits and demerits of different joining processes [1,3,7,10,11,12]
2.	Understand the working principle and importance of welding allied processes[1,3,4,10,11,12]
3.	Solve welding heat flow related problems[2,5,8,12]
4.	Learn weldability and welding related problems of different materials[5,6,7,9]

Course Code	:	MTPC21
Course Title	:	**Iron making and steel making**
Number of Credits		**4**
LTPC Breakup	:	L: 3, T: 1, P: 0, C: 4
Prerequisites (Course code)	:	MTPC13, MTPC17
Course Type	:	PC

Course Learning Objectives

To know the importance of the 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', 2nd Edition, 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, PHI EEE, 2008.*

Course Outcomes

At the end of the course student will be able to

1. Classify different kinds of furnaces and their ancillary equipments used for Iron & Steel making [10, 11, 5]
2. Analyze various factors influencing quality of the product in blast furnace during Iron & Steel making[10, 11, 5]
3. Analyze the irregularities and cause of failures in blast furnace and apply the remedial measures for immediate rectification [2, 1]
4. Compare the traditional steel making to modern day manufacturing routes for the improvement of quality [11, 1, 2]

Course Code	:	MTPC23
Course Title	:	**Mechanical behaviour of materials**
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	MTPC11, MTPC15
Course Type	:	PC

Course Learning Objectives

To know the fundamental concepts of mechanical behavior of materials 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 Misses, 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 in tension, 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 Rock well hardness tests, Meyer hardness, analysis of indendation by an indenter, relationship between hardness and the flow curve, microhardness tests, hardness conversion; hardness at elevated temperatures.

Introduction, mechanical properties in torsion, torsional stresses for large plastic strains, types of torsion failures torsion test vs. tension test, hot torsion testing.

Reference Books

1	*Dieter G. E., 'Mechanical Metallurgy', 3rd Edition, McGraw Hill Publications, 2004*
2	*Suryanarayana, 'Testing of Metallic Materials', Prentice Hall India, 1979*
3	*Rose R. M., Shepard L. A., Wulff J., 'Structure and Properties of Materials', Volume III, 4th Edition, John Wiley, 1984*
4	*Honeycombe R. W. K., 'Plastic Deformation of Materials', Edward Arnold Publishers, 1984*

Course Outcomes

	At the end of the course student will be able
1.	Define various mechanical properties of materials and their importance in materials selection criteria [1, 2, 5]
2.	Classify different mechanical properties and how they can influence the materials behavior with respect to applied load [5]
3.	Provide the microstructure-mechanical property correlation for the betterment of the materials performance [1, 2, 11]
4.	Select the appropriate processing route and alter the microstructures of various engineering materials to meet the design and application demands [1]
5.	Select the suitable processing route in order to achieve the superior strength of materials [1, 5]
6.	Analyze the various metallurgical factors affecting mechanical properties of different metals and alloys [2, 1, 11]

Course Code	:	MTLR33				
Course Title	:	**Foundry and welding lab**				
Number of Credits		**2**				
LTPC Breakup	:	L	T	P	C	
		0	0	2	2	
Prerequisites (Course code)	:	MTPC19, MTPC20				
Course Type	:	ELR				

Course Learning Objectives

To know the concepts of materials joining technology and to apply them for the advanced manufacturing processing for various structural 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 student will be able
1.	Determination of properties of foundry sand [1,11,12]
2.	Understand the foundry melting practice [1,11]
3.	Develop basic welding skills in manual arc welding processes [1,2,11,12]
4.	Analysis the weldment microstructure [2,7,9]
5.	Analyze the various metallurgical factors affecting mechanical properties of different metals and alloys [2, 1, 11]

Course Code	:	MTLR34
Course Title	:	**Materials testing lab**
Number of Credits		**2**
LTPC Breakup	:	L: 0, T: 0, P: 2, C: 2
Prerequisites (Course code)	:	MTPC23
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 student will be able
1.	Classify the different mechanical testing methods with their inherent merits and limitations [1, 10, 5]
2.	Analyze the test sample for different testing methods [1, 2]
3.	Solve the materials problems associated testing [1, 11]

Course Code	:	MTPC24
Course Title	:	**Metal forming technology**
Number of Credits		**4**
LTPC Breakup	:	L: 3, T: 1, P: 0, C: 4
Prerequisites (Course code)	:	MTPC23
Course Type	:	PC

Course Learning Objectives

To know the concepts of metal forming and associate 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 close 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

Reference Books

1	*Dieter G. E, 'Mechanical Metallurgy', 3rd Edition, McGraw Hill, 1988*
2	*Higgins R.A, 'Engineering Metallurgy', Volume II, ELBS, 1975*
3	*Harris J.N, 'Mechanical Working of Metals-Theory and Practice', Pergamon Press, 1983*
4	*Narayanasamy R, 'Metal Forming Technology', Ahuja Book Company, 1997*

Course Outcomes

At the end of the course student will be able

1. Apply the concept of plastic deformation for metals and alloys to convert them in to useful shapes for intended engineering applications [1, 8]

2. Differentiate the various metal forming technology and choose the appropriate one for required engineering applications [1, 5]

3. Provide the successful solution to the various materials design and selection criteria for demanding engineering applications. [2, 5]

4. Analyze various operational and materials parameters influencing the metal forming quality [1, 2, 3, 10, 11]

Course Code	:	MTPC25
Course Title	:	**Particulate processing**
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	MTPC23
Course Type	:	PC

Course Learning Objectives

To introduce the importance 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 - Advantage 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 – Uni axial 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’, 2nd ed., MPIF, 1994*
4. *Fritz.V. Lenel ‘Powder metallurgy – Principles and Applications” Metal powder Industries federation, New Jersey, 1980*

Course Outcomes

1. Describe the basic mechanism of powder production for variety of materials to meet the demand of the research and industrial needs[1]
2. Characterize the various powders (materials) based on the engineering applications [1, 2]
3. Differentiate the processing routes for various powders (materials) and associated technology [1, 2, 5]
4. Define modern day processing routes and apply them successfully to materials processing [1]
5. Apply the powder metallurgy concepts to design new materials for advanced engineering materials [1, 3]
6. Apply the concepts of particulate processing to produce non-conventional materials which are difficult to produce other techniques. [1, 10]

Course Code	:	MTPC26
Course Title	:	**Non-ferrous extraction**
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	MTPC13, MTPC14
Course Type	:	PC

Course Learning Objectives

To evaluate the various microstructure of the non-ferrous metals and alloys using microscope and apply the concepts to make tailor made materials for given engineering design and applications.

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; physico chemical principles of fused salt electrolysis
Principles of hydrometallurgy; 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 McGraw Hill, 1983*
3	*Raghavan R., 'Extractive Metallurgy of Non-Ferrous Metals', Vijay Nicole Imprints, 2015.*

Course Outcomes

At the end of the course student will be able

1.	Differentiate variety of microstructure of non-ferrous materials (Al, Mg, Ti etc) using microscope [1, 2]
2.	Provide the comprehensive metallography procedure for a given non-ferrous metal or alloy [2, 1, 5, 11]
3.	Analyze the microstructure of the given non-ferrous metal or alloy using microscope [1, 2, 11]
4.	Classify different heat treated microstructure of non-ferrous metals and alloys [1, 2]

Course Code	:	MTPC 27				
Course Title	:	**Non-ferrous physical metallurgy**				
Number of Credits		**3**				
LTPC Breakup	:	L	T	P	C	
		3	0	0	3	
Prerequisites (Course code)	:	MTPC15				
Course Type	:	PC				

Course Learning Objectives
To comprehend the basic principles of physical metallurgy 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 Creep resistant materials, structure-property relationship, high temperature applications, superalloys, applications based on structure and properties, Intermetallics.

Reference Books	
1	*Polmear I. J., Light Alloys: From Traditional Alloys to Nanocrystals, 4th Edition, Butterworth-Heinemann, 2006*
2	*Alan Russell and, Kok Loong Lee ., Structure-Property Relations in Nonferrous Metals, Wiley-Interscience, 2005.*
3	*ASM Handbook: Properties and Selection : Nonferrous Alloys and Special-Purpose Material, 10th edition, ASM International, 1990*
4	*Joseph R. Davis, Alloying: Understanding the Basics, ASM International, 2001*
Course Outcomes	
	After the completion of this course, the student will be able to:
1.	Understand the structure and properties of nonferrous metals and alloys [1, 2, 5, 11]
2	Identify the phases present in different alloy systems by analyzing the phase diagrams [1, 2, 11]
	Design the heat-treatment cycles for different alloy systems to obtain the desired phases [1, 5, 11]
3.	Understand the structure-property correlation in different nonferrous materials [1, 2, 11]
4.	Apply the basic principles of non-ferrous physical metallurgy for recommending materials for specific applications [1, 3, 10]
5.	Apply the basic principles of non-ferrous physical metallurgy for developing new non-ferrous
6.	alloys and composites [1, 3, 5, 10]

Course Code	:	MTLR35
Course Title	:	**Non-ferrous metallography and Characterization lab**
Number of Credits		**2**
LTPC Breakup	:	L: 0, T: 0, P: 2, C: 2
Prerequisites (Course code)	:	MTPC27
Course Type	:	ELR

Course Learning Objectives

- To evaluate the various microstructure 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 and Heat treatment of super alloys

Course Outcomes

1. At the end of the course student will be able Differentiate variety of microstructure of non-ferrous materials (Al, Mg, Ti etc) using microscope [1, 2]
2. Provide the comprehensive metallography procedure for a given non-ferrous metal or alloy [2, 1, 5, 11]
3. Analyze the microstructure of the given non-ferrous metal or alloy using microscope [1, 2, 11]
4. Classify different heat treated microstructure of non-ferrous metals and alloys [1, 2]
5. Define various heat treatment procedures for variety of non-ferrous engineering materials and their importance in materials behavior [1, 2]
6. Provide the practical solution procedure for the betterment of the materials performance based heat treatment on non-ferrous metal or alloy [1, 2, 10]

Course Code	**:**	MTIR16
Course Title	**:**	Internship / Industrial Training / Academic Attachment
Number of Credits		**1**
LTPC Breakup	**:**	L T P C 0 0 1 1
Prerequisites (Course code)	**:**	Nil
Course Type	**:**	GIR

Course Learning Objectives
To become familiar with current practises and emerging trends in the engineering sector, with emphasis on processing of metals and materials
Course Content
[Flexible; series of lectures in topics of current interest, as visualized by the course co-ordinator and the Head of the department, considering relevant institute guidelines

Course Outcomes

	At the end of the course student will be able
1.	Become familiar with current design, manufacturing and application activities in the domain of metallurgical and materials engineering [10]
2	Understand professional responsibility of the engineer and become capable of engineering problem solving [5,6]
3.	Visualize emerging trends in the context of metals and materials [12]

Course Code	:	MTPC28				
Course Title	:	**Corrosion Engineering**				
Number of Credits		**3**				
LTPC Breakup	:	L	T	P	C	
		3	0	0	3	
Prerequisites (Course code)	:	nil				
Course Type	:	PC				

Course Learning Objectives

To provide a practical knowledge about corrosion and its application in engineering field.

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 remedial measures

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, metallic, non-metallic and inorganic coatings, mechanical and chemical methods and various corrosion inhibitors

Reference Books

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

Course Outcomes

At the end of the course student will be able to

1. Do electro and electroless plating of Cu, Al alloys [1, 2, 11]

2 Determine the corrosion rate by weight loss method, electrical resistance method, potentionstatic polarization experiment and atmospheric corrosion using colour indicator method [1, 2, 4, 10, 11]

3. Analyze galvanic corrosion, pitting corrosion and stress corrosion cracking [1, 2, 11]

4. Estimate the corrosion resistance by IGC susceptibility test, salt spray test and coating thickness [1, 2, 10, 11]

Course Code	:	MTPC29
Course Title	:	**Testing and Characterization of Materials**
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	NIL
Course Type	:	PC

Course Learning Objectives

On completion of the course the students are expected to be knowledgeable in microstructure evaluation, crystal structure analysis, electron microscopy, Chemical/Thermal Analysis, static and dynamic mechanical testing methods.

Course Content

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.

Principles of optical microscopy, bright and dark field illumination, polarized and interference contrast microscopy; quantitative metallography – estimation and expression of grain size; specimen preparation techniques for optical microscopy. Differential thermal analysis (DTA), differential scanning calorimetry (DSC) and thermo gravimetric analysis (TGA)

Interaction of electron beam with materials; transmission electron microscopy - bright and dark field imaging and diffraction techniques; specimen preparation for TEM; applications of TEM; scanning electron microscopy – construction and working of SEM, various imaging techniques, applications; EDS and WDS - EPMA.

X-ray diffraction - 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.

Reference Books

1	*Culity B.D., Stock S.R& Stock S., Elements of X ray Diffraction, (3rd Edition). Prentice Hall, 2001*
2	*Dieter G.E., Mechanical Metallurgy, (3rd Edition), ISBN: 0070168938, McGraw Hill, 1988.*
3	*Suryanarayana A. V. K., Testing of metallic materials, (2nd Edition), BS publications, 2007.*
4	*David Brandon, Wayne D. Kaplan, Microstructural Characterization of Materials,Wiley, 2008*
5	*R.F. Egerton, Physical Principles of Electron Microscopy: An Introduction to TEM, SEM and AEM Springer, 2010*

Course Outcomes

	At the end of the course student will be able to
1.	Perform various mechanical testing of materials and follow relevant standards [1, 2]
2	Know the principles of metallurgical microscope, X-ray Diffractrometer (XRD), Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Thermal analysis and dilatometer [1, 11]
3.	Describe the various sample/specimen preparation techniques for XRD, SEM, TEM and thermal analysis and quantitative metallography. Determine crystal structure, lattice parameter, phase identification, solvus line estimation and residual stress analysis using XRD [1, 2, 11]
4.	Describe the modes of SEM operation, study the surface topography using different modes, elemental compositional analysis and spectroscopy studies [1, 11]
5.	Select the appropriate tool to characterize the material by knowing its merits and demerits.
6.	Analyze the material in atomic level by using different modes of TEM like bright and dark field imaging, selected area diffraction [1, 2, 5, 11]
7.	Evaluate the specimen by thermal, calorimetric and gravimetric analysis [11]

Course Code	:	**MTLR37**
Course Title	:	**Corrosion and Surface Engineering lab**
Number of Credits		**2**
LTPC Breakup	:	L: 0, T: 0, P: 2, C: 2
Prerequisites (Course code)	:	
Course Type	:	**ELR**

Course Learning Objectives

To provide a practical knowledge about corrosion and its application in engineering field.

To study various coating procedures and their wear studies using different test procedures

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 student will be able
1.	Do electro and electroless plating of Cu, Al alloys [1, 2, 11]
2	Determine the corrosion rate by weight loss method, electrical resistance method, potentionstatic polarization experiment and atmospheric corrosion using color indicator method [1, 2, 4, 10, 11]
3.	Estimate the corrosion resistance by IGC susceptibility test, salt spray test and coating thickness [1, 2, 10, 11]
4.	Define different forms of coating techniques of surface engineering materials[4, 6 ,1,5]

Course Code	:	MTLR36
Course Title	:	**Particulate processing and Ceramic materials lab**
Number of Credits		**2**
LTPC Breakup	:	L: 0, T: 0, P: 2, C: 2
Prerequisites (Course code)	:	
Course Type	:	ELR

Course Learning Objectives

To study the characteristics of Powder particles.

Course Content

List of Experiments

1. Characterization of powders (size, shape)
2. Determine flow rate of powder
3. Determination of compressibility of powders
4. Determination of green density and sinter density
5. Sintering behavior of metallic powders
6. Sythesis of ceramic materials by mechano-chemical methods
7. Determination of hardness/fracture-toughness of ceramic materials by indentation method
8. Determination of crystal size and precise lattice parameters of ceramic materials using XRD
9. Identification of functional groups present in the ceramic materials by FTIR spectroscopy
10. Preparation of glasses/glass-ceramics

Course Outcomes

	At the end of the course student will be able to
1.	Determine the Particle size and shape
2.	Measure various type of density, flow rate and compressibility
3.	Compare the density of Green and sintered compacts

Course Code	:	HSIR13
Course Title	:	**Industrial Economics and foreign trade**
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	
Course Type	:	GIR

Course Learning Objectives

The objective of this paper intends (i) to provide knowledge to the students on the basic issues such as productivity, efficiency, capacity utilization and debates involved in industrial development; and (ii) to give thorough knowledge about the economics of industry in a cogent and analytical manner.

Course Content

Micro Economics; demand analysis - Law of Demand Demand forecasting - Supply Analysis - Determinants of supply - Supply Elascticities - Consumption laws - Indifference curve analysis – Cost, Revenue and Break even analysis - Competitions

Macroeconomics - Importance of macro economic analysis - Keynes' theory of Income and Employment - Multiplier and Accelerator - Functions of Central and Commercial bank - Credit creation by Commercial Banks

Contributions of Fayol, Taylor - Managerial functions - Preparation of Balance Sheet- Sources of Finance - Capital Budgeting

Differences between marketing and selling - 4 P's of Marketing and Marketing Myopia - Market Segmentation - Product Life Cycle

Recruitment and Selection - Job Evaluation and performance Appraisal Methods - Industrial Accidents and Fatigue - Communication - Motivation - Leadership

Reference Books

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

Course Outcomes

At the end of the course student will be able

1. Define micro economics, demand analysis, supply analysis, consumption laws, indifference curve analysis and competitions. [4, 6]
2. Define macro economics, differentiate with micro economics, importance, Keynes theory, functions of central and commercial bank. [4, 8]
3. Contributions of Fayol, Taylor in managerial functions, balance sheet, and sources of finance. [4, 8]
4. Differentiate marketing and selling, marketing myopia, and product life cycle. [3, 4]
5. Describe recruitment and selection, job evaluation and performance appraisal methods, communication, motivation and leadership. [3, 4, 8]

Course Code	**:**	MTIR17
Course Title	**:**	**Project work**
Number of Credits		**6**
LTPC Breakup	**:**	L: 0, T: 0, P: 6, C: 6
Prerequisites (Course code)	**:**	
Course Type	**:**	GIR

Course Learning Objectives	
To get hands-on experience in problem solving, design and experimental skill in the context of metals and materials	
Course Content	
The details/content of the project work will be worked out by the project student and project guide considering the generic instructions provided be the department and institute	
Reference Books	
Need based	
Course Outcomes	
	[Project work is expected to deliver outcomes, as many of the 12 programme outcome as defined in the program].
1.	Apply basic knowledge of mathematics, science and engineering towards development of new process, product, materials and comprehend industrial problems [1,11]
2.	Comprehend engineering problems and to come up with solutions based on theoretical, conceptual, experimental and innovative approached [8,12]
3.	Perform experimental investigations in the shop floor/research laboratory in a logical manner [9]

Course Code	:	MTPE01				
Course Title	:	Fatigue, Creep and Fracture Mechanics				
Number of Credits		**3**				
LTPC Breakup	:	L	T	P	C	
		3	0	0	3	
Prerequisites (Course code)	:	MTPC23				
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, KIC plane strain toughness testing, plasticity corrections, crack opening displacement, J integral, R curve, toughness of materials.

Reference Books

1	*Dieter G. E., 'Mechanical Metallurgy', 3rd Edition, McGraw Hill Publications, 1988*
2	*Suryanarayana, 'Testing of Metallic Materials', Prentice Hall India, 1979*
3	*Rose R. M., Shepard L. A., Wulff J., 'Structure and Properties of Materials'Volume III, 4th Edition, John Wiley, 1984*
4	*Honeycombe R. W. K., 'Plastic Deformation of Materials', Edward Arnold Publishers, 1984*

Course Outcomes

	At the end of this course, the students would be able to:
1.	Define the life assessment of various engineering materials and associated testing methods [1]
2	Describe basic mechanisms of fatigue and creep behavior of various engineering materials and their importance in materials design [1, 2]
3.	Analyze the various metallurgical factors influencing the fatigue and creep performance of materials for different structural engineering applications [1, 2, 5]
4.	Select the appropriate processing route and alter the microstructure for the life enhancement of materials at room and elevated temperatures [1, 10, 11]
5.	Provide suitable remedial measure to prevent premature failure and reduction in performance [1, 5
6.	Describe the failure modes and root cause of the materials failure based on fracture mechanics and fractography approach [1, 11]

Course Code	:	MTPE02				
Course Title	:	Special Steels and Cast Irons				
Number of Credits		**3**				
LTPC Breakup	:	L	T	P	C	
		3	0	0	3	
Prerequisites (Course code)	:	MTPC18				
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, 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', McGraw Hill, 1982*
2. *Pickering P. B., 'Physical Metallurgy and the Design of Steels', Applied Science Publishers, 1983*

Course Outcomes

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

1. Understand major types of special steels such as HSLA, TRIP, Dualand Tool steels and cast-irons [1, 5]
2. Know the processing techniques of specials steels and cast-irons[1, 2, 5]
3. Selection of Special steels and cast-irons for specific engineering applications[1, 2, 5,11]

Course Code	:	MTPE03
Course Title	:	Special Casting Techniques
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	MTPC19
Course Type	:	PE

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 the 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, semi centrifugal and centrifuging processes , process variables and characteristics, application

Squeeze casting , Low pressure die casting , thixo and rheo casting , full mold process , electro slag casting , Magnetic casting , No bake or pepsetmoulding, casting process for reactive metals.

Reference Books

1	*Heine R., Loper C.R., Rosenthal P.C. , Principles of metal casting . 2nd edition , Tata Mcgraw Hill publishers ,1985*
2	*Jain P.L., Principles of foundry technology, 3 rd edition, Tata Mcgraw Hill, 2004*
3	*Beeley P.R. Foundry Technology , , Butterworth- Heimann publishers, London 2006*

Course Outcomes

At the end of this course, the students would be able to:

1. Select the appropriate pattern equipment used for shell moulding [1,3]
2. Techniques and optimization parameters to enhance productivity in centrifugal casting processes
3. To gain knowledge on using proper patterns and mould materials in investment casting[3,6]
4. To develop basic concepts in understanding the operation of various newly developed process like V process, hot box process and no bake processing.[6,8,9]

Course Code	:	MTPE04
Course Title	:	Special Topics in metal forming
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	MTPC24
Course Type	:	PE

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

Petro forge system – rubber pad forming – electro magnetic forming coil requirements – effect of work piece dimensions and conductivity - applications – electro hydraulic 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, Volume 5, 1984*
4	*Padmanabhan K A and G.J.Davis, Superplasticity, Springer Verlag, Berlin Heidberg, NY, 1980.*
5	*Equal Channel Angular Pressing (ECAP) by B.Ravisankar in the “Handbook of Mechanical Nanostructuring” Edited by Mahmood Aliofkhazraei, Wiley-VCH Verlag GmbH & Co, Germany, 2015.*

Course Outcomes

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

1. Select the appropriate technique for forming components [1,3]
2. Techniques and optimization parameters to enhance productivity and quality
3. To gain knowledge on using proper methods for forming com[ponents [3,6]
4. To develop basic concepts in understanding the operation of various newly developed process [6,8,9]

Course Code	:	MTPE05				
Course Title	:	Ladle Metallurgy & Continuous Casting of steels				
Number of Credits		**3**				
LTPC Breakup	:	L	T	P	C	
		2	1	0	3	
Prerequisites (Course code)	:	MTPC21				
Course Type	:	PE				

Course Learning Objectives	
To develop an understanding of the basic principles of ladle metallurgy and continuous casting, impart modeling skills and to apply them for industrial problems to enable them to solve the problems encountered in the steel industries.	
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; injectibles – 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 modeling; applications in ladle metallurgy and CC; mathematical modeling of solidification; physical modeling 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	
	After the successful completion of this course, the student would be able to:
1.	Understand the terminologies used in the field of ladle metallurgy and continuous casting of steels [3]
2	Classify different kinds of treatments for the steel during manufacturing [5, 11]
3.	Compare the capabilities of ingot casting and continuous casting [11]
4.	Apply the basic modeling skills in the area of ladle metallurgy and continuous casting [1,4]

Course Code	**:**	MTPE06
Course Title	**:**	Welding Metallurgy
Number of Credits		**3**
LTPC Breakup	**:**	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	**:**	MTPC20
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 joins 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

Epitaxial growth - weld metal solidification - columnar structures and growth morphology- effect of welding parameters - absorption of gases - gas/metal and slag/metal reactions

Phase transformations- weld CCT diagrams - carbon equivalent-preheating and post heating- weldability of low alloy steels, welding of stainless steels use of Schaffler and Delong diagrams, welding of cast irons

Welding of Cu, Al, Ti and Ni alloys – processes, difficulties, microstructures, defects and remedial measures

Origin - types - process induced defects, - significance - remedial measures, Hot cracking - cold cracking -lamellar tearing - reheat cracking - weldability tests - effect of metallurgical parameters.

Reference Books

1	*Linnert G. E.,'Welding Metallurgy', Volume I and II, 4th Edition, AWS, 1994*
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', Chapman and Hall, 1985*
5	*Jackson M. D., 'Welding Methods and Metallurgy', Grffin, London, 1967*

Course Outcomes

	Upon completion of this class, students are expected to
1.	Explain the influence of heat input and temperature distribution across a welded structure based on weld geometry.
2	Correlate the solidification behavior and structure of weld zone with the welding parameters
3.	Analyze and predict the weldability of low alloy steels and cast irons based on weld CCT , Shaffler and Delong diagrams
4.	Identify the origin and types of process induced defects and conduct weldability tests
5.	Apply remedial measures to minimize defects in welding of Cu, Al, Ti and Ni alloys based on proper understanding of the processes used and microstructural study of weld joints

Course Code	:	MTPE07				
Course Title	:	Processing of Light alloys				
Number of Credits		**3**				
LTPC Breakup	:	L	T	P	C	
		3	0	0	3	
Prerequisites (Course code)	:	MTPC27				
Course Type	:	PE				

Course Learning Objectives

- To gain understanding the various processing methods to fabricate light alloys
- Gain knowledge of design and selection of suitable process for fabricating engineering light weight structures

Course Content

Introduction to light alloys: Aluminium alloys, Magnesium alloys, titanium alloys and non-structural light elements and their importance in various engineering applications. Limitations of light in harsh environments. Introduction to various processing methods: casting, metal forming, powder metallurgy, welding, etc.

Pre-requisite:

Knowledge in physical metallurgy of non-ferrous alloys and various manufacturing methods

Casting: Casting processes used for processing light alloys. Special processes employed for fabrication Al, Ti and Mg alloys. Problems in castings and the remedial actions.

Forming: Forming methods used for fabrication light alloys. Difficulties in forming Al, Ti and Mg alloys. Special processes used for forming light alloys. Superplasticity and superplastic forming of Al, Ti and Mg.

Metal joining: Metal joining techniques used for light alloys. Difficulty in fusion welding processes. Solid state joining techniques employed for light alloys, Other joining techniques such as mechanical methods, adhesive bonding etc.,

Machining: Machinability of light alloys. Problems during machining of Al, Ti and Mg. Unconventional machining processes.

Powder methods: Composites and ODS aluminium alloys, Hot isostatic pressing, Spark plasma sintering.

Processing of other light alloys (beryllium and lithium) for structural and non-structural applications

Reference Books

1	*Light Alloys: Metallurgy of the Light Metals (Metallurgy & Materials Science) , Wiley Publishers, I. J. Polmear*
2	*Magnesium and Magnesium Alloys (ASM Specialty Handbook) M. M. Avedesian and Hugh Baker*
3	*Titanium: Physical Metallurgy, Processing, and Applications, ASM International, F.H. Froes*
4	*Titanium: A Technical Guide 2nd Edition,ASM International, Matthew J. Donachie*

Course Outcomes

	Upon completion of the course, the student will be able to:
1.	Understand the various processing methods to fabricate light alloys
2.	Capable of designing process procedure in developing light alloy components
3.	Design and selection of suitable process for fabricating engineering light weight structures
4.	Difficulties involved in processing of light alloys

Course Code	:	MTPE08
Course Title	:	Design of Casting and Weldments
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	MTPC19. MTPC20
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 lading, 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, Loper and Rosenthal, "Principles of Metal Casting", Tata McGraw Hill Publishing Co,1995.*
4	*Harry Peck, "Designing for Manufacture", Pitman Publications, 1983.*

Course Outcomes

	Upon completion of the course, the student will be able to:
1.	Select the appropriate design for the particular casting. [1, 3, 11]
2	Minimize the defects by proper selection of casting systems [1, 8]
3.	Choose the appropriate codes for the production of pipeline and structural materials [3, 8]
4.	Categorize welding procedures for different applications [1, 9]

Course Code	:	MTPE09
Course Title	:	Thermodynamics of Solidification
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	MTPC13, MTPC19
Course Type	:	PE

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.

Course Content

Introduction and important thermodynamic functions: Laws ofthermodynamics-enthalpy, heat capacity, applications of first law to open and closedsystems including chemical reactions; entropy, free energy and their interrelationships

Thermodynamics of solidification; Nucleation and growth; Pure metalsolidification, Alloy Solidification, Constitutional undercooling, Mullins-Sekerkainstability; Single phase solidification: Cellular and Dendritic growth; Multiphasesolidification: eutectic, peritectic and monotectic; Modelling of solidification

Heterogeneous systems –equilibrium constants, Ellingham-Richardson diagrams,predominant area diagrams, principles of free energy minimization; energy balance ofindustrial systems; solutions-chemical potential, Raoult/Henry's law, Gibbs-Duhemequations, regular solutions, quasi chemical theory

Evolution of Phase diagrams -phase rule, free-energy-composition diagrams,solidus-liquidus lines, retrograde solidus; determination of activity and otherthermodynamic parameters from phase diagrams,; thermodynamic analysis of ternaryand multi component systems, interaction parameters

Principles of applications- principles of applications to molten slags and silicatemelts; electrochemical methods and applications, aqueous systems; Interfaces-energy,shape, segregation at external and internal interfaces; solid electrolytes; Effect of highpressure 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 Publications,Switzerland, 1989*

Course Outcomes

	The students will be able to analyze and understand the
1.	Thermodynamics of solidification processes and alloys.[2]
2	Thermodynamic modelling of solid-liquid phase change and solutions[4]
3.	Kinetics of solidification such as nucleation, growth, and constitutional super cooling[S, 11]
4.	Multiphase solidification. [3,4]
5.	Thermodynamic analysis of ternary and multicomponent system.[S,11]

Course Code	:	MTPE10				
Course Title	:	Alloy Development				
Number of Credits		**3**				
LTPC Breakup	:	L	T	P	C	
		3	0	0	3	
Prerequisites (Course code)	:	MTPC18				
Course Type	:	PE				

Course Learning Objectives

To study the fundamentals, classification, 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 David A. Porter, Kenneth E. 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

	Upon completion of the course the student will be able to,
1.	Describe various alloy systems, their classification [1, 2, 4].
2	Define and differentiate engineering materials on the basis of structure and properties for engineering applications [1,4, 8].
3.	Proper processing technologies for synthesizing and fabricating different materials [1, 3, 10, 11].

Course Code	**:**	MTPE11
Course Title	**:**	Ceramic Materials
Number of Credits		**3**
LTPC Breakup	**:**	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	**:**	Nil
Course Type	**:**	PE

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, Kgroger-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, devetrification; 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 bio-ceramics.
Reference Books

1	*Richerson D. W., 'Modern Ceramic Engineering – Properties, Processing and Use in Design', 3rd edition, CRC press, 2006*
2	*Yet-Ming Chiang, Dunbar P. Birnie and W. David Kingery, Physical Ceramics: Principles for Ceramic Science and Engineering John Wiley & Sons, 1996*
3	*Carter, C. Barry, Norton, M. Grant, Ceramic Materials: Science and Engineering, 2nd Ed, Springer,2013*
4	*Kingery W. D., Bowen, H. K. and Ulhmen D. R., 'Introduction to Ceramics', 2nd E, John Wiley, 1991*

Course Outcomes

	After the completion of this course, the student will be able to:
1.	Know the structure and properties of different ceramic materials [1, 2, 5, 11]
2	Understand the phase diagrams and comprehend the phase transformations in ceramic materials [1, 3, 11]
3.	Understand the testing methods for evaluating the mechanical properties of ceramic materials [2, 5, 11]
4.	Understand and design the electrical, magnetic and optical properties of ceramic systems [1, 2, 3, 11]
5.	Select ceramic materials and to develop new ceramics for different engineering applications [1, 3, 10, 11]

Course Code	:	MTPE12				
Course Title	:	Ceramic Processing				
Number of Credits		**3**				
LTPC Breakup	:	L	T	P	C	
		3	0	0	3	
Prerequisites (Course code)	:	MTPC22				
Course Type	:	PE				

Course Learning Objectives

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

Course Content

Surface and interfaces, grain boundaries, interfacial energy and wetting; phase equilibria in ceramic system - single component SiO_2 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

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	*McColm J., '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', 2nd Ed, John Wiley, 1976*

Course Outcomes

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

1. Define the Type of Component system present in the refractory materials.[1, 7, 10]
2. Select the powder Processing route to prepare the ceramics[1, 3, 5]
3. Differentiate Pressing and Casting techniques for the ceramic materials[3, 4, 11]
4. Develop refractory materials for specific application[1, 2, 11]
5. Apply the Principle and Evaluate the properties of materials[1, 2]

Course Code	:	MTPE13
Course Title	:	High Temperature Materials
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	NIL
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

Design of 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 micro void 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 alloys 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', 4th Edition, John Wiley, 1996*
3	*Courtney T.H, 'Mechanical Behaviour of Materials', McGraw Hill, 1990*

Course Outcomes

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

1. Describe the basic mechanism of high temperature deformation [1, 5]
2. Understand the details of creep deformation mechanisms [1, 5]
3. Analyze the fracture phenomenon in various materials in high temperature failures [2, 3, 5, 10, 11]
4. Apply basic understanding of high temperature phenomenon like oxidation and hot corrosion in identifying suitable materials for specific high temperature applications [1, 5, 10, 11]
5. Study the high temperature behaviour of superalloys [1, 5]
6. Design new materials for high temperature applications [2, 3, 10]

Course Code	:	MTPE14				
Course Title	:	Emerging Materials				
Number of Credits		**3**				
LTPC Breakup	:	L	T	P	C	
		3	0	0	3	
Prerequisites (Course code)	:	Nil				
Course Type	:	PE				

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 super alloys-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 nano tubes and fullerenes; shape memory alloys, functionally gradient materials, high temperature super conductors - bio materials

Reference Books

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

Course Outcomes

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

1.	Describe various processing techniques of different engineering materials.[1, 3,5]
2.	Analye the Phase diagram and Microstructure using Microscope for different type of Stainless steel materials.[2, 4, 5, 11]
3.	Select the material for Biological, Nuclear, Space and Cryogenic service applications.[1, 4, 10, 3]

Course Code	:	MTPE15
Course Title	:	AUTOMOTIVE MATERIALS
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	MTPC15
Course Type	:	PE

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.

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	*Hajra Choudhury, Elements of Workshop Technology, Vol-I and Vol-II Asia Publishing House, 1996.*

Course Outcomes

At the end of the course student will be able

1. To understand air standard cycles and to estimate efficiencies of air standard cycles [1].
2. To understand the functions of engine block and materials for engine block [3].
3. To study various components used in automobile and selection of materials [2,4]
4. To understand the automobile emissions and methods of controlling them [4,3,8]

Course Code	:	MTPE18
Course Title	:	ADVANCED CHARACTERIZATION TECHNIQUES
Number of Credits		**3**
LTPC Breakup	:	L T P C 3 0 0 3
Prerequisites (Course code)	:	Nil
Course Type	:	PE

Course Learning Objectives

To make the students understand the concepts of various advanced characterization tools and their applications.

Course Content

Concepts, principles and applications of Electron diffraction, Synchrotron diffraction, Neutron diffraction and Electron back scattered diffraction.

Introduction, principles and applications of CBED, nano-diffraction, LEED, RHEED and HAADF

Introduction principles and applications of advanced spectroscopic techniques like XPS, SANS and SAXS, GISAXS, AES and SIMS

Basics and applications of *in-situ* metallographic techniques, *in-situ* SEM and *in-situ* TEM

Introduction, basic principles and applications of nano-mechanical characterization like AFM, STM and Nanoindentation studies

Reference Books

1	Transmission Electron Microscopy; D.B. Williams and C.B. Carter, Plenum Press (2004)
2	Modern ESCAThe Principles and Practice of X-Ray Photoelectron Spectroscopy, Terry L.Barr, CRC press, (1994)
3	Scanning Electron Microscopy and X-ray Microanalysis by Joseph Goldstein, Dale E. Newbury, David C. Joy, and Charles E.; Springer Science (2003)
4	Advanced Techniques for Materials Characterization, Materials Science Foundations (monograph series) A. K. Tyagi, Mainak Roy, S. K. Kulshreshtha and S. Banerjee;, Volumes 49 – 51 (2009)
5	Encyclopedia of Materials Characterisation Editors: C.R. Brundle, C.A. Evens, Jr, S. Wilson, Butterworth-Heinmann, Boston (1992)

Course Outcomes

	At the end of the course student will be able to
1.	Understanding diffraction phenomenon and its application in identifying phases
2.	Understanding specialized diffraction tools in TEM
3.	Understanding the specialized spectroscopic techniques
4.	Understanding the concepts of in-situ microscopic techniques
5.	Understanding the various nano-mechanical characterization techniques

Course Code	:	MTPE19
Course Title	:	Materials for extreme environments
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	Nil
Course Type	:	PE

Course Learning Objectives

Student should be capable of understand various extreme environment conditions and choose suitable materials for various 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 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", Mc Graw Hill Publishers, NY,2002
2	Materials Under Extreme Conditions, Vincenzo Schettino and Roberto Bini, Imperial College Press, winter 2012.

Course Outcomes

At the end of the course student will be able

1. Can understand the behavior of high temperature materials
2. Capable of assessing behavior of various irradiation damage resistance materials
3. Can understand the space environment and choosing materials for space applications
4. Analyze the high strain rate deformation behavior and capable of choosing or fabricating materials
5. Capable of understanding deformation at cryogenic temperatures

Course Code	:	MTPE21
Course Title	:	Biomaterials
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	Nil
Course Type	:	PE

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; Nanomaterials and nanocomposites for medical applications; Nanostructured coatings for bio-implants.

Mechanical property evaluation and phyisco-chemical characterization of biomaterials; *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, & Wilson J., (Editors), An Introduction to Bio ceramics, World Scientific, 1994.*

Course Outcomes

At the end of the course student will be able

1. Understand the properties of different biomaterials, know the advantages and disadvantages of different biomaterials and select materials for different applications. [1,2,11]
2. Understand the processing and testing of biomaterials [2,5]
3. Characterize the biomaterials for their physico-chemical properties and analyze the cell-material interactions [1,2]
4. Understand the basics of tissue engineering.[1]
5. Design and develop new biomaterials for different biomedical applications [2,3,4,5,11]

Course Code	:	MTOE41
Course Title	:	Non Destructive Testing and Failure Analysis
Number of Credits		**3**
LTPC Breakup	:	L T P C 3 0 0 3
Prerequisites (Course code)	:	Nil
Course Type	:	OE

Course Learning Objectives

To develop the fundamental knowledge about non-destructive and destructive analysis, in order to control the 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 characterization 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.

Failure analysis methodology, tools and techniques of failure analysis, failure data retrieval, procedural steps for investigation of a failure for failure analysis; types of failure and techniques for failure analysis.

Some case studies of failure analysis, Introduction to quality management, concept of ISO9000, ISO14000, QS9000; Inspection, inspection by sampling.

Reference Books

1	*Baldevraj, Jayakumar T., Thavasimuthu M., 'Practical Non-Destructive Testing', Narosa Publishing, 1997*
2	*Das A. K., 'Metallurgy of Failure Analysis', TMH, 1992*
3	*Colangelo V. A., 'Analysis of Metallurgical Failures', John Wiley, 1985*
4	*Suryanarayana, 'Testing of Metallic Materials', Prentice Hall India, 1979*

Course Outcomes

	At the completion of this course, the student will be able to
1.	Differentiate various defect types and describe the main criteria to select the appropriate NDT methods for the product [1, 4, 5]
2.	Define tools and techniques of failure analysis, procedural steps for investigation of failure and failure data retrieval [1, 4, 5, 11]
3.	Describe various types of failure and select suitable techniques for failure analysis [1, 4, 5]
4.	Know about various ISO standards, inspection, inspection by sampling and quality management [2, 3, 4, 7, 8, 9]

Course Code	:	MTOE42
Course Title	:	Process Modelling and Applications
Number of Credits		**3**
LTPC Breakup	:	L: 1, T: 1, P: 1, C: 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 tp process modelling; to get hands on experience in some aspects of modelling; to be able to visualise modelling of complex industrial scale metallurgical processes

Course Content

Mathematical modeling, 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 modeling – cold and hot models; case studies of water models, use of computers for the construction of phase diagrams, alloy design, crystallography, phase transformations and thermo chemical calculations.

Case studies from literature – pertaining to modeling 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 McGraw Hill, New Delhi, 1998*

Course Outcomes

At the completion of this course, the student will be able to

1. Obtain comprehensive knowledge of basic equations and concepts related to process modelling and comfortably interact with researchers and shop floor engineers [1,4]
2. Understand terminologies related to process modelling [3]
3. Become familiar with use of modelling as a tool for wide range of metallurgical process [11].

Course Code	:	MTOE43				
Course Title	:	Computational Techniques				
Number of Credits		**3**				
LTPC Breakup	:	L	T	P	C	
		3	0	0	3	
Prerequisites (Course code)	:	Nil				
Course Type	:	OE				

Course Learning Objectives

To become familiar with computational techniques including related mathematical background

Course Content

Design of Experiments and Analysis: Factorial design, Taguchi Techniques, ANOVA

Artificial Intelligence: Artificial Neural Networks, Fuzzy logic, Genetic Algorithm; Applications in Materials Engg.,

Numerical Fluid Flow and Heat Transfer: Classification of PDE, finite differences, Steady and unsteady conduction, explicit and implicit method

Finite Element Methods: Introduction to I-D FEM. Problems in structural mechanics using two dimensional elements; Plane stress, plane strain, axisymmetric analysis; Three dimensional stress analysis

Optimization Methods: Classical optimization methods, unconstrained minimization. Univariate, conjugate direction, gradient and variable metric methods, constrained minimization, feasible direction and projections. Integer and Geometric programming,

Reference Books

1	*Douglas C. Montgomery Design and analysis of experiments, 5th ed., John Wiley and Sons, 2005*
2	*Phillip J. Ross Taguchi techniques for quality engineering - McGraw-Hill Book company,2002*
3	*Suhas V. PatankarNumerical heat transfer and fluid flow, Hemisphere Publishing Corp, 1998*
4	*Tirupathi R. Chandrupatla and Ashok D. BelegunduIntroduction to Finite Elements in Engineering, 3rd Ed., Prentice-Hall, 2003*
5	*Simon Haykin, Neural Networks- A comprehensive foundation, 2nd Ed., Pearson Education Asia, 2002*

Course Outcomes

At the completion of this course, the student will be able to

1. Get an overview of certain specific tools in the domain of computational techniques [1,4]
2. Solve simple engineering problems in application involving fluid flow, heat transfer and structures [5]
3. Design optimum number of experiments for studying various metallurgical problems [2,5]
4. To have familiarity with the emerging tools such as Neural networks, Genetic algorithm, Geometric programming and optimization methods [10,11]

Course Code	:	MTOE44
Course Title	:	Design and Selection of Materials
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, 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 micro structural 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	*GladiusLewis,"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.*

Course Outcomes

At the completion of this course, the student will be able to

1. Understand types of materials and properties [1, 5]
2. Know different methods for materials selection [1, 2, 5]
3.. Selection of materials for Specific engineering applications [1, 2, 11, 5, 7]

Course Code	:	MTOE45
Course Title	:	New Product Development
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	Nil
Course Type	:	OE

Course Learning Objectives

Expose students to the structured New Product Development (NPD) Methodology and help 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 & Modeling - Introduction to System Modeling - 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, Gama) - 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, 4th edition, 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, McGraw Hill Companies Inc. New York, USA*
6	*A.K.Chitale, R.C.Gupta, 'Product Design and manufacturing'*
7	*Hand outs provided by industrial experts*
8	*Resource Materials / 'BoK' provided by NASSCOM, related to NPD*
Course Outcomes	
1.	Clear understanding of the NPD Methodology
2.	Clear understanding of the influence of STEEP Factors for the success of New Product
3.	Clear understanding of the importance of Customer study, requirement gathering and analysis, Patent Study and analysis and Concept Generation
4.	Techniques and Evaluation Methods
5.	Execution of Pilot NPD Project
6.	Enhance the ability of students to apply individual Creative skills, work as a team to achieve the results and present the project outcome to management review team

Course Code	:	MTOE46
Course Title	:	Introduction to Quality Management
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	Nil
Course Type	:	OE

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 ISO9000, ISO14000, QS9000.

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.Juran and 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 – Eastern Economy Edition, 1997.*

Course Outcomes

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

1. Understand the significance of quality management [1]
2. Actively participate in quality systems certification initiatives[3, 4, 5, 6, 7]
3. Qualitatively use quality concepts to real applications[2, 5]
4. Perform basic calculations in SQC / SPC[3, 5]
5. Appreciate the benefits of advanced concepts such as Six Sigma[1, 10, 6]
6. Perform simple calculations in reliability[2, 5, 11]

Course Code	:	MTOE47
Course Title	:	Surface Engineering
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	Nil
Course Type	:	OE

Course Learning Objectives

To Analyse the various concepts of surface engineering and comprehend the design difficulties.

Course Content

Introduction 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, electrocomposite plating, properties of electro deposits, 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 T S, '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

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

1. Define different forms of processing techniques of surface engineering materials[4, 6 ,1,5]
2. Know the types of Pre-treatment methods to be given to surface engineering[1, 4, 6, 8, 11]
3. Select the Type of Deposition and Spraying technique with respect to the application [1, 3, 5]
4. Study of surface degradation of materials[1]
5. Asses the surface testing methods and Comprehend the degradation properties[1, 2, 5,11]

Course Code	:	MTOE48				
Course Title	:	Nanomaterials and Applications				
Number of Credits		**3**				
LTPC Breakup	:	L	T	P	C	
		3	0	0	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 arching, chemical vapour deposition, sol-gel process, electro deposition, ball milling, severe plastic deposition, 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, nanosensors, nanomedicines, etc.

Health Issues: Understanding the toxicity of nanoparticls and fibers, exposure to quartz, asbestos, air pollution. Environmental issues: Effect on the environmental and other species. Societal implications: Implications of nanoscience and technology in society, government regulations, etc.

Reference Books

1	*T. Pradeep, Nano: The Essentials, Tata McGraw Hill, 2007.*
2	*Mick Wilson et al, Nanotechnology: Basic Science and Emerging Technologies,Overseas Press, 2005.*
3	*Charles P. Poole Jr, Frank J. Owens, Introduction to nanotechnology, Wiley-India (P) Ltd., 2006.*

Course Outcomes

	At the end of the course student will be able
1.	Understand the terminologies used in the field of nanomaterials [3]
2.	Classify different methods of manufacturing of nanomaterials [5, 11]
3.	Observe the morphology, phase composition of nanomaterials [3, 5, 11]
4.	To select nanomaterials for different industrial applications [4,9,11]
5.	To understand the health issues related to nanomaterials [10]

Course Code	:	MTOE49
Course Title	:	Intellectual Property Rights
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 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 Intellectual Property Law – The Evolutionary Past - The IPR Tool -Legal Tasks in Intellectual Property Law – Ethical obligations in Para Legal Tasks in Intellectual Property Law - Innovations and Inventions Trade related Intellectual Property Right. Introduction to Trade mark – Trade mark Registration Process – Post registration Procedures – Trade mark maintenance - Transfer of Rights - Infringement - Dilution Ownership of Trade mark – Likelihood of confusion - Trademarks claims – Trademarks Litigations – International Trade mark Law Introduction to Copyrights – Principles of Copyright Principles -The subjects Matter of Copy right – The Rights Afforded by Copyright Law – Copy right 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 Managing intellectual property in a knowledge-based society. IPR and technology transfer, case studies.	
Reference Books	
1	*Debirag E.Bouchoux: “Intellectual Property”. Cengage learning , New Delhi*
2	*M.Ashok Kumar and Mohd.Iqbal Ali: “Intellectual Property Right” Serials Pub.*
3	*Cyber Law. Texts & Cases, South-Western’s Special Topics Collections*
4	*Prabhuddha Ganguli: ‘ Intellectual Property Rights” Tata Mc-Graw –Hill, New Delhi*
Course Outcomes	
1. 2. 3.	Understand the different types of IPR Study the fundamentals of IPR laws Understand scope of patent, copy right, geographic indication and trade secrete

Course Code	:	MTMI81
Course Title	:	Materials Technology
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	Nil
Course Type	:	MI

Course Learning Objectives

To impart knowledge in material properties and manufacturing methods. Students will be able to understand various material and its 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 stereo isomers- Thermosetting and Thermo plastics.

(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- Pre stressed 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

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

1. Define and differentiate engineering materials on the basis of structure and properties for engineering applications. [1, 2, 5]
2. Select a material for a particular application based on the requirements. [2, 5, 10]
3. Predict and apply the necessary protection mechanism to prevent corrosion [3, 9, 10]

Course Code	**:**	MTMI82
Course Title	**:**	Fundamentals of Metallurgy
Number of Credits		**3**
LTPC Breakup	**:**	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	**:**	Nil
Course Type	**:**	MI

Course Learning Objectives

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

Course Content

Type of steels; Plain carbon steel, alloy steels, tool steels, Stainless steel

Types of cast iron; Grey, White, SG, Malleable and alloy cast iron

Industrially important Cu, Al, Ti, Mg and Ni based non-ferrous 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, the student will be able to,
1.	Understand the basic classification of steels and cast iron [1, 2]
2.	Characterize the materials by microscopy and X-ray diffraction [1, 2, 11]
3.	Identify the form of corrosion and suggest protection methods [1, 3, 9, 10]

Course Code	:	MTMI83
Course Title	:	Physical Metallurgy and Heat Treatment
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	Nil
Course Type	:	MI

Course Learning Objectives

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

Course Content

Introduction to engineering materials. Atomic structure and inter atomic bondings, theoretical concept of crystalline materials – types of packing, voids and packing factors for each of the packings, concept of alloy design using lattice positions and intristitial voids. Planes and directions and imperfections in solids. Polymorphism and allotropy.

Diffusion, energetic of solidification Nucleation and growth-dealing homogeneous and heterogeneous nucleations and growth of solids, dendritic growth in pure metals, constitutional super cooling and dendritic growth in alloys.

Phase diagrams – solid solution –types, Hume –Rothery rule. Phase diagrams – Binary- types – Lever rule. Solidification of different types of solid solutions – Iron-Carbon diagram – Effect of alloying element 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. Thermo mechanical treatments. Heat treatment furnaces – atmospheres – quenching media – case hardening techniques.

Basic concept of dislocations their types and its interactions.Dislocations and strengthening mechanisms strengthening by grain-size reduction, solid solution strengthening, strain hardening, dispersion hardening and other recent modes of hardening.

Reference Books

1	*Avner, S. H., “Introduction to Physical Metallurgy”, second 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 NathPrinters, Delhi.*
5	*Willam D. Callister, Jr. Materials Science and Engineering, Wiley India Pvt. Ltd.*
6	*Vijendra Singh, Physical Metallurgy, Standard Publishers.*

Course Outcomes

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

1. Describe the basic crystal structures (BCC, FCC, and HCP), recognize other crystal structures, and their relationship with the properties.
2. Define and differentiate engineering materials on the basis of structure and properties for engineering applications.
3. Proper processing technologies for synthesizing and fabricating different materials.
4. Analyse the microstructure of metallic materials using phase diagrams and modify the microstructure and properties using different heat treatments

Course Code	:	MTMI84				
Course Title	:	Deformation Processing				
Number of Credits		**3**				
LTPC Breakup	:	L	T	P	C	
		3	0	0	3	
Prerequisites (Course code)	:	Nil				
Course Type	:	MI				

Course Learning Objectives
To know the concepts of metal forming and associate technologies and apply them to the conventional and advanced materials manufacturing for various structural applications.
Course Content
Yielding criteria of von Mises and Tresca. Levy-Von Mises equations and Prantl Reuses 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 softwares like OPTRIS, DEFORM, etc. Workability. Sol-gel and other processes for powders. Slip casting, extrusion injection moulding, HIP and CIP (Isostatic pressing), sintering. Blow moulding, Injection Moulding. Compression and transfer Moulding, Pultrusion. Filament Moulding. Resin Transfer Moulding

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	*Pat.L.Manganon, “Principles of Materials Selection for Engineering Design”, Prentice Hall,1999*
6	*Knigery,W.D., Ceramic Fabrication Processes, John Urley, 1950.*
7	*ASM, “Metals Handbook, Vol. I”, Properties and selection, McGraw Hill, 2001.*
Course Outcomes	

	At the end of this course, the students would be able to:
1.	Apply the concept of plastic deformation for metals and alloys to convert them in to useful shapes for intended engineering applications
2.	Differentiate the various metal forming technology and choose the appropriate one for required engineering applications
3.	Provide the successful solution to the various materials design and selection criteria for demanding engineering applications.
4.	Analyze various operational and materials parameters influencing the metal forming quality.
5.	Classify various metal forming technology (forging, rolling, extrusion etc.) and associated forming equipments
6.	Define various secondary forming procedures like stretch forming, deep drawing blanking and associated equipments

Course Code	**:**	MTMI85
Course Title	**:**	Manufacturing Methods
Number of Credits		3
LTPC Breakup	**:**	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	**:**	Nil
Course Type	**:**	MI

Course Learning Objectives

To understand the fundamentals of manufacturing methods in the view of 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, riser, sprues and gating system, 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. 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, 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 this course, the students would be able to:

1. Understand the basic principles of different manufacturing processes in terms of metallurgical perspective
2. Understand the solidification mechanism of casting and welding
3. Learn causes of defects due to various manufacturing processes and remedies

Course Code	:	MTMI86
Course Title	:	Testing and Evaluation of materials
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	Nil
Course Type	:	MI

Course Learning Objectives

To develop the fundamental knowledge on testing and evaluation of materials, in order to control the 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 Publishing, 1997*
2. *Das A. K., 'Metallurgy of Failure Analysis', TMH, 1992*
3. *Colangelo V. A., 'Analysis of Metallurgical Failures', John Wiley, 1985*
4. *Suryanarayana A. V. K., Testing of metallic materials, (2nd Edition), BS publications, 2007*
5. *Dieter G.E., Mechanical Metallurgy, (3rd Edition), ISBN: 0070168938, McGraw Hill, 1988.*

Course Outcomes

At the completion of this course, the student will be able to

1. Differentiate various defect types and describe the main criteria to select the appropriate NDT methods [1, 4, 5]
2. Select suitable NDT method for specific industrial application [1, 2, 8, 10]
3. Understand the criteria to select the appropriate destructive testing methods and corresponding standards for a specific application [1, 4, 5]
4. Carry out destructive to evaluate the mechanical properties for industrial purposes [2, 5, 10, 11]

Course Code	:	MTMI87
Course Title	:	Physics of Materials
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	Nil
Course Type	:	MI

Course Learning Objectives

To provide an understanding of the various approaches used to understand important properties of materials and the relationships between these properties.

Course Content

Introduction and Approach, Properties of materials and some important relationships, Free electron theory of metals, Drude model Electronic Conductivity, Drude model Thermal Conductivity - Ratio the Wiedemann Franz Law.

Maxwell Boltzmann Statistics, Limitations of the Drude model, Elementary quantum mechanics: History and Significant concepts, The DrudeSommerfeld model, Fermi Dirac statistics, Density of states, Fermi Energy and Fermi Surface, Improvements over Drude model, remaining limitations.

Specific heat, phonons, Real space VsRecirpocal space, Diffraction condition and its significance for electron energy, Wigner Seitz cells, Brillouin zones, Band Theory, Density of occupied states, the origin of anisotropy.

Electrons and Holes, Classification of semiconductors, Direct Band gap, indirect Band gap, opto electronic materials, Magnetic properties, superconductivity, Meissner effect, Bose-Einstein Statistics, BCS theory, High temperature superconductors, physics of nano scale materials

Principles of photoconductivity, luminescence- - photo detectors – Optical disc and optoelectronic materials –LCD, LED and diode laser materials - electro optic modulators - Kerr and Pockel's effect – LiNbO3.

Reference Books

1	*David Jiles, "Introduction to electronic properties of materials", Chapman and Hall, 1994.*
2	*S.O. Kasap, "Principles of Electrical Engineering Materials" McGraw Hill, 1977.*
3	*Alan Cottrell, "Introduction to the Modern Theory of Metals", Ashgate Publishing Company, 1988.*
4	*Ed. Kasap and Capper, "Handbook of electronic and photonic materials", Springer, 2006.*
5	*Ashcroft and Mermin, "Solid State Physics", Saunders College Publishing, 1976.*
6	*William D. Callister, Jr., "An introduction to Materials Science and Engineering", John Wiley & Sons, 2003.*
7	*David R. Gaskell , "Introduction to Metallurgical Thermodynamics", Hemisphere Publishing, 1981.*

Course Outcomes

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

1. To understand the electrical and thermal conductivity of the materials based on the modular, statistical approach. [1, 2]
2. To understand the conduction mechanism exhibited by materials based on band gap theory for conducting, semiconducting and insulating materials. [1, 2]
3. To study the theory of superconductivity phenomenon and superconducting materials and their applications along with recent advancement [1, 9, 10]
4. To learn about photoconduction phenomenon, optical materials and various optical devices and their performances. [1, 2]

Course Code	:	MTMI88
Course Title	:	Overview of Non-Metallic Materials
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	Nil
Course Type	:	MI

Course Learning Objectives

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

Course Content

Clasisification 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	*Van Vlack 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 Pradeep phule, The science and Egineering Materials.Thmson,2003

Course Outcomes

1.	Select different materials other than conventional metals and alloys for specific engineering applications [3, 4]
2.	Solve the materials problems associated with the weight reduction through the appropriate choice of polymers ceramics, and composites [1, 11]
3.	Provide low cost alternative to expensive metals and alloys [8]
4.	Describe the selection criterion for polymers, ceramics and composites for various engineering applications [1, 10, 11]
5.	Analyze different microstructure of polymers, ceramics and composites and alter them according to application requirements [1, 11, 5]
6.	Emphasis the need of modern materials over conventional metal and alloys [8]

Course Code	:	MTHO10
Course Title	:	Advanced thermodynamics of materials
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	MTPC13
Course Type	:	HONOURS

Course Learning Objectives

To become familiar with recent developments in thermodynamics and 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 co-efficient, 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

Modeling 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, 4th E, Taylor & Francis, NY 2003*
2	*R.T. Dehoff, Thermodynamics in Materials Science, 1st and 2nd Edition, 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. Porter and K. E. Easterling, Phase Transformation in Metals and Alloys, 2nd Edition, Chapman and Hall, 1992.*
6	*J.J. Moore, Chemical Metallurgy, 2nd Edition, Butterworths, 1990.*
7	*Current literature, open web resources and materials for case study*

Course Outcomes

	Upon completion of this class, the students will be able to:
1.	Use thermodynamics as a tool for developing metals and materials [1, 2, 5, 8]
2.	Develop next generation materials with superior properties [3, 5, 8, 10, 12]

Course Code	:	MTHO11
Course Title	:	Advanced Solidification Processing
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 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; 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	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

The students will be able to analyse and understand the
1. Thermodynamics of solidification processes and alloys.
2. Thermodynamic modelling of solid-liquid phase change and solutions
3. Kinetics of solidification such as nucleation, growth, and constitutional super cooling and Multiphase solidification.
4. Thermodynamic analysis of ternary and multicomponent system

Course Code	:	MTHO12
Course Title	:	Crystallography
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	MTPC15
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,AB03 A 2B04 crystal structures

Frenkel- Schkotty 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 position

Reference Books

1	Donald R. Askeland and Pradeep phule, The science and Engineering Materials.Thmson,2003
2	Cullity B.D., Elements of X-ray diffraction, Addison-Wesley Publishing company 1956

Course Outcomes

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

1. Understand the concept anisotropy in determining materials properties such as electrical and magnetic, plastic deformation, density [1, 4, 5].
2. Understand how defects determines the properties.[2,3,5]
3. Understand the correlation between symmetry and properties[1,4]

Course Code	:	MTHO13
Course Title	:	Aerospace Materials
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	Nil
Course Type	:	HONOURS

Course Learning Objectives

To learn about Aerospace components and Critical requirements of materials
To develop an understanding of the different type of materials used in aerospace and future needs.
Assess the surface testing methods and comprehend the degradation properties

Course Content

Classification and different components in Aircraft, Helicopter and Rocket – Properties of Materials-Airworthiness-Aerospace material design drivers-Quality Standards for aerospace industry-Materials 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 – Materials selection for aerospace, space environments and its effect on materials – stealth technology

Yield strength anomaly(Kerf-Wilsdorf Mechanism)-Materials for Gas turbine-Ni-based super alloys-Intermetallics-Ti-Al alloy – Bond coat-Thermal barrier coating(plasma spraying)-Materials for Rocket combustion chambers and Nozzles-Copper alloys-Cobalt base alloy- Stellite-Columbium alloy

Al-Li alloys-Magnesium alloys-Titanium alloys-Super alloys-Stainless steels-Maraging steel

Composites-Polymer matrix composites-Carbon-Carbon composites-Ablative composites

Reference Books

1	*Adrian P Mouritz, Introduction to Aerospace Materials, Wood head publishing,2012*
2	*Cantor,B.,Assender.H., and Grant.P(Ed),Aerospace Materials, CRC press,2007*
3	*Reed.R.C., The Superalloys – Fundamentals and 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 this course, the students will be able to,

1. Know about the components used in Aircraft, Rocket and Helicopter
2. Understand different type of testing methods for aerospace components
3. Acquire knowledge about different material properties
4. Select suitable material for specific application

Course Code	:	MTHO14
Course Title	:	Recent Developments in Welding Processes
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	MTPC20
Course Type	:	HONOURS

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, CO_2 welding, pulsed and synergic MIG welding and surface tension transfer, CMT-Concepts, processes and applications.
key hole 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, Micro wave 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 under water 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

	Upon completion of this class, students are expected to
1.	Explain the various advancements in GMW and theirapplications [3, 4, 6]
2.	Explain the various advancements in TIG welding and theirapplications [3, 4, 6]
3.	Explain the various advancements in MEAB, microwave welding, EBW, Laser and resistance welding and theirapplications [3, 4, 6]
4.	Describe the various advancements in under water welding and theirapplications [3, 4, 6]
5.	Explain the various advancements in FSW and theirapplications [3, 4, 6]
6.	Explain the various advancements in surfacing methods and theirapplications [3, 4, 6]

Course Code	:	MTHO15
Course Title	:	Recent Developments in Forming Processes
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	MTPC24
Course Type	:	HONOURS

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 non ferrous 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: Superplasticity – definition, types, structural Superplasticity – 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 of ring rolling technology, Steel Res Int, 76 (2005), pp. 111–120*
3	*J.M. Allwood, A.E. Tekkaya, T.F. Stanistreet, The development of ring rolling technology-part 2: 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 engineers handbook, SME, p. 42-17, ISBN 978-0-87263-351-3*
7	*K.A. Padmanabhan and G.J. Davies "Superplasticity", Springer Verlag, Berlin-Heidelberg-New York, August 1980,*
8	*Angelo P C and Subramanian R, "Powder Metallurgy: Science Technology and Applications", PHI, New Delhi, 2011.*

Course Outcomes

At the end of this course, the students would be able to:

1. Understand the Concepts of the advanced forming processes
2. Understand the applications of the advanced forming processes
3. Can choose suitable process for the given material.

Course Code	:	MTHO16
Course Title	:	Recent Trends in Nano materials
Number of Credits		**3**
LTPC Breakup	:	L / T / P / C: 3 / 0 / 0 / 3
Prerequisites (Course code)	:	Nil
Course Type	:	HONOURS

Course Learning Objectives

To provide an understanding of the various concepts involved in fabrication of nanomaterial and the focus is 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) - Micro lithography, Vapor (or solution) – liquid – solid (VLS or SLS) growth - pulsed 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 Radom Access Memory- Nonvolatile 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 – Super capacitors- 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 nanosensor 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 – Nanosensors 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- Productinnovation 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 Nanofood to consumers

Nanotechnology in Defence and Aerospace Pathways to Physical protection- Detection and diagnostics of chemical and biological agents, methods- Chemical and Biological counter measures-Decontamination- Post exposure and pre exposure protection and decontamination- Nanotechnology enabled bio chemical 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 space craft and launch support- Micro/Nano pressure and temperature sensors for space missions.

Reference Books

1 Charles P. Poole, Jr., Frank J. Owens, “Introduction to nano technology”, Wiley, 2003

2	Gunter Schmid, “Nanoparticles: From Theory to Applications”, Wiley-VCH Verlag GmbH & Co., 2004.
3	Bharat Bhushan, “Springer Handbook of Nanotechnology”, Barnes &Noble, 2004.
4	Neelina H. Malsch (Ed.), “Biomedical Nanotechnology”, CRC Press 2005.
5	W.N. Chang, “Nanofibres fabrication, performance and applications”, Nova Science Publishers Inc, 2009.
6	Margaret E, Kosal, “Nanotechnology for Chemical and Biological defence”, Springer 2009.
Course Outcomes	
	At the end of the course, the student will be able to
1.	To choose a tailor made synthesis route according to the requirements of the end product. [1,2,3]
2.	To provide instances of contemporary industrial applications of Nanotechnology. [1,2,5,8,10,11]
3.	To provide an overview of future technological advancements and increasing role of nanotechnology in industries. [3,5,8,9,11,12]

Course Code	:	MTHO17
Course Title	:	Economics of Metal Production Processes
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	MTPC14, MTPC21
Course Type	:	HONOURS

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; Time frame required for moving from idea to actual production, in green field 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; 2nd Edition, 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

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

1. Understand the practices in operation in industries [1, 2, 4, 7]
2. Explore new grades of metals and materials compatible with green manufacturing [3, 5, 6, 8, 12]

Course Code	:	MTHO18
Course Title	:	**Mathematical Techniques in Materials Research**
Number of Credits		**3**
LTPC Breakup	:	L: 3, T: 0, P: 0, C: 3
Prerequisites (Course code)	:	MAIR 11, MAIR 21, MAIR 32, MAIR 41, MTPC 13, MTPC 15
Course Type	:	HONOURS

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; 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 modeling 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 Boltzman models for complex engineering fluids
Vector Calculus and the Behaviour of Engineering Materials
Constitutive Modeling 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 Modeling 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

Upon completion of this class, the students will be able to apply concepts of higher mathematics in studying and developing advanced materials and processes; and work in inter-disciplinary research teams [1, 4, 5]