

DEPARTMENT OF MME, MANIT, BHOPAL
PROPOSED SCHEME FOR BTECH (MSME)
(Revised April 2020)

First Semester:

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
MTH111 / MTH121	Mathematics 1 / Mathematics 2	3	1	-	4
PHY112	Physics	3	1	-	4
HUM113	Communication Skill	2	1	-	3
CSE114	Computer Programming & Problem Solving	3	-	-	3
ME115	Engineering Graphics	2	2	-	4
CSE116	Computer Programming & Problem Solving Lab	-	-	3	2
PHY117	Physics Laboratory	-	-	3	2
SPR118	Sports / Digital India Program	-	-	3	0
Total Hours – 27		Total Credit			22

I semester (Group-A) and II semester (Group-B)

Group-A means Sections A, B, C, D, E

Group-B means Sections F, G, H, I, J

Second Semester:

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
MTH121 / MTH111	Mathematics 2 / Mathematics 1	3	1	-	4
CH122	Engineering Chemistry	3	1	-	4
CH123	Environment Studies	2	-	-	2
EE124	Basic Electrical & Electronics Engineering	3	1	-	4
CE125	Engineering Mechanics	3	1	-	4
ME126	Workshop Practice	1	-	3	3
EE127	Basic Electrical & Electronics Engineering Laboratory	-	-	2	1
CH128	Chemistry Laboratory	-	-	2	1
SPR129	Yoga / Swachha Bharat Abhiyan	-	-	2	0
Total Hours – 27		Total Credit			23

I semester (Group-B) and II semester (Group-A)

The courses with zero credit are to be completed with Satisfactory Grade.

SPR118 and 129 will be exempted to NCC/ NSS students

Group-A means Sections A, B, C, D, E

Group-B means Sections F, G, H, I, J

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Third Semester:

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
MTH6301	Mathematics -3	3	1	-	4
HUM6302	Fundamentals of Entrepreneurship	3	1	-	4
MM6303	Fundamentals of Metal Extraction	3	1	-	4
MM6304	Thermodynamics of Materials	3	1	-	4
MM6305	Physical Metallurgy	3	1	-	4
MM6306	Metal Extraction Lab			2	1
MM6307	Physical Metallurgy Lab	-	-	2	1
MM6308	Projects on Furnace Design	-	2	-	2
Total Hours = 26		15	7	4	24
Total Credits (Cumulative)					69

Fourth Semester:

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
MTH6401	Mathematics -4	3	1	-	4
MM6402	Design of Metallurgical Processes	3	1	-	4
MM6403	Mechanical Behavior of Materials	3	1	-	4
MM6404	Iron & Steel Making	3	1	-	4
MM6405	Casting and Solidification	3	1	-	4
MM6406	Materials Testing Lab			2	1
MM6407	Foundry Lab.	-	-	2	1
MM6408	Projects on Mechanical Metallurgy	-	2	-	2
Total Hours = 26		15	7	4	24
Total Credits (Cumulative)					93

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Fifth Semester:

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
ME6501	Mechanics of Materials	3	1	-	4
MM6502	Materials Characterization	3	1	-	4
MM6503	Welding and Joining Technology	3	1	-	4
MM6504	Phase Transformation and Heat Treatment	3	1	-	4
ME6505	Engineering Management	3	1		4
MM6506	Heat Treatment Lab			2	1
MM6507	Materials Characterization Lab			2	1
MM6508	Projects on Welding and Joining		2		2
MM6509	Internship/Training (6 weeks)		2		1
Total Hours = 28		15	9	4	25
Total Credits (Cumulative)					118

Sixth Semester:

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
CS6601	Data Structures	3	1	-	4
MM6602	Project-1	-	-	4	2
MM6603	Metal Forming and Powder Metallurgy	3	1		4
MM6604	Non-Ferrous Metal Extraction	3	1		4
MM6605	Ceramics and Polymers	3	1		4
	Departmental elective 1 (A)	3	1		4
MM6606	Ceramics and Polymers Lab		-	2	1
MM6607	Metal Forming and Powder Metallurgy Lab		-	2	1
Total Hours = 28		15	5	8	24
Total Credits (Cumulative)					142

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Seventh Semester:

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
HUM6701	Engineering Economics & IPR	3	1	-	4
MM6702	Project-2 Phase -1			2	1
	Departmental Elective 2 (A)	3	1	-	4
MM6703	Corrosion and Surface Engineering	3	-	-	3
MM6704	Fracture and Failure Analysis	3	-	-	3
	Open Elective1 (C)	3	-	-	3
MM6705	Corrosion and Surface Engineering Lab			2	1
MM6706	Internship/Training		2		1
Total Hours = 23		15	4	4	20
Total Credits (Cumulative)					162

Eighth Semester:

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
MM6801	Project-2 Phase 2			4	2
	Departmental Elective-3 (A)	3	0	-	3
	Departmental Elective-4 (A)	3	0	-	3
	Departmental Elective-5 (A)	3	0	-	3
	Departmental Elective-6 (A)	3	0	-	3
	Department Elective-7(A)	3	0	-	3
MM6802	General Proficiency			2	1
Total Hours = 21		15	-	6	18
Total Credits (Cumulative)					180

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List of Electives

Group A Department Electives

MM501	Functional Materials
MM502	Physics of Materials
MM503	Destructive and Non-Destructive Testing
MM504	Composite Materials
MM505	Polymer Engineering
MM506	Additive Manufacturing
MM507	Selection and Design of Materials
MM508	Biomaterials
MM509	Advanced Steel Making
MM510	Nuclear Materials
MM511	Extraction of Rare Earth Metals and Alloys
MM512	Utilization of Metallurgical Wastes
MM513	Light Weight Metallic Materials
MM514	Wear of Engineering of Materials
MM515	Advanced Manufacturing Processes
MM516	Welding Metallurgy
MM517	Non-equilibrium Processing of Materials
MM518	Advanced Materials and Processes
MM519	Computational Techniques in Metallurgy
MM520	Advanced Characterization Techniques
MM521	Advanced Ceramic Materials
MM522	Optical, Electronics and Magnetic Materials
MM523	Semiconductor Devices and Applications

Group – C Open Electives (for other departments)

MM701	Materials Characterization
MM702	Welding and Joining Technology
MM703	Introduction to Materials
MM704	Corrosion and Surface Engineering
MM705	Fracture and Failure Analysis
MM706	Advanced Ceramic Materials
MM707	Welding Metallurgy
MM708	Advanced Manufacturing Processes

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Syllabus

First Semester

Name of Program	B.Tech.	Semester-I	Session 2020-21
Name of Course	Mathematics-1		
Course Code	MTH-111		
Core / Elective / Other	Core		
Prerequisite: JEE Mathematics			
Course Outcomes: At the end of the course, the student will be able to:			
1.	Understand and interpret the concepts of differential calculus, integral calculus, vector calculus.		
2.	Compute the solution of high dimensional homogeneous and non-homogeneous differential equations.		
3.	Integrate higher dimension and vector calculus problems.		
4.	Design and find the analytical solution of their engineering problems.		
Description of Contents in brief:			
1.	Curve Tracing, Singular points, Asymptotes, Expansion of Functions: Taylor's and Maclaurin's theorem.		
2.	Partial differentiation: Euler's theorem, Differentiation of composite functions, Taylor's Series. Maximum and Minima of functions of two or more variables, Lagrange method of undetermined multipliers.		
3.	Multiple Integral: Double and triple integral, Change of order of integration, Beta and Gamma functions, length of curves, Area, Volume and Surfaces of solids of revolution.		
4.	Vector Calculus: Vector Differentiation, Gradient, Directional Derivative, Divergence & Curl of Vector point function, Line Integral, Surface Integral, Gauss Divergence Theorem, Stokes theorem & Green's Theorem.		
5.	Ordinary Differential Equation: Differential Equation of First Order and Higher Degree, Linear Differential Equation with Constant Coefficient of Higher Order, Cauchy's Differential Equation, Method of Variation of Parameter, Simultaneous Differential Equation, Second Order Differential Equation.		
List of Text Books:			
1.	R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, 5 th Edition, CRC Press, Narosa Publishing House, New Delhi, 2016.		
2.	E. Kreyszig, Advanced Engineering Mathematics, 10 th Edition, John Wiley & Sons, Inc., New York, 2016.		

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List of Reference Books:	
1.	B.V. Ramana, Higher Engineering Mathematics, 1 st Edition, Tata McGraw-Hill Education, New Delhi, 2017.
2.	G. B. Thomas, Jr., M. D. Weir and J. R. Hass, Thomas' Calculus, 13 th Edition, Pearson Education, Inc., New York, 2014.
URLs:	
1.	https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-ma49/
2.	https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-ma37/
3.	https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-ma27/
4.	https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-ma12/
Lecture Plan (about 40-50 Lectures):	
Lecture No.	Topic
1-2	Singular points: definition, problems and significance
3-4	Asymptotes in Cartesian and polar coordinate systems: definition, problems and importance
5-6	Expansion of functions using Taylor's and Maclaurin's theorem.
7-10	Curve Tracing using Cartesian, polar and parametric coordinate systems
11	Partial differentiation: definition, simple derivatives and based problems
12-13	Homogeneous functions, Euler's theorem with proof and its extension up to second order
14-15	Differentiation of composite functions
16-17	Maxima and minima of functions of two or more variables
18	Lagrange method of undetermined multipliers
19	Beta and gamma functions and their applications in real integration
20-22	Multiple integral: double and triple integral in cartesian, polar and parametric coordinates, change of order of integration
23-26	Length of curves, Area, Volume and Surfaces of solids of revolution
27-28	Vector differentiation, gradient, directional derivative: Applications and physical significance
29-30	Divergence & curl of vector point functions: Problems and physical significance
31-32	Line integral, surface integral and their applications
33-35	Gauss divergence theorem, Stokes theorem, Green's theorem and their applications
36	Introduction to ordinary differential equations: Applications, examples and significance
37-39	Solution of differential equations of first order and higher degree including variable separable, homogeneous and reducible to homogeneous, linear and exact
40-41	Solution of linear differential equation with constant coefficient and higher

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	orders
42	Euler-Cauchy differential equations
43	Method of variation of parameters
44	simultaneous differential equations
45-46	Solution of second order differential when C.F is known and change of independent variables

Name of Program	B.Tech.	Semester-I & II	Year: 2020-21
Name of Course	Physics		
Course Code	PHY-112		
Core / Elective / Other	Core		

Prerequisite:

- The knowledge of physics with special reference to concept of light, types of static / dynamic forces, Newton's laws of motions, Ohms Law, basic semiconductor, structure of atoms and knowledge of mathematics involving differentiation and integration.

Course Outcomes: Upon successful completion of the course the student will be able to:

- Understand basic physical fundamentals and the key vocabulary to describe them: Interference and Diffraction of light, Energy band gaps, Quantum effect, Particle accelerator, Fission & Fusion, LASER, Fiber optics communication, Theory of Relativity and Electron ballistics.
- Apply an understanding of these concepts to various systems and devises.
- Acquire problem solving skills, mathematical techniques, and the ability to apply conceptual understanding of the Physics to general real-world situations.

Description of Contents in brief:

- Wave Optics: Interference and Diffraction, Michelson's interferometer
- Solid State and Semi-Conductor Physics: Energy bands in solids, Electron and hole mobility, Hall effect, PN junction transistor, Transistor parameters, Photo cell and Solar cell
- Quantum Mechanics: Schrodinger wave equation, Particle in a box, Harmonic oscillator, Tunnel effect
- Nuclear Physics: Nuclear properties, Nuclear models, Particle accelerator, Fission & Fusion, Chain reaction, Nuclear reactor, Particle detectors
- Laser and Fiber Optics: Laser phenomena, Ruby and He-Ne laser and applications, laser holography, Types of optical fibers, Attenuation, Fiber losses, Fiber optics communication
- Theory of Relativity: Transformation equations, Time dilation mass energy equation
- Electron ballistics: Motion of charged particles in electric and magnetic field, Electron microscope, Mass spectrographs

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List of Text Books:	
1.	Engineering Physics: M.N. Avadhanulu, P.G.Kshirsagar, T V S Arun Murthy, (S. Chand)
2.	Engineering Physics: Hitendra K Malik, A. K. Singh, (Tata McGraw-Hill)
3.	Concepts of Modern Physics: ArtherBeiser (McGraw-Hill)
4.	Principles of Optics: Brijlal Subramanyam (S. Chand)
5.	Engineering Physics: Majneet Singh
List of Reference Books:	
1.	Modern Physics: Kenneth Krane, (John Wiley Eastern)
2.	Modern Physics: Paul A. Tipler & Ralph A. Llewellyn, (W. H. Freeman)
3.	Quantum Mechanics Concepts and Applications: NouredineZettili (Wiley)
4.	Optics: AjoyK. Ghatak, (Tata McGraw-Hill Education)
5.	Fiber Optics & Lasers The Two Revolutions: AjoyGhatak& K. Thyagarajan, (Macmillan India Limited)
6.	Fundamental of Physics: Resnick, Walker& Halliday, (John Willey and Sons. Inc)
7.	Modern Physics by Mani & Mehta (East-West Press)
8.	Essentials of Quantum Mechanics by Fozia Z. Haque (Asian Books)
9.	University Physics: H.D. Young, Roger A Freedman, (Pearson)
10.	Solid State Electronics: B. G. Streetman, (Prentice Hall India)
11.	Solid State Physics: S. O. Pillai, (New Age International Publishers)
12.	A Textbook of Optics: N Subrahmanyam, Brij Lal& M N Avadhanulu, (S. Chand)
URLs:	
1.	https://nptel.ac.in/courses/122107035/#
2.	https://nptel.ac.in/course.html
3.	http://www.tndte.gov.in/site/wp-content/uploads/2016/08/Engineering-physics.pdf
4.	https://physicstoday.scitation.org
Lecture Plan (about 40-50 Lectures):	
Lecture No.	Topic
Lecture 1	Introduction to syllabus, Interference: Introduction, Coherence, Types of Interference, Interference in thin (parallel surfaced) films
Lecture 2	Wedge shaped film, Newton's rings Experiment, Numerical Problems
Lecture 3	Michelson's Interferometer: Theory and applications, Numerical Problems
Lecture 4	Diffraction: definition, types and diffraction, Single slit diffraction
Lecture 5	Double slit diffraction p, missing order
Lecture 6	Diffraction through n-slit, Transmission Grating, Numerical Problems
Lecture 7	Tutorial of wave optics
Lecture 8	Semiconductor Physics: Free electron theory, Band theory of solids
Lecture 9	Fermi Energy and Fermi Energy level in Intrinsic and Extrinsic Semiconductors
Lecture 10	Charge carrier concentration in intrinsic semiconductor, electron hole mobility

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	and conductivity, Numerical Problems
Lecture 11	P- N junction diode, Photocell
Lecture 12	Solar cell and its applications
Lecture 13	Hall effect and its applications, Numerical Problems
Lecture 14	Introduction to transistor: CE, CB and CC mode.
Lecture 15	Transistor parameters (α , β , γ and their relation), Numerical Problems
Lecture 16	Tutorial of semiconductor Physics
Lecture 17	Quantum Mechanics: Introduction to Quantum Mechanics, de-Broglie hypothesis, Concept of wave packet, Heisenberg's uncertainty principle, Postulates of Quantum Mechanics
Lecture 18	Properties of matter wave, Probabilistic interpretation of wave function
Lecture 19	Schrodinger's time dependent and time independent wave equation.
Lecture 20	Particle in a box (1D and 3D), Tunnel effect (α -decay)
Lecture 21	Harmonic Oscillator, Zero-point energy, Numerical Problems
Lecture 22	Tutorial of quantum mechanics
Lecture 23	Nuclear Physics: Nuclear properties, Mass defect, Semi-empirical mass formula, binding energy and Numerical Problems
Lecture 24	Nuclear Models: Liquid drop model and its success & failure
Lecture 25	Shell model
Lecture 26	Particle accelerators: Cyclotron, synchro-cyclotron, Numerical Problems
Lecture 27	Betatron and Numerical Problems
Lecture 28	Nuclear fission and fusion, Chain reaction and Nuclear reactor
Lecture 29	Nuclear particle detectors (GM counter), Numerical problems
Lecture 30	Mass Spectrographs (Bainbridge and Aston)
Lecture 31	Tutorial of Nuclear Physics
Lecture 32	LASER: Absorption and Emission process, Einstein's A & B coefficient
Lecture 33	Pumping Scheme and its types, component of LASER
Lecture 34	Ruby laser and He-Ne Laser
Lecture 35	Laser Holography and applications
Lecture 36	Fibre Optics: Introduction to optical fibre, Acceptance angle.
Lecture 37	Types of fibre, V-number, Losses in optical fibre, Uses & applications of fibre
Lecture 38	Tutorial of LASER and optical fibre
Lecture 39	Theory of Relativity: Introduction, Michelson-Morley Experiment, Postulates of special theory of relativity
Lecture 40	Galilean transformation and Lorentz transformation equation
Lecture 41	Length contraction and time dilation
Lecture 42	Theorem of addition of velocities, Principle of simultaneity
Lecture 43	Mass energy equivalence relation, Relativistic mass, Numerical problems
Lecture 44	Tutorial of theory of relativity
Lecture 45	Electron Ballistic: Motion of charged particle (electron) in uniform electric field when the field is parallel, perpendicular and at an angle to velocity of electron
Lecture 46	Motion of charged particle (electron) in uniform magnetic field when the field is parallel, perpendicular and at an angle to velocity of electron

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Lecture 47	Electron Optics: Bethe's law, electrostatic lens
Lecture 48	CRT, Electron microscope and Numerical Problems
Lecture 49	Tutorial of electron ballistic

Name of Program	B.Tech.	Semester- I & II	Year: 2020-21
Name of Course	Communication Skills		
Course Code	HUM-113		
Core / Elective / Other	Core		

Prerequisite:

1. In order to succeed in this course, the students should have basic knowledge of English grammar
2. They should be able to frame sentences in English using appropriate vocabulary and grammar and apply them in societal and professional life
3. The students should also have the ability to analyse communication behaviours

Course Outcomes:

1. On successful completion of this course, undergraduate students will be able to comprehend and communicate in English through exposure to theory and practice of communication skills.
2. They will be able to apply the basic grammatical skills of English Language through intensive practice.
3. The students will also be able to write, organise, comprehend, and present short and long forms technical work effectively.

Description of Contents in brief:

1.

Unit I: Communication
Communication: a vital necessity for good management, Communication process, Barriers to communication viz, organizational, individual, and interpersonal, Dealing with these barriers. Effective communication and modern techniques of spoken and written communication. Electronic devices in communication: computers (LAN,WAN, MAN), Facsimile, Telephone, Teleconferencing, Internet, E-Commerce
2.

Unit II: Oral Communication Skills
Oral communication skills – verbal and non-verbal communication. Executive speaking and listening skills, Presentation skills, Body language, Voice modulation, Negotiation skills, Development of positive personal attitudes, Personal SWOT analysis and development of career plan, Identifying the job, Selection process, Written test-structural, situational, and psychological analysis, Principles of interviewing, Reducing

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	stress, Retaining control, Setting objectives for the interview, Planning and preparation – the challenge of face to face skills
3.	<p>Unit III: Written Communication Skills</p> <p>Written communication skills – writing techniques and guidelines, Letter writing- basic principle and purpose, Body language of business letter, Tone of business letter, Types of business correspondence: inviting quotations, answering quotations, orders, tenders, sales letters, claim and adjustment letters, Writing smart e-mail, credit/collection letters, job application and writing resume, Report writing: types of reports, Parts of a report, Qualities of good report, Drafting reports-preparation, Analysis and interpretation of reports</p>
4.	<p>Unit IV: Developing Other Skills- I</p> <p>Developing other skills: interpersonal and human skills, Reading skills, Time management skills: avoiding time wasters and identification of prime time, Choosing an appropriate leadership style, Development of an ideal mix of skills</p>
5.	<p>Unit V: Developing Other Skills-II</p> <p>Communication roadblocks, Dealing with those roadblocks, Writing persuasive proposals, Memorandum, Public speaking, Group communication: kinds of discussions-forum discussion, Panel discussions, Symposium discussion and group discussions, Planning and meetings, Setting agendas for meetings, Writing and circulating minutes, Notices, Reading comprehension skills</p>
List of Text Books:	
1.	Business Communication strategies – Monipally, (Tata McGraw Hill)
2.	Personal Development for Life and Work – Wallace & Masters, (Thomson Publishing)
3.	The Essence of Effective Communication – Ron Ludlow & Fergus Panton,(PHI)
List of Reference Books:	
1.	Communication in Organisations - Dalmar Fisher (Jayco Publishing)
2.	Effective Business Communication - Murphy, (Allied pub.)
3.	Effective Technical Communication – A Ashraf Rizvi (Tata McGraw Hill)
URLs:	
1.	https://nptel.ac.in/courses/109/105/109105110
2.	https://nptel.ac.in/courses/109/105/109105117
3.	https://nptel.ac.in/courses/109/104/109104115
Lecture Plan (about 40-50 Lectures):	
Lecture No.	Topic
1	Communication: a vital necessity for good management
2-3	Communication process, Barriers to communication viz, organizational, individual, and interpersonal, Dealing with these barriers

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4-5	Electronic devices in communication: computers (LAN,WAN, MAN), Facsimile, Telephone, Teleconferencing, Internet, E-Commerce
6	Oral communication skills – verbal and non-verbal communication
7-8	Executive speaking and listening skills
9-11	Presentation skills
12-13	Body language, Voice modulation
14	Negotiation skills
15	Development of positive personal attitudes
16	Personal SWOT analysis and development of career plan
17-18	Identifying the job, Selection process, Written test- structural, situational, and psychological analysis
19	Principles of interviewing
20	Reducing stress, Retaining control
21-24	Setting objectives for the interview, Planning and preparation – the challenge of face to face skills
25	Written communication skills – writing techniques and guidelines
26-27	Letter writing- basic principle and purpose, Body language of business letter, Tone of business letter
28-30	Types of business correspondence: inviting quotations, answering quotations, orders, tenders, sales letters, claim and adjustment letters
31	Writing smart e-mail, credit/collection letters
32-33	Job application and writing resume
34	Report writing: types of reports, Parts of a report, Qualities of good report, Drafting reports-preparation
35	Analysis and interpretation of reports
36	Developing other skills: interpersonal and human skills
37	Reading skills
38	Time management skills: avoiding time wasters and identification of prime time
39	Choosing an appropriate leadership style
40	Development of an ideal mix of skills
41	Communication roadblocks, Dealing with those roadblocks
42	Writing persuasive proposals, Memorandum
43	Public speaking
44	Group communication: kinds of discussions-forum discussion, Panel discussions
45-47	Symposium discussion and group discussions
48	Planning and meetings, Setting agendas for meetings
49	Writing and circulating minutes, Notices
50	Reading comprehension skills

Name of Program	B. Tech.	Semester: First/Second	Year: 2020-21
Name of Course	Computer Programming and Problem Solving		

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Course Code	CSE-114
Core / Elective / Other	Core
Prerequisite:	
1.	There are no prerequisites to learn C programming.
2.	Just a bit of logical skills should be enough.
Course Outcomes:	
1.	Identify situations where computational methods and computers would be useful
2.	Given a computational problem, identify and abstract the programming task involved.
3.	Design algorithm and illustrate flowchart for a given problem.
4.	Write the program on a computer, edit, compile, debug, correct, recompile and run it.
5.	Identify tasks in which the numerical techniques learned are applicable and apply them to write programs, and hence use computers effectively to solve the task.
6.	Learn the basics of the Internet of Things and its applications. Understand Arduino Architecture, programming and interfacing with sensors.
Description of Contents in brief:	
1.	Introduction to Computer and its organization.
2.	Problem solving using Computers by Flowchart and Algorithms.
3.	Developing a running computer program in C.
4.	C programming using conditions, loop, array, functions, pointers and structures.
5.	Introduction to IoT using Arduino.
List of Textbooks:	
1.	E. Balaguruswamy, "Programming in ANSI C", Tata McGraw-Hill.
2.	Suresh Kumar Srivastava, "C in Depth", BPB Publication.
3.	R. G. Dromey, "How to Solve It By Computer", Pearson
4.	K R Venugopal, "Mastering C", Tata McGraw-Hill.
List of Reference Books:	
1.	Yashavant P. Kanetkar, "Let us C", BPB Publication
2.	A.R. Bradley, "Programming for Engineers", Springer
3.	Schildt Herbert, "C- The Complete Reference" ,Tata McGraw-Hill.
4.	Dan Gookin,"Begin programming with C for Dummies", Wiley
URLs:	
1.	https://nptel.ac.in/courses/106/105/106105171/
2.	https://www.nptel.ac.in/courses/106/104/106104128/
Lecture Plan (about 40-50 Lectures):	

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Lecture No.	Topic
1.	Fundamentals of Computing
2.	Evolution of Computer Hardware and Moore's Law
3.	Organization of Computing Systems - Input/Output devices, Memory, Instructions, Program
4.	Software, Operating System, Program execution
5.	Problem solving using Computers- Flow charting technique,
6.	Writing algorithms
7.	Generation of programming languages
8.	Assembler, Compiler, Interpreter, Debugger, Editor
9.	Phases of developing a running computer program in C
10.	Constants, Variables, Expressions, Operators, Operator precedence in C
11.	Data types, size and values, Char, Unsigned and Signed data types, Overflow
12.	Number systems and representations.
13.	Statements: Declarations, Input-Output Statements, Compound statements
14.	Selection Statements, Conditions -I
15.	Selection Statements, Conditions -II
16.	Repetitive statements - While loop -I
17.	While loop-II
18.	Do-while loop -I
19.	Do-while loop -II
20.	For loop -I
21.	For loop -II
22.	Arrays
23.	Sorting problem: Bubble Sort
24.	Search problem: Linear search
25.	Multidimensional Arrays and Matrices -I
26.	Multidimensional Arrays and Matrices -II
27.	Functions: The prototype declaration, Function definition
28.	Function call: Passing arguments to a function by value
29.	Pointers: Pointer variables, Declaring and dereferencing pointer variables
30.	Function call: Passing arguments to a function by reference
31.	Accessing arrays through pointers
32.	Scope of variable
33.	Recursive function call -I
34.	Recursive function call -II
35.	Pointer arithmetic
36.	Pointer Types
37.	Strings: String operations in C
38.	Structures and Union in C
39.	Typedef Structures.
40.	File input-output in C. Opening, closing and reading from files

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41.	Introduction to Internet of Things and Arduino
42.	Sensors
43.	Interfacing with LED with an Arduino board and ON/OFF the LED.
44.	Interfacing with different sensors with an Arduino board and displaying their reading -I
45.	Interfacing with different sensors with an Arduino board and displaying their reading -II

Name of Program	B.Tech	Semester I & II	Year: 2020-21
Name of Course	Engineering Graphics		
Course Code	ME-115		
Core / Elective / Other	Core		

Prerequisite:

1. Basic knowledge of drawing concepts and drawing instruments
2. Basic skills of making free hand sketches
3. Capability to visualize the objects in different orientations

Course Outcomes:

1. Learner will be able to understand the language of engineering graphics so that they can write it clearly for those familiar with it and read it readily when written by another.
2. Learner will know the basic theory and be familiar with its accepted conventions and abbreviations.
3. Learner will be able to work on various platform forms of CAD softwares using the basic knowledge of this subject.

Description of Contents in brief:

1. Basic Concepts-introduction to drawing and engineering drawing, lines, dimensioning, title block, drawing instruments etc., Engineering Scales
2. Theory of Projections, reference planes, types of projection methods, orthographic projection
3. Projection of points in different angles, projection of lines, projection of planes, projections using auxiliary planes method.
4. Projection of solids- Projection of polyhedrons, Prism and pyramids, Projection of solids of revolution in different positions.
5. Section of solids- cutting planes, auxiliary planes, frustum and truncated parts of solids, Development of solids- principle of development, parallel line method, radial line method.

List of Text Books:

1. Engineering Graphics By P.I. Vargheese

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2.	Engineering Drawing By N.D. Bhatt
3.	Engineering Drawing by R.K. Dhawan
List of Reference Books:	
1.	Engineering Drawing By Dhananjay A. Jolhe
2.	Engineering Drawing By P.S. Gill
3.	Engineering Drawing and Graphic Technology By French, Vierch, Foster
URLs:	
1.	https://nptel.ac.in/courses/112104172/
2.	
3.	
Lecture Plan (about 40-50 Lectures):	
Lecture No.	Topic
1.	Introduction to engineering drawing Introduction to drawing instruments and sheet layout List of drawing instruments
2.	Title block Introduction to line, letter writing and dimensioning Configuration, drafting and types of lines Lettering
3.	Dimensioning; placement, methods and general rules Introduction to geometrical construction Methods of drawing lines, perpendicular, bisections, line division, tangents etc.
4.	Methods for construction of regular polygons using general and special methods. Inscribing and circumscribing regular polygons in circle and square.
5.	Introduction to engineering scales Types and representation of scales Representative fraction
6.	Method for the construction of plain scale and diagonal scale
7.	Method for the construction of comparative scale and vernier scale
8.	Method for the construction of scale of chords
9.	Introduction to conic sections Methods for the construction of following conic sections; Ellipse, Parabola, Hyperbola, Tangents and normal,
10.	Methods for the construction of following conic sections; Hyperbola, Tangents and normal
11.	Introduction to engineering curves Methods for the construction of following engineering curves; Cycloid, Epicycloids, Hypocycloids, Involute, Spiral, Tangents and normal
12.	Methods for the construction of following engineering curves; Hypocycloids, Involute, Spiral, Tangents and normal

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13.	Methods for the construction of following engineering curves; Involute, Spiral, Tangents and normal
14.	Types of projections Introduction to orthographic projections Four angles of projections
15.	Methods of construction of multi views Introduction to projection of points
16.	Location of a point in various quadrants Method of representation
17.	Introduction to projections of straight lines Orientation of straight lines using rotation method
18.	Trapezoidal method Traces of straight lines
19.	Lines parallel to reference planes Line perpendicular to reference planes
20.	Line incline to one reference planes
21.	Line inclined to both the reference planes
22.	Line contained in the reference planes Summary
23.	Introduction to projections of planes Types of regular planes
24.	Orientation of planes
25.	Rotation and auxiliary plane methods Traces of planes
26.	planes parallel to reference planes planes perpendicular to reference planes
27.	planes incline to one reference planes
28.	planes inclined to both the reference planes
29.	planes contained in the reference planes Summary
30.	Introduction to projections of solids Classification of solids Orientations of solid
31.	Axis parallel to reference planes
32.	Axis perpendicular to reference planes
33.	Axis inclined to one reference planes
34.	Axis inclined to both reference planes
35.	Solid resting on its edge
36.	Solid resting on its corner Summary
37.	Introduction to sections of solids Types of section planes
38.	Sections of prisms
39.	Sections of pyramids

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40.	Sections of cones
41.	Sections of cylinders
42.	Section of composite solids
43.	Anti- section of solid Summary
44.	Introduction to development of surfaces Classification of surfaces
45.	Methods of development; parallel line method and radial line method
46.	Development of prisms
47.	Development of pyramid
48.	Development of cone
49.	Development of cylinders Development of composite objects
50.	Anti- development of object summary

Name of Program	B.Tech.	Semester: I & II	Year: 2020-21
Name of Course	Physics Laboratory		
Course Code	PHY-117		
Core / Elective / Other	Core		

Prerequisite:

- | | |
|----|---|
| 1. | The knowledge of physics with special reference to concept of light, types of static/dynamic forces, Newton's law of motions, basic semiconductor devices and knowledge of Engineering mathematics involving differentiation and integration. |
|----|---|

Course Outcomes:

Upon successful completion of the course the student will be able:

- | | |
|----|---|
| 1. | To design and conduct simple experiments as well as analyze and interpret data. |
| 2. | Develop skills in observation, interpretation, reasoning, synthesis, generalizing, predicting, and questioning as a way to learn new knowledge. |
| 3. | To apply conceptual understanding of the physics to general real-world situations. |

Description of Contents in brief:

- | | |
|----|---|
| 1. | To plot the characteristics curves of a p-n junction diode and calculate its resistance. |
| 2. | To plot the characteristics curves of PNP transistors in CE mode. |
| 3. | To perform Melde's Experiment in transverse and longitudinal modes and determine the frequency of an electrically maintained tuning fork. |
| 4. | To determine frequency of AC mains using an electrical vibrator. |
| 5. | To determine the radius of curvature of a lens by Newton's ring method. |
| 6. | To determine the refractive index of the material of the prism for various colors of mercury light using prism and spectrometer. |
| 7. | To determine the dispersive power of the material of the prism using spectrometer. |
| 8. | To determine the wavelength of different colors of mercury light using a plane |

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	transmission grating.
9.	To determine percentage of transmission of light for a semitransparent film using Lummer-Brodhum photometer.
10.	To study diffraction at a single slit using He-Ne laser.
11.	To determine the wavelength of He-Ne laser by Michelson Interferometer.
12.	To determine Hall Potential and Hall Coefficient.
13.	To study the characteristic of Photo Cell.
14.	To verify the formula for the combination of lenses and to determine the cardinal points of the combination using Nodal Slide assembly.
15.	To measure resistivity of a semiconductor by Four Probe method at different temperatures and determine the Band-gap.
16.	To determine the Plank's Constant using LED
17.	To study the characteristic of Photoconductive material.

List of Text Books:

1.	Engineering Physics: M.N. Avadhanulu, P.G.Kshirsagar, T V S Arun Murthy, (S. Chand)
2.	Concepts of Modern Physics: ArtherBeiser (McGraw-Hill)
3.	Principles of Optics: Brijlal Subramanyam (S. Chand)

List of Reference Books:

1.	Concepts of Modern Physics: ArtherBeiser (McGraw-Hill)
2.	Text Book on Advanced Practical Physics by Chauhan &Singh
3.	Laboratory Manual of MANIT Physics Lab

URLs:

1.	http://www.vlab.co.in/broad-area-physical-sciences
2.	https://nptel.ac.in/courses/115/105/115105121/
3.	https://en.wikipedia.org/wiki/Engineering_physics

Lab Plan (about 45 Lectures):

Lecture No.	Topic
15x3=45 Periods	15 Labs of 3 periods

Second Semester

Name of Program	B.Tech.	Semester-II	Session 2020-21
Name of Course	Mathematics-2		
Course Code	MTH-121		
Core / Elective / Other	Core		
Prerequisite:	JEE Mathematics		

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Course Outcomes: At the end of the course, the student will be able to:	
1.	Understand and interpret the concepts of PDE, integral transform, matrix algebra and complex numbers
2.	Find the analytical and series solution of ordinary and partial differential equations
3.	Apply various mathematical transformations on their engineering problems
4.	Use the basic idea of complex analysis in evaluating real integrals
5.	Solve different boundary value real-life problems
Description of Contents in brief:	
1.	Matrices: Matrix Algebra, Rank of a Matrix, Solution of a system of Linear Equation. Eigen Values & Eigen Vectors, Cayley Hamilton Theorem, LU Decomposition
2.	Laplace Transforms, Inverse Laplace Transforms, Solution of differential equation by using Laplace transforms, Fourier Series and Fourier Transforms
3.	Partial Differential Equation: Linear & Non-Linear P.D.E of First Order, Homogeneous & Non-Homogeneous Linear P.D.E with constant coefficient of Higher Order, Separation of Variables, Boundary Value Problems of P.D.E: Wave equation & Heat Equation
4.	Function of Complex variables: Calculus of Complex Function and its Applications for the Evaluation of Real Definite Integral
5.	Series solution of Differential Equations, Bessel function and Legendre's Polynomial
List of Text Books:	
1.	R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, 5 th Edition, CRC Press, Narosa Publishing House, New Delhi, 2016.
2.	E. Kreyszig, Advanced Engineering Mathematics, 10 th Edition, John Wiley & Sons, Inc., New York, 2016.
List of Reference Books:	
1.	B.V. Ramana, Higher Engineering Mathematics, 1 st Edition, Tata McGraw-Hill Education, New Delhi, 2017.
2.	G. B. Thomas, Jr., M. D. Weir and J. R. Hass, Thomas' Calculus, 13 th Edition, Pearson Education, Inc., New York, 2014.
URLs: None	
1.	https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-ma34/
2.	https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-ma41/
3.	https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-ma31/
4.	https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-ma49/
5.	https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-ma50/
6.	https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-ma12/

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Lecture Plan (about 40-50 Lectures):	
Lecture No.	Topic
1-3	Types of Matrices, Matrix Algebra, Rank of a Matrix,
4	Solution of a system of Linear Equation.
5-7	Eigen Values & Eigen Vectors, Cayley Hamilton Theorem, LU Decomposition
8-9	Laplace Transform: definition, conditions, Laplace transform of some standard functions, Shifting theorems, Laplace transform of derivatives and integrals
10-11	Inverse Laplace Transform: definition, conditions, Inverse Laplace transform of some standard functions, Convolution theorem
12-13	Applications: Solution of differential equation by using Laplace transforms
14-16	Fourier Series: Trigonometric Fourier series and its convergence, Fourier series of even and odd functions, Fourier half-range series
17-19	Fourier sine and cosine transforms and their elementary properties
20	Partial Differential Equation: Formation of first and second order partial differential equations
21-23	Solution of first order partial differential equations: Lagrange's equation, Four standard forms of non-linear first order equations
24-27	Homogeneous & Non-Homogeneous Linear P.D.E with constant coefficient of Higher Order
28	Separation of Variables method for PDE
29-31	Boundary Value Problems of P.D.E: Wave equation & Heat Equation
32-33	Function of Complex variables: analyticity of functions, C-R equations, necessary and sufficient conditions
34	Harmonic functions, Harmonic conjugates, Milne's method
35-36	Complex integration: contours, complex line integration, Cauchy's theorem for simply and multiply connected domains, Cauchy's integral formula for the derivatives of an analytic function, Morera's theorem
37-38	Taylor series, Laurent series, Zeros and poles of a function
39-41	Residue Calculus: residue at a singularity, Residue theorem, evaluation of a real integrals,
42-43	Introduction to series solution method: ordinary and regular singular point
44-45	Legendre differential equation: solution and properties
46-47	Bessel differential equation: solution and properties

Name of Program	B.Tech.	Semester: I and II	Year 2020-21
Name of Course	Engineering Chemistry		
Course Code	CH-122		
Core / Elective / Other	Core		
Prerequisite:			

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1.	Student should have sound knowledge of basics of chemistry, like atomic structure, bonding, chemical reactions, periodic table, their properties etc.
2.	Student should have the capability to understand how chemistry can explain various concepts of technology.
3.	Basic mathematics for doing calculations and numerical problems is desired.
Course Outcomes:	
Upon successful completion of the course the student will be able to:	
1.	Select lubricants for various purposes and can apply accordingly.
2.	Understand the importance of fuel in modern world scenario.
3.	Describe impurities present in water, boiler troubles, removal of impurities.
4.	Apply corrosion technology methods that are useful to know about the protection of metals from corrosion by various technologies.
5.	Describe advanced polymer materials and their industrial applications.
Description of Contents in brief:	
1.	LUBRICANTS- Introduction, Role and Effects of Friction, Functions of Lubricants, Mechanism of Lubrication – Thick Layer, Thin layer and Extreme Pressure Lubrication. Liquid Lubricants: Detailed classification of Vegetable Oils, Animal Oils, Mineral Oils, Blended and Synthetic Oils, Physical and Chemical Properties, Their Importance and Testing; Semi-solid Lubricants: Examples, Physical and Chemical Properties, Their Importance and Testing; Solid Lubricants: Examples and Their Structures; Biodegradable Lubricants; Lubricating Emulsions; Cutting Fluids; Selection of Lubricants.
2.	FUELS- Introduction, Classification, Calorific value, Characteristic of a Good Fuel, Comparison between Solid, Liquid and Gaseous Fuels, Bomb Calorimeter. Coal: Classification, Selection Criteria, Proximate and Ultimate Analysis, Pulverized Coal. Petroleum: Classification, Types of Cracking, Knocking, Octane and Cetane Number, LPG, Natural Gas, Producer Gas, Water Gas, Bio Gas. Numerical Problems based on Calorific Value, Bomb Calorimeter, Proximate and Ultimate Analysis.
3.	WATER- Introduction, Sources of water, Specifications of Drinking Water, Steps for Purification of water, Screening Process, Sedimentation, Sedimentation with Coagulation, Filtration and Disinfection. Difference between Disinfection and Sterilization, Break Point Chlorination. Hardness: Units and Disadvantages. Scale and Sludge formation: Disadvantages, Prevention (Internal & External Treatments), Caustic Embrittlement, Boiler Corrosion, Priming and Foaming. Softening Methods: Lime-Soda Processes (cold and hot both), Zeolite Process, Ion-Exchange Process. Numerical problems based on Lime-Soda Processes and water analysis.

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4.	<p>MATERIALS</p> <p>Polymer: Introduction, Nomenclature, Functionality, Types of Polymerization, Mechanism of Addition Polymerization, Thermosetting & Thermoplastic Polymers, Methods of Moulding of Plastics, Thermoplastic Resins: Polyethylene, Polypropylene, Polyvinylchloride, Polyvinyl Acetate, Polystyrene, Polymethyl Methacrylate, Polytetrafluoroethylene, Nylon-6:6, Kevlar. Thermosetting Resins, Polyurethane, Epoxy Resin, etc.: Bakelite, Silicone Resins, Polymer Composites. Rubber: Classification, Vulcanization, Synthetic Rubbers (Buna-S, Buna-N), PANVC, ABS etc.</p> <p>Cement: Introduction, Classification, Raw Materials, Gypsum, Manufacture of Portland Cement (Both Wet and Dry Process), Chemical Composition of Cement, Chemical Constitution of Cement, Setting and Hardening of Cement, Special Cements: Aluminous Cement, High Early Strength Cement, White Portland Cement, Water Proof Cement, Physical Requirements of Cement. Introduction of Concrete and RCC</p>
5.	<p>CORROSION AND ITS CONTROL</p> <p>Introduction and Mechanism of Chemical and Electrochemical Corrosion, Galvanic Corrosion, Concentration Cell Corrosion, Passivity, Soil Corrosion, Pitting Corrosion, Inter-granular Corrosion, Waterline Corrosion, Stress Corrosion, Galvanic Series, Factors influencing Corrosion, Ways to protect against Corrosion. Introduction of Protective Coatings, Metallic Coatings (Introduction of Anodic and Cathodic Coatings, Methods of application of Metal Coatings, Objectives and theory of Electroplating), Chemical Conversion Coatings, Paints, Varnishes and Enamels</p>
List of Text Books:	
1.	Engineering Chemistry by Jain and Jain
2.	Engineering Chemistry by S.S. Dara
3.	Engineering Chemistry by B.K. Sharma
4.	Engineering Chemistry by Shashi Chawla
List of Reference Books:	
1.	Engineering Chemistry by Shikha Agarwal; Cambridge University Press, 2015 edition.
2.	Engineering Chemistry of Wiley India Pvt. Ltd., Vairam and others, 2014 edition (second).
3.	Engineering Chemistry by PrasanthRath, Cengage Learning, 2015 edition.
4.	Applied Chemistry by H.D. Gesser, Springer Publishers
5.	B. Siva Shankar, "Engineering Chemistry", Tata Mc Graw Hill Publishing Limited, 3rd Edition, 2015.
6.	C. V. Agarwal, C. P. Murthy, A. Naidu, "Chemistry of Engineering Materials", Wiley India, 5th Edition, 2013.
7.	R. P. Mani, K. N. Mishra, "Chemistry of Engineering Materials", Cengage Learning, 3rd Edition, 2015.

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URLs:	
1.	https://www.iare.ac.in/sites/default/files/lecture_notes/EC-Lecture%20Notes_7.pdf
2.	https://nptel.ac.in/courses/105104102/
3.	https://nptel.ac.in/courses/103105110/
4.	https://nptel.ac.in/courses/113108051/
5.	http://tndte.gov.in/wp-content/uploads/2016/08/Engineering-Chemistry.pdf
6.	https://nptel.ac.in/courses/112102014/
Lecture Plan (about 40-50 Lectures):	
Lecture No.	Topic
1-8	UNIT – 1 (LUBRICANTS)
Lecture 1	Introduction, Role and Effects of Friction, Functions of Lubricants.
Lecture 2	Mechanism of Lubrication – Thick Layer, Thin layer and Extreme
Lecture 3	Pressure Lubrication.
Lecture 4	Physical and Chemical Properties of oils, Their Importance and
Tutorial	Testing.
Lecture 5	Physical and Chemical Properties of oils, Their Importance and
	Testing.
Lecture 6	Problems based on topics covered in above four lectures and
	discussions.
Lecture 7	Liquid Lubricants: Detailed classification of Vegetable Oils, Animal Oils,
Lecture 8	Mineral Oils, Blended and Synthetic Oils.
Tutorial	Semi-solid Lubricants: Examples, Physical and Chemical Properties,
	Their Importance and Testing.
	Solid Lubricants: Examples and Their Structures, Biodegradable
	Lubricants.
	Lubricating Emulsions; Cutting Fluids; Selection of Lubricants.
	Problems based on topics covered in above three lectures and
	discussions
9-16	UNIT – 2 (Fuels)
Lecture 1	Introduction, Classification, Calorific value, Characteristic of a Good
Lecture 2	Fuel, Comparison between Solid, Liquid and Gaseous Fuels.
	Numerical Problems based on Calorific Value.
Lecture 3	Bomb Calorimeter, Numerical Problems based on calorimeter.
Lecture 4	Coal: Classification, Selection Criteria, Proximate Analysis, Numerical
	Problems based on Proximate Analysis.
Tutorial	Problems based on topics covered in above three lectures and
Lecture 5	discussions.
	Ultimate Analysis of coal, Numerical Problems based on Ultimate
Lecture 6	Analysis.
Lecture 7	Pulverized Coal. Petroleum: Classification and separation.

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	Lecture 8 Tutorial	Types of Cracking. Knocking, Octane and Cetane Number. LPG, Natural Gas, Producer Gas, Water Gas, Bio Gas. Problems based on topics covered in above three lectures and discussions.
17-24	UNIT – 3 (Water)	
	Lecture 1 Lecture 2 Lecture 3 Lecture 4 Tutorial Lecture 5 Lecture 6 Lecture 7 Lecture 8 Tutorial	Introduction, Sources of water, Specifications of Drinking Water. Steps for Purification of water, Screening Process, Sedimentation, Sedimentation with Coagulation. Filtration and Disinfection. Difference between Disinfection and Sterilization. Break Point Chlorination, Hardness: Units and Disadvantages. Problems based on topics covered in above three lectures and discussions. Scale and Sludge formation: Disadvantages, Prevention (Internal & External Treatments), Caustic Embrittlement. Boiler Corrosion, Priming and Foaming. Softening Methods: Lime-Soda Processes (cold and hot both). Zeolite Process, Ion-Exchange Process. Numerical problems based on Lime-Soda Processes and water analysis.
25-32	UNIT – 4 (Materials)	
	Lecture 1 Lecture 2 Lecture 3 Lecture 4 Tutorial Lecture 5 Lecture 6 Lecture 7 Lecture 8 Tutorial	Polymer: Introduction, Nomenclature, Functionality, Types of Polymerization, Mechanism of Addition Polymerization. Thermosetting & Thermoplastic Polymers, Methods of Moulding of Plastics. Thermoplastic Resins: Polyethylene, Polypropylene, Polyvinylchloride, Polyvinyl Acetate, Polystyrene, Polymethyl Methacrylate. Polytetrafluoroethylene, Nylon-6:6, Kevlar. Thermosetting Resins, Polyurethane, Epoxy Resin, Alkydes etc. Problems based on topics covered in above three lectures and discussions. Bakelite, Silicone Resins, Polymer Composites. Rubber: Classification, Vulcanization, Synthetic Rubbers (Buna-S, Buna-N), PANVC, ABS etc. Cement: Introduction, Classification, Raw Materials, Gypsum, Manufacture of Portland Cement (Both Wet and Dry Process). Chemical Composition of Cement, Chemical Constitution of Cement, Setting and Hardening of Cement. Special Cements: Aluminous Cement, High Early Strength Cement, White Portland Cement, Water Proof Cement, Physical Requirements of Cement, Introduction of Concrete and RCC.

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		Problems based on topics covered in above three lectures and discussions.
33-40	UNIT – 5 (CORROSION AND ITS CONTROL)	
	Lecture 1	Introduction and Mechanism of Chemical and Electrochemical
	Lecture 2	Corrosion. Galvanic Corrosion, Concentration Cell Corrosion, Passivity,
	Lecture 3	Soil Corrosion.
	Lecture 4	Pitting Corrosion, Intergranular Corrosion, Waterline Corrosion, Stress
	Tutorial	Corrosion.
	Lecture 5	Galvanic Series, Factors influencing Corrosion, Ways to protect against
	Lecture 6	Corrosion.
	Lecture 7	Problems based on topics covered in above three lectures and
	Lecture 8	discussions.
Tutorial	Introduction of Protective Coatings, Metallic Coatings.	
		Introduction of Anodic and Cathodic Coatings, Methods of application of Metal coatings.
		Objectives and theory of Electroplating.
		Chemical Conversion Coatings, Paints, Varnishes and Enamels.
		Problems based on topics covered in above three lectures and discussions.

Name of Program	B.Tech.	Semester I & II	Year 2020-21
Name of Course	Environmental Studies		
Course Code	CH-123		
Core / Elective / Other	Core		
Prerequisite:			
1.	Student should have basic understanding of environment and its components.		
2.	Knowledge of essential chemical reactions is required.		
3.	Concept of pollution, its basic sources and need for its prevention should be clear.		
Course Outcomes:			
Upon successful completion of the course the student will be able to:			
1.	Demonstrate knowledge of chemical and biochemical principles of fundamental environmental processes in air, water, and soil.		
2.	Recognize different types of toxic substances & responses and analyze toxicological information.		
3.	Apply basic chemical concepts to analyze chemical processes involved in different environmental problems (air, water & soil).		
4.	Describe water purification and waste treatment processes and the practical chemistry		

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	involved.
5.	Describe causes and effects of environmental pollution by various industries and discuss some remedial strategies.
6.	Explain energy crisis and different aspects of sustainability.
7.	Discuss local and global environmental issues based on the knowledge gained throughout the course.

Description of Contents in brief:

1.	ATMOSPHERE AND AIR POLLUTION Structure of Atmosphere, Reactions of Air in Troposphere, Stratosphere, Mesosphere and Ionosphere, Smog formation - causes, effects and control with reactions, Classification and Effects of Air Pollutants (Oxides of S, C, N, Hydrocarbons and Particulates), Ways of Monitoring, Prevention and control of Air Pollution, Greenhouse effect and Global warming - major sources, effects and remedial measures, Ozone layer - mechanism of ozone depletion, Acid rain and their adverse effects, Indoor Pollution - causes and effects, Volatile Organic Compounds – origin and negative effects
2.	HYDROSPHERE AND WATER POLLUTION Characteristics of water, Types and Sources of Water pollution, Classification of Water pollutants and their detrimental effects, Characterization of waste water (including DO, COD, BOD), Methods and Equipment used in wastewater treatment- Preliminary, Primary, Secondary and Tertiary treatments (including Trickling filters, Aerated lagoon, Activated sludge etc.)
3.	LITHOSPHERE AND SOIL POLLUTION Composition and importance of Soil, Soil pollution - sources, effects and control.
4.	BIOSPHERE AND ITS POLLUTION Basic concept of Ecology, Biogeochemical cycles (Water, Hydrogen, Oxygen, Carbon, Nitrogen, Sulphur, Phosphorus), Effect of pollution on Biosphere.
5.	GREEN CHEMISTRY Basic principles and importance of Green Chemistry, Sustainability and its ten commandments.

List of Text Books:

1.	Textbook of Environmental Chemistry by BalramPani
2.	Environmental Chemistry by Stanley E. Manahan
3.	Environmental Chemistry by B.K.Sharma
4.	Environmental Chemistry by A.K.De

List of Reference Books:

1.	"Wastewater Engineering Treatment and Reuse" by MetCalf&Eddy, McGraw-Hill Education
2.	"Chemistry for Environmental Engineering and science" by Sawyer, McCarty and Parkin, McGraw Hill Education; 5 edition
3.	"Environmental Engineering" - by Howard S. Peavy, Donald R. Rowe and George

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	Tchobanoglous. McGraw Hill Education; First edition	
URLs:		
1.	https://nptel.ac.in/courses/123105001/	
2.	https://nptel.ac.in/courses/119106008/	
3.	https://www.youtube.com/watch?v=4AuwG2G_ERU	
4.	https://nptel.ac.in/content/storage2/courses/122106030/Pdfs/1_1.pdf	
5.	https://nptel.ac.in/courses/103/107/103107084/	
6.	https://www.asdlib.org/onlineArticles/ecourseware/Manahan/GreenChem-2.pdf	
7.	https://www2.hcmuaf.edu.vn/data/quoctuan/Basics_of_Environmental_Sci%20(Section%201).pdf	
8.	https://nptel.ac.in/courses/105104099/	
9.	https://www.ugc.ac.in/oldpdf/modelcurriculum/env.pdf	
10.	https://kupdf.net/download/kaushik-and-kaushik-evs_59ffb409e2b6f5c73be7cfc6_pdf	
11.	file:///C:/Users/DR.%20R%20K%20VISHWAKARMA/Downloads/d78456fce3bebc84d9320fa2f9cf9e2a-original.pdf	
Lecture Plan (about 40-50 Lectures):		
Lecture No.	Topic	
1-6	UNIT – 1 (ATMOSPHERE AND AIR POLLUTION)	
Lecture 1	Structure of Atmosphere, Reactions of Air in Troposphere,	
Lecture 2	Stratosphere. Reactions of Air in Mesosphere and Ionosphere, Smog formation - causes, effects and control with reactions.	
Lecture 3	Classification and Effects of Air Pollutants (Oxides of S, C, N, Hydrocarbons and Particulates).	
Tutorial	Problems based on topics covered in above three lectures and discussions.	
Lecture 4	Ways of Monitoring, Prevention and control of Air Pollution.	
Lecture 5	Greenhouse effect and Global warming - major sources, effects and remedial measures, Ozone layer - mechanism of ozone depletion.	
Lecture 6	Acid rain and their adverse effects, Indoor Pollution - causes and effects, Volatile Organic Compounds – origin and negative effects	
Tutorial	Problems based on topics covered in above three lectures and discussions.	
7-12	UNIT – 2 (HYDROSPHERE AND WATER POLLUTION)	
Lecture 1	Characteristics of water, Types and Sources of Water pollution.	
Lecture 2	Classification of Water pollutants and their detrimental effects.	
Lecture 3	Characterization of waste water (including DO, COD, BOD).	
Tutorial	Problems based on topics covered in above three lectures and discussions.	
Lecture 4	Methods and Equipment used in wastewater treatment- Preliminary,	
Lecture 5		

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	Lecture 6 Tutorial	Primary. Methods and Equipment used in wastewater treatment- Secondary treatments (Trickling filters, Aerated lagoon). Methods and Equipment used in wastewater treatment- Secondary (Activated sludge etc.) and Tertiary treatments Problems based on topics covered in above three lectures and discussions.
13-16	UNIT – 3 (LITHOSPHERE AND SOIL POLLUTION)	
	Lecture 1 Lecture 2 Lecture 3 Lecture 4 Tutorial	Composition and importance of Soil. Sources of Soil pollution. Effects of Soil pollution. Methods to control Soil pollution. Problems based on topics covered in above four lectures and discussions.
17-20	UNIT – 4 (BIOSPHERE AND ITS POLLUTION)	
	Lecture 1 Lecture 2 Lecture 3 Lecture 4 Tutorial	Basic concept of Ecology. Biogeochemical cycles (Water, Hydrogen, Oxygen). Biogeochemical cycles (Carbon, Nitrogen, Sulphur, Phosphorus). Effect of pollution on Biosphere. Problems based on topics covered in above four lectures and discussions.
21-24	UNIT – 5 (GREEN CHEMISTRY)	
	Lecture 1 Lecture 2 Lecture 3 Lecture 4 Tutorial	Basic principles of Green Chemistry. Importance of Green Chemistry. Sustainability and its ten commandments. Sustainability and its ten commandments. Problems based on topics covered in above four lectures and discussions

Name of the Program:	B.Tech.	Semester- I & II	Year: 2020-21
Name of the Course:	Basic Electrical and Electronics Engineering		
Course Code:	EE-124		
Core/Elective/Other:	Core		
Pre-requisites:	Engineering Physics		
Course Outcomes:			
1	Understand and solve simple AC and DC electric circuits.		
2	Identify types of transformers and calculate its efficiency for a given application		
3	Identify types of electric machines for a given application.		
4	Understand the working principle of basic semiconductor devices.		

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5	Differentiate the characteristics of semiconductor devices.
Description of Content in Brief:	
1	DC circuits: Review of basic concepts of charge, voltage and current, power and energy, Voltage & Current sources, Ohm's Law and its application, effect of temperature on resistance of conductors, semiconductors and insulators. Voltage & Current sources, KCL, KVL, loop and nodal equations, Network theorems, Star-Delta transformations for resistances, Simple series and parallel circuits.
2	AC Circuits: Alternating quantities, RMS and average value, Phase and Phase Difference, Power and power factor, Series and Parallel AC circuits, resonance, Concept of Single Phase and Three Phase Supply; 3-phase Star-Delta connections, Inter-Relation between phase and line values of voltages and currents. Faraday's law of electromagnetic induction, its application to transformer and machines.
3	Transformers: construction, principle of operation, phasor diagrams, equivalent circuit, losses and efficiency, OC/SC tests.
4	DC machines: Types of DC machines and their Construction, principle of operation, emf and torque equations, speed and torque control methods, starters.
5	Semiconductor devices and applications: Characteristics of PN Junction Diode and Zener Diode, applications of Zener diodes, half wave and full wave rectifiers, ripple factor, conversion efficiency,
6	Bipolar Junction Transistor: Principle of operation, Input/output & transfer characteristics of BJT in CB, CE, CC configurations and their applications.
List of Text Books:	
1	Hughes, Electrical and Electronic Technology, 10 th Edition, Pearson Education, 2010
2	D.P.Kothari& I.J. Nagrath, Basic Electrical Electronics and Engineering, MC Graw Hill Education, 2006.
3	V.N.Mittle, Basic Electrical Engineering, MC Graw Hill Education, 2005.
List of Reference Books	
1	V. Del Toro, Electrical Engineering Fundamentals, 2 nd Edition, Pearson Education, 2015.
2	A P Malvino and D J Bates, Electronic Principles, 7 th Edition, MC Graw Hill, 2017
3	Schaum's Outline Series, Electrical Circuits, 6th, MC Graw Hill Education, 1 Jan 2014.
4	Boylestad&Nashelsky, Electronic Devices and circuit Theory, Pearson Education, 2009.
URLs:	
1	https://nptel.ac.in/courses/108/104/108104139/
2	https://nptel.ac.in/courses/108/101/108101091/
3	https://nptel.ac.in/courses/108/105/108105053/
Lecture Plan	

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1.	Review of basic concepts of charge, voltage and current, power and energy, Voltage & Current sources, Ohm's Law and its application, effect of temperature on resistance of conductors, semiconductors and insulators.
2.	Kirchoff's current law (KCL) and nodal equations for simple DC circuits
3.	Practice problems based on KCL for simple DC circuits
4.	Practice problems based on KCL for simple DC circuits
5.	Practice problems based on KCL for simple DC circuits
6.	Kirchoff's voltage law (KVL) and loop equations for simple DC circuits
7.	Practice problems based on KVL for simple DC circuits
8.	Practice problems based on KVL for simple DC circuits
9.	Practice problems based on KVL for simple DC circuits
10.	Network (Superposition) Theorem for simple DC circuits
11.	Practice problems based on Superposition theorems for simple DC circuits
12.	Practice problems based on Superposition theorems for simple DC circuits
13.	Practice problems based on Superposition theorems for simple DC circuits
14.	Network (Thevenin and Norton) Theorems for simple DC circuits
15.	Practice problems based on Thevenin and Norton theorems
16.	Practice problems based on Thevenin and Norton theorems
17.	Practice problems based on Thevenin and Norton theorems
18.	Star-Delta transformations for resistances
19.	Practice problems based on Star-Delta transformations for resistances
20.	Alternating quantities, RMS and average value, Phase and Phase Difference, Power and power factor
21.	Series and Parallel AC circuits, Practice problems
22.	Practice problems based on Series and Parallel AC circuits
23.	Resonance in AC circuits, Practice problems
24.	Practice problems based on Resonance in AC circuits
25.	Concept of Single Phase and Three Phase Supply, 3-phase Star-Delta connections, Inter-Relation between phase and line values of voltages and currents.
26.	Practice problems based on three phase AC circuits
27.	Practice problems based on three phase AC circuits
28.	Faraday's law of electromagnetic induction, its application to transformer and machines.
29.	Transformers: construction, principle of operation
30.	Transformers: equivalent circuit
31.	Transformers: Phasor diagrams
32.	Transformers: losses and efficiency
33.	Transformers: OC and SC tests
34.	Practice problems based on Transformers

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35.	Practice problems based on Transformers
36.	DC machines: Types of DC machines and their Construction
37.	DC machines: principle of operation, emf and torque equations
38.	DC machines: Starters
39.	DC machines: Speed and torque control
40.	Practice problems based on DC Machines
41.	Practice problems based on DC Machines
42.	Characteristics of PN Junction Diode and Zener Diode
43.	Applications of Zener diodes
44.	Half wave rectifiers: Circuit operation, Ripple factor, conversion efficiency
45.	Full wave rectifiers: Circuit operation, Ripple factor, conversion efficiency
46.	Bipolar Junction Transistor (BJT): Principle of operation, Input/output and transfer characteristics of BJT in CB configuration and its applications
47.	Input/output and transfer characteristics of BJT in CE configuration and its applications
48.	Input/output and transfer characteristics of BJT in CC configuration and its applications
49.	Problem solving related to any topics above
50.	Problem solving related to any topics above

Name of Program	B.Tech. (All Branches)	Semester I & II	Year 2020-21
Name of Course	Engineering Mechanics		
Course Code	CE-125		
Core / Elective / Other	Core		
Prerequisite:			
1.	The knowledge of physics with special reference to concept of forces, concept of rigid and elastic bodies.		
2.	General Concept of conditions of static/dynamic equilibrium.		
3.	Basic knowledge of Engineering mathematics involving differentiation and integration, matrix algebra etc.		
Course Outcomes:			
1.	Learn how a solid body (rigid body/elastic body) behaves when it is subjected to static/dynamic forces/loads.		
2.	The concept of elastic structure subjected to various types of forces or their combination and response developed in the structure.		

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3.	Learn to evaluate deformation and stress resultants to investigate safety of the structure or remedial measures to avoid failure, Provide students the fundamental basis for solving real field problem in the area of structural analysis/design, material science, and fracture mechanics etc.
Description of Contents in brief:	
1.	Force systems and concept of equilibrium
2.	Analysis of statically determinate trusses
3.	Centroid and moment of Inertia of plane sections
4.	Shear force and Bending moment in Beams
5.	Simple stresses and strains and Mechanical Properties of Materials
List of Text Books:	
1.	Engineering Mechanics by S.S. Bhavikatti
2.	Mechanics of Materials by S.S. Bhavikatti
3.	Mechanics of Materials by E.J. Hearn
List of Reference Books:	
1.	Introduction to Solid Mechanics by I H Shames
2.	Schaum's Outline of Engineering Mechanics by E Nelson
3.	Engineering Mechanics Statics and Dynamics by A Nelson
URLs:	
1.	https://nptel.ac.in/courses/112106286/
2.	https://nptel.ac.in/courses/112103109/
3.	https://nptel.ac.in/courses/122104014/
Lecture Plan (about 40-50 Lectures):	
No. of Lectures	Topic
1-7	Types of forces, force systems, coplanar, concurrent force systems, determination of resultant for different types of forces, Lami's theorem, law of triangle and law of polygon of forces, Conditions of static equilibrium, supports, reactions in beams, free body diagrams
8-14	Meaning of trusses, types of trusses, technical terms related to truss analysis, Assumptions in the analysis of trusses, method of joint, method of section, method of tension coefficients and graphical method
15-20	Methods of finding centroid of any plane figures, moment of Inertia of plane figures, polar moment of inertia, perpendicular and parallel axes theorems, product moment of inertia, principal axes and principal moment of inertia, Moh'r circle for finding moment of inertia
21-28	Meaning and importance of bending moment and shear force in structures and

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	their definitions, sign conventions for bending moment and shear force, Shear force and Bending moment diagrams for simply supported, cantilever and overhanging beams, relationship between shear force and bending moment
29-36	Meaning of stress, various types of stresses, direct/normal stress and strain, Normal and true stresses, shear stress and strain, Generalized Hook's law, Modulus of elasticity, modulus of rigidity, volumetric strain and bulk modulus, Poisson's ratio, Relationship between elastic constants, Evaluation of stresses and strains in compound, tapering and composite bars, Temperature stress and strain, Mechanical properties of materials
37-40	Different properties of materials like ductile, brittle, hardness, resilience, etc. Experimental techniques for mechanical testing of engineering materials subjected to tension, compression, bending or torsion. Tension test for mild steel, tor-steel and iron bars to evaluate tensile strength yield strength, elastic modulus, percent elongation and the reduction in area and other properties like toughness, resilience, Poisson's ratio

Name of Program	B.Tech.	Semester I &II	Year I
Name of Course	Workshop Practice		
Course Code	ME-126		
Core / Elective / Other	Core		
Pre-requisite:			
1.	Basic knowledge of manufacturing process and drawing thoughts.		
2.	Basic skills like cutting, molding, painting and knowledge of physical and chemical processes.		
3.	Capability to visualize and make the objects with different shapes and sizes.		
Course Outcomes:			
1.	Workshop practice provides the basic practical knowledge required for working with various materials used in the production of different Engineering components.		
2.	Workshop practice explains the construction, function, use and application of different working tools, equipment, machines as well as the technique of manufacturing a product from its raw material.		
3.	The Workshop Practice course makes students competent in handling practical work in Engineering environment.		
Description of Contents in brief:			
1.	Carpentry: Introduction to carpentry, types of timber: study of various tools used in carpentry, types of joints, JOB: Making of "L" joint.		
2.	Fitting: Introduction to fitting and its tools, JOB: Preparation of rectangular job piece by use of filling and cutting.		
3.	Foundry: Introduction to casting, study of tools used in making moulds and sands,		

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	JOB: preparation of mould.
4.	Welding: Introduction to metal joining processes, types of welding processes and joints, JOB: Joining of two M.S plates by metal arc welding. JOB: Joining of two M.S plates by metal arc welding
List of Text Books:	
1.	A text book of Workshop Technology by R.S.Kurmi and J.K Gupta.
2.	A Textbook of Workshop Technology: Manufacturing Processes N Khurmi R.S Khurmi
List of Reference Books:	
1.	Workshop Praticce, K.C.John, PHI Learning Pvt. Ltd
2.	Elements of Workshop Technology, Vol I and II by S.K.Hajra Choudhury.
URLs:	
1.	https://nptel.ac.in
Practical classes plan (about 32-40 Laboratory session): (2 Hrs. Each)	
Practical classes (02 Hrs.)	Topic
1.	Introduction to workshop practice. Introduction to various instruments and tools used in workshop practical. Brief study and demonstration of instruments and tools.
2.	Carpentry: Introduction to carpentry and types of wood used in carpentry.
3.	Study and demonstration of various tools used in carpentry.
4.	Types of joints and other components.
5.	JOB: Making of "L" joint.
6.	Fitting: Introduction to basics of machining and fitting process.
7.	Demonstration of measuring tools and of and its tools.
8-9	JOB: Preparation of rectangular job piece by use of filling and cutting. JOB: Providing shape (L or V) from rectangular job piece.
10.	Foundry: Introduction to casting and black smithy
11.	Study and demonstration of tools used in making casting and black smithy
12.	JOB: Molding processes practical
13.	JOB: Black smithy practical
14.	Welding: Introduction to metal joining processes, types of welding processes and joints.
15.	Study and demonstration of tools used in welding processes.
16-17	JOB: Joining of two M.S plates by metal arc welding. JOB: Joining of two M.S plates by metal arc welding.

Name of the	B.Tech	Semester- I & II	Year: 2020-21
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Program:			
Name of the Course:	Basic Electrical and Electronics Engineering Laboratory		
Course Code:	EE-127		
Core/Elective/Other :	Core		
Pre-requisites:	Engineering Physics		
Course Outcomes:			
1	Understand the safety measures of handling electrical equipment		
2	Identify and use different electrical tools and equipments		
3	Connect the measuring instruments and record the measured values correctly		
4	Analyze the results of given electrical circuit and plot the desired characteristics		
Description of Content in Brief:			
1	Study of basic electrical safety equipment's such as Fuses, Earthings, MCBs, ELCBs and their operation.		
2	Study of various Electrical lab tools and their applications.		
3	Fault diagnosis and removal in general electrical connection /apparatus.		
4	Selection and replacement of different passive components e.g. fuses, lamps and lamp holders, switches, cables, cable connectors etc.		
5	Verification of Kirchoff's current law (KCL).		
6	Verification of Kirchoff's voltage law (KVL).		
7	Measurement of various characteristic values of a Sinusoidal waveform with the help of CRO.		
8	Measurement of power and power factor in single phase AC circuits.		
9	Measurement of losses in a single-phase transformer using OC and SC Tests.		
10	Load test and voltage regulation measurement in a single-phase transformer.		
11	Starting and reversing various AC and DC motors.		
12	Speed control of DC shunt motor below and above base speed.		
13	Measurement of output voltage of Half wave diode rectifier and visualization of its waveforms.		
14	Measurement of output voltage of full wave diode rectifier and visualization of its waveforms.		
List of Text Books:			
1.	Laboratory Manual of Basic Electrical and Electronics Engineering Lab, MANIT Bhopal		
2.	S G Tarnekar, Laboratory Courses in Electrical Engineering, S Chand, 2006.		
List of Reference Books			
1.	D.P.Kothari& I.J. Nagrath, Basic Electrical Electronics and Engineering, MC Graw Hill		

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	Education, 2006.
2.	V.N. Mittle, Basic Electrical Engineering, MC Graw Hill Education, 2005
URLs:	
1	https://nptel.ac.in/courses/108/108/108108076/
Lab Plan	
1.	Introduction of lab equipments, experiments and demonstration of safety measures
2.	Study of basic electrical safety equipments such as Fuses, Earthings, MCBs, ELCBs and their operation.
3.	Study of various Electrical lab tools and their applications.
4.	Fault diagnosis and removal in general electrical connection /apparatus.
5.	Selection and replacement of different passive components e.g. fuses, lamps and lamp holders, switches, cables, cable connectors etc.
6.	Verification of Kirchoff's current law (KCL).
7.	Verification of Kirchoff's voltage law (KVL).
8.	Measurement of various characteristic values of a Sinusoidal waveform with the help of CRO.
9.	Measurement of power and power factor in single phase AC circuits.
10	Measurement of losses in a single-phase transformer using OC and SC Tests.
11	Load test and voltage regulation measurement in a single-phase transformer.
12	Starting and reversing various AC and DC motors.
13	Speed control of DC shunt motor below and above base speed.
14	Measurement of output voltage of Half wave diode rectifier and visualization of its waveforms.
15	Measurement of output voltage of full wave diode rectifier and visualization of its waveforms.

Name of Program	B.Tech.	Semester: I and II	Year 2020-21
Name of Course	Chemistry Laboratory		
Course Code	CH-128		
Core / Elective / Other	Core		
Prerequisite:			
1.	Student should be capable of handling glass-wares like burette, pipette etc., and		

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	minorequipments like pH meter, weighing balance etc.
2.	Student should understand the sensitivity of working in the chemistry lab with utmost care so that no harm should come to him or others.
3.	Knowledge of basic mathematics is required.
Course Outcomes:	
Upon successful completion of the course the student will be able to:	
1.	Acquire basic analytical and technical skills to work effectively in the various fields of chemistry.
2.	Gain the ability to perform accurate quantitative measurements with an understanding of the theory.
3.	Able to present scientific and technical information resulting from laboratory experimentation in both written and oral formats.
4.	Acquire knowledge and understanding of the issues of safety regulations.
Description of Contents in brief:	
1.	Oxidation - Reduction Titrations Estimation of percentage of iron using potassium dichromate by internal indicator method Estimation of percentage of iron using potassium dichromate by external indicators
2.	IODOMETRIC TITRATIONS Iodometric titration of copper sulphate by hypo. Iodometric titration of potassium dichromate by hypo.
3.	Water Analysis Determination of alkalinity of water sample by acid method. Determination of total hardness in water using EDTA titrations Determination of pH of tap water sample (Demonstration)
4.	Lubricant Testing Determination of viscosity and viscosity-index of lubricating oil by a. Red Wood Viscometer Number 1 b. Red Wood Viscometer number 2 Determination of cloud point and pour point of lubricating oil. Determination of drop point of semi solid lubricant. Determination of consistency of semi solid lubricant.
5.	Determination of Flash and Fire point of liquid fuel and lubricants by a. Cleaveland's Open Cup Method b. Abel's Flash Point Apparatus c. Pensky Martin's Flash Point Apparatus
List of Text Books:	
1.	"A Textbook of Experiments and Calculations in Engineering Chemistry" by S.S. Dara
2.	Practical Engineering Chemistry" by A.Mittal, J.Mittal and H.L.Kapoor

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List of Reference Books:	
1.	Laboratory manual on Engineering Chemistry" by Sudha Rani
2.	Theory and Practicals of Engineering Chemistry by Shashi Chawla
URLs:	
1.	https://www.youtube.com/watch?v=yPNhAks7mtE&list=PLmB0ThS_49Y6sr4kXOr-KPBtKEOyy7tPn
2.	https://www.youtube.com/watch?v=JhBs_8DrPYo&list=PLz311NKW0XBtP0jV9_LaHcQSyArlDxIPX

Third Semester

Name of Program	B.Tech (MME)	Semester-III	Session-2021-22
Name of Course	Mathematics III		
Course Code	MTH-6301		
Core / Elective / Other	Core		
Prerequisite:			
1.	Knowledge of Engineering Mathematics		
2.	Basics of statistical concepts such as central tendencies, dispersion etc.		
Course Outcomes:			
1.	Apply suitable numerical techniques for real world problems related to Material & Metallurgical Engineering		
2.	Have ability of understanding statistical inferences		
Description of Contents in brief:			
1.	Numerical Methods: Solution of algebraic and transcendental equations, Solution of linear Simultaneous Equations.		
2.	Finite Differences, Interpolation and Extrapolation, Inverse Interpolation.		
3.	Numerical Differentiation and Integration.		
4.	Numerical solution of Ordinary & Partial Differential Equations.		
5.	Statistics: Curve fitting, Correlation and Regression Analysis		
6.	Probability Distribution. Sampling and Testing of Hypothesis		
List of Text Books:			
1.	Numerical Methods by Dr. B. S. Grewal		
2.	Mathematical Statistics-Ray, Sharma and Chaudhary		
List of Reference Books:			
1.	Numerical Analysis by Hildebrand, Mcgraw Hill.		
2.	Numerical Analysis by Scarborough, Oxford.		
3.	Mathematical Statistics – J E Freund & R E Walpole		
4.	Numerical Methods by E .Balaguruswamy, TMH		

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URLs:	
1.	https://nptel.ac.in/courses/111/107/111107105/
2.	https://nptel.ac.in/courses/111/105/111105041/
3.	https://nptel.ac.in/courses/111/106/111106101/
4.	https://nptel.ac.in/courses/110/107/110107114/
Lecture Plan (about 40-50 Lectures):	
Lecture No.	Topic
Solution of Algebraic and Transcendental Equations (10 L)	
1.	Basic Concept and Motivation
2.	Bisection method, Regula Falsi method, Secant method
3.	General iteration method, sufficient condition for convergence, efficiency of method
4.	Newton-Raphson method, Chebyshev Method
5.	Rate of Convergence and order of convergence of different methods
6.	Newton's method for multiple roots
7.	Problems on previous topics
8.	Direct method; Graeffe's Root Squaring Method
9.	Descartes Rule of Signs, Lin Bairstow's Method for finding complex roots
10.	Problems on Graeffe's and Lin Bairstow's methods
Solution of Linear and Non-Linear Simultaneous Equations (5 L)	
11.	Direct Methods (Gauss Elimination and Gauss Jordan)
12.	Iterative Method: Jacobi Iterative Method, Gauss-Seidel Method
13.	Factorization Method- LU Decomposition method
14.	Convergence of iterative methods and some problems on previous topics
15.	Newton Raphson method for Non-Linear Simultaneous Equations & its convergence
Finite Differences, Interpolation, Numerical Differentiation and Integration (12 L)	
16.	Forward, Backward and Central difference operators and table
17.	Relation between different operators and some problems
18.	Interpolation with equidistant point: Newton Gregory's Forward interpolation Formula, Backward interpolation formula
19.	Central difference formulae: Gauss Forward, Gauss Backward, Stirling's Formula
20.	Central difference formulae (continued): Bessel's Formula, Laplace-Everette's Formula

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21.	Newton Interpolating Polynomial using divided Difference Table
22.	Lagrange Interpolation Polynomial, Lagrange's inverse interpolation
23.	Differentiating tabulated functions, Finding maxima and minima of tabulated functions
24.	Newton-Cotes quadrature formulae: Trapezoidal Rule, Simpson 1/3 Rule
25.	Simpson 3/8 Rule, Weddle Rule
26.	Error analysis
27.	Double Integration
Numerical Solution of ODE and PDE (12 L)	
28.	Picard's method, Taylor's Series (ODE)
29.	Euler and Euler's Modified method (ODE)
30.	Error in these methods and problems (ODE)
31.	Runge- Kutta Method; III & IV order methods, (ODE)
32.	Problems on these methods (ODE)
33.	Milne's Method and Error Analysis (ODE)
34.	Adams Bash-forth Method and Error Analysis (ODE)
35.	Problems on Milne's and Adams Bash-forth methods (ODE)
36.	Classification of second order PDE's, Finite difference approximations to derivatives
37.	Solution of Laplace and Poisson's Equations (case of elliptic equations)
38.	Solution of Heat equation (case of parabolic equation)
39.	Solution of Wave equation (case of hyperbolic equation)
Statistics (10 L)	
40.	Curve Fitting by Method of Least Squares
41.	Correlation: concept, Type of correlation, Coefficient of correlation, Rank correlation
42.	Regression: concept, Line of regression of X on Y, Line of regression of Y on X,
43.	Relation between correlation and regression, Standard Error of Estimate
44.	Binomial and Poisson Distribution (Discrete)
45.	Normal Distribution (Continuous)
46.	Introduction to Sampling, Sampling Distribution and important terminology
47.	Introduction to Testing of Hypothesis related terminology
48.	Z-test
49.	t-test, Chi-square test

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Name of Program	Bachelor of Technology	Semester: III	Year: 2ND Year
Name of Course	Fundamentals of Entrepreneurship		
Course Code	HUM-6302		
Core	CORE (3 rd Semester Civil, Chemical, ME)		
Prerequisite:			
1	Fundamental Understanding of Personnel Administration is an integral part for Engineers before entry into organization and to setup any startup business.		
2	Organizational theories and Motivation for Entrepreneurship enthusiastic for systematic approach to handle the materialistic and non-materialistic motivation.		
3	Business Plan and fundamentals of Entrepreneur Development for engineering graduates to survive in this competitive world.		
4	A hybrid approach for technocrats to handle the multifunctional technicalities in case of industrial laws and New social security and pension rules.		
Course Outcomes:			
1	Course will inculcate administrative skills for Engineers to handle the all the matters related to personnel and their dimensions.		
2	Engineering students will be in position to take appropriate decision to understand the industrial Laws and application of administrative principles for smooth functioning of Industry and a fresh idea to setup new business.		
3	Boost up the engineers to develop Business ideas to become successful entrepreneurs to setup new operational business units to address the need of society.		

Description of Contents in brief:	
1	Meaning, nature and scope of Personnel Administration in India, functions and significance of Personnel Administration, Recruitment, Training, Promotion and Disciplinary Action, Classification of Services, Generalists and Specialists, Development of Public Services in India, Bureaucracy and Modern Democratic System, Performance Appraisal
2	Organizational Development Theories, Fredric Winslow Taylor, Marry Parker Follett, Elton Mayo, Max Weber, Henry Fayol, Power, Accountability, Responsibility, Control, Transparency and Conflict Resolutions.
3	Meaning and importance of Entrepreneurship, Evolution of Entrepreneurship, Factors influencing Entrepreneurship: Social factors, psychological factors, economical factors and environmental factors. Characteristics of an Entrepreneur, Types of Entrepreneur: type of business, use of technology, motivation. New Generation of entrepreneurship: social entrepreneurship, tourism entrepreneurship, women entrepreneurship. Barriers to Entrepreneurship.
4	Entrepreneurial motivation: Relevance of Motivation, Maslow's Theory, Herzberg's Theory, Douglas McGregor, Ethics, Corruption and Anti-Corruption Machinery in country
5	Factory Act 1948, Provident Fund Act 1952, Compensation Act 1919, Special Economic Zone (SEZ), National Small Industries, Quality Standard with Special reference to (ISO), Small Industries Development Bank of India (SIDBI), New Pension Scheme 2004 Act.

List of Text Books:	
1	D. Ravindra Prasad, V.S. Prasad, P. Satyanarayana, Y. Pardhasaradhi. Administrative Thinkers. Sterling Publishers Private Limited Second Revised Enlarged Edition, New Delhi. 2010.
2	Haidi, Patricia & Brush, Teaching Entrepreneurship, Edward Elgar, United States of America, 2014.

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	India, Contribution of Max Weber
7	Promotion, types of promotion, disciplinary action and classification of services, Administrative tribunals
8	Generalists Vs. Specialists, their arguments and need of the hierarchy at the top of the organization.
9	Modern Democratic system and organizations in the world
10	Organizational Theories and its development; Contributions of classical thinkers in the professionalism.
11	Contributions of Frederick Winslow Taylor in the development of Scientific management approach, functional foremanship and development of scientific tools and techniques for more efficiency.
12	Top level management and contribution of French engineer in the development of basic professional principles for high rise in production.
13	Hawthorne Experiment and emergence of new Human Relation approach by the Elton Mayo
14	Marry Parker Follet and orders to follow in different situations and understand the behavior of employees.
15	Accountability, Responsibility, Power, Control, Authority and its Impact on people.
16	Transparency and conflicts in the organizations
17	Interdependence between the Entrepreneurship and Personnel administration
18	Basic understanding of entrepreneurship ,its relevance and challenges
19	Factors influencing the entrepreneurship
20	Social factors, psychological factors, economical factors and environmental factors

Lecture No	Topic
21	Characteristics of an Entrepreneur,
22	Types of Entrepreneur: type of business, use of technology, motivation
23	New Generation of entrepreneurship: social entrepreneurship, tourism entrepreneurship, women entrepreneurship.
24	Barriers to Entrepreneurship
25	Entrepreneurial motivation: Relevance of Motivation to start a new business
26	Maslow's Need Hierarchy Theory, Herzberg's Theory X and Y.
27	Douglas McGregor, Ethics,
28	Corruption and Anti-Corruption Machinery in country
29	Factory Act 1948, Provident Fund Act ,1952
30	Compensation Act, 1919 and its implementation in the industries
31	Provident Fund Act, 1952 its provisions and benefits.
32	Rural Entrepreneurship in India
33	Quality Standard with Special reference to (ISO)
34	New Pension Scheme 2004,Act for all the central and states government employees
35	Industrial Development Bank of India (IDBI)
36	Case studies on Entrepreneurship in the world and India
37	National Institute of Entrepreneurship in India
38	Banking system in India and Entrepreneurship
39	Central Government Initiatives to start a business
40	Problems and Prospects of entrepreneurship in India
41	Special Economic Zone (SEZ)
42	Industrial Dispute Act,1947
43	Trade Union Act, 1926

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44	Equal Remuneration Act, 1976
45	Inter-state Migrant Workmen Act, 1979
46	Child Labor (Prohibition & Regulations) Act, 1986
47	Sexual Harassment at the Workplace (Prevention, Prohibition & Redresses) Act, 2013
48	Contract Labor (Regulation & Abolition) Act, 1970
49	Apprentices Act, 1961
50	Case Studies

Name of Program	B.Tech (MME)	Semester-III	Session-2021-22
Course Title	Fundamentals of Metal Extraction		
Course Code	MME 6303		
Course Type	Department Core		
No of credits	4		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	B.Tech. in Materials and Metallurgical Engineering		
Pre-requisites'	Basic Courses on Physics, Chemistry and Mathematics		
Course Coordinator	Dr C Sasikumar		
Learning Hours	50 Hours		

Course Description

This course is designed for undergraduate students of materials and metallurgical engineering. It provides the fundamental understanding on types properties of fuels, furnaces and refractories and the unit operations used in the metallurgical processes. The course enhances the understanding of complexities in processing and their solutions through numerical interpretation of data. These details will be used to build the concepts, underlying principles, and limitations related to fundamental processes of metal extraction. The students will be able to understand design metal extraction process based on this knowledge.

Course Objectives

1. Determine the energy requirement in designing a metal extraction process
2. Understand the requirements for designing a furnace
3. Evaluate the process parameters in unit operations such as comminution, separation, metal extraction, and refining
4. Recognize the importance of Ellingham diagram used in process metallurgy
5. Recognize the underlying principles, advantages and limitations related to fundamental processes of metal extractions

Course Content

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- | | | |
|-----------|--|-----------------|
| 1) | Fuels characterization, Secondary fuel, Combustion | 5 hours |
| | Energy Resources, Characterization of Fuels, Carbonization, Coke making, Gasification, Combustion principles, Heat and mass balance Calculations, Flame temperature, Carbon credit, Carbon offset. | |
| 2) | Refractory and Furnaces Design | 10 hours |
| | Properties, Applications, Classification, Heat Utilization in furnaces, Energy flow diagrams, Heat Recovery, Burner Design, Flame type, Heat flow in Furnace and heat exchanger, Pyrometry, Temperature measurement, Furnace Efficiency, Electric Resistance heating, Heat Transfer Calculations | |
| 3) | Introduction, Role of Unit Processes in Metal Extraction | 10 hours |
| | Ore Preparation: Principles of Comminution, Crushing, Grinding, Sizing of comminuted particles, Drying, Calcination, Roasting, Sintering; Role of Ellingham Diagrams in Extraction of metals | |
| 4) | Pyrometallurgical Processes | 8 hours |
| | Reduction and smelting using Blast Furnace and Electric arc furnace, Flash smelting, Converting, Principles of metallothermic reduction, Fire refining, Calculations | |
| 5) | Hydrometallurgical Processes | 10 hours |
| | Leaching, Types: Pressure leaching and Bacterial leaching, Methods: In-situ, Heap, and Percolation leaching, Solution purification methods: Chemical, Ion exchange and Solvent extraction, Cementation, Calculations | |
| 6) | Electrometallurgical processes | 7 hours |
| | Faraday's law, Aqueous electrolyte properties, Ionic mobilities, Transport number and conductivity in electrolytes, Debey-Huckle limiting law. Mean activity coefficient of ions in electrolytes, Electrode potential, Polarization, Gas and Metal over voltage, E.M.F. of cells, Electro deposition, Electro winning and Electro refining. Calculations | |

Learning Outcomes

Out of this course the student will be able to understand the underlying principles of metal extraction and refining. The student will be able to determine the energy requirements, engineering process parameters and design a furnace out of this course

Teaching Learning Activities

- 1) Lectures of the theoretical topics related to fuels, furnace design and unit operations
- 2) Mapping of concepts from the theories the industrial requirement
- 3) Identifying the problems related to calculation of parameters in industrial scenario
- 4) Calculation and solving of these problems using fundamental laws
- 5) Group activities on understanding the unit operations in recent and historical trends
- 6) Formative quizzes on the learning outcomes

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<p>Course Assessment Methods</p> <p>A. Assignments and Performance in the class 20</p> <p>B. Class Test 10</p> <p>C. Mid Term Examination 20</p> <p>D. End Term Examination 50</p>
<p>Books and References</p> <p>Textbook:</p> <p>1) “Principles of extractive metallurgy”, by A Ghosh and H. S. Ray</p> <p>2) “Industrial and Process furnaces”, by P. Mullinger and B. Jenkins</p> <p>References:</p> <p>3) “Unit Processes of Extractive metallurgy”, by R.D. Pehike</p> <p>4) “Metallurgical Engineering Principles” by R. Schumann</p>
<p>Links to online references</p> <p>1. https://nptel.ac.in/courses/113/104/113104060/</p> <p>2. https://nptel.ac.in/courses/113/104/113104010/</p> <p>3. https://nptel.ac.in/courses/113/104/113104058/</p> <p>4. https://dspace.mit.edu/handle/1721.1/35739</p>

Name of Program	B.Tech (MME)	Semester-III	Session-2021-22
Course Title	Thermodynamics of Materials		
Course Code	MM 6304		
Course Type	Department Core		
No of credits	L T P (3 1 0)		Total credits = 4
Semester	3		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	B.Tech. in Materials Science and Metallurgical Engineering		
Pre-requisites'	Basic courses of Engineering Physics, Chemistry and Mathematics		
Course Coordinator	Dr C Sasikumar		
Learning Hours	50 Hours		

Course Description

This course is designed for undergraduate students of materials and metallurgical engineering. It provides the fundamental understanding of process design of engineering materials. The course enhances the understanding of complexities in processing and their solutions through thermodynamic calculations and modelling. The students will be able to predict the nature and properties of the materials in real time process industries based on

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this knowledge.

Course Objectives

1. Know-how to determine the thermodynamic properties of engineering materials
2. Determine the energy requirements of different metallurgical processes using thermodynamic properties.
3. Calculate energy content of fuels and make a heat balance sheet
4. Predict the stability of materials, thermodynamic feasibilities of different metallurgical processes based on thermodynamic concepts.
5. Create thermodynamic process models/diagrams for metal extraction
6. Thermodynamic prediction of corrosion and electrochemical reactions
7. Design ceramic/ functional materials using thermodynamic approach

Course Content

First Law of thermodynamics

10

Review of heat, work and their relationship, the concept of internal energy and first law, thermodynamic processes, heat capacity and internal energy, enthalpy relations, theoretical models of heat capacity, enthalpy changes with temperature, heat balance in metallurgical processes, adiabatic flame temperature.

Case studies

- Determination energy requirements in iron and steel extraction
- Determination of energy requirements of Cu/Zn extraction
- Determination of energy requirements in designing a furnace
- Determination of maximum theoretical temperature in combustion of fuels

Second law of thermodynamics and entropy

10

Spontaneous/Natural Processes, entropy and quantification of irreversibility, reversible process, entropy and reversible heat, thermodynamic temperature scale, second law of thermodynamics, maximum work, entropy and criterion for equilibrium, Entropy Calculations at high temperature, concept of free energy, criterion of spontaneity of based on free energy, calculations of free energy at different temperatures.

Case studies

- Predicting the stable phases in metals and alloys
- Predicting the temperature stability of metal oxides, sulphides, carbides etc.
- Determination entropy in a process

Configurational Entropy, Third law of thermodynamics

Entropy and disorder in atomic scale, the concept of microstate, determination of most probable state, Boltzmann relation, configurational entropy, third law of thermodynamics, absolute value of entropy

Case studies

- Determination of equilibrium concentration of defects in materials

Auxiliary Functions and relations

Phase equilibrium in a one component system

10

Helmholtz free energy, combined expressions of first and second laws-Maxwell equations, Gibbs-Helmholtz equation, Von't Hoff's equation, Clausius-Clapeyron equation, Trotons' rule, Fugacity, activity, equilibrium constant, chemical potential Variation of Gibb's free energy with temperature at constant pressure, Variation of Gibb's free energy at constant temperature with pressure, Gibb's free energy as a function of temperature and pressure

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Case studies

- Numerical examples to find out the processing limits
- Graphical representation of phase equilibrium in one component system
- Ellingham diagram
- Predominant Area Diagrams
- Numerical examples to study the effect of pressure on solid-solid, solid-liquid, solid-gas and liquid-gas transformation temperatures.
- Thermodynamics of nucleation and growth of crystals

The Behaviour of Solutions

10

partial molar quantities, Gibbs-Duhem Equations, Ideal and non-ideal solutions, Raoult's Law, Henry's Law, alternate standard state, Sivert's Law, regular solutions, excess functions, determination of activity, interactions in a multi-component systems,

Gibbs free energy composition and phase diagrams of binary systems

Case studies

- Binary solutions with unlimited solubility
- Eutectic phase diagrams
- Temperature dependence of solubility
- Binary solutions with ordering
- Binary solutions with intermediate phases

Electrochemistry

10

The relationship between chemical and electrical driving forces, Nernst equation, the effect of temperature and concentration on e.m.f, formation cells, concentration cells, the Gibbs free energy of formation of ions and standard reduction potential,

Case studies

- Numerical examples to determine the thermodynamic quantities using reversible electrochemical cells
- Lead oxide formation cells
- Oxygen concentration cells – Lime stabilized ZrO₂ as a solid electrolyte
- The calomel cell and standard reduction potential
- Construction of Pourbaix diagrams

Learning Outcomes

Out of this course you will be able to

1. Quantify the energy requirements for a metallurgical processes : iron and steel making, non-ferrous metals such as Cu, Al, Zn,Pb etc.,
2. Determine the energy requirements in designing a furnace, reactors or process units.
3. Precisely determine whether a material can be used for an application or not.
4. Precisely determine the theoretical limits in materials processing
5. Predict novel materials/processing conditions for engineering applications

Teaching Learning Activities

- A. Lectures
- B. Problem Solving
- C. Concept Mapping
- D. Questioning
- E. Formative Quizzes
- F. Small group activities

Course

- A. Assignments and Performance in the class **20**

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Assessment Methods	B. Class Test 10 C. Mid Term Examination 20 D. End Term Examination 50
Books and References	
Text Books	
1. Introduction to Metallurgical Thermodynamics, D.R. Gaskell.	
2. Problems in Metallurgical Thermodynamics and Kinetics : G.S.Upadhyaya and R.K. Dube	
3. Metallurgical Thermodynamics and Kinetics Numericals : S.K. Dutta & A.B. Lele	
Reference Books	
4. Textbook of Materials and Metallurgical Thermodynamics, Ahindra Ghosh.	
5. Physical Chemistry of Metals: L.S. Darken and R.W. Gurry	
6. Thermodynamics of Solids: R.A. Swalin	
Links to online references	
1. https://nptel.ac.in/courses/113106031/	
2. https://www.coursera.org/courses?query=thermodynamics	
3. https://study.com/academy/course/thermodynamics-study-guide.html	
4. www.oup.com/ukhe/product/9780198769866	
5. http://ocw.mit.edu/5-60S08	
6. https://www.thermocalc.com/	
Lecture Plan	
Lecture No.	Topic
1.	Introduction
2.	Review of heat, work and their relationship, the concept of internal energy and first law, thermodynamic processes, heat capacity and internal energy, enthalpy relations
3.	Heat Capacity as a function of temperature Theoretical models of heat capacity - Einstein model, Debye's model
4.	Theoretical models of heat capacity - Lattice theory, Empirical relationship of heat capacities
5.	Enthalpy changes with temperature, Hess' law, Kirchoff's law, heat balance in metallurgical processes.
6.	Case studies - Determination energy requirements in iron and steel extraction - Determination of energy requirements in various metallurgical processes
7.	Case studies - Determination of energy requirements of Cu, Zn extraction etc.
8.	- Adiabatic flame temperature. - Determination of maximum theoretical temperature in combustion of fuels
9.	Case studies - Determination of energy requirements in designing a furnace
10.	Case studies - Energy balance in blast furnace
11.	The concept of Entropy Spontaneous/Natural Processes, entropy and quantification of irreversibility

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12.	Reversible process, entropy and reversible heat, thermodynamic temperature scale,
13.	Second law of thermodynamics, maximum work, entropy and criterion for equilibrium,
14.	Entropy Calculations at high temperature
15.	Concept of free energy, criterion of spontaneity of based on free energy, calculations of free energy at different temperatures
16.	Case studies - Predicting the stable phases in metals and alloys
17.	Case studies - Predicting the temperature stability of metal oxides, sulphides, carbides etc. - Determination entropy in a process
18.	Configurational Entropy, : Entropy and disorder in atomic scale, the concept of microstate, determination of most probable state, Boltzmann relation,
19.	Third law of thermodynamics, absolute value of entropy
20.	Case studies - Determination of equilibrium concentration of defects in materials
21.	Auxiliary Functions and relations : Helmholtz free energy, combined expressions of first and second laws-Maxwell equations,
22.	Gibbs-Helmholtz equation, Von't Hoff's equation,
23.	Variation of Gibb's free energy with temperature at constant pressure
24.	Clausius-Clapeyron equation, Trotons' rule, Numerical examples to study the effect of pressure on solid-solid, solid-liquid, solid-gas and liquid-gas transformation temperatures.
25.	Variation of Gibb's free energy at constant temperature with pressure, Gibb's free energy as a function of temperature and pressure
26.	Fugacity, activity, equilibrium constant, chemical potential,
27.	Case studies: Numerical examples to find out the processing limits
28.	Case studies: Graphical representation of phase equilibrium in one component system
29.	Case studies: Ellingham diagram, Predominant Area Diagrams, Numerical examples to study the effect of pressure on solid-solid, solid-liquid, solid-gas and liquid-gas transformation temperatures.
30.	Case studies - Thermodynamics of nucleation and growth of crystals
31.	The Behaviour of Solutions: Partial molar quantities, Gibbs-Duhem Equations
32.	Ideal and non-ideal solutions, Raoult's Law, Hentry's Law, Numerical examples
33.	Alternate standard state, Numerical examples
34.	Sivert's Law and Nuerical Examples
35.	Regular solutions, excess functions, determination of activity
36.	Interactions in a multi-component systems
37.	Gibbs free energy composition and phase diagrams of binary systems

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38.	Case studies: Binary solutions with unlimited solubility
39.	Case studies: Eutectic phase diagrams, Temperature dependence of solubility
40.	Case studies: Binary solutions with ordering, Binary solutions with intermediate phases
41.	Electrochemistry The relationship between chemical and electrical driving forces, Nernst equation
42.	The effect of temperature and concentration on e.m.f, formation cells, concentration cells,
43.	Gibbs free energy of formation of ions and standard reduction potential
44.	Case studies: Numerical examples to determine the thermodynamic quantities using reversible electrochemical cells
45.	Case studies: Lead oxide formation cells
46.	Case studies: Oxygen concentration cells – Lime stabilized ZrO ₂ as a solid electrolyte
47.	Case studies: Oxygen concentration cells – Lime stabilized ZrO ₂ as a solid electrolyte
48.	Case studies: The calomel cell and standard reduction potential
49.	Case studies: Construction of Pourbaix diagrams and its application in metallurgical processing
50.	Case studies: Construction of Pourbaix diagrams and its application in metallurgical processing

Name of Program	B.Tech (MME)	Semester-III	Session-2021-22
Course Title	Physical Metallurgy		
Course Code	MM 6305		
Course Type	Department Core		
No of credits	4		
Semester	3		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	B.Tech. in Materials and Metallurgical Engineering		
Pre-requisites'	Fundamentals of Material Science Microstructural Evolution in Materials		
Course Coordinator	Dr. Ramkishor Anant		
Learning Hours	50 Hours		

Course Description

This course is designed for undergraduate students of materials and metallurgical engineering. It provides the fundamental understanding of processing/characterization/design of engineering materials. The central point of this course is to provide a physical basis that links the structure of materials with their properties, focusing primarily on metals. With this understanding in hand, the concepts of alloy design and microstructural engineering are also discussed, linking processing and thermodynamics to the structure and properties of metals.

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Course Objectives

The course consists the first fundamental introductory course of the Physical Metallurgy field. The course aims to the understanding of the fundamental knowledge and the substantial issues and terms concerning the structure and properties of metallic materials and especially of those of a single phase system. The phenomena and mechanisms that are related with the microstructure and its interrelation with the mechanical response are discussed in details. The course is the first step for gaining further knowledge in the area of metallic materials such as: a) special and industrial alloys, b) manufacturing and shaping processes, c) performance and degradation under different environmental conditions.

Course Content

Atomic Bonding & Crystal Structure: No of hours: 3

Metallic bond, unit cell, atomic packing, interstitial sites, Miller indices, crystal orientation, stereographic projection.

Experimental tools & techniques: No of hours: 3

Metallography (Optical TEM, SEM), X Ray Diffraction, Mechanical Properties, Thermal analysis.

Solidification of Pure Metal: No of hours: 3

Phase rule, Concept of Free Energy, Entropy, Surface Energy (grain boundary)& under cooling, Nucleation& Growth, homogeneous& heterogeneous nucleation, directional solidification.

Plastic Deformation of Pure Metal: No of hours: 3

Mechanisms(slip& twin), critical resolved shear stress, single crystal tensile test (fcc), theoretical strength of ideal crystal.

Crystal Defects in Metals: No of hours: 5

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

Diffusion: No of hours: 3

Elementary concepts of phenomenological& atomistic approaches.

Solidification of binary alloys: No of hours: 8

Limits of solubility, isomorphous system, lever rule, constitutional super cooling, effect of non equilibrium cooling, eutectic, peritectic, eutectoid& peritectoid system, complex phase diagram, ternary diagram, composition triangle, ternary eutectic, vertical& horizontal sections, structure of cast metal, segregation& porosity, iron-carbon diagram, steel& cast iron.

Binary Phase Diagrams of Common Commercial Alloys: No of hours:3

Cu-Ni, Au-Cu, Ni-Cr, Al-Si, Al-Zn, Al-Ag, Pb-Sn, Cu-Zn, Cu-Sn, Cu-Al, Ti-Al, Ti-V: interpretation of microstructure& properties.

Cold Working & Annealing: No of hours: 3

Recovery, recrystallization& grain growth, phenomenological& mechanistic approaches.

Precipitation From Super-saturated Terminal Solid Solution: No of hours: 3

Thermodynamics& kinetics of precipitation, precipitation hardening.

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Heat Treatment of Steel:		No of hours: 8
T-T-T diagram, Pearlitic, Martensitic & Bainitic transformation, effect of alloy elements on phase diagram & TTT diagram, CCT diagram, Annealing, normalizing, hardening & tempering, hardenability.		
Application of Physical Metallurgy:		No of hours: 5
Strengthening mechanism, strength vs. toughness (ductility), thermo mechanical processing, micro alloyed steel, ultra high strength steel, superalloy, control of texture.		
Learning Outcomes		
1) Understanding the fundamental principles governing the manufacturing, shaping, control and properties of the single phase metallic materials.		
2) Recognising the importance of the microstructures and the mechanical properties of the metallic materials so that a constructive material selection process can be adopted.		
3) Predicting a material response under various servicing conditions.		
4) Designing the appropriate processes for receiving the optimum properties.		
Teaching Learning Activities	Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, interactive teaching, educational visits, small projects.	
Course Assessment Methods	A. Assignments and Performance in the class 20 B. Class Test 10 C. Mid Term Examination 20 D. End Term Examination 50	
Books and References		
1. Fundamentals of Material Science and Engineering: William D. Callister		
2. Introduction to Physical Metallurgy : S. H. Avnor		
1. Physical Metallurgy Principles - Robert E Reed-Hill and Reza Abbaschian		
2. Phase Transformation in Metals & Alloys - D A Porter & K Easterling		
3. Fundamentals of Physical Metallurgy - John D Verhoeven		
4. Physical Metallurgy - Peter Haasen		
5. Structure and Properties of Alloys - R M Brick, R B Gordon, A. Phillips		
6. Physical Foundations of Materials Science - G. Gottstein		
Links to online references		
Lecture Plan (about 40-50 Lectures):		
Lecture No.	Topic	

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Name of Program	B.Tech (MME)	Semester-III	Session-2021-22
Course Title	Metal Extraction Lab		
Course Code	MM 6306		
Course Type	Department Core - Practical		
No of credits	01		
Semester	3		
Department	Materials Science and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	B.Tech. in Materials and Metallurgical Engineering		
Pre-requisites'	Basic Courses on Physics, Chemistry and Mathematics Fundamentals of metal extraction		
Course Coordinator	Dr C Sasikumar		
Learning Hours	25 Hours		
Course Description			
<p>This course is designed for undergraduate students of materials and metallurgical engineering. It provides the fundamental understanding on metal extraction processes. The students will be able to understand and design metal extraction process based on this knowledge.</p>			
Course Objectives			
<ol style="list-style-type: none"> 1. Identify the ores and minerals 2. Understand the mineral processing steps such as comminution and separation through lab experiments 3. Understand and Design metal extraction processes through laboratory experiments. 4. Understand the process controls and complexities involved in metal extraction and processing 			
Course Content			
<ol style="list-style-type: none"> 1. Introduction to Basic Laboratory Instruments , Data Acquisition and Analysis 2. Techniques for identification of minerals 3. Laboratory experiments for formative assessment: Whether an ore/mineral contains enough metal to make it worth extracting the metal 4. Identification of suitable reducing agent and experiments of metal extraction. 5. Laboratory experiments to understand mineral processing steps: Size reduction, gravity separation etc. 6. Lab experiments on pyro-metallurgical extraction: Calcinations, Roasting, DRI Production 7. Lab experiments on Hydro-metallurgical extraction : Leaching experiments, recovery of metals from leach solution by cementation 8. Lab experiments on Electro-metallurgical extraction and refining: Electro-winning and 			

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Electro-plating experiments

9. Process control studies using simulation software: Process Modeling – Iron Making,
10. Process Modeling – Steel Making in BOF,
11. Process Modeling – Steel Making in EAF,
12. Process Modeling – Continuous Casting
13. Experimental studies on recovery of metals from Industrial waste.

Learning Outcomes

Out of this course the student will be able to understand the underlying principles of metal extraction and refining. The student will be able to understand the process controls and design a process through lab experiments

Teaching Learning Activities

- 1) Lab experiments
- 2) Simulation studies using software modules
- 3) Mapping of concepts from the theories the industrial requirement
- 4) Identifying the problems related to calculation of parameters in industrial scenario
- 5) Calculation and solving of these problems using fundamental laws
- 6) Group activities on understanding the unit operations in recent and historical trends
- 7) Formative quizzes on the learning outcomes

Course Assessment Methods

- A. Continuous evaluation **50**
- B. End Term Examination **50**

Books and References

Textbook:

- 1) “Principles of extractive metallurgy”, by A Ghosh and H. S. Ray
- 2) “Industrial and Process furnaces”, by P. Mullinger and B. Jenkins

References:

- 3) “Unit Processes of Extractive metallurgy”, by R.D. Pehike
- 4) “Metallurgical Engineering Principles” by R. Schumann

Links to online references

1. <https://nptel.ac.in/courses/113/104/113104060/>
2. <https://nptel.ac.in/courses/113/104/113104010/>
3. <https://nptel.ac.in/courses/113/104/113104058/>
4. <https://dspace.mit.edu/handle/1721.1/35739>

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Name of Program	B.Tech (MME)	Semester-III	Session-2021-22
Course Title	Physical Metallurgy Lab		
Course Code	MM 6307		
Course Type	Department Core – Practical		
No of credits	01		
Semester	3		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	B.Tech. in Materials Science and Metallurgical Engineering		
Pre-requisites'	Physical metallurgy theory course, Basic courses of Physics		
Course Coordinator	Dr Jayashree		
Learning Hours	25 Hours		
Course Description			
<p>This course is designed for undergraduate students of materials and metallurgical engineering. It provides the fundamental understanding on structure and properties of materials. The students will be able to understand metallographic sample preparation techniques and interpretation of microstructures.</p>			
Course Objectives			
<ol style="list-style-type: none"> 1. Understand the metallographic specimen preparation steps for micro-structural analysis of metals and alloys. 2. Select appropriate etchants for metallographic studies 3. To identify the phases in steels, cast iron and non-ferrous metals 4. Ability to determine the grain size, identify the inclusions and rating of inclusions. 5. Ability to quantify the phases 			
Course contents			
<ol style="list-style-type: none"> 1. Introduction to Basic Laboratory Instruments, Data Acquisition and Analysis 2. Cooling Curves of Binary Alloys 3. Metallographic techniques : Specimen preparation, Mounting, mechanical grinding and polishing, chemical and electrolytic polishing, etching, contrast enhancement etching, digital imaging 4. Microstructure analysis of low carbon, medium carbon and high carbon steels 5. Microstructure analysis of Grey cast iron, white cast iron and SG iron 6. Microstructure analysis of Aluminium alloys and Copper Alloys 7. Microstructure analysis of heat treated steels and tool steels 			

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<p>8. Inclusion rating using metallographic analysis</p> <p>9. Determination of grain size</p> <p>10. Microstructure of coatings, weldments</p> <p>11. Effect of microstructure on hardness of metals</p> <p>12. Quantitative metallography</p>	
<p>Learning Outcomes</p> <p>Out of this course the student will be able to understand the underlying principles of metallographic techniques and interpretation of microstructures. Able to understand the relation between the structures and properties of materials.</p>	
<p>Teaching Learning Activities</p>	<p>1) Lab experiments</p> <p>2) Interpretation of microstructures</p> <p>3) Quantification from microstructures</p> <p>4) Inclusion rating, grain size analysis</p> <p>5) Develop analytical skills</p>
<p>Course Assessment Methods</p>	<p>C. Continuous evaluation 50</p> <p>D. End Term Examination 50</p>
<p>Books and References</p> <p>1. "Metallographic and Materialographic Specimen Preparation, Light Microscopy, Image Analysis and Hardness Testing", Kay Geels in collaboration with Struers A/S, ASTM International 2006.</p> <p>2. Metallography and Microstructures, Vol. 9, ASM Handbook, ASM International, Materials Park, OH, 2005.</p> <p>3. Metallographic Techniques, Khel</p>	
<p>Links to online references</p>	

Name of Program	B.Tech (MME)	Semester-III	Session-2021-22
Course Title	Projects on Furnace Design		
Course Code	MM 6308		
Course Type	Core - Practical		
No of credits	2		
Semester	3		
Department	Materials and Metallurgical Engineering		

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U.G./P.G.	Undergraduate Programme
Programme	B.Tech. in Materials Science and Metallurgical Engineering
Pre-requisites'	Theory courses on fundamentals of metal extraction, thermodynamics of materials
Course Coordinator	Dr C Sasikumar
Learning Hours	25 Hours
Course Description	
This course is designed for undergraduate students of materials and metallurgical engineering. It provides the fundamental understanding on furnace design.	
Course Objectives	
Understand the design principles. Practical skills on furnace design	
Course Content	
The project based learning help the student with practical skills and better understanding about the subject. A mentor will be provided for a group of students and the mentor will guide to design a furnace. The projects shall be in any one of the following areas	
<ol style="list-style-type: none"> 1. Experimental design of small laboratory furnace: Based on resistance heating, induction heating, fuel heating, electron beam heating, laser beam heating etc. 2. Design of heating coils: Based on Nichrome, SiC, etc 3. Design of effective heat insulation 4. Performance studies/improvements of existing furnace 5. Simulation studies of Industrial furnaces 6. Numerical design of furnace : with specified capacity 7. Micro-furnaces for thermal analysis 8. Vacuum melting furnace and process control 9. Any other relevant area 	
Learning Outcomes	
Out of this course the student will be able to understand the underlying principles of furnace design through projects.	
Teaching Learning Activities	Self designing/modeling Simulations through software Numerical calculations Group activities on understanding the unit operations in recent and historical trends Formative quizzes on the learning outcomes

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Course Assessment Methods	Continuous evaluation 100
Books and References	
Industrial and Process Furnaces: Principles, Design and Operation by Barrie Jenkins, Peter Mullinger	
Practical Industrial Furnace Design, <u>Matthew Holmes</u> , Mawhinney	
A New Design Vacuum Melting Furnace by J. M. Taub, D. T. Doll	
Design & Construction of Electric Furnaces, By Wilhelm Borchers	
Links to online references	

Fourth Semester

Name of Program	B.Tech.(MME)	Semester IV	Session 2021- 2022
Name of Course	Mathematics-4		
Course Code	MTH 6401		
Core/Elective/Other	CORE		
Prerequisite:			
1	Basic concepts of algebra and arithmetic.		
2	Basic concepts of maximization and minimization of functions.		
3	Curiosity to formulate and solve real world optimization problem.		
Course Outcomes:			
1	Ability to understand the importance of operations research in decision making and use them effectively in different situations.		
2	Ability of modeling, solving and analyzing optimization problems by using Operations Research.		
3	Ability to understand the characteristics of different types of decision-making environments and the appropriate decision making approaches and tools to be used .		
Description of Contents in Brief:			
1	Linear Programming, Graphical method, Simplex algorithm, Duality, Transportation problem, Assignment problem.		
2	Duality theory, Dual Simplex method, Revised simplex method, Sensitivity analysis. Integer programming- Cutting plane algorithm, Branch and bound technique, Travelling salesman problem..		
3	Nonlinear programming, Kuhn- Tucker conditions, quadratic programming, Wolfe's algorithm. Dynamic programming- Deterministic and stochastic example.		
4	Queuing Theory, Queuing Problem and System, Transient and Steady State Distributions in Queuing System, Poisson Process, Exponential Process, Classification of Queuing Model.		

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5	Games Theory, Minimax-Maxmin Principle for Mixed Strategy Games, Graphical Method, Solution of (MxN) Job Sequencing, PERT – CPM.
List of Text Books:	
1	Operations Research, S. D. Sharma, Kedarnath Ramnath & Sons. 14/e
2	Optimal Trading Strategies by Robert Kissell, Morton Glantz
3	Numerical Optimization Techniques with Applications by Suresh Chandra
List of Reference Books:	
1	Operations Research, Gupta and Hira, S.Chand Publication
2	Introduction to Optimization Operations Research, J.C. Pant, Jain Brothers
3	Introduction to Operations Research- Hillier and Lieberman, McGraw-Hill
4	Operations Research An Introduction- Taha Hamdy, Prentice-Hall
URLs:	
1	http://www.pondiuni.edu.in/storage/dde/downloads/mbaii qt.pdf
2	https://www.thelearningpoint.net/home/mathematics/an-introduction-to-operations-research
3	nptel
Lecture Plan	

Lecture No.	Topic
1	Linear Programming (LPP) – Introduction
2	Formulation of LP Problem
3	Graphical method of LPP
4	Simplex algorithm of LPP
5	Two phase method
6	Big-M Method
7	Degeneracy in LPP
8	Duality in LPP
9	Transportation problem (TP): Introduction, Mathematical Formulation, Matrix Representation of TP
10	Initial Basic Feasible Solution of Transportation problem : North West Corner Rule, Row Minima Method
11	Column Minima Method, Matrix Minima Method
12	Vogel's Approximation Method
13	Optimality test for TP – UV Method
14	Unbalanced Problem of TP
15	Assignment problem: : Introduction, Mathematical Formulation, Matrix

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	Representation of Assignment Problem
16	Hungarian Method for Assignment problem
17	Unbalanced Problem
18	Maximization Problem
19	Duality theory
20	Dual Simplex method
21	Revised simplex method
22	Sensitivity analysis
23	Integer programming (IPP)- Cutting plane algorithm
24	Branch and bound technique for IPP
25	Travelling salesman problem
26	Nonlinear programming: Introduction
27	Kuhn- Tucker conditions
28	Illustrative examples on Kuhn- Tucker conditions
29	Quadratic programming
30	Wolfe's algorithm
31	Dynamic programming : Introduction, Bellman's Principle of Optimality
32	Minimum Path Problem in Dynamic Programming
33	Single additive constraint, multiplicatively separable return
34	Single additive constraint, additively separable return
35	Deterministic and Stochastic examples
36	Queuing Theory: Introduction, Terminologies, List of Symbols
37	Queuing Problem and System
38	Transient and Steady State Distributions in Queuing System
39	Poisson Process
40	Exponential Process
41	Classification of Queuing Model
42	Games Theory: Introduction, Characteristics, Basic Definitions
43	Minimax-Maxmin Criterion and Optimality Strategy
44	Principle for Mixed Strategy Games
45	Graphical Method
46	Solution of (Mxn) Job Sequencing
47	Practice Problems on Job Sequencing
48	Project Management : Introduction, Basic Definitions, Network Diagram
49	CPM
50	PERT

Name of Program	B.Tech (MME)	Semester-IV	Session-2021-22
Course Title	Design of Metallurgical Processes		
Course Code	MM 6402		
Course Type	Department core		
No of credits	L T P (3 1 0)	Total credits = 4	
Semester	4		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	B.Tech. in Materials Science and Metallurgical Engineering		
Pre-requisites'	Basic courses of Thermodynamics and Kinetics of Materials, Fundamentals of metal extraction		
Course Coordinator	Dr C Sasikumar		

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Learning Hours	50 Hours
Course Description	
<p>This course is designed for postgraduate students of materials science and technology. It provides the fundamental understanding of process design of engineering materials. The course enhances the understanding of complexities in processing and their solutions through numeric calculations and data interpretations. The students will be able to design the engineering parameters and metallurgical processes based on this knowledge.</p>	
Course Objectives	
<ol style="list-style-type: none"> 1. Know-how the role of process engineer in a process industry. 2. Recognize the fluid flow and design requirements. 3. Calculate energy requirement for a metallurgical process. 4. Recognize the heat flow while processing materials 5. Kinetic design of metallurgical processes. 	
Course Content	
Introduction	2 hours
<p>Introduction to Metallurgical Processes</p> <p>Responsibilities of Process Engineer</p> <p>Metallurgical reactors</p>	
Fluid dynamics in Metallurgical Processes	10 hours
<p>Newtonian fluid, viscosity of liquids, liquid metals and alloys, Viscosity of slags and salts, Non-Newtonian fluid</p> <p>Laminar flow and momentum balances : Flow of falling film, flow between parallel plates, Flow through a circular tube, equation of continuity, Navier-Stoke's equation, Numerical examples</p> <p>Turbulent flow : Friction factor, dimensional analysis, flow in non-circular conduits, flow past submerged bodies</p> <p>Flow through packed beds of solids, Darcy's Law, Tube-Bundle theory and Ergun's equation, wall effect, void fraction, fluidized beds</p>	
Energy balance Applications in fluid flow	10 hours
<p>Conservation of energy: Kinetic energy, potential energy, Bernoulli's theorem, Friction losses, enlargement and contraction, flow through valves and fittings, bends and coils, Flow measurements</p> <p>Flow and vacuum production: pumps, Fans and Blowers, High velocity jets, Jet behavior, Vacuum production, Molecular flow mechanics, Mechanical pumps, Diffusion pumps, Pumpdown time, Ejectors</p>	
Energy transport in Metallurgical Processes	13 hours
<p>Fourier's law and thermal conductivity, thermal conductivity of gases, solids and liquids,</p>	

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porous materials, bulk materials

Heat transfer and energy equation: heat transfer with forced convection in a tube, flat plate, heat transfer with natural convection, heat conduction, heat transfer in forced convection, Quenching heat transfer coefficients, boiling heat transfer

Heat conduction in solids: the energy equation for conduction, steady state 1D analysis, infinite flat plate, series composite wall, infinite cylinder, composite cylinder wall, 2D heat flow, cooling and heating rates, transient flow

Solidification heat transfer: Solidification in sand moulds, effect of contour on solidification time, effect of superheat on solidification time, solidification in metal moulds, interface resistance, integral solution for solidification, continuous casting

Radiation heat transfer, the black radiator and emissivity

The energy distribution and emissive power, Gray bodies and absorptivity, exchange between parallel plates, view factors, furnace enclosures, radiation combined with convection, radiation from gases

Thermal behavior of metallurgical packed-bed reactors

Mass Transport and Kinetics in Metallurgical Processes

10 hours

Fick's law and diffusivity of materials : self diffusion, influence of composition gradient, Darken's equations, temperature dependence of diffusion in solids, diffusion in non-metals, diffusion in liquids, diffusion through porous media

Diffusion in solids, steady state diffusion, finite solutions

Diffusion controlled processes with moving interface, surface coatings

Mass transfer in fluid systems, diffusion through a stagnant gas film, diffusion into falling liquid film, the mass transfer co-efficient, forced convection over a flat plate, diffusion with convection, mass transfer coefficients for turbulent flow

Interface mass transfer, two resistance mass transfer theory, mixed control in gas-solid reactions, mass transfer with vaporizations, Knudsen effusion cells, alloy vaporization during melting

Case Studies in Metallurgical Process Design

5 hours

Diffusion controlled metallurgical processes, Iron making in blast furnace, Steel Making operations, Electrolysis/electroplating, Corrosion/oxidation resistant materials, Surface/Interface controlled processes

Learning Outcomes

Out of this course you will be able to

1. Understand the fluid flow and determine the efficient reactor design.
2. Understand the heat flow in metallurgical processes and quantify the energy requirements for a metallurgical processes
3. Determine the kinetic parameters in process metallurgy

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Teaching Learning Activities	A. Lectures B. Problem Solving C. Concept Mapping D. Questioning E. Formative Quizzes F. Small group activities
Course Assessment Methods	A. Assignments and Performance in the class 20 B. Class Test 10 C. Mid Term Examination 20 D. End Term Examination 50

Books and References

List of Text Books:

1. Geiger G.H. and Poirier D.R., Transport Phenomena in Materials Processing, Addison Wesley, 1994.
2. A.K. Mohanty, Rate Processes in Metallurgy, Prentice Hall, New Delhi, 2000.
3. H.S. Ray, Kinetics of Metallurgical Reactions, Oxford & IBH, New Delhi, 1993.
4. A textbook of Metallurgical Kinetics, A. Gosh, S. Gosh, PHI Publishers, New Delhi, 2014.

List of Reference Books:

5. Bird R.B., Stewart W.E. and Lightfoot E.N., Transport Phenomena, Wiley, 1960.
6. R.I.L. Guthrie, Engineering in Process Metallurgy, Oxford Science, 1992.
7. J.R. Welty, R.E. Wilson, C.E. Wicks, Fundamentals of Momentum, Heat and Mass Transfer, Wiley, 1976.

Links to online references

1. <https://nptel.ac.in/courses/113106031/>
2. <https://www.coursera.org/courses?query=thermodynamics>
3. <https://study.com/academy/course/thermodynamics-study-guide.html>
4. www.oup.com/ukhe/product/9780198769866
5. <http://ocw.mit.edu/5-60S08>
6. <https://www.thermocalc.com/>

Lecture Plan

Lecture no	Topic
1.	Introduction
2.	Metallurgical reactors

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3.	Fluid dynamics in Metallurgical Processes: Fluid, Fluid types, Thermodynamic properties, Viscosity, pressure distribution in static fluid, hydrostatic forces on plane surfaces, examples.
4.	Fluid dynamics in Metallurgical Processes: Newtonian fluid, viscosity of liquids, liquid metals and alloys, Viscosity of slags and salts, Non-Newtonian fluid, numerical examples
5.	Fluid dynamics in Metallurgical Processes: Laminar flow and momentum balances : Flow of falling film, flow between parallel plates,
6.	Fluid dynamics in Metallurgical Processes: Flow through a circular tube, equation of continuity
7.	Fluid dynamics in Metallurgical Processes: Navier-Stoke's equation, Numerical examples
8.	Fluid dynamics in Metallurgical Processes: Turbulent flow : Friction factor
9.	Fluid dynamics in Metallurgical Processes: Dimensional analysis
10.	Fluid dynamics in Metallurgical Processes: Flow in non-circular conduits , flow past submerged bodies
11.	Fluid dynamics in Metallurgical Processes: Flow through packed beds of solids, Darcy's Law
12.	Fluid dynamics in Metallurgical Processes: Tube-Bundle theory and Ergun's equation, wall effect
13.	Fluid dynamics in Metallurgical Processes: Void fraction, fluidized beds
14.	Fluid dynamics in Metallurgical Processes: Conservation of energy: Kinetic energy, potential energy, Bernoulli's theorem
15.	Fluid dynamics in Metallurgical Processes: Friction losses, Numerical Examples
16.	Fluid dynamics in Metallurgical Processes: enlargement and contraction, flow through valves and fittings, bends and coils, Flow measurements
17.	Flow and vacuum production: pumps, Fans and Blowers, High velocity jets, Jet behavior
18.	Vacuum production, Molecular flow mechanics
19.	Mechanical pumps, Diffusion pumps ,Pump down time, Ejectors
20.	Mechanical pumps, Diffusion pumps ,Pump down time, Ejectors
21.	Energy transport in Metallurgical Processes: Fourier's law and thermal conductivity, thermal conductivity of gases, solids and liquids, porous materials, bulk materials
22.	Energy transport in Metallurgical Processes: Heat transfer and energy equation: heat transfer with forced convection in a tube, Numericals
23.	Energy transport in Metallurgical Processes: Heat transfer and energy equation : flat plate, Numerical
24.	Energy transport in Metallurgical Processes: heat transfer with natural convection, heat conduction
25.	Energy transport in Metallurgical Processes: heat transfer in forced convection, Quenching heat transfer coefficients, boiling heat transfer
26.	Energy transport in Metallurgical Processes: Heat conduction in solids: the energy equation for conduction, steady state 1D analysis
27.	Energy transport in Metallurgical Processes: infinite flat plate, series composite wall, infinite cylinder, composite cylinder wall, 2D heat flow, cooling and heating rates, transient flow

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28.	Energy transport in Metallurgical Processes: infinite flat plate, series composite wall, infinite cylinder, composite cylinder wall, 2D heat flow, cooling and heating rates transient flow
29.	Energy transport in Metallurgical Processes: infinite flat plate, series composite wall, infinite cylinder, composite cylinder wall, 2D heat flow, cooling and heating rates, transient flow
30.	Energy transport in Metallurgical Processes: Solidification heat transfer: Solidification in sand moulds, effect of contour on solidification time, effect of superheat on moulds, interface resistance, integral solution for solidification, continuous casting
31.	Energy transport in Metallurgical Processes: Solidification heat transfer: Solidification in sand moulds, effect of contour on solidification time, effect of superheat on moulds, interface resistance, integral solution for solidification, continuous casting
32.	Energy transport in Metallurgical Processes: Solidification heat transfer: Solidification in sand moulds, effect of contour on solidification time, effect of superheat on moulds, interface resistance, integral solution for solidification,
33.	Energy transport in Metallurgical Processes: Radiation heat transfer, the black radiator and emissivity
34.	Energy transport in Metallurgical Processes: Radiation heat transfer, the black radiator and emissivity
35.	Energy transport in Metallurgical Processes: The energy distribution and emissive power, Gray bodies and absorptivity, exchange between parallel plates, view factors, furnace enclosures, radiation combined with convection, radiation from gases
36.	Energy transport in Metallurgical Processes: The energy distribution and emissive power, Gray bodies and absorptivity, exchange between parallel plates, view factors, furnace enclosures, radiation combined with convection, radiation from gases
37.	Energy transport in Metallurgical Processes: The energy distribution and emissive power, Gray bodies and absorptivity, exchange between parallel plates, view factors, furnace enclosures, radiation combined with convection, radiation from gases
38.	Energy transport in Metallurgical Processes: Thermal behavior of metallurgical packed-bed reactors
39.	Mass Transport and Kinetics in Metallurgical Processes: Fick's law and diffusivity of materials : self diffusion, influence of composition gradient, Darken's equations, temperature dependence of diffusion in solids, diffusion in non-metals, diffusion in liquids, diffusion through porous media
40.	Mass Transport and Kinetics in Metallurgical Processes: Fick's law and diffusivity of materials : self diffusion, influence of composition gradient, Darken's equations, temperature dependence of diffusion in solids, diffusion in non-metals, diffusion in liquids, diffusion through porous media
41.	Mass Transport and Kinetics in Metallurgical Processes: Diffusion in solids, steady state diffusion, finite solutions
42.	Mass Transport and Kinetics in Metallurgical Processes: Diffusion controlled processes with moving interface, surface coatings

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43.	Mass Transport and Kinetics in Metallurgical Processes: Mass transfer in fluid systems, diffusion through a stagnant gas film, diffusion into falling liquid film, the mass transfer co-efficient, forced convection over a flat plate, diffusion with convection, mass transfer coefficients for turbulent flow
44.	Mass Transport and Kinetics in Metallurgical Processes: Interface mass transfer, two resistance mass transfer theory, mixed control in gas-solid reactions, mass transfer with vaporizations, Knudsen effusion cells, alloy vaporization during melting
45.	Case Studies : Iron Making
46.	Case Studies : Steel making operations
47.	Case Studies : Leaching processes
48.	Case Studies : Electrolysis/Electroplating processes
49.	Case Studies : Corrosion/High temperature oxidation
50.	Case Studies : Surface area/Interfacial area controlled processes

Name of Program	B.Tech (MME)	Semester-IV	Session-2021-22
Course Title	Mechanical Behaviour of Materials		
Course Code	MM 6403		
Course Type	Department core		
No of credits	4, (L-3 and T-1)		
Semester	Fourth		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	B.Tech. in Materials and Metallurgical Engineering		
Pre-requisites'	Physical metallurgy, basic courses of physics, mathematics		
Course Coordinator	Dr. S. Das		
Learning Hours	50 Hours (Including Tutorial Classes)		

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Course Description

Introduction to deformation behaviour: Concepts of stresses and strains, types of loading, stress - strain response for metal, ceramic and polymer, elastic region, yield point, plastic deformation, necking and fracture, Bonding and Material Behaviour, theoretical strength in metals and ceramics, Elasticity Theory: The State of Stress and strain, stress and strain tensor, transformation, principal stress and strain, elastic stress-strain relation, anisotropy, Yielding and Plastic, Deformation: Hydrostatic and Deviatoric stress, Octahedral stress, yield criteria and yield surface, texture and distortion of yield surface, true stress and true strain, flow rules, strain hardening, Ramberg-Osgood equation, stress - strain relation in plasticity dislocations, slip and glide, dislocation generation - Frank Read and grain boundary sources, stress and strain field around dislocations, force on dislocation - self-stress, dislocation interactions, partial dislocations, twinning, dislocation movement and strain rate, deformation behavior of single crystal, critical resolved shear stress (CRSS), deformation of poly-crystals - Hall-Petch and other hardening mechanisms, grain size effect, Fracture: types of fractures, KIC, elasto-plastic fracture mechanics, JIC, Measurement and ASTM standards, Fatigue: S-N curves, Low and high cycle fatigue, Life cycle prediction, Deformation at High temperature: different stages of creep, creep and stress rupture, creep mechanisms and creep resistant alloys.

Course Objectives

Objective of this course is to teach the students the various aspects of mechanical behavior of materials. The various aspects namely: Deformation behavior, fundamentals of stress strain behavior of various materials like metal, polymer, ceramics etc under different types of loading. A basic understanding of elastic and plastic deformation of materials will be covered during the deliberation of this course. The elastic theory, the basic theory of dislocation mechanisms, deformation of single crystals, failure mechanism fatigue and creep failure of the material will be dealt with.

Course Content

Basics of Deformation Mechanism and Concept of Stress and Strain: No of hours: 4

Introduction to deformation mechanism, concepts of stress strain under different types of loading, stress strain behaviour of metal polymers and ceramics

True stress and Engineering Stress, concept of modulus No of hours:4

Concepts of True stress- true strain, relation between engineering stress-strain and true stress-strain, concept of shear modulus, young modulus and bulk modulus and poisson ratio

Yield point criteria and theoretical approach of strength : No of hours:5

Concepts of elastic deformation, yield point phenomena, Cottrell atmosphere, luders band, uniform and non-uniform plastic deformation, necking behavior, different kinds of strain of metallic materials, bonding of materials and theoretical strength

Mohr's Circle and Flow stresses

No of hours: 8

Mohr's circle in 2D and 3D conditions, Elasticity theory of metals and alloys, yield point

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criteria, hydrostatic and deviatoric stress, Von misses and Tresca yield criteria, flow stress, Ramberg-Osgood equation, distortion yield surface. Problem solving

Strengthening Mechanism

No of hours:6

Deformation behaviour of single crystal, Concept of critical resolved shear stress, Hall- Petch equation, concept various strengthening mechanism

Dislocation Mechanisms

No of hours:8

Dislocation mechanism, Frank Read source and grain boundary source for dislocation generation, Stress field around the dislocation, forces on dislocation, dislocation interaction, Partial dislocation, deformation due to twinning

Fracture Mechanics

No of hours:5

Fracture mechanics, elasto-plastic fracture, K_{Ic} , J_{Ic}

Fatigue Failure of Metallic Materials

No of hours:5

Fatigue failure S-N curve, Low and high cycle fatigue, Goodman diagram, Prediction of Fatigue life

Creep Failure

No of hours:5

Creep failure of material deformation at high temperature, stages of creep, stress rupture, creep resistant alloys

Learning Outcomes

The outcome of this course would be to understand the students the basic concept and mechanism of deformation behavior of material under elastic and plastic regions. Additionally failure mechanisms under elastic and plastic fracture mechanisms: creep, fatigue etc.

Teaching Learning Activities

Mostly using White Board, 10% learning through power point, Problem solving activities in tutorial classes

Course Assessment Methods

- A. Quiz, Assignments and Performance in the class **20**
- B. Class Test **10**
- C. Mid Term Examination **20**
- D. End Term Examination **50**

Books and References

1. Mechanical Metallurgy George Ellwood. Dieter, McGraw- Hill
2. Mechanical Properties of Materials, Joshua Pelleg
3. Mechanical Behavior of Materials, Norman E. Dowling, Pearson
4. Mechanical Behavior of Materials William F. Hosford, Cambridge University Press
5. Mechanical Metallurgy: Principles and Applications, Marc A. Meyers, Krishan Kumar

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Chawla , Published by Prentice-Hall, Inc.
6. Dislocation and Mechanical Behaviour of Materials, M.N. Shetty, PHI Learning
7. Fracture Mechanics, Nestor Percz, Springer
8. Fracture Mechanics: Fundamentals and Applications , T.L. Anderson, Taylor and Francis
Links to online references
Link to online references will be provided to students during Lectures.

Name of Program	B.Tech (MME)	Semester-IV	Session-2021-22
Course Title	Iron & Steel Making		
Course Code	MME 6404		
Course Type	Department core		
No of credits	4		
Semester	4		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	B.Tech. in Materials Science and Metallurgical Engineering		
Pre-requisites'	Fundamental of Metal Extraction, Thermodynamics of Materials Basic courses of Mathematics and Chemistry		
Course Coordinator	Dr Ramkishor Anant		
Learning Hours	50 Hours		
Course Description			
<p>This course is designed for undergraduate students of materials and metallurgical engineering. It provides the fundamental understanding of processing/characterization/design of engineering materials. The course enhances the understanding of complexities in processing/characterization/designing and their solutions through numerical/analytical/modelling/experiments/proto-type designs/interpretation of data. The students will be able to handle the modern equipments in processing industries/design/process novel materials based on this knowledge.</p>			
Course Objectives			
<p>This course covers the fundamentals of both science and technologies of iron and steel making covering both theory and industrial practice. It introduces the processes related to extraction of iron from iron ores and further conversion of same to steel followed by casting it as a product. It also gives a basic idea about the raw materials, by-products and environmental aspects of this processes. It also throws light on the current scenario, historical aspects of this broad field.</p>			
Course Content			
1) Introduction to iron and steel making			2 hours

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	Need of iron and steel, Production current scenario, historical aspects	
2)	Blast furnace Iron making	8 hours
	Constructional Features, Regions, Internal Zones, Physical chemistry Numerical problems for Mass and Heat Balance, Calculation of RAFT, Plotting of RIST Diagram, Gas flow calculations by Ergun equation	
3)	Blast furnace Raw Materials and Products	16 hours
	Coke, coke making, iron ores, raw materials characterization, Sintering and pelletization, Calculation of coke quality, ore quality Hot metal handling, slag utilization and top gas cleaning	
4)	Alternate Iron making	2 hours
	Direct Reduction and Smelting Reduction processes	
5)	BOF Steel making	12 hours
	Overview, Chemistry, Plant practice, Metallurgical Features Calculations of Mass balance, Sulphide capacity and Phosphorus partition Static and Dynamic control studies, Secondary steel making introduction	
6)	Other Steel making processes	2 hours
	EAF and Open-hearth processes	
7)	Casting of Steel Product	4 hours
	Ingot casting and Continuous casting Calculations on Segregation, Heat transfer in solidification	
8)	Future Scope	2 hours
	Process control and modelling of iron and steel making	

Learning Outcomes

At the end of this course students will be able to:

- 1) Understand the functions, raw materials, products, handling, of blast furnace, basic oxygen furnace and continuous caster.
- 2) Explain the underlying principles for these processes
- 3) Calculate the processing parameters for each of these processes.
- 4) Identify the environmental and economic impact on the current scenario of these processes.

Teaching Learning Activities

- G. Lectures
- H. Problem Solving
- I. Concept Mapping
- J. Questioning

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	<p>K. Formative Quizzes</p> <p>L. Small group activities</p> <p>M. Browsing Steelwrold.org, Ministry of steel website for current situation</p>
Course Assessment Methods	<p>E. Assignments and Performance in the class 20</p> <p>F. Class Test 10</p> <p>G. Mid Term Examination 20</p> <p>H. End Term Examination 50</p>
Books and References	
<p>Textbook:</p> <ol style="list-style-type: none"> 1) Iron and Steel Making Theory and Practice, by Ahindra Ghosh and Amit Chatterjee, PHI Learning Private Limited, New Delhi, 2008 2) First Course in Iron and Steel Making, by Deepak Mazumdar, Orient Blackswan Private Limited, New Delhi, 2015 <p>References:</p> <ol style="list-style-type: none"> 3) Fundamentals of Steel Making, by E.T. Turkdogan, Maney Publishing, 1996 4) Principles of Blast Furnace Ironmaking, by A.K. Biswas, SBA Publications, Calcutta, 1984 5) Beyond the Blast Furnace, by Amit Chatterjee, CRC Press, Florida, 1994 	
Links to online references	<p>https://www.worldsteel.org/</p> <p>https://steeluniversity.org/</p> <p>https://steel.gov.in</p> <p>https://www.coal.nic.in</p>

Name of Program	B.Tech (MME)	Semester-III	Session-2021-22
Course Title	Casting and Solidification		
Course Code	MM-6405		
Course Type	Department core		
No of credits	04		
Semester	04		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	B.Tech. in Materials and Metallurgical Engineering		
Pre-requisites'	NA		
Course Coordinator	Dr. Ramesh Kumar Nayak		
Learning Hours	50 Hours		
Course Description			

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This course is designed for undergraduate students of materials and metallurgical engineering. It provides the fundamental understanding of processing/characterization/design of engineering materials. The course enhances the understanding of complexities in processing/characterization/designing and their solutions through numerical/analytical/modelling/experiments/proto-type designs/interpretation of data. The students will be able to handle the modern equipments in processing industries/design/process novel materials based on this knowledge.

Course Objectives

1. To understand of the overview of the different casting processes.
2. To evaluate various defects arises during metal casting and their remedies
3. To understand the design of mould
4. To analysis the Economics, Environment, Health and Safety Aspects

Course Content

Introduction to Casting Process

04 hours

Introduction: Casting as a process of Manufacturing. Moulding Processes, Equipments and Mechanization: Different types of Moulds, Moulding Materials and Moulding processes.

Sand Casting Process

12 hours

Basic principles of Sand casting processes; sequence in foundry operations; patterns; moulding practice; ingredients of moulding sand and core sand, sand testing; different moulding processes, 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

Melting Practice

04 Hours

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

Special Casting Process

08 hours

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

Designing of casting Process

12 hours

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.

Industrial Visit

10 hours

Learning Outcomes

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At the end of the course, the students will be able to	
<ol style="list-style-type: none"> 1. Understand the principle of metal castings and its importance. 2. Select the correct casting process for a particular product. 3. Analysis the quality of the casting. 4. Design the pattern and gating system for the casting. 5. Produce the casting and supply to the customer in a foundry 	
Teaching Learning Activities	Class room Lectures, Assignment, Tutorials, case studies, quiz, group discussion, ppt presentation, micro projects and Industrial Visits.
Course Assessment Methods	I. Assignments and Performance in the class 20 J. Class Test 10 K. Mid Term Examination 20 L. End Term Examination 50
Books and References	
Text Books	
<ol style="list-style-type: none"> 1. Heine R. W., Loper C. R., Rosenthal P. C., ' Principles of Metal Casting',2nd Edition, Tata McGraw Hill Publishers, 1985. 2. P. R. Beeley, Foundry Technology, Newnes-Butttherworths 3. P. D. Webster, Fundamentals of Foundry Technology, Portwillis press, Red hill 	
Reference Books	
<ol style="list-style-type: none"> 4. M.C. Flemmings, Solidification Processing 5. P. C. Mukherjee, Fundamentals of Metal casting Technology, Oxford IBH 6. John Campbell, Metal casting Process, Techniques and Design, Elsevier, 2011 	
Links to online references	
https://nptel.ac.in/courses/112/107/112107083/ https://nptel.ac.in/courses/112/107/112107215/ https://nptel.ac.in/courses/112/107/112107084/	

Name of Program	B.Tech (MME)	Semester-IV	Session-2021-22
Course Title	Materials Testing Lab		
Course Code	MM-6406		
Course Type	Department core - Practical		
No of credits	01		
Semester	4 th		
Department	Materials and Metallurgical Engineering		

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U.G./P.G.	Graduate Programme
Programme	B.Tech. in Materials Science and Metallurgical Engineering
Pre-requisites'	Theory course on Mechanical Behaviour of Materials
Course Coordinator	Dr. C Sasikumar
Learning Hours	25 Hours

Course Description

This course is designed for undergraduate students of materials and metallurgical engineering. It provides practical and theoretical knowledge about the mechanical properties of materials, the equipments required for testing, preparation of standard samples, analyzing the data. This course also provides practical understanding about how to evaluate the mechanical properties of materials which is used to design engineering materials for various applications.

Course Objectives

1. To select appropriate testing method for evaluating mechanical properties
2. Know-how to prepare standard samples as per required standards
3. Experimentation skills on evaluating mechanical properties
4. Plot and analyze the data
5. Interpretations of data
6. Determination of engineering design parameters using the test data

Course Contents

1. Introduction to Basic Laboratory Instruments, Data Acquisition and Analysis
2. Preparation of standard samples for property evaluation: tensile, compression, shear, bending and fracture toughness
3. Evaluation of mechanical properties of materials using tensile and compression testing
4. Evaluation of material properties using bending test
5. Evaluation of material properties using shear test
6. Hardness Testing : Rockwell Hardness, Vickers hardness, Micro Vickers Hardness and Knoop hardness
7. Friction wear and Surface Testing
8. Impact toughness testing and DBTT : Charpy, Izod, Plane-Strain Fracture Toughness of Metallic Materials
9. Fatigue testing
10. Non Destructive Testing: Die penetration test, Ultrasonic test, Eddy current test
11. Study experiments on creep
12. Testing of components

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Learning Outcomes	
<p>Material testing has widest scope in the manufacturing industries as their nature and properties decides the method of manufacturing and applications. Out of this course the student will be able to</p> <ol style="list-style-type: none"> 1) Prepare precise standard specimens for mechanical testing 2) Test and evaluate the material properties as per the standards 3) Be familiar with the common errors in testing materials 4) Plot and analyze the data 5) Evaluate the engineering design parameters 6) Determine the suitability of materials for proposed engineering any application. 7) Evaluate the quality of engineering components. <p>This course provides the testing skills required for manufacturing industries, testing centers, quality control and R&D sectors.</p>	
Teaching Learning Activities	<ol style="list-style-type: none"> 1. Lab experiments 2. Data plotting and analysis 3. Engineering design parameter calculations 4. Concept Mapping 5. Questioning 6. Formative Quizzes 7. Small group activities
Course Assessment Methods	<p>A. Continuous evaluation 50</p> <p>B. End Term Examination 50</p>
<ol style="list-style-type: none"> 1. Mechanical Testing and Evaluation, Vol. 8, ASM Handbook, ASM International, Materials Park, OH, 2000. 	
Links to online references	

Name of Program	B.Tech (MME)	Semester-IV	Session-2021-22
Course Title	Foundry Lab		
Course Code	MM-6407		
Course Type	Department core - Practical		
No of credits	01		
Semester	4 th		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Graduate Programme		
Programme	B.Tech. in Materials Science and Technology		
Pre-requisites'	Nil		
Course Coordinator	Dr. Ramesh Kumar Nayak		
Learning Hours	24 Hours		

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<p>Course Description</p> <p>This course is designed for undergraduate students of materials and metallurgical engineering. It provides the fundamental understanding of processing/characterization/design of engineering materials. The course enhances the understanding of complexities in processing/characterization/designing and their solutions through numerical/analytical/modelling/experiments/proto-type designs/interpretation of data. The students will be able to handle the modern equipments in processing industries/design/process novel materials based on this knowledge.</p>									
<p>Course Objectives</p> <ol style="list-style-type: none"> 7. To understand the sand and die casting processes live 8. To design the pattern and gating system for sand casting 9. To manufacture casting using sand and die mold 10. To Analysis various defects arises during metal casting and their remedies 									
<p>Course Content</p> <p>Lab experiments</p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 80%;">1. To determine the sand mould properties</td> <td style="text-align: right;">08 hours</td> </tr> <tr> <td>2. Manufacturing of sand casting product</td> <td style="text-align: right;">06 hours</td> </tr> <tr> <td>3. To determine the fluidity of liquid metal</td> <td style="text-align: right;">04 hours</td> </tr> <tr> <td>4. To evaluate the microstructure of cast metals</td> <td style="text-align: right;">06 hours</td> </tr> </table>		1. To determine the sand mould properties	08 hours	2. Manufacturing of sand casting product	06 hours	3. To determine the fluidity of liquid metal	04 hours	4. To evaluate the microstructure of cast metals	06 hours
1. To determine the sand mould properties	08 hours								
2. Manufacturing of sand casting product	06 hours								
3. To determine the fluidity of liquid metal	04 hours								
4. To evaluate the microstructure of cast metals	06 hours								
<p>Learning Outcomes</p> <p>At the end of the course, the students will be able to</p> <ol style="list-style-type: none"> 1. Understand the melting practice of casting process 2. Cast a product through sand and die casting 3. Evaluate the as cast structure 4. Design the pattern, mold and gating system for the casting. 									
Teaching Learning Activities	Experiments								
Course Assessment Methods	<ol style="list-style-type: none"> A. Assignments and Performance in the class 20 B. Class Test 10 C. Mid Term Examination 20 D. End Term Examination 50 								
<p>Books and References</p> <p>Text Books</p>									

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(Revised April 2020)

1. Heine R. W., Loper C. R., Rosenthal P. C., ' Principles of Metal Casting', 2nd Edition, Tata McGraw Hill Publishers, 1985.
2. P. R. Beeley, Foundry Technology, Newnes-Butttherworths
3. P. D. Webster, Fundamentals of Foundry Technology, Portwillis press, Red hill

Reference Books

4. M.C. Flemmings, Solidification Processing
5. P. C. Mukherjee, Fundamentals of Metal casting Technology, Oxford IBH
6. John Campbell, Metal casting Process, Techniques and Design, Elsevier, 2011

Links to online references

<https://nptel.ac.in/courses/112/107/112107083/>

<https://nptel.ac.in/courses/112/107/112107215/>

<https://nptel.ac.in/courses/112/107/112107084/>

Name of Program	B.Tech (MME)	Semester-IV	Session-2021-22
Course Title	Projects on Mechanical Metallurgy		
Course Code	MM 6408		
Course Type	Department core - Practical		
No of credits	2		
Semester	3		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	B.Tech. in Materials Science and Metallurgical Engineering		
Pre-requisites'	Theory courses on physical metallurgy, mechanical behavior of materials, materials testing		
Course Coordinator	Dr C Sasikumar		
Learning Hours	25 Hours		

Course Description

This course is designed for undergraduate students of materials and metallurgical engineering. It provides the fundamental understanding on engineering designs based on mechanical behavior of materials.

Course Objectives

Understand the design principles, Practical skills on materials and engineering design

Course Content

The project based learning help the student with practical skills and better understanding about the subject. A mentor will be assigned to group of students and the mentor will guide the students for carrying out the projects on mechanical metallurgy. The projects shall be in any one of the following areas

1. Elastic behavior of materials

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	<ol style="list-style-type: none"> 2. Plastic behavior of materials 3. Fracture behavior of materials 4. Materials testing 5. High strength materials 6. Light weight materials 7. Porous materials 8. Visco-elastic materials 9. Strengthening of materials 10. Indentation and evaluation of mechanical properties 11. Any other relevant area
Learning Outcomes	
Out of this course the student will be able to understand the underlying principles of engineering design based on the mechanical behavior of materials.	
Teaching Learning Activities	Self designing/modeling Simulations through software Numerical calculations Group activities on understanding the unit operations in recent and historical trends Formative quizzes on the learning outcomes
Course Assessment Methods	Continuous evaluation 100
Books and References	
Reference materials will be provided by the mentor	
Links to online references	

Fifth Semester

Name of Program	B. Tech. (U.G.)	Semester V (Odd Semester)	Year 2020 - 2021
Name of Course	Mechanics of Materials		
Course Code	ME – 6501		
Core / Elective / Other	Core Course		

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Prerequisites if any:	
1.	Engineering Mechanics
2.	Physics / Mathematics
Course Outcomes:	
1.	Understand the mechanical behaviour of bodies, components, machines and structures when they are subjected to external loads / loading systems.
2.	Design a component / machine / structure that can operate safely within realistic constraints.
3.	Utilize appropriate materials in design considering the relevant engineering properties, sustainability, cost and weight.
Description of Contents in brief:	
Unit 1.	Axially Loaded Members, Uniaxial Loading, Tension, Compression and Shear, Stresses and Strains, Hooke's Law, Fundamental Assumptions, Poisson's Ratio, Stress – Strain Diagrams and Mechanical Properties of Materials, Allowable Stresses and Allowable Loads, Factor of Safety, Stresses in Composite Sections, Thermal Stresses.
Unit 2.	Biaxial and Triaxial Loads, Principle of Complementary Shear Stresses, Stresses on Inclined Sections, Stress Transformation, Strain Transformation, Principal Stresses, Principal Strains, and Principal Axes, Mohr's Circle.
Unit 3.	Strain Energy in Tension, Compression, Shear, and due to Principal Stresses, Impact Loading, Elastic Constants and their relationships.
Unit 4.	Shafts, Simple Torsion Theory for Shafts of Circular Cross Section, Power Transmission through Circular Shafts, Solid and Hollow Shafts, Non – uniform Torsion, Compound Shafts, Strain Energy in Torsion and Pure Shear, Pressure Vessels, Thin Cylindrical and Spherical Pressure Vessels.
Unit 5.	Beams, Relationship between Loads, Shear Forces and Bending Moments, Pure Bending / Non-uniform Bending, Normal Stresses and Normal Strains in Beams, Theory of Pure Bending, Deflection of Beams, Method of Double Integration, Macaulay's Method, Method of Superposition, Moment - Area Method, Strain Energy Method, Castigliano's Theorem, Maxwell's Reciprocal Theorem.
Unit 6	Springs, Close Coiled Helical Springs, Open Coiled Helical Springs, Spiral and Leaf Springs, Columns and Struts, Buckling, Stability, and Critical Load Concepts, Euler's Theory, Columns with various support conditions, Design Formulas for Columns.
List of Text Books:	
1.	Mechanics of Materials, Enhanced 9E/2020, Barry Goodno & James M. Gere, Cengage Learning.
2.	Mechanics of Materials, 10E/2016, R. C. Hibbeler, Pearson.
3.	Mechanics of Materials, 8E/2019, Ferdinand Beer, et al, McGraw – Hill Education.
4.	Strength of Materials: A New Unified Theory for the 21st Century, 2004E, Dale Hopkins & Surya N. Patnaik, Elsevier
List of Reference Books:	
1.	Strength of Materials, Part I & II, 3E, Stephen Timoshenko, Krieger Pub Co.
2.	Strength of Materials, 2012, J. P. Den Hartog, Dover Publications
3.	Strength of Materials, G. H. Ryder, Palgrave Macmillan
4.	History of Strength of Materials, 1983, Stephen P. Timoshenko, Dover Publications

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URLs:		
1.	https://nptel.ac.in/courses/105/105/105105108/	
2.	https://nptel.ac.in/courses/112/107/112107147/	
3.	https://gradeup.co/theories-of-failures-i-2bcb95d0-83cf-11e6-890c-51e8ac482cfb	
Lecture Plan (about 40-50 Lectures):		
Lecture No.	Topic	Remarks
1.	Axially Loaded Members, Uniaxial Loading, Tension, Compression and Shear.	
2.	Stresses and Strains, Hooke's Law, Fundamental Assumptions, Poisson's Ratio – I	
3.	Stresses and Strains, Hooke's Law, Fundamental Assumptions, Poisson's Ratio – II	
4.	Tutorial Class	T - 01
5.	Stress – Strain Diagrams and Mechanical Properties of Materials - I	
6.	Stress – Strain Diagrams and Mechanical Properties of Materials - II	
7.	Allowable Stresses and Allowable Loads, Factor of Safety.	
8.	Tutorial Class	T - 02
9.	Stresses in Composite Sections	
10.	Thermal Stresses	
11.	Biaxial and Triaxial Loads, Principle of Complementary Shear Stresses	
12.	Tutorial Class	T - 03
13.	Stress Transformation - I	
14.	Stress Transformation – II	
15.	Stress Transformation – III	
16.	Tutorial Class	T - 04
17.	Strain Transformation	
18.	Principal Stresses	
19.	Principal Strains	
20.	Tutorial Class	T - 05
21.	Mohr's Circle - I	
22.	Mohr's Circle - II	
23.	Theories of Failure	
24.	Tutorial Class	T - 06
25.	Strain Energy in Tension and/or Compression	
26.	Strain energy in Shear and due to Principal Stresses	
27.	Impact Loading	
28.	Tutorial Class	T - 07
29.	Elastic Constants and their relationships	
30.	Shafts, Simple Torsion Theory for Shafts of Circular Cross Section.	
31.	Power Transmission through Circular Shafts, Solid and Hollow Shafts.	
32.	Tutorial Class	T - 08
33.	Non – uniform Torsion, Compound Shafts.	
34.	Strain Energy in Torsion and Pure Shear	

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35.	Pressure Vessels and Analysis of Thin Cylindrical and Spherical Pressure Vessels - I	
36.	Tutorial Class	T - 09
37.	Pressure Vessels and Analysis of Thin Cylindrical and Spherical Pressure Vessels - II	
38.	Beams, Relationship between Loads, Shear Forces and Bending Moments	
39.	Pure Bending and Non-uniform Bending, Normal Stresses and Normal Strains in Beams, Theory of Pure Bending	
40.	Tutorial Class	T - 10
41.	Deflection of Beams: Method of Double Integration	
42.	Deflection of Beams: Macaulay's Method	
43.	Deflection of Beams: Method of Superposition & Maxwell's Reciprocal Theorem	
44.	Tutorial Class	T - 11
45.	Deflection of Beams: Moment - Area Method	
46.	Deflection of Beams: Strain Energy Method	
47.	Deflection of Beams: Castigliano's Theorem	
48.	Tutorial Class	T - 12
49.	Springs, Close Coiled Helical Springs	
50.	Open Coiled Helical Springs	
51.	Spiral and Leaf Springs	
52.	Tutorial Class	T - 13
53.	Columns and Struts – I	
54.	Columns and Struts – II	
55.	Columns and Struts – III	
56.	Tutorial Class	T - 14

Name of Program	B.Tech (MME)	Semester-V	Session-2021-22
Course Title	Materials Characterization		
Course Code	MM 6502		
Course Type	Department core		
No of credits	4		
Semester	5 th		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	Materials And Metallurgical Engineering (MME)		
Pre-requisites'	Basic knowledge of Materials Science Crystal Structure, Physical Metallurgy		
Course Coordinator	Dr. Mangesh Lodhe		
Learning Hours	50 Hours		

Course Description

This course is designed for undergraduate students of Materials And Metallurgical Engineering (MME) programme. It provides the fundamental understanding of characterization of engineering materials. The course enhances the understanding of complexities in processing/characterization and their solutions through

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analytical/experiments/interpretation of data.

Course Objectives

The objective of this course is to teach the students the importance of materials characterization and its correlation through structure-property polyhedra. Students will be able to understand the various techniques like Optical microscopy, X-ray diffraction, Scanning electron microscopy, Transmission electron microscopy, etc.

Course Content

Scope of optical metallographic studies: Image formation, resolving power, numerical aperture, empty magnification, depth of focus, components of microscopes, important lens defects and their correction, principles of phase contrast, interference and polarized light microscopy, elements of quantitative metallography and image processing, sample preparation techniques

X-Ray diffraction and their applications: Production and properties of X-ray, absorption of X-rays and filters, X-ray-diffraction directions, diffraction methods. X-ray - diffraction intensities, factors affecting intensity, 'structure factor' calculations for simple, body centered, face centered, diamond cubic and hexagonal crystal structures. Working principles of diffractometer, counters and cameras. Indexing of XRD patterns. Precise lattice parameter determination, determination of particle size

Scanning electron microscope: construction, interaction of electrons with matter, modes of operation, image formation of plane and fractured surfaces.

Transmission electron microscopes: Construction and working principles, Image formation, resolving power, magnification, depth of focus, Bright field and dark field images. Stereographic projection and their applications. Formation of selected area diffraction patterns, indexing of diffraction patterns, sample preparation techniques.

Learning Outcomes

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

- 1) Characterize the various type of materials
- 2) Index the X-ray diffraction pattern, and calculate the particle size
- 3) Differentiate the various phases and determine their phase fraction

Teaching Learning Activities	Mostly using White Board, 20% learning through power point, Problem solving activities in tutorial classes, Performing experiments in laboratory
Course Assessment Methods	A. Assignments and Performance in the class 20 B. Class Test 10 C. Mid Term Examination 20 D. End Term Examination 50

Books and References

1. Spencer, Michael, Fundamentals of Light Microscopy, Cambridge University

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Press,1982.	
2. David B. Williams, C.Barry Carter," Transmission Electron Microscopy:A Textbook for Materials Science" ,Springer, pub. 2009.	
3. B.D.Cullity and S.R.Stock,"Elements of X-Ray Diffraction" Third edition,Prentice Hall, NJ , 2001.	
4. 'Fundamentals of light microscopy and electronic imaging' Douglas B. Murphy, 2001, Wiley-Liss, Inc. USA	
5. Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, by Yang Leng	
6. X-Ray Diffraction: A Practical Approach, C. Suryanarayana and M. Grant Norton	
7. 'Encyclopedia of Materials Characterization,Surfaces, Interfaces, Thin Films,' Editors C. Richard Brundle, Charles A.Evans, Jr.,Shaun Wilson,Butterworth-Heinemann, Boston London Oxford Singapore Sydney Toronto Wellington	
Links to online references	www.microscopyu.com Other Link to online references will be provided to students during Lectures.

Name of Program	B.Tech (MME)	Semester-V	Session-2021-22
Course Title	Welding and Joining Technology		
Course Code	MM 6503		
Course Type	Department core		
No of credits	4		
Semester	5		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	B.Tech. in Materials Science and Metallurgical Engineering		
Pre-requisites'	Fundamentals of Physical Metallurgy Microstructural Evolution in Metals		
Course Coordinator	Dr. Ramkishor Anant		
Learning Hours	50 Hours		

Course Description

This course is designed for undergraduate students of materials and metallurgical engineering. It provides the fundamental understanding of processing/characterization/design of engineering materials. This course is discussed about wide variety of processes and materials from the viewpoint of their fundamental physical and chemical properties. Specific topics: cold welding, adhesive bonding, diffusion bonding, soldering, brazing, flames, arcs, high-energy density heat sources, solidification, cracking resistance, shielding methods, and electric contacts. Emphasis on underlying science of a given process rather than a detailed description of the technique or equipment.

Course Objectives

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Materials and Metallurgical engineers need to know different types of metal joining processes for production of intricate part in combination with the accuracy, tolerance & surface finish. The present course intends to give the exposure of various joining processes for a product whose scale ranges from miniature to extra-large. Since joining of metals is an important manufacturing route to fabricate bulk storage and processing equipment's. The subject focuses on knowledge and understanding of various joining process and equipment's, the underlying principles and their relative merits and demerits. Basic understanding regarding weldability of different metals and alloys is also duly emphasized. It also helps them to understand the advancement of technology in manufacturing.

Course Content

Metal Joining Processes

No of hours: 6

Introduction, classification of welding processes as per AWS, commonly welded base metals, advantages and disadvantages of welding. Welding as compared to riveting and casting. Soldering, brazing, adhesive bonding processes, welding of dissimilar metals.

Gas Welding Processes

No of hours: 8

Introduction, oxy-acetylene welding, oxy-hydrogen, air-acetylene welding. Principle of operation, types of welding flames, Lighting the torch, flame adjustment, gas welding techniques .welding techniques- leftward & rightward. Filler metals and fluxes, gas welding equipments, applications.

Arc Welding Processes

No of hours:10

Introduction, Principle, Working, Specifications, Equipments, Merits and demerits, applications of Carbon arc welding, Flux Shielded Metal arc Welding, Gravity Welding, Sub Merged Arc Welding, GTAW Welding, GMAW Welding, CO2 Welding, Flux Cored Arc Welding(FCAW),Electro Slag welding, Electro Gas welding, Plasma Arc Welding. Source of Power Supply: AC/DC & their characteristics

Resistance Welding Processes

No of hours: 6

Introduction, Principle, Working, Specifications, Equipments, Merits and demerits, applications of Spot welding, Seam welding, Projection Welding, Upset welding, Flash Butt welding, Percussion Welding.

Solid State and Thermo Chemical Joining Processes

No of hours: 6

Introduction, Principle, Working, Specifications, Equipments, Merits and demerits, applications of Solid State welding Processes like Cold (or pressure welding), Diffusion(Bonding), Explosive welding, Friction ,Inertia and forged welding. Thermo chemical welding processes like thermit welding, atomic hydrogen welding.

Automation in Welding

No of hours: 6

Welding sequence and classification of processes, manual and semi-automatic, automatic, automated welding- adaptive controls- remote welding, robotic welding- selecting welding system, gravity welding and fire cracker welding, under water welding- wet and dry.

Weld Defects & Tests

No of hours: 4

Introduction, type of defects in weldments, causes and remedies of defects. Repair of

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defective welds, Visual examination of welding, Fabrication Weldability tests , Hydrostatic Pressure testing and Hydraulic or Gas Pressure testing for leakage, Use of NDT for weldments, Pre and post weld heat treatment, safety standards

Weld Joints & Metallurgy

No of hours: 4

Various types of weld joints & weld symbols, Standard location of elements of welding symbols. Heat affected zone and its properties.

Learning Outcomes

After learning the course the students should be able to:

Indicate which types of Welding Processes are suited for production.

Determine various gas, arc, solid state, thermo chemical welding processes with their process parameters.

Identify various advances welding processes.

Determine various Nondestructive testing for weldments.

Identify the various types of electrodes used for welding processes

Identify the various Weld Joints & Metallurgy

Teaching Learning Activities

Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, interactive teaching, educational visits, small projects.

Course Assessment Methods

- A. Assignments and Performance in the class **20**
- B. Class Test **10**
- C. Mid Term Examination **20**
- D. End Term Examination **50**

Books and References

1. Metallurgy of Welding: Lancaster J
2. Welding Processes and Technology: R.S.Parmar
3. Welding, Brazing and Soldering ASM Metals Hand Book, Vol. 6
4. Welding Metallurgy: Linnert G E
5. AWS Welding Handbook: Materials and Applications - Part 1 Vol.3:, AWS
6. Welding Metallurgy: Sindo Kou

Links to online references

Name of Program	B.Tech (MME)	Semester-V	Session-2021-22
Name of Course	Phase Transformation and Heat Treatment		
Course Code	MM 6504		
Core / Elective / Other	Department Core		
Prerequisite:			

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1.	Physical Metallurgy	
2.	Thermodynamics and Kinetics of materials	
Course Outcomes:		
<ol style="list-style-type: none"> 1. To understand the phase transformation mechanisms 2. To determine the kinetics of transformation 3. To understand different heat treatment techniques and their effect on the properties of materials 		
Description of Contents in brief:		
<p>Laws and mechanisms of diffusion, Kirkendall effect, concentration and temperature dependence of diffusion coefficient, Darken's equations, Matano method, intrinsic diffusivities, diffusion along dislocations and grain boundaries. Homogenous and heterogeneous nucleation, Thermodynamic barrier for nucleation, nucleation rate, Structure and energy of interfaces. Strain energy and its effect on nucleation.</p> <p>Diffusion controlled and interface controlled growth mechanisms. Redistribution of solute during solidification, constitutional supercooling. Origin of cellular and dendritic structures, solidification at high undercooling, Rapid solidification, Zone refining, Growth of single crystals. Classification, KJMA kinetics, Precipitation reactions, Spinodal decomposition, Particle coarsening, Cellular precipitation, Eutectoidal transformation,</p> <p>Order-disorder transformation. Characteristics of diffusionless transformations, Crystallography and thermodynamics of martensitic transformation, Bainitic and Massive transformation.</p> <p>Iron-carbon equilibrium diagram, Isothermal transformation diagrams, continuous cooling transformation diagram. Austenitisation and austenite grain size. Hardenability, its measurement and control. Homogenisation, quenching and quenching media, annealing, normalizing, hardening and tempering of steels.</p> <p>Case hardening treatments-case carburizing and post carburizing heat treatment, nitriding, carbonitriding, boronising, chromising, Toyota diffusion processes. Surface hardening treatments-induction hardening, flame hardening, laser hardening and electron beam hardening processes.</p> <p>Recrystallisation annealing of cold worked metals, age hardening. Temper designations for aluminum and magnesium alloys. Heat treatment of aluminium, copper, magnesium, titanium and nickel alloys.</p>		
List of Text Books and Reference Books		
1	Fundamentals of Physical Metallurgy, Wiley.	J. D. Verhoeven:
2	Phase Transformations in Metals and Alloys, Chapman and Hall.	D.A. Porter and K.E. Easterling:
3	Solid State Phase Transformations, Prentice-Hall.	V. Raghavan:
4	Physical Metallurgy Principles, Third Edition, PWS, Boston.	R.E. Reed-Hill and R. Abbaschian:
5	Metallography of Phase Transformations,	G.A. Chadwick:

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6	Physical Metallurgy Principles, PWS, Publishing Company, Boston, Third Edition.	Butterworths R.E. Reed-Hill and R. Abbaschian:
7	Heat treatment of Metals, Standard Publishers Distributors, Delhi	Vijendra Singh:
8	Principles of Heat Treatment of Steels, New Age International (P) Ltd. Publisher.	R.C. Sharma:
9	Principles of Heat Treatment of steel, ASM, 1980	G. Krauss.
10	Engineering Physical Metallurgy and Heat Treatment, Mir publisher, 1979.	Yu. M. Lakhtin

URLs:

1.

Lecture Plan (about 40-50 Lectures):

Lecture No.	Topic	
S.No.	Course Content	Number of Classes
1	Laws and mechanisms of diffusion, Kirkendall effect, concentration and temperature dependence of diffusion coefficient,	04
2	Darken's equations, Matano method, intrinsic diffusivities, diffusion along dislocations and grain boundaries. Homogenous and heterogeneous nucleation, Thermodynamic barrier for nucleation, nucleation rate, Structure and energy of interfaces. Strain energy and its effect on nucleation.	05
3	Diffusion controlled and interface controlled growth mechanisms. Redistribution of solute during solidification, constitutional supercooling.	03
4	Origin of cellular and dendritic structures, solidification at high undercooling,	06
5	Rapid solidification, Zone refining, Growth of single crystals. Classification, KJMA kinetics,	05
6	Precipitation reactions, Spinodal decomposition, Particle coarsening, Cellular precipitation, Eutectoidal transformation,	05
7	Order-disorder transformation	03
8	Characteristics of diffusionless transformations,	04
9	Crystallography and thermodynamics of martensitic transformation, Bainitic and Massive transformation.	05
10	Iron-carbon equilibrium diagram, Isothermal transformation diagrams, continuous cooling transformation diagram.	04
11	Austenitisation and austenite grain size. Hardenability, its measurement and control. Homogenisation, quenching and quenching media, annealing, normalizing, hardening and tempering of steels.	02
12	Case hardening treatments-case carburizing and post carburizing heat treatment, nitriding, carbonitriding, boronising, chromising,	04
13	Toyota diffusion processes. Surface hardening treatments-induction	04

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	hardening, flame hardening, laser hardening and electron beam hardening processes.	
14	Recrystallisation annealing of cold worked metals, age hardening.	02
15	Temper designations for aluminum and magnesium alloys..	03
16	Heat treatment of aluminium, copper, magnesium, titanium and nickel alloys.	03

Name of Program	B. Tech	Semester V	Year III Year
Name of Course	Engineering Management		
Course Code	ME 6505		
Core / Elective / Other	Core (for all the branches)		
Prerequisite if any:			
1.	None		
2.	None		
Course Outcomes: Students shall develop			
1.	Understanding the relevance and importance of Management Practices for Engineers.		
2.	Knowledge and Practices on the interdisciplinary course content that combines an engineering focus with core business and management knowledge.		
3.	Ability to understand various methods of analysis and decision making related to operations, human resources, finances and marketing management.		
Description of Contents in brief:			
Unit 1.	Principles/Functions of Management, Measure of Productivity and ways to enhance Productivity. Management challenges for Engineers.		
Unit 2.	Operations Management and its scope, Production Systems, Facility Location, Facility Planning & Plant Layouts.		
Unit 3.	Industrial Design, Product Design, Product / Project Life Cycle, Quality Control and Quality Management, Forecasting Methods, Introduction to Supply Chain Management.		
Unit 4.	Material Management – Purchasing, Inventory & JIT Systems, Material Resource Planning, Scheduling, Project Management, PERT and CPM, Project Crashing.		
Unit 5.	Introduction to Financial Management, Financial Statements and Analysis, Operations Decision making - Break Even Analysis & Decision Trees		
Unit 6	Fundamentals of Marketing Management, Organizational Behavior and Leadership, Strategic Management, Statutory and Legal Issues.		
List of Text Books:			
1.	Modern production/operations management by Buffa: Wiley India		
2.	Marketing Management by Kotler; PHI		
3.	Operations Management by Russel & Taylor; Wiley		
List of Reference Books:			

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1.	Handbook of Industrial Engineering: Technology and Operations Management by Gavriel Salvendy; Wiley publication
2.	Operations management by Krajewski; pearson
3.	Industrial Engineering by Shankar Ravi; Galgotia Publication
4.	Financial Management by I M Pandey; Vikas
5.	Strategic Management by Pearce, Robinson and Mital; Mc Graw Hill Education

URLs:

1.	https://nptel.ac.in/courses/112/107/112107238/
2.	https://nptel.ac.in/courses/110/107/110107144/

Lecture Plan (about 40-50 Lectures):

*Lecture No.	Topic	Remarks
1.	Introduction to the course and its scope	
2.	Principles and Functions of Management	
3.	Principles and Functions of Management	
4.	Productivity and its Measures	
5.	Productivity and its Measures	
6.	Ways to enhance Productivity	
7.	Management Challenges for Engineers	
8.	Operations Management and Its Scope	
9.	Production Systems	
10.	Plant Location and Site Selection – An Introduction	
11.	Factors affecting Plant Location	
12.	Plant Layout, Types and characteristics of a good plant layout	
13.	Procedure and Methods of Plant Layout	
14.	Procedure and Methods of Plant Layout	
15.	Factors affecting Plant Layout	
16.	Installation and evaluation of Plant Layout	
17.	Industrial Design & Morphology of Design	
18.	Product Life Cycle	
19.	Product Design and Approaches to Product Design	
20.	Product Design and Approaches to Product Design	
21.	Product Design and Approaches to Product Design	
22.	Introduction to Forecasting Methods	
23.	Forecasting Models	
24.	Quality Control and Quality Management - Introduction	
25.	Quality Circle and Total Quality Management	
26.	Supply Chain Management	
27.	Characteristics of Supply Chain Management	
28.	Application of SCM	
29.	Material Management – Purchasing	
30.	Inventory Models	
31.	Inventory Models	
32.	JIT Systems	
33.	Material Resource Planning	
34.	Introduction to Project Management– Planning, Scheduling & Controlling	

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35.	CPM	
36.	PERT	
37.	Project Crashing	
38.	Financial management – Introduction & Its interface with other functions of Management	
39.	Financial Planning, Estimation of Financial Requirements of a Project	
40.	Working Capital Management	
41.	Break Even Analysis, Risk Analysis and Decision Trees	
42.	Concept and Functions of Marketing Management	
43.	Marketing Process – Marketing Mix	
44.	Marketing Environment and Marketing Research	
45.	Consumer & Business Buyer Behavior	
46.	Segmentation & Targeting	
47.	Distribution and Pricing	
48.	Organizational Behavior and Leadership	
49.	Organizational Behavior and Leadership Contd	
50.	Strategic Management	
51.	Statutory and Legal Issues.	

Name of Program	B.Tech (MME)	Semester-V	Session-2021-22
Course Title	Heat Treatment Lab		
Course Code	MM-6506		
Course Type	Department core - Practical		
No of credits	01		
Semester	5 th		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Graduate Programme		
Programme	B.Tech. in Materials Science and Metallurgical Engineering		
Pre-requisites'	Theory course on Phase Transformation and Heat Treatment		
Course Coordinator	Dr. C Sasikumar		
Learning Hours	25 Hours		

Course Description

This course is designed for undergraduate students of materials and metallurgical engineering. It provides practical knowledge about the heat treatment and phase transformation. The knowledge about types of heat treatment furnaces, temperature measurement and control systems will be covered. Practical knowledge and skills on different types of heat treatment techniques, hardening methods and quality evaluation techniques will be provided.

Course Objectives

1. To select appropriate heat treatment to modify the properties of materials
2. To understand the microstructural changes caused by the heat treatment technique
3. To evaluate and appreciate the change in mechanical properties by heat treatment

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4. To design engineering materials by appropriate heat treatment
5. To test the quality of heat treatment
6. To understand the defects the caused by the heat treatment

Course Contents

Experimental studies to learn

Heat Treatment Processes for Steels: Stress Relieving, Annealing, Spheroidizing, Normalizing, Hardening, Tempering, Austempering, Martempering, Sub-zero treatment

Hardenability : Relationship with transformation rates, Determination of Hardenability, Grossman's Critical Diameter, Jominey End Quench Test, Estimation of hardenability from chemical composition, Fracture Test, Factors Affecting Hardenability

Quenchants: Quenching Media and evaluating the characteristics of Quenching Medium,

Chemical Heat Treatment of Steels: Carburizing, Salt Bath Nitrocarburizing, Boronizing

Surface Hardening : Flame Hardening, Case Depth Measurement in Steels

Study experiments on Thermomechanical Treatment : Ausforming, Marstraining, Thermomechanical Treatment of Non-Ferrous Metals and Alloys

Heat Treatment of Non-Ferrous Metals and Alloys: Aluminium and its alloys, Magnesium Alloys, Titanium Alloys

Learning Outcomes

Practical knowledge on Heat Treatment has widest scope in the manufacturing industries. By this knowledge the engineer will be able to modify the mechanical properties of materials as required for any specific application.

Teaching Learning Activities

1. Lab experiments
2. Data plotting and analysis
3. Engineering design parameter calculations
4. Concept Mapping
5. Questioning
6. Formative Quizzes
7. Small group activities

Course Assessment Methods

- A. Continuous evaluation **50**
- B. End Term Examination **50**

Books and References

1. T.V. Rajan, C.P. Sharma, Ashok Sharma 2012. *Heat Treatment Principles and Techniques*, PHI Learning Private Limited, New Delhi.
2. Romesh C Sharma, 2003. *Principles of Heat Treatment of Steels*, New Age International Limited, New Delhi.

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3. K H Prabhudev, 2008. *Handbook of Heat Treatment of Steel*, Tata McGraw Hill, New Delhi.
4. George E Totten, 2006. *Steel Heat Treatment: Equipment and Process Design*, Taylor & Franchis, New York.

Links to online references

Name of Program	B.Tech (MME)	Semester-V	Session-2021-22
Course Title	Materials Characterization Lab		
Course Code	MM-6507		
Course Type	Department core - Practical		
No of credits	01		
Semester	5 th		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Graduate Programme		
Programme	B.Tech. in Materials Science and Metallurgical Engineering		
Pre-requisites'	Theory course on Physical Metallurgy, Materials Characterization		
Course Coordinator	Dr. Mangesh Lodhe		
Learning Hours	25 Hours		

Course Description

This course is designed for undergraduate students of materials and metallurgical engineering. It provides practical knowledge about different characterization techniques. The skills on testing and interpreting the physical, chemical, structural and thermal properties of materials will be covered in this course.

Course Objectives

1. Practical skills in analyzing the physical properties of materials
2. Practical skills in analyzing the chemical composition of materials
3. Understand the working principle and methodologies of working of XRD, SEM, EDX, FTIR, Raman To understand the select appropriate heat treatment to modify the properties of materials
4. To understand the microstructural changes caused by the heat treatment technique
5. To evaluate and appreciate the change in mechanical properties by heat treatment
6. To design engineering materials by appropriate heat treatment
7. To test the quality of heat treatment
8. To understand the defects the caused by the heat treatment

Course Contents

The Materials characterization lab is a compulsory, with a six hour weekly program, four hours of teaching and a two -hour practical. The lab experiments includes the following titles:

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- Morphological studies using scanning electron microscope
- Micro-chemical analysis using EDX
- Bulk chemical composition of metals using OES
- Thermal analysis of materials
- Metallographic preparation of specimens
- Microscopic microstructure observation
- X-ray diffraction
- Interaction of X-rays with matter
- Identification of minerals, metals, ceramics etc.
- Surface characterization using AFM
- Structural characterization using FTIR, UV-vis spectroscopy, Raman Spectroscopy

Learning Outcomes

Ability of performing basic characterization of physical, chemical, structural, thermal and morphological properties of materials.

Teaching Learning Activities

1. Lab experiments
2. Data plotting and analysis
3. Concept Mapping
4. Questioning
5. Formative Quizzes
6. Small group activities

Course Assessment Methods

- A. Continuous evaluation **50**
- B. End Term Examination **50**

Books and References

1. Spencer, Michael, Fundamentals of Light Microscopy, Cambridge University Press, 1982.
2. David B. Williams, C. Barry Carter, "Transmission Electron Microscopy: A Textbook for Materials Science", Springer, pub. 2009.
3. B.D. Cullity and S.R. Stock, "Elements of X-Ray Diffraction" Third edition, Prentice Hall, NJ, 2001.
4. 'Fundamentals of light microscopy and electronic imaging' Douglas B. Murphy, 2001, Wiley-Liss, Inc. USA
5. Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, by Yang Leng

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6. X-Ray Diffraction: A Practical Approach, C. Suryanarayana and M. Grant Norton
7. 'Encyclopedia of Materials Characterization, Surfaces, Interfaces, Thin Films,' Editors C. Richard Brundle, Charles A. Evans, Jr., Shaun Wilson, Butterworth-Heinemann, Boston London Oxford Singapore Sydney Toronto Wellington
Links to online references

Name of Program	B.Tech (MME)	Semester-V	Session-2021-22
Course Title	Projects on Welding and Joining		
Course Code	MM 6508		
Course Type	Department core - Practical		
No of credits	2		
Semester	3		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	B.Tech. in Materials Science and Metallurgical Engineering		
Pre-requisites'	Theory courses on physical metallurgy, mechanical behavior of materials, materials testing, welding and joining techniques		
Course Coordinator	Dr Ramkishor Anant		
Learning Hours	25 Hours		

Course Description

This course is designed for undergraduate students of materials and metallurgical engineering. It provides the fundamental understanding on engineering designs based on welding and joining of materials.

Course Objectives

To acquire practical skills on welding, welding metallurgy and quality inspection of weldments and joints.

Course Content

The project based learning help the student with practical skills and better understanding about the subject. A mentor will be assigned to group of students and the mentor will guide the students for carrying out the projects on welding. The projects shall be in any one of the following areas

1. Gas Welding
2. Arc Welding
3. Resistance Welding
4. Solid state Welding
5. E-beam/Laser Welding
6. Welding Metallurgy

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7. Weld Quality Inspection 8. Microstructure of weldments/joints 9. Soldering 10. Brazing 11. Any other relevant area	
Learning Outcomes Out of this course the student will be able to understand the underlying principles of engineering design based on the welding and joining.	
Teaching Learning Activities	Self designing/modeling Simulations through software Numerical calculations Group activities on understanding the unit operations in recent and historical trends Formative quizzes on the learning outcomes
Course Assessment Methods	Continuous evaluation 100
Books and References Reference materials will be provided by the mentor	
Links to online references	

Name of Program	B.Tech (MME)	Semester-V	Session-2021-22
Course Title	Internship/Training (6 weeks)		
Course Code	MM 6509		
Course Type	Department core - Practical		
No of credits	1		
Semester	3		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	B.Tech. in Materials Science and Metallurgical Engineering		
Pre-requisites'			
Course Coordinator	Dr Ramesh Kumar Nayak		
Learning Hours	6 weeks		
Course Objectives To acquire practical knowledge on Industrial iron and steel making, heat treatment, metal			

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forming, powder metallurgy, polymer processing, ceramic processing, non-ferrous metal extraction, manufacturing and other relevant area.	
Learning Outcomes Out of this course the student will get practical understanding of processing materials.	
Teaching Learning Activities	Industrial Visit R&D Projects Internships Industrial Training
Course Assessment Methods	Continuous evaluation 100 Students need to submit report and certificate acquired from the Industry/training Institute Presentations & Viva

Sixth Semester

Name of Program	B.Tech.	Semester VI	Session-2021-22
Name of Course	Data Structures		
Course Code	CS 6601		
Core / Elective / Other	Core		
Prerequisite:			
1.	Programming Languages		
2.			
3.			
Course Outcomes:			
1.	Concept and importance of data structures		
2.	Learn to implement various types of data structure		
3.	Learn how to determine algorithm correctness and its efficiency		
Description of Contents in brief:			
	Introduction to Data Structures, Algorithm Evaluation, Arrays, Multi-dimensional Arrays, Sparse Matrices, Structure, Pointers, Stacks: representation of stacks and basic operations, applications of Stacks, Prefix, Postfix and Infix notations and conversion, Recursion, Towers of Hanoi. Queues: Types of Queue and its application. Linked lists: Types of Linked list, implementation of Stack and Queue using Linked list, Polynomial representation and Arithmetic. Trees: binary tree, n-ary Tree, Tree Traversal, AVL		

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	Trees, Binary Search trees, Graphs: Representation, Traversing. Searching: Sequential Search, Binary Search, and Hashing. Sorting: External and Internal Sort, Selection Sort, Bubble Sort, Insertion Sort, Radix Sort, and Bucket Sort.
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List of Text Books:

- | | |
|----|--|
| 1. | Fundamentals of Data Structures by E.Horowitz and S.Sahni, Computer Science Press. |
| 2. | Data Structure Using C by A. M. Tanenbaum, PHI. |
| 3. | |

List of Reference Books:

- | | |
|----|---|
| 1. | Data Structures and Algorithms in C (Second edition) by M. T. Goodriche and R. Tamassia, John Wiley & Sons. |
| 2. | Data Structures and Algorithm Analysis in C (Second Edition), by M. A. Weiss, Addison-Wesley, 2013. |
| 3. | Classic Data Structures by D. Samantha, PHI. |
| 4. | Data Structures, Schaum's Series |

URLs:

- | | |
|----|---|
| 1. | NOC:Programming, Data Structures and Algorithms - https://nptel.ac.in/courses/106102064/ |
| 2. | Stanford CS166: Data Structures - http://web.stanford.edu/class/cs166/ |
| 3. | |

Lecture Plan (about 40-50 Lectures):

Lecture No.	Topic
1.	Introduction to data structures, algorithm evaluation
2.	Time complexity analysis (Asymptotic Notations)
3.	Arrays and its operations
4.	Multidimensional arrays
5.	Sparse matrices
6.	Structure, Pointers
7.	Recursion
8.	Linked List an Operations on Linked List
9.	Double linked list and its operations
10.	Applications of linked lists
11.	Storage Pools, Garbage Collection
12.	Tutorial
13.	Stacks and operations on a stack
14.	Prefix, Postfix and Infix notations
15.	Difference between stacks and queues
16.	Postfix evaluation, Parenthesis checking
17.	Infix to Postfix conversion
18.	Quicksort
19.	Implementation of recursion using stacks
20.	Towers of Hanoi
21.	Queues and Operations on a queue
22.	Queues application
23.	Circular queues, Priority queue

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24.	Tutorial
25.	Trees: applications & representation in memory
26.	Binary tree: Operations on binary tree
27.	Tree Traversals
28.	Graphs: Representation
29.	Graph Traversals
30.	Tutorial
31.	Sequential Search
32.	Binary Search
33.	Hashing
34.	Hash functions
35.	Hashing(Collision resolution techniques)
36.	Sorting Techniques: Bubble Sort
37.	Selection Sort, Insertion Sort
38.	Merge Sort
39.	Heap Sort: Max & Min Heap
40.	Radix Sort
41.	Tutorial

Name of Program	B.Tech (MME)	Semester-VI	Session-2021-22
Course Title	Project 1		
Course Code	MM 6602		
Course Type	Department core - Practical		
No of credits	2		
Semester	6		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	B.Tech. in Materials Science and Metallurgical Engineering		
Pre-requisites'	Theory courses on Materials Processing and Characterization		
Course Coordinator	Dr C Sasikumar		
Learning Hours	40-50 Hours		

Course Description

This course is designed for undergraduate students of materials and metallurgical engineering. This course is designed to instill the qualities of inventing novel materials, engineering structures, testing procedures, novel processing techniques etc.,

Course Objectives

.To develop innovation capabilities, engineering management, acquaintance with existing Industrial practices.

Course Content

A mentor will be assigned to group of students and the mentor will guide the students for carrying out the projects. The projects shall be in any one of the following areas

1. Materials processing

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<ol style="list-style-type: none"> 2. Design of novel/existing engineering structures/materials 3. Advanced materials 4. Material characterization 5. Any other relevant area 	
<p>Learning Outcomes</p> <p>Out of this course the student will be able to acquire practical skills on materials processing and characterization.</p>	
Teaching Learning Activities	<p>Experimental setup</p> <p>Simulations through software</p> <p>Evaluation of the properties of materials</p> <p>Group activities</p> <p>Review of Research papers</p>
Course Assessment Methods	Continuous evaluation 100
<p>Books and References</p> <p>Reference materials will be provided by the mentor</p>	
<p>Links to online references</p>	

Name of Program	B.Tech (MME)	Semester-VI	Session-2021-22
Course Title	Metal Forming and Powder Metallurgy		
Course Code	MM 6603		
Course Type	Department core		
No of credits	L T P (3 1 0)	Total credits = 4	
Semester	6		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	B.Tech. in Materials Science and Metallurgical Engineering		
Pre-requisites'	Basic courses of Engineering mechanics, Mechanical Behaviour of Materials		
Course Coordinator	Dr C Sasikumar & Dr Mangesh Lodhe		
Learning Hours	50 Hours		

Course Description

This course is designed for undergraduate students of materials and metallurgical engineering. It provides the fundamental understanding of processing of materials. The course enhances the understanding of complexities in processing and applications of metals

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and ceramic materials.

Course Objectives

1. Know-how to determine the load required to deform the materials.
2. Determine the power requirements.
3. Design of die.
4. Knowledge of different metal forming techniques.

Course Content

Fundamentals of metal forming

10

Classification of forming processes, mechanisms of metal forming: slab method, Upper and lower bound analysis, hot working, cold working, friction and lubricants.

Case studies: Formability test and criteria, Friction in forming operation, Experimental techniques for forming analysis.

Rolling of Metals

5

Rolling processes, forces and geometrical relationship in rolling, simplified analysis, rolling load, rolling variables, theories of cold and hot rolling, problems and defects in rolling, torque and power calculations, Problems.

Case studies: Deformation in Rolling, Defects in Rolling

Forging

5

Classification of forging processes, forging of plate, forging of circular discs, open die and closed-die forging, forging defects, and powder metallurgy forging. problems on flow stress, true strain and forging load. Press tool design: Design of various press tools and dies like piercing dies, blanking dies, compound dies and progressive blanking dies, design of bending, forming and drawing dies.

Case studies: Deformation in compression, Design of dies

Extrusion

5

Classification, Hot Extrusion, Analysis of Extrusion process, defects in extrusion, extrusion of tubes, production of seamless pipes. Problems on extrusion load. Drawing: Drawing of tubes, rods, and wires: Wire drawing dies, tube drawing process, analysis of wire, deep drawing and tube drawing. Problems on draw force.

Case studies: Design of extrusion setup

Sheet Metal Forming

5

Forming methods, Bending, stretch forming, spinning and Advanced techniques of Sheet Metal Forming, Forming limit criteria, defect in formed parts. Advanced Metal forming processes: HERF, Electromagnetic forming, residual stresses, in-process heat treatment, and computer applications in metal forming. problems on Blanking force, Blank diagram in Cup Diagram, Maximum considering shear.

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Case studies: -High energy rate forming product

Powder Metallurgy

20

Metallic powder manufacturing, Physical methods (different techniques of grinding), chemical routes - coprecipitation, sol-gel, hydrothermal, combustion synthesis, high temperature reaction (solid state reaction). Powder characterization, powder preconditioning, environment health and safety considerations, Basic principles and techniques of consolidation and shaping of ceramics: powder pressing- uniaxial, biaxial and cold isostatic and hot isostatic, injection moulding, slip casting, tape-casting, calendaring, multilayering conventional and near-net shape forming processes, stages in sintering, secondary operations, testing standard and quality control, applications, Ceramics for energy and environment technologies (fuel cell, lithium battery, gas sensor and catalytic support), Exotic ceramics: functionally graded, smart/ Intelligent, bio-mimetic and nano- ceramics - basic principles, preparation and applications

Learning Outcomes

Out of this course you will be able to

1. Quantify the energy requirements for a metal forming processes.
2. Determine the power requirements in designing a die.
3. Precisely determine whether a material can be used for an application or not.
4. Precisely determine the theoretical limits in materials processing
5. Predict novel materials/processing conditions for engineering applications

Teaching Learning Activities

- A. Lectures
- B. Problem Solving
- C. Concept Mapping
- D. Questioning
- E. Formative Quizzes
- F. Small group activities

Course Assessment Methods

- A. Assignments and Performance in the class **20**
- B. Class Test **10**
- C. Mid Term Examination **20**
- D. End Term Examination **50**

Books and References

1. Mechanical Metallurgy – George E. Dieter
2. Principles of Metal Working processes – G.W. Rowe
3. Metal Forming Mechanics and Metallurgy -Hosford and Caddell
4. Hot Rolling and Steels -Roberts.

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5. Physical Ceramics: Principles for Ceramic Science and Engineering, Yet-Ming Chiang, Dunbar P. Birnie, W. David Kingery
6. Fundamental of Ceramics by Michel W. Barsoum, McGraw Hill International edition, 1997
7. Modern Ceramic Engineering by David. W. Richerson, Mercel Dekker, NY 1992
8. Ceramic Processing and Sintering by M. N. Rahman, Mercel Dekker, 2003
9. Handbook of Advanced Ceramics by S. Somiya, Academic Press 2003
10. Handbook of Advanced Ceramics, Parts 1 and 2, S. Somiya, Academic Press, 2006

Links to online references

Link to online references will be provided to students during Lectures.

Name of Program	B.Tech (MME)	Semester-VI	Session-2021-22
Course Title	Non-Ferrous Metal Extraction		
Course Code	MM 6604		
Course Type	Department Core		
No of credits	04		
Semester	6 th		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	B.Tech. in Materials Science and Metallurgical Engineering		
Pre-requisites	Knowledge of Principle of Extractive metallurgy		
Course Coordinator	Dr. Jayashree Baral		
Learning Hours	50 Hours		

Course Description

History of metal extraction, thermodynamic and kinetics principles of metal extraction. General principles of Metal extraction: pyro metallurgy, hydrometallurgy and electrometallurgy. Metal extraction from oxides, sulphides, halides and their refining processes

Course Objectives

To understand various metallurgical unit processes (such as roasting, reduction, smelting and electrolysis) for the extraction, and refining of the most common nonferrous metals. It also emphasizes the energy and environmental aspects of the extraction process, in addition to the current developments in the technology.

Course Content

Early developments in metal extraction

3hrs

Introduction, discovery of metals and their importance, important landmarks, nonferrous metals in Indian history, uses of nonferrous metals, Sources of nonferrous metals (Sources in land and sea, exploration methods, methods of beneficiation, nonferrous metals wealth in India)

Principles of metals extraction,

5hrs

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<p>Thermodynamic principles, homogeneous and heterogeneous reactions, Ellingham diagrams, kinetic principles, principles of electro-chemistry</p>	
<p>General methods of extraction 10hrs</p> <p>Pyrometallurgy–calcinations ,roasting and smelting, Hydrometallurgy – leaching, solvent extraction, ion exchange, precipitation, and electrometallurgy – electrolysis and electro-refining)</p>	
<p>General methods of refining 2hrs</p> <p>Basic approaches, preparation of pure compounds, purification of crude metal produced in bulk),</p>	
<p>Extraction of metals from oxide ores 10hrs</p> <p>Basic approaches and special features of specific extraction processes, extraction of metals such as magnesium, aluminum, tin</p>	
<p>Extraction of metals from sulphide ores, 10hrs</p> <p>Pyrometallurgy and hydro-metallurgy of sulphides, production of metals such as copper, lead, zinc, nickel etc.),</p>	
<p>Extraction of metals from halides 10hrs</p> <p>(Production of halides and refining methods, production of reactive and reactor metals. Methods of extraction of metals such as titanium, rare earths, uranium, thorium, plutonium, beryllium, zirconium etc</p>	
<p>Learning Outcomes</p> <p>To develop student’s knowledge of current methods to recover base metals from natural ores.</p> <p>To develop student’s individual skills at performing relevant heat, mass and thermodynamic calculations for the extraction of base metals</p>	
Teaching Learning Activities	<p>Teaching and learning modes for this course are through contact lectures, and tutorials. The lectures provide the background theory for the subject. The numerical questions are expected to be answered by the students during the tutorial sessions. The question answers and explanations will be provided by the subject coordinator.</p>
Course Assessment Methods	<p>L. Assignments and Performance in the class 20</p> <p>M. Class Test 10</p> <p>N. Mid Term Examination 20</p> <p>O. End Term Examination 50</p>
<p>Books and References</p> <ol style="list-style-type: none"> 1. A.Ghose and H. S. Ray, <i>Principles of Extractive Metallurgy</i>, Wiley Eastern, 1991 2. Extraction of non- ferrous metals by H.S .Ray, R.Sristidhr & K.P.Abraham 	

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3. Unit Processes in Extractive Metallurgy, Pehlke.R D., American Elsevier Publishing Co.. New York. USA. 1993.
4. Principles of Extractive Metallurgy, Terkel Rosenqvist, 2nd ed.McGraw-Hill International Book Co. London. 1983
5. Non Ferrous Metallurgy, Sevryukov.N. 1975. Mir. Moscow
6. Metallurgy of Non-Ferrous Metals, W.H. Dennis, Ditman, London
7. Elements of Metallurgy, Dr.Swarup & Dr.Saxena, Rastogi Publications,Meerut

Links to online references

1. Habashi, F. (2009). Recent trends in extractive metallurgy. *Journal of Mining and Metallurgy, Section B: Metallurgy*, 45(1), 1-13.
2. Habashi, F. (2005). A short history of hydrometallurgy. *Hydrometallurgy*, 79(1-2), 15-22.
3. Year, C. G. N. (1995). Bayer's process for alumina production: a historical perspective. *Bull. Hist. Chem*, 17(18), 15.

Name of Program	B.Tech (MME)	Semester-VI	Session-2021-22
Course Title	Ceramics and Polymers		
Course Code	MM 6605		
Course Type	Department Core		
No of credits	4		
Semester	6 th		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	Materials and Metallurgical Engineering (MME)		
Pre-requisites'	Basic knowledge of Materials Science Crystal Structure		
Course Coordinator	Dr. Mangesh Lodhe		
Learning Hours	50 Hours		

Course Description

This course is designed for undergraduate students of Materials and Metallurgical Engineering (MME) programme. It provides the fundamental understanding of science and applications of ceramic and polymeric materials. The course enhances the understanding of complexities in crystal structure /processing/characterization of these materials

Course Objectives

The objective of this course is to teach the students the what is ceramic and polymeric materials and how it is different from other class of materials. Students will be introduced to the science, crystal structure, processing and applications of these materials

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Course Content

Introduction: oxide and non-oxide ceramics, their chemical formulae, and typical properties. Traditional ceramics and advanced ceramics, ceramic crystal structures, defect reactions, silicate glass formation and glass formation, Solid state sintering fundamentals, Liquid phase sintering, Powder Preparation: Physical methods (different techniques of grinding), chemical routes - co-precipitation, sol-gel, hydrothermal, combustion synthesis, high temperature reaction (solid state reaction Basic principles and techniques of consolidation and shaping of ceramics: powder pressing- uniaxial, biaxial and cold isostatic and hot isostatic, injection moulding, slip casting, tape-casting, calendaring, multilayering. Characterization of powders, physical properties-particle size and shape determination, technological properties-apparent density, flow rate etc.

Basic concepts on polymers, Classification of polymers; Polymer structure: Copolymers, Tacticity, Geometric Isomerism, Nomenclature. Polymerization principles and processes Structure and properties of polymers: Amorphous state, crystalline state, Thermal transitions; Glass transition; Crystalline melting temperature; Structure property relationships, Effect of weight, composition and pressure on T_g, Mechanical properties of polymers

Learning Outcomes

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

- 1) Identify the different class of materials
- 2) Understand the science and processing of ceramic and polymeric materials.
- 3) Know the various application of these materials

Teaching Learning Activities

Mostly using White Board, 20% learning through power point, Problem solving activities
in tutorial classes, Performing experiments in laboratory

Course Assessment Methods

P. Assignments and Performance in the class **20**
Q. Class Test **10**
R. Mid Term Examination **20**
S. End Term Examination **50**

Books and References

1. Fundamental of Ceramics by Michel W. Barsoum, McGraw Hill International edition, 1997
2. Modern Ceramic Engineering by David. W. Richerson, Mercel Dekker, NY 1992
3. Ceramic Processing and Sintering by M. N. Rahman, Mercel Dekker, 2003
4. Introduction to Ceramics by W. David Kingery, H. K. Bowen, Donald R. Uhlmann
5. Physical Ceramics: Principles for Ceramic Science and Engineering by Yet-Ming Chiang, Dunbar P. Birnie, W. David Kingery

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6. Powder Metallurgy Technology, G. S. Upadhyaya
7. Powder Metallurgy: An Advanced Technique of Processing Engineering Materials, B. K. Datta
8. Polymer Science, W.Billmerycr
9. Structure & Properties of Polymeic materials, D.W. Clegg & A. A. Collyer
10. Engineering Materials Vol. I and II, Jones
11. Polymer Science & Technology, J.R.Fried
Links to online references
Link to online references will be provided to students during Lectures.

Name of Program	B.Tech (MME)	Semester-VI	Session-2021-22
Course Title	Ceramics and Polymer Lab		
Course Code	MM-6606		
Course Type	Department core - Practical		
No of credits	01		
Semester	6 th		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	B.Tech. in Materials Science and Metallurgical Engineering		
Pre-requisites'	Theory course on Physical Metallurgy, Materials Characterization		
Course Coordinator	Dr. Mangesh Lodhe		
Learning Hours	25 Hours		

Course Description

This course is designed for undergraduate students of materials and metallurgical engineering. This course provides an overview of the properties, manufacturing and design of ceramics, nanostructured ceramics, films, coatings and polymers.

Course Objectives

1. To learn different synthesis and characterization techniques of ceramics and polymers.

Course Contents

The Ceramics and Polymer lab is a compulsory, with a six hour weekly program, four hours of teaching and a two -hour practical. The lab experiments includes the following titles:

1. Characterization of ceramic raw materials.
2. Synthesis of ceramic powders
3. Manufacturing of ceramic components
4. Characterization of ceramic materials

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5. Analysis & Characterization of raw materials of polymers
6. Different techniques of polymer synthesis
7. Characterization of resins & polymers
8. Design and Fabrication of Moulds (Polymers).
9. Evaluation and Testing of Polymers

Learning Outcomes

1. Ability to understand basic concepts of polymers and applications
2. Ability to understand the general structural features of polymers
3. Manufacturing processes involved in various synthetic and natural rubber.
4. Machineries used for production and compounding process of different elastomers

Teaching Learning Activities

1. Lab experiments
2. Data plotting and analysis
3. Concept Mapping
4. Questioning
5. Formative Quizzes
6. Small group activities

Course Assessment Methods

- A. Continuous evaluation **50**
- B. End Term Examination **50**

Books and References

1. Fundamental of Ceramics by Michel W. Barsoum, McGraw Hill International edition, 1997
2. Modern Ceramic Engineering by David. W. Richerson, Mercel Dekker, NY 1992
3. Ceramic Processing and Sintering by M. N. Rahman, Mercel Dekker, 2003
4. Introduction to Ceramics by W. David Kingery, H. K. Bowen, Donald R. Uhlmann
5. Physical Ceramics: Principles for Ceramic Science and Engineering by Yet-Ming Chiang, Dunbar P. Birnie, W. David Kingery
6. Powder Metallurgy Technology, G. S. Upadhyaya
7. Powder Metallurgy: An Advanced Technique of Processing Engineering Materials, B. K. Datta
8. Polymer Science, W. Billmeyer
9. Structure & Properties of Polymeric materials, D.W. Clegg & A. A. Collyer
10. Engineering Materials Vol. I and II, Jones
11. Polymer Science & Technology, J.R. Fried

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Links to online references

Name of Program	B.Tech (MME)	Semester-VI	Session-2021-22
Course Title	Metal Forming and Powder Metallurgy Lab		
Course Code	MM-6607		
Course Type	Department core - Practical		
No of credits	01		
Semester	6 th		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	B.Tech. in Materials Science and Metallurgical Engineering		
Pre-requisites'	Theory courses on Metal forming and Powder Metallurgy		
Course Coordinator	Dr. Mangesh Lodhe		
Learning Hours	25 Hours		

Course Description

This course is designed for undergraduate students of materials and metallurgical engineering. This course provides an practical skills in designing metal forming dies, evaluate forming limits, and deform metals and alloys to required shapes.

Course Objectives

1. To design metal forming dies
2. To evaluate the forming limit in sheet metal drawing
3. Practical skills in different metal forming operations
4. Practical skills in manufacturing components by P/M

Course Contents

The metal forming and powder metallurgy is a compulsory, with a six hour weekly program, four hours of teaching and a two -hour practical. The lab experiments includes the following titles:

1. Erichsen cupping test and Forming Limit Diagram
2. Experiments to determine plastic anisotropy
3. Design of dies for metal forming
4. Machining
5. Open die and closed die forging
6. Coining, Blanking and Piercing
7. Deep drawing
8. Extrusion

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9. Synthesis of metal or ceramic powders
10. Comminution of ceramic powders: size reduction processes, crushing grinding and milling.
11. Characterization of particles, Shape and Size, specific surface area, powders colloids and agglomerates.
12. Separation and classification of particles- screening operations and screening efficiency. Size distribution curves.
13. Powder preparation, compaction and sintering
14. Manufacturing of Graphite Electrode by P/M Method
15. Manufacturing of Al Components by P/M Method

Learning Outcomes

Ability to make engineering components through metal forming and powder metallurgical techniques.

Teaching Learning Activities

1. Lab experiments
2. Data plotting and analysis
3. Concept Mapping
4. Questioning
5. Formative Quizzes
6. Small group activities

Course Assessment Methods

- A. Continuous evaluation **50**
- B. End Term Examination **50**

Books and References

1. Mechanical Metallurgy – George E. Dieter
2. Principles of Metal Working processes – G.W. Rowe
3. Metal Forming Mechanics and Metallurgy -Hosford and Caddell
4. Hot Rolling and Steels -Roberts.
5. Physical Ceramics: Principles for Ceramic Science and Engineering, Yet-Ming Chiang, Dunbar P. Birnie, W. David Kingery
6. Fundamental of Ceramics by Michel W. Barsoum, McGraw Hill International edition, 1997
7. Modern Ceramic Engineering by David. W. Richerson, Mercel Dekker, NY 1992
8. Ceramic Processing and Sintering by M. N. Rahman, Mercel Dekker, 2003
9. Handbook of Advanced Ceramics by S. Somiya, Academic Press 2003
10. Handbook of Advanced Ceramics, Parts 1 and 2, S. Somiya, Academic Press, 2006

Links to online references

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Seventh Semester

Name of Program		Semester: VII	Session-2021-22
Name of Course	Engineering Economics and IPR		
Course Code	HUM-6701		
Core / Elective / Other	Core		
Prerequisite:			
1.	Theoretical underpinning of the concepts related to Economics is crucial.		
2.	Technical knowledge and basic understanding of IPR laws is important.		
Course Outcomes:			
1.	Students would be in a position to link the concepts of Economics and Engineering		
2.	Understanding the production and related it with cash flow and payments		
3.	Students will understand the benefits of IPR		
4.	Understanding of Indian laws and acts regarding IPR		
Description of Contents in Brief:			
	<p>Introduction to Economics- Flow in an economy, Law of supply and demand, Concept of Engineering Economics – Engineering efficiency, Economic efficiency, Scope of engineering economics – Element of costs, Marginal cost, Marginal Revenue, Sunk cost, Opportunity cost, Break-even analysis – V ratio, Elementary economic Analysis – Material selection for product Design selection for a product, Process planning.</p> <p>Methods of comparison of alternatives – present worth method (Revenue dominated cash flow diagram), Future worth method (Revenue dominated cash flow diagram, cost dominated cash flow diagram), Annual equivalent method (Revenue dominated cash flow diagram, cost dominated cash flow diagram), rate of return method, Examples in all the methods.</p> <p>Make or buy decision, Value engineering – Function, aims, and Value engineering procedure. Interest formulae and their applications –Time value of money, Single payment compound amount factor, Single payment present worth factor, Equal payment series sinking fund factor, Equal payment series payment Present worth factor- equal payment series capital recovery factor – Uniform gradient series annual equivalent factor, Effective interest rate, Examples in all the methods.</p> <p>Basic concepts, characteristics and nature of Intellectual Property Right, IPR and Economic Development, major international instrument relating to the protection of IP. Meaning, Criteria for obtaining patents, Non Patentable inventions, procedure for registration, term of Patent, Rights of patentee, basic concept of compulsory license and government use of patent, infringement of patents and remedies in case of</p>		

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	infringement, Relevant Sections. Meaning of mark, trademark, and categories of trademark: Certification Mark and well known mark and Non-conventional marks, concepts of distinctiveness. Designs, GI and other forms of IP, Designs: meaning design protection, concept of original design, term of protection, relevant sections. Geographical Indication: meaning of GI, difference between GI and Trade Mark, Concept of Authorized Use, Homonymous GI, Relevant section,. Trade-secret: meaning, Criteria of Protection, relevant sections. Plant Variety, Protection and Farmer's Right: meaning, criteria of protection, relevant sections.
List of Text Books:	
1.	A. Koutsoyiannis "Modern Microeconomics'. Macmillan Education.
2.	Subbaram N.R. "Handbook of Indian Patent Law and Practice ", S. Viswanathan, Printers and Publishers Pvt. Ltd.,1998
3.	Stephen Ross and Randolph Westerfield and Jeffrey Jaffe and Bradford Jordan, "Corporate Finance', Mc Graw Hill.
List of Reference Books:	
1.	Chan Spark, "Contemporary Engineering Economics", Prentice Hall of India, 2011.
2.	Donald. Newman, Jerome.P.Lavelle, "Engineering Economics and analysis" Egg. Press, Texas, 2010.
3.	Degarmo, E.P., Sullivan, W.G and Canada, J.R, "Engineering Economy", Macmillan, New York, 2011.
4.	Zahid A khan: Engineering Economy, "Engineering Economy", Dorling Kindersley, 2012
5.	V.K. Ahuja , " Law related to Intellectual Property Rights". Publisher- Lexis-Nexi
6.	R. Radhakrishnan and S. Balasubramanian, "Intellectual Property Rights- Texts and Cases", publisher- Excel Books India.
7.	A. Koutsoyiannis "Modern Microeconomics'. Macmillan Education.
8.	Stephen Ross and Randolph Westerfield and Jeffrey Jaffe and Bradford Jordan, "Corporate Finance', Mc Graw Hill.
URLs:	
1.	https://nptel.ac.in/courses/109/104/109104125/
2.	https://nptel.ac.in/courses/110/107/110107144/
3.	http://www.ipindia.nic.in/
4.	https://nptel.ac.in/courses/109106100/
Lecture Plan (about 40-50 Lectures):	
Lecture No.	Topic
	Engg. Economics
1	Introduction to Economics and Flow in an economy
2	Law of supply and demand
3	Concept of Engineering Economics: Engineering efficiency
4	Economic efficiency
5	Scope of engineering economics
6	Element of costs: Marginal cost, Marginal Revenue, Sunk cost, Opportunity

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	cost
7	Break-even analysis: PV ratio
8	Elementary economic Analysis: Material selection for product Design selection for a product,
9	Process planning
10	Methods of comparison of alternatives: present worth method
11	Revenue dominated cash flow diagram
12	Future worth method (Revenue dominated cash flow diagram)
13	Future worth method (Cost dominated cash flow diagram)
14	Annual equivalent method (Revenue dominated cash flow diagram)
15	Annual equivalent method (Cost dominated cash flow diagram)
16	Rate of return method
17	Make or buy decision, Value engineering: Function, aims, and Value engineering procedure
18	Interest formulae and their applications: Time value of money
19	Single payment compound amount factor
20	Single payment present worth factor
21	Equal payment series sinking fund factor
22	Equal payment series capital recovery factor
23	Equal payment series capital recovery factor
24	Uniform gradient series annual equivalent factor
25	Effective interest rate
	Intellectual Property Rights
1.	Introduction to IPR, its Importance, Need and Characteristics
2.	IPR and Economic Development
3.	Major International Instrument relating to the protection of IP
4.	Patents : Meaning & Criteria for obtaining Patents
5.	Procedure for Registration & Non Patentable inventions
6.	Term of Patent and Rights of patentee
7.	Basic concept of Compulsory License
8.	Government use of Patent
9.	Infringement of patents and Remedies in case of Infringement
10.	Relevant Sections of Patents
11.	Introduction to Mark and Trademark, Rights and Limitations of Trade Marks
12.	Categories of Trademark
13.	Certification Mark, Well known Marks and Non-Conventional Marks
14.	Concepts of Distinctiveness
15.	Introduction to Design: Its meaning and Registration process
16.	Meaning of Design Protection, Concept of Original Design, Term of Design
17.	Relevant Sections of Design
18.	Meaning of Geographical Indication and Difference between GI and Trade Mark
19.	Concept of Authorized Use
20.	Homonymous GI and Relevant section of GI
21.	Trade-secret: Meaning, Criteria of Protection, Relevant Sections of it.
22.	Plant Variety, Protection and Farmer's Right: Meaning, Criteria of Protection, Relevant Sections of it.
23.	Case Studies On – Patents (Basumati Rice, Turmeric, Neem, Etc.)

Name of Program	B.Tech (MME)	Semester-VII	Session-2021-22
Course Title	Project -2 Phase -1		

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Course Code	MM 6702
Course Type	Department core - Practical
No of credits	1
Semester	7
Department	Materials and Metallurgical Engineering
U.G./P.G.	Undergraduate Programme
Programme	B.Tech. in Materials Science and Metallurgical Engineering
Pre-requisites'	Theory courses on Materials Processing and Characterization
Course Coordinator	Dr C Sasikumar
Learning Hours	25 Hours
Course Description	
<p>This course is designed for undergraduate students of materials and metallurgical engineering. This course is designed to instill the qualities of inventing novel materials, engineering structures, testing procedures, novel processing techniques etc.,</p>	
Course Objectives	
<p>.To develop innovation capabilities, engineering management, acquaintance with existing Industrial practices.</p>	
Course Content	
<p>A mentor will be assigned to group of students and the mentor will guide the students for carrying out the projects. The projects shall be in any one of the following areas</p> <ol style="list-style-type: none"> 1. Materials processing 2. Design of novel/existing engineering structures/materials 3. Advanced materials 4. Material characterization 5. Any other relevant area 	
Learning Outcomes	
<p>Out of this course the student will be able to acquire practical skills on materials processing and characterization.</p>	
Teaching Learning Activities	<p>Experimental setup</p> <p>Simulations through software</p> <p>Evaluation of the properties of materials</p> <p>Group activities</p> <p>Review of Research papers</p>
Course Assessment Methods	Continuous evaluation 100

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Books and References
Reference materials will be provided by the mentor
Links to online references

Name of Program	B.Tech (MME)	Semester-VII	Session-2021-22
Course Title	Corrosion and Surface Engineering		
Course Code	MM-6703		
Course Type	Department core		
No of credits	04		
Semester	7th		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	B.Tech. in Materials and Metallurgical Engineering		
Pre-requisites'	Nil		
Course Coordinator	Dr. Ramesh Kumar Nayak		
Learning Hours	50 Hours		

Course Description

This course is designed for undergraduate students of materials and metallurgical engineering. It provides the fundamental understanding of processing / characterization / design of engineering materials. The course enhances the understanding of complexities in processing / characterization /designing and their solutions through numerical /analytical / modeling / experiments/proto-type designs/interpretation of data. The students will be able to handle the modern equipments in processing industries/design/process novel materials based on this knowledge.

Course Objectives

The course will enable the students to understand the corrosion losses, possible failure in service and necessary remedial measures. It will also be helpful in design and selection of material

Course Content

Corrosion Principle

08 Hrs

Corrosion, Corrosion due to Electrochemical and thermodynamic principles, Nernst equation and electrode potentials of metals, EMF and galvanic series, merits and demerits; Applications.

Corrosion Type and its Prevention

18 Hrs

Polarization - concentration, activation and resistance, Tafel equation; origin of Pourbaix diagram and its importance to iron, aluminium and magnesium metals, Exchange current density, passivity, electrochemical behaviour of active/passive metals, theories of passivity Atmospheric, pitting, de-alloying, stress corrosion cracking, inter-granular corrosion, corrosion

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<p>fatigue, fretting corrosion and high temperature oxidation; causes and remedial measures,</p> <p>Measurement of Corrosion 08 Hrs</p> <p>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,</p> <p>Design Aspect of Corrosion 08 Hrs</p> <p>Corrosion prevention by design improvements, anodic and cathodic protection, metallic, non-metallic and inorganic coatings, mechanical and chemical methods and various corrosion inhibitors</p> <p>Surface Engineering 08 Hrs</p> <p>Improvement of surface properties by heat treatment, mechanical and coating methods, Evaluation of surface modified properties.</p>	
<p>Learning Outcomes</p> <p>At the end of the course the students will be able to</p> <ul style="list-style-type: none"> ➤ Understand different types of corrosion and its causes. ➤ Determine the corrosion rate by weight loss method, electrical resistance method and salt spray test. ➤ Protect the corrosion by electro and electro-less plating of different alloys. ➤ Analyze galvanic corrosion, pitting corrosion and stress corrosion cracking. ➤ Design the product to prevent corrosion through different surface treatment. 	
Teaching Learning Activities	Class room Lectures, Assignment, Tutorials, case studies, quiz, group discussion, ppt presentation, micro projects.
Course Assessment Methods	<p>A. Assignments and Performance in the class 20</p> <p>B. Class Test 10</p> <p>C. Mid Term Examination 20</p> <p>D. End Term Examination 50</p>
<p>Books and References</p> <p><u>Text Books</u></p> <ol style="list-style-type: none"> 1. Fontana M. G., Greene N. D., 'Corrosion Engineering', 2nd Edition, McGraw Hill, 1983 2. J.C. Scully: the Fundamentals of Corrosion, Pergamon. 3. S. Glasstone: An Introduction to Electrochemistry, Van Nostrand <p><u>Reference Books</u></p>	

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4. F.A.Lovenheim: Electroplating, McGraw-Hill.
5. SatyaNarain and R. Saran: An Introduction to Electrometallurgy, Standard Publishers.
6. C C.L. Mantell: Electrochemical Engineering, McGraw-Hill.
7. Denny Jones, "Principles and Prevention of Corrosion", Prentice Hall of India, 1996.

Links to online references

<https://nptel.ac.in/courses/113/104/113104082/>

<https://nptel.ac.in/courses/113/108/113108051/>

<https://nptel.ac.in/courses/113/105/113105086/>

Name of Program	B.Tech (MME)	Semester-VII	Session-2021-22
Course Title	Fracture and Failure Analysis		
Course Code	MM 6704		
Course Type	Department core		
No of credits	03		
Semester	7 th		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	B.Tech. in Materials and Metallurgical Engineering		
Pre-requisites	An undergraduate level understanding of Metallurgy for the Non-Metallurgist, Elements of Metallurgy , Metallographic Interpretation, mechanical testing		
Course Coordinator	Dr. Jayashree Baral		
Learning Hours	50 Hours		

Course Description

Failure, Failure Analysis, various modes of failure, types of failure and case study. Fracture Mechanics, Linear elastic fracture mechanics. Procedural steps for investigation: Nondestructive testing,

Course Objectives

- To understand about various modes of failure of engineering components, this leads to safe design.
- To expose to fracture mechanics and failure analysis tools

Course Content

Introduction

(3hr)

Phenomenological description of various modes of failure and fracture, an overview of the basic problems and concepts of fracture in structural materials, Failure Analysis Methodology, Tools and Techniques of Failure Analysis

Fundamentals of fracture mechanics:

17hrs

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<p>Linear elastic fracture mechanics, Crack-tip plastic zone and the elastic plastic fracture Mechanics, Fracture toughness testing, Microstructural aspect of fracture toughness, and the fracture toughness approach for toughening of structural materials.</p> <p>Non-destructive testing of defects: 5hrs</p> <p>Visual inspection, liquid penetration inspection, magnetic particle inspection, eddy current inspection, ultrasonic testing, radiographic inspection.</p> <p>Failure mode and effect analysis: 4hrs</p> <p>Phenomenological description of various modes of failure, fracture, fractography</p> <p>Different failures: 10hrs</p> <p>Fatigue failure, creep and stress rupture failures, environment-assisted failures, wear failures, common failures in castings, weldments, gears, shafts and springs, failures of composites</p> <p>Analyses of engineering failures: 10hrs</p> <p>Typical defects, macroscopic fracture surface examination, metallographic and fractographic examination, steps in failure analysis, case histories</p>	
<p>Learning Outcomes</p> <p>On completion of the course, students should:</p> <p>Understand and be able to identify the common modes of failure of engineering components and making recommendations on failure prevention.</p> <p>Understand the process of materials selection and be able to use available tools for making decisions on materials selection for engineering applications</p> <p>To be able to write a professional engineering failure analysis report</p>	
Teaching Learning Activities	<p>Teaching and learning modes for this course are through contact lectures, tutorials, and case studies. The lectures provide the background theory for the subject, while the tutorial and case studies give students hands-on experience on materials selection and failure analysis. The numerical questions are expected to be answered by the students before the tutorial sessions (all marked as part of assignment) where the answers and explanations will be provided by the subject coordinator.</p>
Course Assessment Methods	<p>A. Assignments and Performance in the class 20</p> <p>B. Class Test 10</p> <p>C. Mid Term Examination 20</p> <p>D. End Term Examination 50</p>
<p>Books and References</p> <p>1. G.E. Dieter: Mechanical Metallurgy, McGraw- Hill, 1988</p>	

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2. Deformation and fracture mechanics of engineering materials, R. W. Hertzberg
3. Elementary engineering fracture mechanics, D. Broek
4. Fundamental of fracture mechanics, J. F. Knott
5. Metallurgy of Failure Analysis. A.K. Das

Links to online references

Anderson, T. L. (2017). *Fracture mechanics: fundamentals and applications*. CRC press
 Becker, W. T., & Shipley, R. J. (Eds.). (1990). *ASM Handbook* (Vol. 11). ASM international.
 Handbook, M. (1987). vol. 12 Fractography. *ASM International Metals Park, Ohio, USA*

Name of Program	B.Tech (MME)	Semester-VII	Session-2021-22
Course Title	Corrosion and Surface Engineering Lab		
Course Code	MM-6705		
Course Type	Department Core-Practical		
No of credits	01		
Semester	7th		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	B.Tech. in Materials and Metallurgical Engineering		
Pre-requisites'	Nil		
Course Coordinator	Dr. Ramesh Kumar Nayak		
Learning Hours	24 Hours		

Course Description

This course is designed for undergraduate students of materials and metallurgical engineering. It provides the fundamental understanding of processing / characterization / design of engineering materials. The course enhances the understanding of complexities in processing / characterization /designing and their solutions through numerical /analytical / modeling / experiments/proto-type designs/interpretation of data. The students will be able to handle the modern equipments in processing industries/design/process novel materials based on this knowledge.

Course Objectives

The course will enable the students to measure the corrosion losses and rate of corrosion in different environment

Course Content

Experiments

24 Hrs

1. To determine the rate of corrosion through weight loss method in acid and alkaline medium.
2. To determine the rate of corrosion at different humidity and temperature condition

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3. To determine the corrosion rate and surface damage through salt spray test
4. To measure the potential difference in a corrosion medium
5. To develop Tafel plot for different materials at different medium
6. To observe pitting corrosion under optical microscope
7. To compare the corrosion rate between coated and uncoated steel
8. To determine the rate of water absorption of composite material in different humidity and temperature condition.
9. To coat the surface of a metal through electrolysis method and determine its wear resistance

Learning Outcomes

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

- Understand different types of corrosion and its causes.
- Determine the corrosion rate by weight loss method, electrical resistance method and salt spray test.
- Protect the corrosion by electro and electro-less plating of different alloys.
- Analyze galvanic corrosion, pitting corrosion and stress corrosion cracking.
- Design the product to prevent corrosion through different surface treatment.

Teaching Learning Activities

Class room Lectures, Assignment, Tutorials, case studies, quiz, group discussion, ppt presentation, micro projects.

Course Assessment Methods

- A. Assignments and Performance in the class 20
- B. Class Test 10
- C. Mid Term Examination 20
- D. End Term Examination 50

Books and References

Text Books

1. Fontana M. G., Greene N. D., 'Corrosion Engineering', 2nd Edition, McGraw Hill, 1983
2. J.C. Scully: the Fundamentals of Corrosion, Pergamon.
3. S. Glasstone: An Introduction to Electrochemistry, Van Nostrand

Reference Books

1. F.A.Lovenheim: Electroplating, McGraw-Hill.
2. SatyaNarain and R. Saran: An Introducton to Electrometallurgy, Standard Publishers.
3. C C.L. Mantell: Electrochemical Engineering, McGraw-Hill.

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4. Denny Jones, "Principles and Prevention of Corrosion", Prentice Hall of India, 1996.

Links to online references

<https://nptel.ac.in/courses/113/104/113104082/>

<https://nptel.ac.in/courses/113/108/113108051/>

<https://nptel.ac.in/courses/113/105/113105086/>

Name of Program	B.Tech (MME)	Semester-VII	Session-2021-22
Course Title	Internship/Training		
Course Code	MM 6706		
Course Type	Department core - Practical		
No of credits	1		
Semester	3		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	B.Tech. in Materials Science and Metallurgical Engineering		
Pre-requisites'			
Course Coordinator	Dr Ramesh Kumar Nayak		
Learning Hours	6 weeks		
Course Objectives			
.To acquire practical knowledge on Industrial iron and steel making, heat treatment, metal forming, powder metallurgy, polymer processing, ceramic processing, non-ferrous metal extraction, manufacturing and other relevant area.			
Learning Outcomes			
Out of this course the student will get practical understanding of processing materials.			
Teaching Learning Activities	Industrial Visit R&D Projects Internships Industrial Training		
Course Assessment Methods	Continuous evaluation 100 Students need to submit report and certificate acquired from the Industry/training Institute Presentations & Viva		

Eighth Semester

Name of Program	B.Tech (MME)	Semester-VIII	Session-2021-22
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Course Title	Project -2 Phase -2
Course Code	MM 6801
Course Type	Department core - Practical
No of credits	1
Semester	8
Department	Materials and Metallurgical Engineering
U.G./P.G.	Undergraduate Programme
Programme	B.Tech. in Materials Science and Metallurgical Engineering
Pre-requisites'	Theory courses on Materials Processing and Characterization
Course Coordinator	Dr C Sasikumar
Learning Hours	25 Hours
Course Description	
This course is designed for undergraduate students of materials and metallurgical engineering. This course is designed to instill the qualities of inventing novel materials, engineering structures, testing procedures, novel processing techniques etc.,	
Course Objectives	
.To develop innovation capabilities, engineering management, acquaintance with existing Industrial practices.	
Course Content	
A mentor will be assigned to group of students and the mentor will guide the students for carrying out the projects. The projects shall be in any one of the following areas	
<ol style="list-style-type: none"> 1. Materials processing 2. Design of novel/existing engineering structures/materials 3. Advanced materials 4. Material characterization 5. Any other relevant area 	
Learning Outcomes	
Out of this course the student will be able to acquire practical skills on materials processing and characterization.	
Teaching Learning Activities	Experimental setup Simulations through software Evaluation of the properties of materials Group activities Review of Research papers
Course Assessment Methods	Continuous evaluation 100

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<p>Books and References</p> <p>Reference materials will be provided by the mentor</p>
<p>Links to online references</p>

Name of Program	B.Tech (MME)	Semester-VIII	Session-2021-22
Course Title	Project -2 Phase -2		
Course Code	MM 6802		
Course Type	Other - Practical		
No of credits	1		
Semester	8		
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme	B.Tech. in Materials Science and Metallurgical Engineering		
Pre-requisites'	None		
Course Coordinator	Head of the Department		
Learning Hours	25 Hours		
Course Description			
This is a practical course to evaluate overall performance and skills of the students based on non-academic activities.			
Course Objectives			
. This course is to inculcate extra-curricular activities of the student.			
Course Assessment Methods	<p>Extra-curricular activities such as sports etc.</p> <p>Organizing/participating cultural events/student clubs/chapters, associations etc.</p> <p>Participating in competitions, seminar, conference and national events</p> <p>Social activities</p> <p>Activities demonstrating Leadership qualities</p> <p>Yoga/Swach Bharat Abhiyan programmes</p> <p>Departmental student activities</p> <p>Other relevant programs</p>		

Group -- A Department Electives

Name of Program	B.Tech (MME)	Session-2021-22
Course Title	Functional Materials	

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Course Code	MM 501	
Course Type	Departmental Elective (A)	
No of credits		
Semester		
Department	Materials and Metallurgical Engineering	
U.G./P.G.	Undergraduate Programme	
Programme	B.Tech in Materials and Metallurgical Engineering	
Pre-requisites'	Basic knowledge of structure, properties and defects of different materials.	
Course Coordinator	Dr Mangesh Lodhe	
Learning Hours	50 Hours	
Course Description		
<p>This course covers the fundamental concepts of functional materials, their properties, manufacturing techniques and industrial applications. This course focuses the properties and applications of different advanced materials in modern technology. Also includes electrical polarization and magnetization, chemical, thermal, electrical, mechanical and optical interactions in solids.</p>		
Course Objectives		
<p>To introduce fundamental principles important to functional materials, including energy band structure, charge and mass transport, electrical polarization and magnetization, chemical, thermal, electrical, mechanical and optical interactions in solids.</p>		
Course Content		No of hours
Introduction:		
Basic concept and introduction of Functional materials. Properties and creation of functional and smart materials.		10
Different functional materials and their properties:		
Fundamentals, properties and applications of shape memory alloys, metallic oxides, conducting polymers, carbon nanotubes, discotic liquid crystalline dimers, calixarenes, crown ethers, chitosan and graphene. Piezoelectric, magnetostrictive, pH-sensitive, halochromic, chromogenic, surface active and biomimetic materials, ferrofluids, electro and magnetorheological material and biomaterials.		15
Shape memory effects and its mechanism:		
Theory of Shape memory effect, response to thermal, magnetic, electrical, piezoelectric and others effects. Generation of shape memory effect, structure, phase transformation and properties, specific property characterization and		15

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<p>interpretation of information.</p> <p>Applications and future trends:</p> <p>Functional materials processing technologies. Economic aspects and applications of functional materials in aerospace, automobile, defense, solar hydrogen generation, supercapacitors, display and organic light-emitting diodes, functional adsorbents, and antimicrobial and biocompatible layer formation. Case Studies related with issues and application.</p>		10
<p>Learning Outcomes</p> <p>1. Better understanding of the relationships between different functional materials and their properties.</p> <p>2. New and improved applications based on their properties.</p>		
Teaching Learning Activities	The course is delivered through a mix of lectures, assignments and small group tutorials with hands on research training.	
Course Assessment Methods	<p>A. Assignments and Performance in the class 20</p> <p>B. Class Test 10</p> <p>C. Mid Term Examination 20</p> <p>D. End Term Examination 50</p>	
<p>Books and References</p> <p>1. Functional Materials: Preparation, Processing and Applications, S. Banerjee, A. K. Tyagi, Elsevier Publications.</p> <p>2. Functional Materials: Electrical, Dielectric, Electromagnetic, Optical and Magnetic Applications, Deborah D. L. Chung, , World Scientific Publishing Company (2010)</p> <p>3. Advanced Functional Materials, Hee-Gweon Woo, Hong Li Hee-Gweon Woo, Hong Li, Springer Science & Business Media (2011)</p> <p>4. Advanced Functional Materials, Ashutosh Tiwari and Lokman Uzun, Scrivener Publishing LLC (2015)</p>		
<p>Links to online references</p> <p>https://onlinelibrary.wiley.com/doi/book/10.1002/9781118998977</p> <p>https://www.springer.com/gp/book/9783642190773</p>		
Name of Program	B.Tech (MME)	Session-2021-22

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Course Title	Physics of Materials
Course Code	MM 502
Course Type	Departmental Elective (A)
No of credits	
Semester	
Department	Materials and Metallurgical Engineering
U.G./P.G.	Undergraduate Programme
Programme	B.Tech in Materials and Metallurgical Engineering
Pre-requisites'	Basic knowledge of structure, properties and defects of different materials.
Course Coordinator	Dr Sanjay Srivastava
Learning Hours	50 Hours
Course Description	
Course Contents	
<p>Classification of solids by binding force, Group theory and crystallographic, some typical crystal structure. Miller indices, Bragg and von laue diffraction, structure determination, Neutron and electron diffraction in crystals.</p> <p>One electron Model, the Kroning Penney Model, band structure, metal, insulator and semiconductor, Effective mass, DOS, concept of holes.</p> <p>Elastic waves, DOS of a continuous medium, Specific heat models of Einstein and Debye. Thermal conductivity, Microwave ultrasonic, Lattice optical properties in the infrared.</p> <p>Important defects in solids, shallow and deep impurity level in semiconductors, color centers, diffusion, edge and screw dislocation, cold –filed emission</p> <p>The free electron model-electrical and thermal conductivity in metals, the AC conductivity and optical properties. Semiconductors-carries concentration, impurities states, electrical conductivity and mobility. Optical properties and absorption processes in semiconductor. Dielectrics and optical properties of solids-source of polarizibility, piezoelectricity and ferroelectricity. Magnetic properties, magnetic susceptibility, classification of materials, Dia, para and ferromagnetism, ferrites, superconductivity-zero resistance, Meissner effect, the critical field, electrodynamic of super conductors, transition temperature, High T_c superconductor.</p> <p>Microstrutre and imperfection, diffusion in solids, Non-crystalline and glassy materials-structure, thermodynamics, glass transition and related models, Amorphous semiconductors-electrical and optical properties, switching and device application.</p> <p>Liquid Crystals-classification, orientation order and intermolecular forces, elasticity, magnetic effects, optical properties, optical properties & application, Polymers-effect-of temperature, mechanical and electrical properties.</p>	
Learning Outcomes	

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Teaching Learning Activities	The course is delivered through a mix of lectures, assignments and small group tutorials with hands on research training.
Course Assessment Methods	A. Assignments and Performance in the class 20 B. Class Test 10 C. Mid Term Examination 20 D. End Term Examination 50

Books and References

1	Introduction to solid state physics	Arun Kumar
2	Introduction to Solid State Physics, Charles Kittel,	John Wiley & Sons 1991
3	Electrical Properties of Materials,	L. Solymar and D. Walsh, Oxford University press, 1998.
4	Physics of Solids,	C. A. Wert and R.M. Thomson, McGraw-Hill Book Company, 1970 or later

Links to online references

Lecture Plan

S.No.	Course Content	Number of Classes
1	Classification of solids by binding force, Group theory and crystallographic, some typical crystal structure. Miller indices,	02
2	Bragg and von laue diffraction, structure determination, Neutron and electron diffraction in crystals.	05
3	One electron Model, the Kroning Penney Model	03
4	band structure, metal, insulator and semiconductor, Effective mass, DOS, concept of holes.	05
5	Elastic waves, DOS of a continuous medium, Specific heat models of Einstein and Debye.	03
6	Thermal conductivity, Microwave ultrasonic, Lattice optical properties in the infrared.	03
7	Important defects in solids, shallow and deep impurity level in semiconductors, color centers, diffusion, edge and screw dislocation, cold –field emission	03
8	The free electron model-electrical and thermal conductivity in metals, the AC conductivity and optical properties.	04
9	Semiconductors-carries concentration, impurities states, electrical conductivity and mobility. Optical properties and absorption processes in semiconductor.	05
10	Dielectrics and optical properties of solids-source of polarizability, piezoelectricity and ferroelectricity.	04
11	Magnetic properties, magnetic susceptibility, classification of materials, Dia, para and ferromagnetism, ferrites,	02
12	superconductivity-zero resistance, Meissner effect, the critical	05

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	field, electrodynamic of super conductors, transition temperature, High Tc superconductor.	
13	Microstructure and imperfection, diffusion in solids, Non-crystalline and glassy materials-structure, thermodynamics, glass transition and related models	04
14	Amorphous semiconductors-electrical and optical properties, switching and device application.	03
15	Liquid Crystals-classification, orientation order and intermolecular forces,	03
16	elasticity, magnetic effects, optical properties, optical properties & application, Polymers-effect-of temperature, mechanical and electrical properties	05

Name of Program	B.Tech (MME)	Session-2021-22
Course Title	Destructive and Non-Destructive Testing	
Course Code	MM-503	
Course Type	Department Elective A	
No of credits		
Semester		
Department	Materials and Metallurgical Engineering	
U.G./P.G.	Undergraduate Programme	
Programme	B.Tech. in Materials Science and Metallurgical Engineering	
Pre-requisites'	NA	
Course Coordinator	Dr. Ramesh Kumar Nayak	
Learning Hours	50 Hours	

Course Description

This course is designed for undergraduate students of materials and metallurgical engineering. It provides the fundamental understanding of processing/characterization/design of engineering materials. The course enhances the understanding of complexities in processing/characterization/designing and their solutions through numerical/analytical/modelling/experiments/proto-type designs/interpretation of data. The students will be able to handle the modern equipments in processing industries/design/process novel materials based on this knowledge.

Course Objectives

5. To understand of the different types of destructive and non-destructive testing principles and their application
6. To evaluate the properties of materials by destructive and non-destructive testing
7. To analysis the Economics, Environment, Health and Safety Aspects

Course Content

Introduction to Materials and Their Applications

05 hours

Classification of materials and their basic properties, Application of materials in different

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industries and their significance	
Destructive Testing	20 hours
Basic principles of stress-strain diagram, engineering stress-strain and true stress- strain for metals, polymers, ceramics and their composites. Evaluation of compressive, flexural or three point bend test properties, Creep properties, fatigue properties, Strengthening mechanism of materials.	
Non-Destructive Testing	25 Hours
Principle and application of visual testing, dye penetrant inspection, leak testing, magnetic particle inspection, radiography, Ultrasonic, Acoustic emission, eddy current test and etc.	
Learning Outcomes	
At the end of the course, the students will be able to	
<ul style="list-style-type: none"> 6. Explain the principle behind the destructive and non-destructive testing 7. Select the correct testing procedure to evaluate the materials properties 8. Judge the testing results carefully 9. Design the methods to evaluate the properties of material 	
Teaching Learning Activities	Class room Lectures, Assignment, Tutorials, case studies, quiz, group discussion, ppt presentation, micro projects and Industrial Visits.
Course Assessment Methods	<ul style="list-style-type: none"> A. Assignments and Performance in the class 20 B. Class Test 10 C. Mid Term Examination 20 D. End Term Examination 50
Books and References	
Text Books	
<ul style="list-style-type: none"> 1. George E. Dieter, Mechanical Metallurgy, Tata McGraw-Hill Education in 2013 2. Baldev Raj, T. Jayakumar, M. Thavasimuthu, Practical Non-destructive Testing, Woodhead Publishing, 2002 3. J Prasad, C. G. Krishnadas Nair, Destructive Test and Evaluation of Materials, Second Edition, McGraw Hill Education (India) Private Limited 	
Reference Books	
<ul style="list-style-type: none"> 1. Ida, Nathan, Meyendorf, Norbert (Eds.), Handbook of Advanced Nondestructive Evaluation, Springer Nature Switzerland AG 2019 	
Links to online references	

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https://nptel.ac.in/courses/113/106/113106070/
https://nptel.ac.in/courses/112/104/112104203/
https://nptel.ac.in/courses/113/104/113104096/

Name of Program	B.Tech (MME)	Session-2021-22
Course Title	Composite Materials	
Course Code	MM 504	
Course Type	Department Electives	
No of credits		
Semester		
Department	Materials and Metallurgical Engineering	
U.G./P.G.	Undergraduate Programme	
Programme	Materials Science and Metallurgical Engineering (MSME)	
Pre-requisites'	Basic knowledge of Materials Science	
Course Coordinator	Dr Sanjay Srivastava /Dr. Mangesh Lodhe	
Learning Hours	50 Hours	

Course Description

This course is designed for undergraduate students of Materials and Metallurgical Engineering (MME) programme. It provides the fundamental understanding of composite materials. The course also focusses on the wide applications of composite materials.

Course Objectives

The objective of the course is to teach the student for the various aspects of composite materials and profitable to understand the basic concept of processing route to produce the light composite materials for different engineering application. The course provides the detail knowledge of strengthening of composite materials and their application in different suitable fields.

Course Content

Types of Composites, Reinforcements, Whiskers, Laminar composites, Flake composites, Filled composites, Particulate reinforced composites, Cremates, Micro-spheres, Solidification of composites. Economics of Composites and Reinforcements, Design of Composite Materials, Mechanics of composites, Applications of Composites. Stress – strain relations for orthotropic, anisotropic materials, Plane stress problems, strength theories, mechanics of laminates, symmetric and non symmetric laminates. Unidirectional fiber composites, Critical volume fraction, Discontinuous fiber composites, Rule-of mixtures equation, Critical angle, Analysis of composite plates and shells. Interfacial bonds, interfacial strength, Laminated metal composites, Ceramic materials, Ceramic-metal systems, Ceramic glass system, Geometric relationships, Ceramic-ceramic systems, Thermal conductivity, Thermal expansion. Metal Matrix Composites, Reinforcement, Reinforcement selection, Matrix selection, effects of reinforcements, Properties, Fabrication, Whisker reinforcement, Whisker composite properties.

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Al-composite foam, functionally gradient composite materials. Composite material for automobile, aerospace and general Engineering applications. Ceramic Matrix Composites: Particulate reinforced composites, Continuous fiber reinforced composites, Chopped fiber and whisker reinforced composites, Fabrication processes, Properties.

Learning Outcomes

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

- 4) Understand the concept of the composite materials
- 5) Design of the composite materials by selecting the different types of the matrix and reinforcement for different engineering application.
- 6) Apply the basic concept of types of composite materials for various applications.

Teaching Learning Activities

Mostly using White Board, 20% learning through power point, Problem solving activities
in tutorial classes, Performing experiments in laboratory

Course Assessment Methods

- A. Assignments and Performance in the class **20**
- B. Class Test **10**
- C. Mid Term Examination **20**
- D. End Term Examination **50**

Books and References

1. Composite Materials, K.K. Chawla
2. Composite Materials, Lawrence J. Broutman
2. Composite Materials, R.M. Jones

Links to online references

Other Link to online references will be provided to students during Lectures.

Lecture Plan

S.No.	Course Content	Number of Classes
1	Types of Composite, Types of Matrix, Reinforcement	04
2	Whisker, Sandwich, Laminar composite, Flake composite, Filled composite, Cremates, Anisotropic materials,	05
3	particulate reinforcement composite	03
4	ceramic composite, polymer composite, carbon-carbon composite, metal matrix composite	06
5	Difference between alloy and composite,	02
6	Solidification of composite,	02
7	General concept of surface tension, contact angle, Design of composite materials	05

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8	Application of composite materials	04
9	Stress-strain relation of composite materials, stiffness,	05
10	Selection of reinforcement, selection of matrix, Al-composite foam	04
11	Economics of composite and reinforcement,	02
12	Continuous and Discontinuous fiber composite,	04
13	Rule of mixture, effect of reinforcement, concept of dislocation , concept of strengthening mechanism and dislocation pile-up,	04
14	chopped fiber and whisker reinforced composite,	02
15	Composite materials for automobile and aerospace application, composite materials for general engineering application,	03
16	Fabrication processes and Properties	03

Name of Program	B.Tech (MME)	Session-2021-22
Course Title	Polymer Engineering	
Course Code	MM505	
Course Type	Department Elective	
No of credits		
Semester		
Department	Materials and Metallurgical Engineering	
U.G./P.G.	Undergraduate Programme	
Programme	B.Tech. in Materials Science and Metallurgical Engineering	
Pre-requisites'	Nil	
Course Coordinator	Dr. Ramesh Kumar Nayak	
Learning Hours	50 Hours	

Course Description

This course is designed for undergraduate students of materials and metallurgical engineering. It provides the fundamental understanding of processing/characterization/design of engineering materials. The course enhances the understanding of complexities in processing/characterization/designing and their solutions through numerical/analytical/modelling/experiments/proto-type designs/interpretation of data. The students will be able to handle the modern equipments in processing industries/design/process novel materials based on this knowledge.

Course 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 to Polymer Engineering

08 hours

Classification of polymers, Polymerization reactions. Polymer characterization, thermal, mechanical and electrical properties, polymer crystalline, structure property correlations in polymers.

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Polymer Engineering		16 hours
Raw materials for production, Polymer processing techniques; fabrication of special polymer products. Introduction and classification of composite materials, strengthening mechanisms in composites, Reinforcing materials: fibres, whiskers and particles. Manufacture of glass fibres, fabrication of fibre reinforced plastics. Industrial manufacturing process of composites: Hand lay-up, spray forming, filament winding, pultrusion, resin transfer moulding, injection moulding,		
Polymer matrix composites		14 hours
Principles of composites, micromechanics of composites. Various types of reinforcements and their properties. Role of interfaces. Fabrication of Polymer matrix composites , composite coatings by electro-deposition and spray forming, nanocomposites, manufacturing of nanocomposites,		
Properties Evolutions and Applications		12 hours
Mechanical physical properties of composites. Mechanisms of fracture in composites. Property evaluation and NDT of composites. Wear and environmental effects in composites. Machining aspect of composites, Environmental effect of composites.		
Learning Outcomes		
At the end of the course the students will be able to		
<ul style="list-style-type: none"> ➤ Learn different types of polymer and their physical and mechanical properties ➤ Evaluate the physical and mechanical properties of polymer and polymer composites ➤ Understand different types of manufacturing process and their applications ➤ Select the polymer for a particular applications ➤ Design the composite to improve the physical and mechanical properties 		
Teaching Learning Activities	Class room Lectures, Assignment, Tutorials, case studies, quiz, group discussion, ppt presentation, micro projects	
Course Assessment Methods	A. Assignments and Performance in the class 20 B. Class Test 10 C. Mid Term Examination 20 D. End Term Examination 50	
Books and References		
Text Book		
<ol style="list-style-type: none"> 1. K.K. Chawla,,: Composite Materials, Springer 2. T. W. Clyne, D. Hull, An Introduction to Composite Materials,3rd edition, Cambridge University Press, 2019 		
Reference Book		

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1. M.M. Schwartz: Composite Materials Handbook, McGraw-Hill Book company, New York.
2. Ramesh Kumar Nayak, Bankim Chandra Ray, Dibyaranjan Rout, Kishore Kumar Mahato, Hydrothermal Behavior of Fiber- and Nanomaterial-Reinforced Polymer Composites, CRC Press, 2020.

Links to online references

<https://nptel.ac.in/courses/113/105/113105028/>

<https://nptel.ac.in/courses/112/107/112107221/>

<https://nptel.ac.in/courses/112/104/112104229/>

Name of Program	B.Tech (MME)	Session-2021-22
Course Title	Additive Manufacturing	
Course Code	MME 506	
Course Type	Department Elective A	
No of credits		
Semester		
Department	Materials and Metallurgical Engineering	
U.G./P.G.	Undergraduate Programme	
Programme	B.Tech. in Materials and Metallurgical Engineering	
Pre-requisites'	Material Science & Engineering Powder Metallurgy, Manufacturing Processes	
Course Coordinator	Dr. Ramkishor Anant	
Learning Hours	50 Hours	

Course Description

This course is designed for undergraduate students of materials and metallurgical engineering. The basic principle of AM is that a model, initially generated using a three-dimensional Computer Aided Design (3D CAD) system, can be fabricated directly. AM processes can be categorized by the type of material used, the deposition technique or by the way the material is fused or solidified. The main objective of this course is to acquaint students with the concept of AM, various AM technologies, selection of materials for AM, modeling of AM processes, and their applications in various fields.

Course Objectives

To Understand the additive manufacturing process, polymerization and powder metallurgy process.

To Understand characterisation techniques in additive manufacturing.

To understand importance of additive manufacturing in advance manufacturing process.

To acquire knowledge, techniques and skills to select relevant additive manufacturing process.

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To Solve complex materials , metallurgical and manufacturing problems for significant technological development.

To explore the potential of additive manufacturing in different industrial sectors.

To apply 3D printing technology for additive manufacturing.

Course Content

Introduction to Additive Manufacturing

No of hours: 7

Overview, Basic principle need and advantages of additive manufacturing, Procedure of product development in additive manufacturing, Classification of additive manufacturing processes, Materials used in additive manufacturing, Challenges in Additive Manufacturing.

Material Science for AM

No of hours: 10

Discussion on different materials used Use of multiple materials,

multifunctional and graded materials in AM Role of solidification rate Evolution of non-equilibrium structure Structure property relationship, Grain structure and microstructure, Choosing Materials for Manufacturing, Multiple Materials Metal AM Processes & Materials Composite Materials Biomaterials, Polymer materials, Heirarchical Materials & Biomimetics Ceramics & Bio-ceramics Shape-Memory Materials, 4D Printing & Bio-active materials Advanced AM Materials

Concepts of Material Processing for AM

No of hours: 12

Polymer Processing: Methods of spinning for additive manufacturing: Wet spinning, Dry spinning. Biopolymers, Compatibility issues with polymers. Moulding and casting of polymers, Polymer processing techniques General Concepts: Introduction and History of Powder Metallurgy (PM), Present and Future Trends of PM Powder Production Techniques: Different Mechanical and Chemical methods, Atomisation of Powder, other emerging processes. Characterization Techniques: Particle Size & Shape Distribution, Electron Microscopy of Powder, Interparticle Friction, Compression ability, Powder Structure, Chemical Characterization Microstructure Control in Powder: Importance of Microstructure Study, Microstructures of Powder by Different techniques. Powder Shaping: Particle Packing Modifications, Lubricants & Binders, Powder Compaction & Process Variables, Pressure & Density Distribution during Compaction, Isotactic Pressing, Injection Moulding, Powder Extrusion, Slip Casting, Tape Casting, Mold making. Sintering: Theory of Sintering, Sintering of Single & Mixed Phase Powder, Liquid Phase Sintering Modern Sintering Techniques, Physical & Mechanical Properties Evaluation, Structure-Property Correlation Study, Modern Sintering techniques, Defects Analysis of Sintered Components

AM Technologies

No of hours: 8

Powder-based AM processes involving sintering and melting (selective laser sintering, shaping, electron beam melting. involvement). Printing processes (droplet based 3D, Solid-based AM processes - extrusion based fused

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deposition modelling, object Stereolithography, Micro- and nano-additive

Post-processing in AM

No of hours: 8

Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques, Brief information on characterization techniques used in additive manufacturing, Applications of additive manufacturing in rapid prototyping, rapid manufacturing, rapid tooling, repairing and coating.

Application of AM

No of hours:5

Direct Digital Manufacturing Distributed Manufacturing Mass Customization Biomedical Applications Aerospace & Automotive Applications Architectural Engineering Food & Consumer Applications Personalized Surgery Art, Fashion, Jewelry, Toys & Other Applications

Learning Outcomes

Able to define the various process used in Additive Manufacturing.

Able to analyse and select suitable process and materials used in Additive Manufacturing.

Able to identify, analyse and solve materials related problems in Additive Manufacturing.

Able to apply knowledge of additive manufacturing for various real-life applications.

Teaching Learning Activities

Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, interactive teaching, educational visits, small projects.

Course Assessment Methods

- A. Assignments and Performance in the class **20**
- B. Class Test **10**
- C. Mid Term Examination **20**
- D. End Term Examination **50**

Books and References

1. Ian Gibson, David W. Rosen, Brent Stucker, Additive manufacturing technologies: rapid prototyping to direct digital manufacturing Springer, 2010.
2. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers, 2011.
3. J.D. Majumdar and I. Manna, Laser-assisted fabrication of materials, Springer Series in Material Science, e-ISBN: 978-3-642- 28359-8.
4. L. Lu, J. Fuh and Y.-S. Wong, Laser-induced materials and processes for rapid prototyping, Kluwer Academic Press, 2001.
5. Zhiqiang Fan and Frank Liou, Numerical modeling of the additive manufacturing (AM) processes of titanium alloy, InTech, 2012.

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6. P. C. Angelo and R. Subramanian: Powder Metallurgy- Science, Technology and Applications, PHI, New Delhi, 2008.

Links to online references

Name of Program	B.Tech (MME)	Session-2021-22
Course Title	Selection and Design of Materials	
Course Code	MM 507	
Course Type	Department Elective (A)	
No of credits		
Semester		
Department	Materials and Metallurgical Engineering	
U.G./P.G.	Undergraduate Programme	
Programme	B.Tech. in Materials and Metallurgical Engineering	
Pre-requisites'	Nil	
Course Coordinator	Dr. S. Das	
Learning Hours	50 Hours	

Course Description

Introduction: Need Identification and Problem Definition, Concept Generation and Evaluation, Selection of Materials and Shapes, Properties of Engineering Materials, Co-selection of Materials and Shapes, Materials and Design ,Evolution of Engineering Materials, Evolution of Engineering Materials, Material Resource in Indian Context, Case Study: Materials Selection for Vehicle Body. Selection of Manufacturing Processes Review of Manufacturing Processes, Design for Sheet Metal Forming Processes, casting and heat treatment process. Design for Reliability and Quality Failure Mode and Effect Analysis, Design for Quality, Design for Reliability, Approach to Robust Design, Design for Optimization. The Role of Shape Factors in Material Selection Material Selection using Ashby Method, Material Selection using Ashby Method ,Case Study, Multiple Constraints in material selection, Multiple Objectives, Role of Materials in Shaping the Product Character.

Course Objectives

Objective of this course is to teach the students the various aspects of Selection and design of materials. This is based on Ashby's material design chart. Reliability, robust product design, constraints, effect analysis optimum product design will be covered in this course. Various manufacturing processes including design of casting technology, investment casting, squeeze casting, riser design etc will be included. Designing sheet metal forming and design of forming limit diagram will be covered in this course.

Course Content

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Materials Selection and Ashby's Chart and shape factors

No of hours: 7

Materials Selection for Engineering Design Application, Material Index, Design Flow Chart, Doubling time, Eco-efficiency, Resource Availability Ashby Chart, Materials Selection for Cantilever Design, Materials Selection for Connecting Rod , Shape Factor, Numerical

Materials Selection for Vehicle Body

No of hours:4

Automotive body and chassis, Light weighting concept for auto body, Ways to achieve weight reduction, Lightweight advanced materials, Advanced high strength steel, Al, Mg and Composite materials in vehicle application,

Material design for reliability

No of hours:3

Cost of Reliability, Design of Reliability, how to improve reliability, Measure of Reliability, Bath-tub-curve, System reliability, Numerical

Robust Product Design

No of hours: 3

Robust Parameters, Parameter (P) diagram, Taguchi Loss Function, Full Factorial Design of Experiments, Taguchi Orthogonal Experimental plan

Multiple constraints

No of hours:4

Deformation behaviour of single crystal, Concept of critical resolved shear stress, Hall- Petch equation, concept various strengthening mechanism

Failure mode and effect analysis (FMEA)

No of hours: 3

When and how to use FMEA, Technique to use FMEA, Calculate Risk Priority number, Implementation of FMEA, Benefit of FMEA.

Optimum Design

No of hours:3

Single variable optimization, Optimization problems

Manufacturing Processes

No of hours:6

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Need, Advantages and limitations, Casting, Forming, Joining, Machining and Regeneration processes. Green sand and moulding processes, Properties of moulding sand, gravity die casting, shell moulding, squeeze casting, Investment casting, continuous casting, Additive Manufacturing

Moulding Sand Test and Riser Design

No of hours:7

Creep failure of material deformation at high temperature, stages of creep, stress rupture, creep resistant alloys

Main Title: **Sheet metal forming process**

No of hours:5

Formability of Sheet metal, Processes of Sheet Metal Forming, Defects in sheet metal forming, Erichsen Cupping Test

Deep Drawing,

No of hours:5

Designing of Deep drawing, limiting drawing ratio, Forming Limit Diagram, Planer Anisotropy

Learning Outcomes

The outcome of this course would be to understand the students the basic concept and selection methods and design of materials for different applications. How to use Ashby's chart for material selection would be a basic outcome. Students will learn how to design various casting and forming of metals and alloys.

Teaching Learning Activities

Mostly using White Board, 10% learning through power point, Problem solving activities in the classes

Course Assessment Methods

- A. Quiz, Assignments and Performance in the class **20**
- B. Class Test **10**
- C. Mid Term Examination **20**
- D. End Term Examination **50**

Books and References

1. Materials and Design: The Art and Science of Material Selection in Product Design, by Michael F. Ashby, **and K Johnson**
2. Materials Selection Engineering Design, By Mahmoud M. Faraq, Publisher: **Prentice Hall**
2. Engineering Design - a materials and processing approach G Dieter
- 3 Material Selection in Mechanical Design M F Ashby
4. Mechanical Behaviour of Materials Thomas H. Courtney

Links to online references

Link to online references will be provided to students during Lectures.

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Course Title	Biomaterials	
Course Code	MME 508	
Course Type	Department Elective (A)	
No of credits		
Semester		
Department	Materials and Metallurgical Engineering	
U.G./P.G.	Undergraduate Programme	
Programme	B.Tech in Materials and Metallurgical Engineering	
Pre-requisites'	Basic concepts of different types of materials and their chemical and engineering properties.	
Course Coordinator	Dr Sanjay Srivastava/ Dr Mangesh Lodhe	
Learning Hours	50 Hours	
Course Description	This course deals with nonviable materials used in a medical device intended to interact with biological systems where the materials are expected to perform with an appropriate host response in a specific application.	
Course Objectives	The primary objective of this course is to teach the chemistry and engineering skills needed to solve challenges in the biomaterials. Apply the math, science, and engineering knowledge gained in the course to biomaterial selection and design.	
Course Content	<p>Introduction of material science: Introduction to basic concepts of materials science. Correlate with different biomaterials.</p> <p>Classification of biomaterials: Classes of materials used in medicine: metals, polymers, nanocomposites. Bioinert, bioactive and bioresorbable ceramics and glasses. Important biometallic alloys: Ti-based, stainless steels, Co-Cr-Mo alloys.</p> <p>Host reactions to biomaterials: Property requirement of biomaterials, Concept of biocompatibility, Cell-material interactions and foreign body response. Assessment of biocompatibility of biomaterials. In vitro and in vivo biochemical assays. Synthesis of biocompatible coatings on structural implant materials.</p> <p>Design of materials for biomedical applications: Design concept of developing new materials for bioimplant applications. Cardiovascular, dental implants, orthopedic application, biomedical and biosensors. Implantation techniques for soft tissue and hard tissue replacements. Problems and possible solutions in implant fixation and failure analysis of medical devices and implants. Case studies of different biomaterials.</p>	<p>No of hours 5</p> <p>15</p> <p>15</p> <p>15</p>
Learning Outcomes	It will help the students to understand the current biomaterials scene, know how these materials are fabricated and their applications. The students will also able to design devices for specific scientific, industrial	

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	and medical applications using current biomaterials.
Teaching Learning Activities	The course is delivered through a mix of lectures, assignments and small group tutorials with hands on research training.
Course Assessment Methods	A. Assignments and Performance in the class 20 B. Class Test 10 C. Mid Term Examination 20 D. End Term Examination 50
Books and References	1. Biomaterials Science: An introduction to Materials in Medicine, Edited by Ratner, Hoffman, Schoet and Lemons, Second Edition: Elsevier Academic Press, 2004. 2. Comprehensive structural integrity, Vol.9: Bioengineering Editors: Mithe, Ritchie and Karihalo, Elsevier Academic Press, 2003. 3. Biomaterials Science and Biocompatibility, Fredrick H. Silver and David L. Christiansen, Piscataway, Springer, New Jersey 4. Biological Performance of Materials: Fundamentals of Biocompatibility, Janathan Black, Marcel Dekker, Inc., New York and Basel, 1981. 5. Biomaterials: Principles and Applications, J.B. Park and J.D. Bronzino. CRC Press. 2002. ISBN: 0849314917
Links to online references	https://www.elsevier.com/books/biomaterials-science/ratner/978-0-08-047036-8 https://link.springer.com/book/10.1007/978-1-4612-0557-9 https://www.routledge.com/Biomaterials-Principles-and-Applications/Park-Bronzino/p/book/9780849314919

Course Title	Advanced Steel Making
Course Code	MM 509
Course Type	Department Elective A
No of credits	
Semester	
Department	Materials and Metallurgical Engineering
U.G./P.G.	Undergraduate Programme
Programme	B.Tech. in Materials and Metallurgical Engineering
Pre-requisites'	MME 2203 Iron and steel Making MME 2102 Thermodynamics of Materials MME 2201 Design of Metallurgical Processes
Course Coordinator	Dr Ramkishor Anant
Learning Hours	50 Hours
Course Description	This course is designed for undergraduate students of materials and metallurgical engineering. It provides the fundamental understanding of processing/characterization/design of engineering materials. The course enhances the understanding of complexities in processing/characterization/designing and their solutions through numerical/analytical/modelling/experiments/proto-type designs/interpretation of data. The students will be able to handle the modern equipments in processing industries/design/process novel materials based on this knowledge.
Course Objectives	This course covers the both science and technology Secondary steel making covering both theory and industrial practices. It covers processes

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	through deoxidation, decarburization, degassing, alloying, ladle and tundish metallurgy
Course Content	<ol style="list-style-type: none"> 1. Introduction to Secondary Steelmaking 2 hours History of Secondary steelmaking, Current trends in steel quality demands 2. Review of Thermodynamic and Kinetic Fundamentals 2 hours Activity, Slag basicity, Fluid flow, Mass transfer kinetics, Mixing 3. Deoxidation, Degassing, Decarburizing 15 hours Thermodynamics, Kinetics, and Fluid flow Calculations for Deoxidation, Degassing and Decarburizations Vacuum Methods Ultra Low Carbon steel, Stainless Steel 4. Composition Adjustment 10 hours Desulfurization, Dephosphorization, Alloying, Injection metallurgy 5. Temperature Adjustment 5 hours Chemical heating, Ladle heating 6. Ferroalloy production 10 hours Classification, Thermodynamics in Production of Ferroalloys, Ferro-chrome, Ferro-Manganese, Silicon Alloys 7. Clean Steel Technologies 4 hours Tundish metallurgy, Teeming Process, Cleanliness control 8. Steel Quality 2 hours Non-metallic inclusions, Casting and Exogenous entrapments, Cracks and Defects
Learning Outcomes	<p>At the end of this course students will be able to:</p> <ol style="list-style-type: none"> 1) Identify the need of different grades and alloys of steel 2) Calculate the process parameters for deoxidation, degassing, decarburizing processes 3) Map the required Compositional adjustment treatments with needed grades 4) Identify the ferroalloy production routes 5) Estimate the control parameters for Clean steel production 6) Identify the issues related to Steel quality and know its genesis.
Teaching Learning Activities	<ol style="list-style-type: none"> 1) Introducing various grades of steel and different ferroalloy 2) Describing deoxidation, decarburizing, degassing processes 3) Studying the composition and temperature adjustment treatments 4) Introducing to the issues relate to steel quality 5) Mapping steel defects with its process genesis.
Course Assessment Methods	<ol style="list-style-type: none"> A. Assignments and Performance in the class 20 B. Class Test 10 C. Mid Term Examination 20 D. End Term Examination 50
Books and References	<p>Textbook:</p> <ol style="list-style-type: none"> 1. "Secondary Steelmaking Principles and Applications" by Ahindra Ghosh, CRC Press, Florida, 2001

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	References: 2. "Chapter 1.6: Secondary Steelmaking" by L. Holappa, in "Treatise of Process Metallurgy" edited by S. Seetharaman, Elsevier, 2014 3. "Chapter 1.10: Production of Ferroalloys" by R. F. Eric, in "Treatise of Process Metallurgy" edited by S. Seetharaman, Elsevier, 2014
Links to online references	https://www.worldsteel.org/ https://steeluniversity.org/ https://steel.gov.in

Course Title	Nuclear Materials
Course Code	MM 510
Course Type	Department Elective A
No of credits	
Semester	
Department	Materials and Metallurgical Engineering
U.G./P.G.	Undergraduate Programme
Programme	B.Tech. in Materials and Metallurgical Engineering
Pre-requisites'	Iron and steel Making Thermodynamics of Materials Design of Metallurgical Processes
Course Coordinator	Dr Sanjay Srivastava
Learning Hours	50 Hours
Course Description	
Course Objectives	

Course Content

Basic nuclear Physics, Nuclides, isotopes, Radiation source-alpha, beta, gamma source, neutron source, spontaneous fission source and synchrotron source. Interaction of gamma rays, charge particles and neutron with matter-photoelectric absorption, Compton scattering, pair production, electromagnetic shower in high energy photon and electron interaction with matter: energy loss of heavy charged particles in matter, electronic stopping power, (Bohr and Bathe-Bloch formulae), Cerenkov radiation: energy loss of electron and positron, electronic stopping and energy loss by bremsstrahlung radiation. Neutron elastic scattering, inelastic scattering, radiative capture (n,p), (n,2n), (n,a), (n, fission) reactions.

Radiation shielding for neutrons, photons and charged particles. Design of radiation shields, including neutrons, photons and charged particles. Dosimetric quantities, materials selection and energy deposition in shields. Techniques for dose estimation including buildup factors, neutron removal cross-sections. Industrial applications — tracing, gauging, material modification, sterilization, food preservation and other applications.

Nuclear chart. Nuclear mass, binding energy and stability, radioactive decay, nuclear reactor. Measurement of nuclear reaction products: charged particles, neutron, gamma radiation, Radiation Physics, Ionizing radiation, dose concepts radiation environment. Nuclear energy, Fission Fuel cycle and waste management, reactor power control, fusion,

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Medical applications — Projection imaging, imaging with external radiation and internal radiation, computerized tomography, positron emission tomography, magnetic resonance imaging, radiation therapy — using photons and electrons, radionuclides, neutrons and heavy charged particles. Biological effects of radiation — direct and indirect physical damage, indirect chemical damage, dose, dose rate and dose distributions, Dose limits, Regulatory requirement, Damage to critical tissues — complex molecules, nucleic acids and damage repair. Human exposure to radiation, radiation in environment, evaluation of dose — external radioactive source and inhaled and ingested radioactivity, risk assessment, risk to occupationally exposed workers, radiation protection and measurement.

Learning Outcomes

Teaching Learning Activities

Course Assessment Methods

- A. Assignments and Performance in the class **20**
- B. Class Test **10**
- C. Mid Term Examination **20**
- D. End Term Examination **50**

Books and References

1	Absorption of Ionizing Radiation,	David W. Anderson, University Park Press — Baltimore (1984).
2	Introduction to Radiological Physics and Radiation Dosimetry,	Frank H. Attix, John Wiley & Sons (1986).
3	Interaction of Photons and Neutrons with Matter,	S.H. Chen and M. Kotlarchyk, World Scientific (1997).
4	Radiation and Radiation Protection,	James Turner's Atoms, 2nd edition, Wiley & Sons, Inc. (1995).
5	Techniques for Nuclear and Particle Physics Experiments:	William R. Leo, A How- to Approach, 2"d revised edition, Springer-Verlag, New York Inc. (1994).
6	Nuclear Physics, Principles and Application,	John Lilley, John Wiley (2002).

Links to online references

Lecture Plan

S.No.	Course Content	Number of Classes
1	Basic nuclear Physics, Nuclides, isotopes, Radiation source-alpha, beta, gamma source, neutron source, spontaneous fission source and synchrotron source.	02
2	Interaction of gamma rays, charge particles and neutron with matter-photoelectric absorption, Compton scattering, pair production,	02
3	electromagnetic shower in high energy photon and electron interaction with matter: energy loss of heavy charged particles in matter, electronic stopping power, (Bohr and Bathe-Bloch formulae),	03
4	Cerenkov radiation: energy loss of electron and positron, electronic	05

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	stopping and energy loss by bremsstrahlung radiation.	
5	Neutron elastic scattering, inelastic scattering, radiative capture (n,p), (n,2n), (n,a), (n, fission) reactions.	03
6	Radiation shielding for neutrons, photons and charged particles. Design of radiation shields, including neutrons, photons and charged particles.	03
7	Dosimetric quantities, materials selection and energy deposition in shields.	03
8	Techniques for dose estimation including buildup factors, neutron removal cross-sections.	04
9	Industrial applications — tracing, gauging, material modification, sterilization, food preservation and other applications.	02
10	Nuclear chart. Nuclear mass, binding energy and stability, radioactive decay, nuclear reactor.	04
11	Measurement of nuclear reaction products: charged particles, neutron, gamma radiation, Radiation Physics, Ionizing radiation, dose concepts radiation environment. Nuclear energy, Fission Fuel cycle and waste management, reactor power control, fusion,	06
12	Medical applications — Projection imaging, imaging with external radiation and internal radiation, computerized tomography,	05
13	positron emission tomography, magnetic resonance imaging, radiation therapy — using photons and electrons, radionuclides, neutrons and heavy charged particles.	04
14	Biological effects of radiation — direct and indirect physical damage, indirect chemical damage, dose, dose rate and dose distributions, Dose limits, Regulatory requirement,	03
15	Damage to critical tissues — complex molecules, nucleic acids and damage repair. Human exposure to radiation, radiation in environment,	03
16	evaluation of dose — external radioactive source and inhaled and ingested radioactivity, risk assessment, risk to occupationally exposed workers, radiation protection and measurement	05

Course Title	Extraction of Rare Earth Metals and Alloys
Course Code	MME 511
Course Type	Department Elective 3A
No of credits	
Semester	
Department	Materials and Metallurgical Engineering
U.G./P.G.	Undergraduate Programme
Programme	B.Tech. in Materials and Metallurgical Engineering
Pre-requisites'	MME 2101: Fundamental of Metal Extraction MME 2102: Thermodynamics of Materials MME 2201: Design of Metallurgical Processes

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	MME 3203: Non-Ferrous Metal Extraction
Course Coordinator	Dr C Sasikumar
Learning Hours	50 Hours
Course Description	
<p>This course is designed for undergraduate students of materials and metallurgical engineering. It provides the fundamental understanding of processing/characterization/design of engineering materials. The course enhances the understanding of complexities in processing/characterization/designing and their solutions through numerical/analytical/modelling/experiments/proto-type designs/interpretation of data. The students will be able to handle the modern equipments in processing industries/design/process novel materials based on this knowledge.</p>	
Course Objectives	
Course Content	
<p>1) Introduction to rare earths, resources and reserves</p> <p>Properties and applications, Reserves, minerals, deposits</p>	4 hours
<p>2) Processing of Resources</p> <p>Mining, Beneficiation, Chemical treatment, Separation and Solvent Extractions</p>	10 hours
<p>3) Reduction of Rare earth chloride, fluorides and oxides</p> <p>Preparation of rare earth chlorides, reduction of chlorides</p> <p>Preparation of rare earth fluorides, reduction of fluorides</p> <p>Reduction distillation, Metallothermic reduction, Carbothermic reduction Electrolytic production and Recovery</p>	20 hours
<p>4) Refining, Recycling of Rare earths</p> <p>Pyrovacuum treatments, Electrorefining, Zone refining, Solid-state Electrotransport, Pyrometallurgical and hydrometallurgical recycling</p>	9 hours
<p>5) Industrial Production of Rare Earths</p> <p>Metallothermic reduction, Reduction distillation, Reduction diffusion, Molten-salt electrolysis process case studies</p>	2 hours
<p>6) High Purity refining methods</p> <p>Vacuum melting, Distillation, Electrotransport, Zone melting, Electrochemical deoxidation Case studies</p>	2 hours
<p>7) Application of Rare Earths</p> <p>Magnets, Rare earth phosphor, Ni-MH batteries, Other applications</p>	2 hours
<p>8) Melting of Rare containing Alloys</p>	1 hour

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Melting of reactive rare earth containing alloys	
Learning Outcomes	
Teaching Learning Activities	
Course Assessment Methods	A. Assignments and Performance in the class 20 B. Class Test 10 C. Mid Term Examination 20 D. End Term Examination 50
Books and References	
Textbooks:	
1) "Extractive Metallurgy of Rare Earths", by N. Krishnamurthy and C. K. Gupta, CRC Press, Florida, Second edition, 2016	
References:	
2) "Chapter 2.9: Rare Earth, Titanium Group Metals, and Reactive Metals Production", by O. Takeda, T. Uda and T. H. Okabe, in "Treatise of Process Metallurgy" edited by S. Seetharaman, Elsevier, 2014	
3) "Case Study 1: Extraction of Rare Earths for Advanced Applications", by G. Balachandran, in "Treatise of Process Metallurgy" edited by S. Seetharaman, Elsevier, 2014	
Links to online references	
www.MineralsUK.com	
https://www.lynascorp.com/products/what-are-rare-earths	

Course Title	Utilization of Metallurgical Wastes
Course Code	MM 512
Course Type	Department Elective A
No of credits	
Semester	
Department	Materials and Metallurgical Engineering
U.G./P.G.	Undergraduate Programme
Programme	B.Tech. in Materials and Metallurgical Engineering
Pre-requisites'	MME 2101: Fundamental of Metal Extraction MME 2203: Iron and steel Making MME 3203: Non-Ferrous Metal Extraction
Course Coordinator	
Learning Hours	50 Hours

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Course Description

This course is designed for undergraduate students of materials and metallurgical engineering. It provides the fundamental understanding of processing/characterization/design of engineering materials. The course enhances the understanding of complexities in processing/characterization/designing and their solutions through numerical/analytical/modelling/experiments/proto-type designs/interpretation of data. The students will be able to handle the modern equipments in processing industries/design/process novel materials based on this knowledge.

Course Objectives

This course covers the various industrial practices to deal with the wastes generated from metallurgical industries. It covers the steelmaking slag, iron making slag, red mud, iron ore waste, fly ash, machining scrap, and foundry wastes related case studies of their utilization and recent advancements in that direction.

Course Content

- | | |
|--|----------------|
| 1) Introduction to metallurgical wastes | 5 hours |
| Extraction waste, foundry wastes, machining wastes | |
| 2) Iron and steel making slag | 5 hours |
| Nature and properties of slag, slag handling, granulation methods, Applications | |
| 3) Coal gasification plants – Coal ash slag | 5 hours |
| Comparison with steel making slag, applications | |
| 4) Copper smelting slag | 5 hours |
| Case studies of Extraction of precious elements from copper smelting slag | |
| 5) Anode mud | 5 hours |
| Case studies related to anode mud utilization | |
| 6) Reuse of Foundry waste | 5 hours |
| Remelting of runner raisers, Fettling operations | |
| 7) Reuse of scrap | 5 hours |
| Accumulation of steel scrap, Evolution of EAF, Scrap charging practices in EAF, Secondary steel making practices | |

Learning Outcomes

After completion of this course the students will be able to:

- 1) Identify the scrap generated from metallurgical industries
- 2) Map the scrap to its utilization procedure

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<p>3) Measure the physical chemical and metallurgical properties for these waste</p> <p>4) Realize the applications of metallurgical wastes based on their nature and properties</p>	
Teaching Learning Activities	<p>1) Introducing the various metallurgical wastes</p> <p>2) Describing iron and steel making process and slag handling</p> <p>3) Discussing case studies of slag handling in copper smelting industries</p> <p>4) Describing the scrap charging operation in EAF</p> <p>5) Discussing various applications of slag utilization, like cement, slag fiber, construction concrete, bricks, tiles made of slag</p>
Course Assessment Methods	<p>A. Assignments and Performance in the class 20</p> <p>B. Class Test 10</p> <p>C. Mid Term Examination 20</p> <p>D. End Term Examination 50</p>
Books and References	
<p>1. "Chapter 5.2: The Structure and Properties of Silicate Slags", by K.C. Mills, M. Hayashi, L. Wang, T. Watanabe, in "Treatise of Process Metallurgy" edited by S. Seetharaman, Elsevier, 2014</p> <p>2. "Chapter 1.5: Electric Furnace Steelmaking" by J Madias, in "Treatise of Process Metallurgy" edited by S. Seetharaman, Elsevier, 2014</p> <p>3. "Chapter 4.4: Process for Recycling" by J. Zhang, H. Matsuura, F. Tsukihashi in "Treatise of Process Metallurgy" edited by S. Seetharaman, Elsevier, 2014</p>	
Links to online references	

Course Title	Lightweight Metallic Materials
Course Code	MM 513
Course Type	Department Elective (A)
No of credits	
Semester	
Department	Materials and Metallurgical Engineering
U.G./P.G.	Undergraduate Programme
Programme	B.Tech. in Materials and Metallurgical Engineering
Pre-requisites'	Nil
Course Coordinator	Dr. Jayashree Baral

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Learning Hours	50 Hours
Course Description	
<p>Light Metals and Alloys Introduction; importance of lightweight metals and alloys. Different methods of synthesis of light-weight metallic materials: ingot metallurgy, semi-solid processing, spray deposition, mechanical alloying, plasma processing, vapor deposition, and electron beam processing. Ti: Production of Ti; processing, properties, and applications (aerospace and others) of Ti-alloys. Mg: Production of Mg; melting and casting; recent development of Mg alloys; applications (aerospace, automobile, and others). Al: Production of Al; wrought Al-alloys; cast Al-alloys; applications (aerospace and others). New materials and processing methods: metal (Al, Mg, Ti)</p>	
Course Objectives	
<p>Objective of the course is to introduce importance of lightweight metallic materials in aerospace, automobile and general engineering sectors. Lightweight metallic materials such as Aluminium, Magnesium and Titanium alloys will be included. Various alloying strategies and available processing routes for each of the three alloy systems will be covered along with discussion of specific applications of these alloys in various systems. Significance of material selection in the context of design stage, cost and commercial feasibility will also be discussed.</p>	
Course Content	
1. Main Title: Light weighting Concept	No of hours:6
<p>A refresher on equilibrium phase diagram ,Advantages and need of weight saving in vehicle and other engineering components, compounding effect, role of lightweight material on weight saving.</p>	
2. Main Title: Aluminium Alloys	No of hours:12
<p>Designation of Aluminium Alloys, Important Al alloy systems and the heat treatment of Al alloys. Wrought Al alloys, such as Al-Mn, Al-Mg etc, their processing and applications.</p> <p>Cast Al alloys (Al-Si) ,their processing and applications. Description of various cast Al alloys namely, LM6, LM13 and LM30, their microstructure, properties and applications. Mechanism of growth phenomenon of Si phase in Al-Si alloys. Modification and refinement of eutectic and hypereutectic Al-Si alloy respectively.</p> <p>Normal and abnormal eutectic of Al alloys. Heat treatment of Al- 4.5%Cu alloys, Al-Mg-Si alloys, Al-Zn-Mg alloys.</p>	
3. Main Title: : Magnesium Alloys	No of hours:10
<p>Nomenclature of Magnesium Alloys, Important Mg-alloy systems and heat treatment of Mg alloys. Effect of alloying elements on the properties of Mg. Mg-Zr alloy.</p> <p>Melting and casting of Mg alloy system. Melting practices of Mg alloy, with Flux covering and with protective atmosphere. Grain refinement of Mg alloy, Mg-Yttrium alloy (WE 43 alloy), mechanical properties and applications.</p>	
4. Corrosion Behaviour	No of hours:4

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Corrosion of Mg alloys, Techniques for corrosion protection of Mg alloy,	
5. Main Title : Cast Mg alloys	No of hours:8
Properties and application of cast Mg alloy.	
6. Main Title: Wrought Mg alloys	No of hours:4
Processing and applications of Wrought Mg alloy.	
7. Main Title: Pressure Die Casting	No of hours:4
Pressure die casting of Mg alloys, Processing and process parameters.	
8. Main Title: Titanium Alloys	
Nomenclature of Ti alloys, Important Ti alloy systems, Alpha and beta stabilizer, Heat treatment of Ti alloys, Cast Ti alloy, their processing and applications, Wrought Ti alloys, their processing and applications.	
9. Safety issues in Lightweighting	No. of Hours: 2
Learning Outcomes	
It is expected that after going through the course, students would be able to fully appreciate the importance of lightweighting, know the various commercially available lightweight alloy systems and be able to decide the factors considered in selection of lightweight alloys for a particular application.	
Teaching Learning Activities	Mostly using White Board, 10% learning through power point, Problem solving activities in the classes
Course Assessment Methods	A. Quiz, Assignments and Performance in the class: 20 B. Class Test 10 C. Mid Term Examination 20 D. End Term Examination 50
Books and References	
1. Lightweight Materials: Understanding the Basics: Ed by F.C. Campbell, ASM International, Materials Park, OH; 2012.	
2. Advanced Materials in Automotive Engineering, Ed By J. Rowe, Woodhead Publishing Ltd., Cambridge, 2012	
3. Materials Selection in Mechanical Design, M.F. Ashby, Pergamon Press.	
4. Light Alloys: Metallurgy of the Light Metals, by I. J. Polmear, Publisher: Butterworth Heinemann.	
5. Aluminium & Its Alloys, By F King, Publisher: John Wiley & Sons	

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6. Fundamentals of Magnesium Alloy Metallurgy, edited by Mihriban O Pekguleryuz, Karl Kainer, A. Arslan Kaya, Woodhead Publishing in Materials
7. Light Metal Alloys Applications, edited by Waldemar Alfredo Monteiro, Intech open
8. Titanium and Titanium Alloys: Fundamentals and Applications, Editor(s):
Dr. Christoph Leyens, Dr. Manfred Peters, Copyright © 2003 Wiley-VCH Verlag GmbH & Co. KGaA

Links to online references

Link to online references will be provided to students during Lectures.

Course Title	Wear of Engineering Materials
Course Code	MM 514
Course Type	Department Elective (A)
No of credits	
Semester	
Department	Materials and Metallurgical Engineering
U.G./P.G.	Undergraduate Programme
Programme	B.Tech. in Materials and Metallurgical Engineering
Pre-requisites'	Nil
Course Coordinator	Dr. S. Das
Learning Hours	50 Hours

Course Description

Topics covered include surface topography, contact of solids, and friction, along with the effect of sliding and rolling resistance including lubrication. Fretting, wear under rolling contact, and the friction and wear of metal, alloys and composites are also discussed. The goal of the course is to give the students knowledge and skills in wear, friction, lubrication, lubricants, corrosion and surface engineering techniques for meeting the needs of the industry in their future professional career.

Course Objectives

Objective of this course is to teach the students the various aspects of Wear of Metals deals with the mechanisms underlying the wear of metals such as brass, cast iron, and aluminium-silicon alloys. Type of wear namely Adhesive, abrasive, corrosive, erosive, erosive-corrosive will be taught. The mechanism of wear, sliding wear surface analysis, wear debris will be major areas to be covered. Lubrication and type of lubricants, hydrodynamic lubrication would a important part to be taught.

Course Content

Main Title: Introduction

No of hours:6

Introduction to Tribology, History of Tribology, Economic Benefit

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<p>Main Title: Friction No of hours:6</p> <p>Causes of friction, Adhesion theory, Junction growth theory, Laws of rolling friction, Friction Instability, Numerical Problem Solving</p>	
<p>Main Title: : Wear No of hours:10</p> <p>Introduction to wear, Adhesive, Abrasive, Erosive, Corrosive, Erosive – corrosive, Fretting wear, Stages of Wear Wear Analysis, Wear surface analysis, Debris Analysis, Wear testing rig, Modeling of wear, Wear Coefficient, Numerical Problem</p>	
<p>Wear Map No of hours:4</p> <p>Generation of wear map, Plotting of various wear in wear map</p>	
<p>Main Title: Lubrication No of hours:8</p> <p>Important of lubrication, boundary lubrication, Mixed Lubrication, Hydrodynamic Lubrication, Elasto-hydrodynamic lubrication, Types and Properties of Lubricants, Lubricants additives</p>	
<p>Main Title: Fluid Film Lubrication No of hours:8</p> <p>Fluid Mechanics Concepts, Equation of continuity and motion, Generalized Reynolds equation, with Compressible and incompressible Lubricants</p>	
<p>Main Title: Application of Tribology No of hours:8</p> <p>Introduction, rolling contact bearings, Automotive engines, Magnetic Storage Devices, Gears, Gas Turbine Engines, Journal Bearing, Nano Tribology, Green Tribology and Biomimetics, Numerical Problem</p>	
<p>Learning Outcomes</p> <p>Corrosion, erosion, wear and friction are central mechanisms for damaging a surface and thereby the integrity of a structure or a component. Tribology is the science of interacting surfaces in relative motion. This course deals with the most central topics within surface protection and Tribology. The course deals with how to achieve desired lifetime of a component or construction by application of coatings, surface modification and/or lubrication. Students will learn Testing and inspection methods as well as the economical aspect.</p>	
Teaching Learning Activities	Mostly using White Board, 10% learning through power point, Problem solving activities in the classes
Course Assessment Methods	<p>Quiz, Assignments and Performance in the class 20</p> <p>Class Test 10</p> <p>Mid Term Examination 20</p> <p>End Term Examination 50</p>
<p>Books and References</p> <p>1. Friction and wear of materials, Ernest Rabinowicz, Wiley, 1965</p>	

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2. Microstructure and Wear of Materials, **K.-H. Zum Gahr, North Holland, eBook ISBN: 9780080875743**
3. Tribology, Friction and Wear of Engineering Materials, Authors: **Ian Hutchings Philip Shipway**, Paperback ISBN: **9780081009109, Butterworth-Heinemann**
4. Wear of Metals: International Series in Materials Science and Technology v.18) Kindle Edition, by A. D. Sarkar, Publisher: Pergamon
5. Principles and Applications of Tribology, by Bharat Bhushan, John Wiley & Sons, new York

Links to online references

Link to online references will be provided to students during Lectures.

Course Title	Advanced Manufacturing Processes
Course Code	MM 515
Course Type	Department Elective A
No of credits	
Semester	
Department	Materials and Metallurgical Engineering
U.G./P.G.	Undergraduate Programme
Programme	B.Tech. in Materials and Metallurgical Engineering
Pre-requisites'	Unconventional sources of material processing
Course Coordinator	Dr. Ramkishor Anant
Learning Hours	50 Hours

Course Description

This course is designed for undergraduate students of materials and metallurgical engineering. The course covers the details of the advanced manufacturing technology and practices, advanced manufacturing processes, advanced metal forming processes, advanced welding processes and advanced foundry processes.. The students will be able to handle the modern equipments in processing industries/design/process novel materials based on this knowledge.

Course Objectives

To aid students involved in the manufacturing of commercial products to design them to be easily made.

To enable students to take advantage of all the inherent cost benefits available in the manufacturing process which will be used.

To know about properties, processing and applications of materials.

To acquire the essential knowledge about the selection of different latest materials for various applications.

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Course Content	
Metal Casting	No of hours: 12
Patterns and moulds including mould design involving feeding, gating and risering, melting, casting practices in sand casting, permanent mould casting, investment casting and shell moulding, casting defects and repair; Hot, warm and cold working of metals.	
Metal Forming	No of hours: 12
Fundamentals of metal forming processes of rolling, forging, extrusion, wire drawing and sheet metal forming, stretch forming, bending, defects in forming; High energy rate forming (HERF).	
Powder Metallurgy	No of hours: 6
Production of powders, compaction and sintering; 3-D Printing of metals (additive manufacturing).	
Metal Joining	No of hours: 15
Soldering, brazing and welding, common welding processes of shielded metal arc welding, gas metal arc welding, gas tungsten arc welding and submerged arc welding; Welding metallurgy, problems associated with welding of steels and aluminium alloys, defects in welded joints, additive manufacturing by arc welding.	
Non-destructive Testing	No of hours: 5
NDT using dyepenetrant, ultrasonic, radiography, eddy current, acoustic emission and magnetic particle methods.	
Learning Outcomes	
Have in-depth knowledge about manufacturing technologies along with recent trends in advanced manufacturing.	
In manufacturing industries, the engineers would be benefited after having learnt the concepts of how the products are manufactured.	
They would be able to apply the cost reduction techniques of forming design, casting design and welding structural design and solve technical problems related to the above field.	
Teaching Learning Activities	Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, interactive teaching, educational visits, small projects.
Course Assessment Methods	<p>A. Assignments and Performance in the class 20</p> <p>B. Class Test 10</p> <p>C. Mid Term Examination 20</p> <p>D. End Term Examination 50</p>

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Books and References

1. Principles of Metal Casting R. W. Hein, C. R. Loper, P. C. Rosenthal
2. *Welding Engineering and Technology*: R. S. Parmar
3. Manufacturing Engineering & Materials Processing: Robert C. Creese
4. Materials Science and Engineering: William D. Callister Jr., David G. Rethwisch.
6. Additive Manufacturing Technologies: Gibson, Ian, Rosen, David, Stucker, Brent

Links to online references

Course Title	Welding Metallurgy	
Course Code	MME 516	
Course Type	Department Elective A	
No of credits		
Semester		
Department	Materials and Metallurgical Engineering	
U.G./P.G.	Undergraduate Programme	
Programme	B.Tech. in Materials and Metallurgical Engineering	
Pre-requisites'	Introduction to courses such as Welding processes, Materials science etc.	
Course Coordinator	Dr. Ramkishor Anant	
Learning Hours	50 Hours	

Course Description

This course is designed for undergraduate students of materials and metallurgical engineering. The course focuses on understanding the metallurgy and solidification of weldments. The course will make the students aware with the metallurgical aspects of welding. For getting a sound weld, the students are required to be aware of the science behind the welding phenomena, especially in the domain of weld metal solidification, heat transfer, heat treatment processes, strengthening mechanisms etc. The course will be useful for engineering graduates as well as professionals working in the area of welding.

Course Objectives

To provide knowledge about the physical metallurgy of welding.

To acquire essential significance of thermal effects of welding and subsequent remedial measures to reduce residual stresses and distortion in weldments.

To gain knowledge about the Weldability of different commercially available materials, their corresponding weld joints design and automation of welding processes.

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Course Content

Introduction to Welding Metallurgy

No of hours: 8

Welding arc, Heat flow in and around weld metal, Metallurgical effects of welding, Weld metal solidification, Absorption of gases by weld, Gas metal reactions, Porosity in weld, Fe-C, T.T.T. and C.C.T. diagrams, Thermal effects of welding on parent metal and its mechanical properties, Effect of welding parameter on weld quality, Hydrogen embrittlement and cracking, Grain size control, Weld cracking, Corrosion of weld, Weld decay, Dilution

Weld Joint Microstructure

No of hours: 8

Introduction, Weld metal zone, General theory of solidification of metal and alloys, Effect of welding speed on grain structure, Properties of weld metals, Fusion boundary zone, Heat affected zone, Properties of HAZ, Microstructural products in weldments, Microstructure of multi-run welds, Effect of alloying elements on microstructure, Delta and sigma phase in welds.

Welding of Carbon Steel

No of hours: 5

Types of carbon steel, Weldability of carbon steel, Weldability of low carbon steel, Weldability of medium carbon steel, Weldability of high carbon steel, Weldability of high strength low alloy (HSLA) steels, Weldability of low alloy steel, WPS & PQR preparation as per ASME SEC-IX (SMAW Process).

Welding of Stainless Steel

No of hours: 5

Types of stainless steel, Welding of Austenitic stainless steel, Schaeffler diagram, DeLong diagram, Problems associated with welding of Austenitic stainless steel, Ferrite and Sigma phase formation, Carbide precipitation, Knife edge attack, Stress corrosion cracking, PWHT of Austenitic stainless steel weldments, Weldability of Ferritic stainless steel, PWHT of Ferritic stainless steel weldments, Weldability of Martenitic stainless steel, Preheating and PWHT of MSS weldments, Weldability of PH stainless steel, Weldability of DSS, WPS & PQR preparation as per ASME SEC-IX (GTAW Process).

Welding of Aluminium and its Alloys

No of hours: 5

Characteristics and application of Aluminium, Welding characteristics of Al & its alloys, Processes used for welding Aluminium & its alloys, Problems encountered in welding of Aluminium.

Welding of Titanium and its Alloys

No of hours: 5

Characteristics of Titanium, Titanium alloys, Welding of Titanium and its alloys, Welding processes and procedure used for Titanium welding, Joint design selection, preheating, selection of preheat and interpass temperature, Protection during Titanium welding, Welding process selection, PWHT, Problems associated with welding of Titanium.

Welding of Other Ferrous and Non-ferrous Alloys

No of hours: 4

Weldability of cast irons, copper and its alloys, Magnesium and its alloys, Nickel and its alloys, weldability tests.

Residual Stresses and Distortion in Weldments

No of hours: 10

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Definition and concept of residual stresses, Types of residual stresses, Residual stresses in welds, Effects of thermal stresses, Control of residual stresses, Need for residual stress relieving, Methods of residual stress relieving 1) Design consideration 2) Material selection 3) Preheating 4) Welding procedure 5) Welding sequence 6) PWHT 7) Natural ageing 8) Peening 9) Vibratory stress relieving (VSR), Concept of distortion, Types of distortion, Control of welding distortion, Minimizing distortion in repair work, Effect of properties on welding distortion

Learning Outcomes

On the completion of this course the students can have the ability:

To select suitable welding process and technique to join a given material.

To identify and minimize the distortion and residual stresses induced in weldments.

To evolve better design for both static and fatigue loading conditions.

Teaching Learning Activities

Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, interactive teaching, educational visits, small projects.

Course Assessment Methods

E. Assignments and Performance in the class **20**
F. Class Test **10**
G. Mid Term Examination **20**
H. End Term Examination **50**

Books and References

1. Welding Technology by O.P.Khanna Dhanpat
2. Welding Engineering & Technology by Dr. R.S.Parmar
3. Welding Metallurgy by Sindo Kou
4. Fundamentals of welding metallurgy, Abington in association with the Welding Institute, 1991 – Henry Granjon
5. Metallurgy of Welding, Woodhead Publishing Limited, 1999 – J.F. Lancaster

Links to online references

Course Title	Non-equilibrium Processing of Materials
Course Code	MME 517
Course Type	Department Elective A
No of credits	

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Semester		
Department	Materials and Metallurgical Engineering	
U.G./P.G.	Undergraduate Programme	
Programme	B.Tech. in Materials and Metallurgical Engineering	
Pre-requisites'	Introduction to courses such as Welding processes, Materials science etc.	
Course Coordinator	Dr. Sanjay Srivastava	
Learning Hours	50 Hours	
Course Description		
This course is designed for undergraduate students of materials and metallurgical engineering.		
Course Objectives		
Course Content		
Introduction to non-equilibrium processing Thermodynamics and kinetics of metastable phase formation; Rapid solidification: Under cooling. Phase diagram metastable states, Methods of rapid solidification, Microstructure formation by rapid solidification, Application for rapid solidification ; Mechanical alloying: Process of mechanical alloying, Mechanism of alloying Energy criteria for mechanical alloying, Synthesis of non-equilibrium phases, Application of mechanical alloying, Metallic glass : Understanding of glass formation, thermal stability and glass forming ability,		
Learning Outcomes		
Teaching Learning Activities	Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, interactive teaching, educational visits, small projects.	
Course Assessment Methods	<p>A. Assignments and Performance in the class 20</p> <p>B. Class Test 10</p> <p>C. Mid Term Examination 20</p> <p>D. End Term Examination 50</p>	
Books and References		
1	Non-equilibrium processing of materials.	C. Suryanarayana
2	Rapid solidification processing principle and technologies III	Editors Mithe, Ritchie and Karihalo, Elsevier Academic press 2004
3	Science and technology of Rapid solidification processing	M.A.Otooni,

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Links to online references		
Lecture Plan		
S.No.	Course Content	Number of Classes
1	Introduction to non-equilibrium processing	02
2	Thermodynamics and kinetics of metastable phase formation;	03
3	Rapid solidification: Under cooling.	03
4	Phase diagram metastable states,	02
5	Methods of rapid solidification,	03
6	Microstructure formation by rapid solidification,	03
7	Application for rapid solidification.	03
8	; Mechanical alloying: Process of mechanical alloying,	04
9	Mechanism of alloying Energy criteria for mechanical alloying,	03
10	Synthesis of non-equilibrium phases,	04
11	Application of mechanical alloying, Metallic glass	02
12	Understanding of glass formation,	05
13	thermal stability and glass forming ability,	04

Course Title	Advanced Materials and Processes
Course Code	MM 518
Course Type	Department Elective A
No of credits	
Semester	
Department	Materials and Metallurgical Engineering
U.G./P.G.	Undergraduate Programme
Programme	B.Tech. in Materials Science and Metallurgical Engineering
Pre-requisites'	Basic courses of Thermodynamics and Kinetics of Materials, Manufacturing processes
Course Coordinator	Dr C Sasikumar
Learning Hours	50 Hours

Course Description

This course is designed for postgraduate students of materials science and technology. It provides the fundamental understanding of process design of engineering materials. The course enhances the understanding of complexities in processing and their solutions through

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thermodynamic calculations and modelling. The students will be able to predict the nature and properties of the materials in real time process industries based on this knowledge.

Course Objectives

1. To learn about the chemical synthesis and characterization of materials with advanced nanostructure and properties.
2. Recognize the properties, applications and synthesis of BMG, super alloys, advanced ceramic materials, nano-particles, thin films, functional thin films, and self-assembled structures

Course Content

Introduction to Advanced Materials

Bulk Metallic Glass and Amorphous Materials

10 hours

Thermodynamics and kinetics of glass formation, Methods to synthesize bulk metallic glasses
Rapid solidification processing, Melt spinning, Flux melting, Bulk metallic glass casting processes, BMG composites, foams, Crystallization behavior, thermal stability and annealing of BMG, Physical and Mechanical Properties and Corrosion of BMG, Applications of BMG, The structure and properties of amorphous materials, New amorphous alloys and their properties
Preparation techniques – hydrogen absorption, irradiation, inter-diffusion of multilayers, chemical reduction, atomization and consolidation, Amorphous plating

Applications

Shape Memory Alloys

5 hours

Phenomenology of shape memory alloys, Experimental characterization of shape memory alloys, Manufacturing techniques – Conventional methods, new methods, thermo-mechanical processes to optimize the properties, near net shape methods, Applications of SMA

High Temperature Materials

5 hours

High temperature materials chemistry and thermodynamics, Oxidation of high temperature materials, High temperature materials processing, Characterization of high temperature materials, High temperature materials and mechanisms: Applications and challenges

Super Alloys

10 hours

Overview of super alloys, Strengthening mechanisms, -Solid solution strengthening, precipitation hardening, oxide dispersion strengthening, carbide hardening, Phases and Microstructures of super alloys, Manufacturing steps, Mechanical properties and corrosion behavior of superalloys

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Electrical Ceramics

10 hours

Ceramics as electrical conductors, Conduction mechanism in ceramics, Applications of high conduction ceramics, semiconductors, Varistors, thermistors, Ion conduction, fast ion conductors, Batteries, Fuel Cells, Ceramic Insulators, Dielectrics, Ceramic superconductors

Nanomaterials

10 hours

Formation of clusters and nano-particles from supersaturated solutions/vapour, Thermodynamics and Kinetics of nano-materials, Properties and applications of typical nano-materials, -Carbon materials, silicon structures, bio-nanomaterials, Processing of nano-materials

Synthesis Methods

Sol-Gel method, consolidation and sintering, Bulk Preparation Methods, Mechanical Alloying and Mechano-chemistry, Rapid Solidification Processing , Combustion Synthesis , Microwave Techniques, Hydrothermal Techniques, Single Crystal Techniques, Thin Film Preparation Methods, Magnetron sputtering, Pulsed Laser Ablation, MBE Processes, Chemical Solution Deposition, Chemical Vapour Deposition, Liquid Phase Epitaxy, Preparation of Nanofluids

Learning Outcomes

The student gained knowledge of

1. advanced materials based on metals, complex metallic systems, non-metals, nanomaterials and biomaterials.
2. Processing of thin layers, functional multilayers, bulk materials with the complex structure (inclusive of amorphous) and advanced composites.

Teaching Learning Activities

- A. Lectures
- B. Problem Solving
- C. Concept Mapping
- D. Questioning
- E. Formative Quizzes
- F. Small group activities

Course Assessment Methods

- A. Assignments and Performance in the class **20**
- B. Class Test **10**
- C. Mid Term Examination **20**
- D. End Term Examination **50**

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Books and References	<p>1. C.J. Brinker and G.W. Scherer, <i>Sol-Gel Science. The Physics and Chemistry of Sol-Gel Processing</i>, Academic Press: San Diego, 1990.</p> <p>2. D.C. Bradley, R.C. Mehrotra, I.P. Rothwell and A. Singh, <i>Alkoxo and Aryloxo Derivatives of Metals</i>, Academic Press: San Diego, 2001.</p> <p>3. G. Cao, <i>Nanostructures and Nanomaterials - Synthesis, Properties and Applications</i>, Imperial College Press: Hackensack, NJ, 2004. [Link to book from Knovel]</p> <p>4. P. Yang (ed.), <i>The Chemistry of Nanostructured Materials</i>, Singapore, 2003. [Link to</p> <p>7. book from Knovel]</p> <p>8.</p>
Links to online references	<p>7. https://nptel.ac.in/courses/113106031/</p> <p>8. https://www.coursera.org/courses?query=thermodynamics</p> <p>9. https://study.com/academy/course/thermodynamics-study-guide.html</p> <p>10. www.oup.com/ukhe/product/9780198769866</p> <p>11. http://ocw.mit.edu/5-60S08</p> <p>12. https://www.thermocalc.com/</p>

Course Title	Computational Techniques in Metallurgy
Course Code	MM 519
Course Type	Department Elective A
No of credits	
Semester	
Department	Materials and Metallurgical Engineering
U.G./P.G.	Undergraduate Programme
Programme	B.Tech. in Materials and Metallurgical Engineering
Pre-requisites'	Numerical Methods Heat and Mass Transfer, Fluid flow, Metallurgical Thermodynamics Fundamentals of Metallurgical Processes
Course Coordinator	
Learning Hours	50 Hours

Course Description

This course is designed for undergraduate students of materials and metallurgical engineering. It provides the fundamental understanding of processing/characterization/design of engineering materials. The course enhances the understanding of complexities in

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processing/characterization/designing and their solutions through numerical/analytical/modelling/experiments/proto-type designs/interpretation of data. The students will be able to handle the modern equipments in processing industries/design/process novel materials based on this knowledge.

Course Objectives

This course starts with recap of numerical methods, and utilization of these methods in simulation of metallurgical processes. The linear, polynomial, exponential differential equations being used in heat, mass, and momentum transport, theories acting as underlying relations in the various metallurgical operations will be solved computationally.

Course Content

- | | |
|--|--------------|
| 1) Introduction to numerical methods | hours |
| Solution of non-linear equations, ODE, and PDE | |
| 2) Solution of Momentum Transport and Fluid flow Problems | hours |
| Newton's law of viscosity, Flow through parallel plates, circular tube | |
| Navier-Stokes Equation's application, Laminar flow, Turbulent flow general momentum balance equations, Fluidized bed, and Packed bed Problems, Ladle flow and Lance flow problems | |
| 3) Solution of Energy Transport in Metallurgical Processes | hours |
| Fourier's law of conduction, Convective heat transfer calculations, Heat conduction in solids, Solidification heat transfer, Metallurgical packed bed reactors, Quenching heat transfer problems | |
| 4) Solution of Mass Transport and Diffusion Problems | hours |
| Fick's laws of diffusion, Homogenization of alloys, surface coating problems | |
| 5) Stress Tensor and Metal Forming Problems | hours |
| Subunits, Subunits, Subunits, Subunits, Subunits, Subunits, Subunits | |
| 6) Computational Thermodynamics | hours |
| Solution of activity coefficients, omega values from Toop's Model | |

Learning Outcomes

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

- 7) Calculate the process parameters for metallurgical processes using numerical methods
- 8) Understand any metallurgical problem mathematically
- 9) Identify the suitable numerical methods for the type of metallurgical problems
- 10) Realize the effect of computational errors associated with the given numerical methods

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Teaching Learning Activities	Refreshing numerical methods Using different numerical methods to calculate metallurgical problems Using any programming environment (ex. C, Fortran, MATLAB) to solve these problems
Course Assessment Methods	A. Assignments and Performance in the class 20 B. Class Test 10 C. Mid Term Examination 20 D. End Term Examination 50
Books and References	
Textbook:	
1) "Numerical Methods for Engineers", by S. C. Chapra, and R. P. Canale, Sixth ed. McGraw Hill Publication, New York. 2010.	
2) "Numerical Heat Transfer and Fluid Flow" by S. V. Patankar, Hemisphere Publishing Corporation, USA, 1980.	
References:	
3) "Transport Phenomena and Materials Processing", by Sindo Ku, Wiley, 1996.	
Links to online references	

Course Title	Advanced Characterization Techniques
Course Code	MM 520
Course Type	Department Elective A
No of credits	
Semester	
Department	Materials and Metallurgical Engineering
U.G./P.G.	Undergraduate Programme
Programme	Materials And Metallurgical Engineering (MME)
Pre-requisites'	Basic knowledge of Materials Science Crystal Structure, Physical Metallurgy
Course Coordinator	Dr. Mangesh Lodhe
Learning Hours	50 Hours
Course Description	
This course is designed for undergraduate students of Materials And Metallurgical Engineering (MME) programme. It provides the fundamental understanding of characterization of engineering materials. The course enhances the understanding of complexities in	

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processing/characterization and their solutions through analytical/experiments/interpretation of data.

Course Objectives

The objective of this course is to teach the students the importance of materials characterization and its correlation through structure-property polyhedra. Students will be able to understand the various techniques like Optical microscopy, X-ray diffraction, Scanning electron microscopy, Transmission electron microscopy, etc.

Course Content

Crystal lattices, crystal systems and structures, Miller Indices, Atomic Co-ordination, Crystal Structure, Diffraction by Crystal, direction and intensity of diffracted beams, symmetry operations, The reciprocal lattice, Diffraction, Bragg Law, chemical analyses (X-ray spectroscopy), diffraction directions, Diffraction methods, Scattering by electron, atom and unit cell. Structure factor calculation, application to powder method, multiplicity factor, Lorentz factor, absorption factor, temperature factor, Intensity calculations of powder pattern, Residual stress/strain analysis

Fundamentals and applications of Electron backscatter diffraction (EBSD).

Construction and working principles of transmission electron microscopes, Image formation, resolving power, magnification, depth of focus, elementary treatment of image contrasts, important lens defects and their correction. Bright field and dark field images, Stereographic projection and their applications, Formation of selected area diffraction patterns, reciprocal lattice and Ewald sphere construction, indexing of diffraction patterns, sample preparation techniques. Scanning electron microscope; construction, interaction of electrons with matter, modes of operation, image formation of plane and fractured surfaces.

Chemical analysis using EDX, EPMA, Atomic force microscopy, working principles of XRF, FTIR, Raman spectroscopy, UV spectroscopy, TG-DTA and DSC.

Learning Outcomes

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

- 1) Characterize the various type of materials
- 2) Determine Residual stress/strain
- 3) Analyze samples for structural and chemical characterization

Teaching Learning Activities

Mostly using White Board, 20% learning through power point, Problem solving activities
in tutorial classes, Performing experiments in laboratory

Course Assessment Methods

- A. Assignments and Performance in the class **20**
- B. Class Test **10**
- C. Mid Term Examination **20**

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D. End Term Examination **50**

Books and References

1. Spencer, Michael, Fundamentals of Light Microscopy, Cambridge University Press, 1982.
2. David B. Williams, C. Barry Carter, "Transmission Electron Microscopy: A Textbook for Materials Science", Springer, pub. 2009.
3. B.D. Cullity and S.R. Stock, "Elements of X-Ray Diffraction" Third edition, Prentice Hall, NJ, 2001.
4. 'Fundamentals of light microscopy and electronic imaging' Douglas B. Murphy, 2001, Wiley-Liss, Inc. USA
5. Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, by Yang Leng
6. X-Ray Diffraction: A Practical Approach, C. Suryanarayana and M. Grant Norton
7. 'Encyclopedia of Materials Characterization, Surfaces, Interfaces, Thin Films,' Editors C. Richard Brundle, Charles A. Evans, Jr., Shaun Wilson, Butterworth-Heinemann, Boston London Oxford Singapore Sydney Toronto Wellington

Links to online references

www.microscopyu.com

Other Link to online references will be provided to students during Lectures.

Course Title	Advanced Ceramic Materials
Course Code	MM 521
Course Type	Department Elective A
No of credits	
Semester	
Department	Materials and Metallurgical Engineering
U.G./P.G.	Undergraduate Programme
Programme	Materials and Metallurgical Engineering (MME)
Pre-requisites'	Basic knowledge of Materials Science Crystal Structure
Course Coordinator	Dr. Mangesh Lodhe
Learning Hours	50 Hours

Course Description

This course is designed for undergraduate students of Materials and Metallurgical Engineering (MME) programme. It provides the fundamental understanding of science and applications of

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ceramic materials. The course enhances the understanding of complexities in crystal structure /processing/characterization of ceramic materials

Course Objectives

The objective of this course is to teach the students the what is ceramic materials and how it is different from other class of materials. Students will be introduced to the science, crystal structure, processing and applications of ceramic materials

Course Content

Traditional ceramics and advanced ceramics, ceramic crystal structures, defect reactions, silicate glass formation and glass formation, Techniques for preparing advanced ceramic powders, Biomimetic processing, Advanced densification techniques, Pressure assisted sintering, Ceramic coatings, Joining of ceramics, Advanced ceramics including fiber glass, machinable ceramics, functional ceramics and functionally grade ceramics, refractories, abrasives and structural ceramics. Microstructural characterization

Engineering applications: at room and high temperatures (including armour application), Electrical behaviour: insulating (dielectric, ferroelectric, piezoelectric, pyroelectric) semiconducting, conducting, superconducting and ionically conducting,

specific materials and their applications. Magnetic behaviour: basic principles, materials and their applications. Transparent ceramics, coatings and films: preparation

and applications, Porous ceramics and ceramic membrane: fabrication techniques and applications in separation technology, Bio-medical applications of ceramic materials, Ceramics for energy and environment technologies (fuel cell, lithium battery, gas sensor and catalytic support), Ceramics matrix composites: different types, their

preparation and properties (including nanocomposites),

Learning Outcomes

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

- 1) Differentiate the different types of ceramics
- 2) Understand the science and processing of ceramic materials.
- 3) Know the various application of these materials

Teaching Learning Activities	Mostly using White Board, 20% learning through power point, Problem solving activities in tutorial classes, Performing experiments in laboratory
Course Assessment Methods	E. Assignments and Performance in the class 20 F. Class Test 10 G. Mid Term Examination 20

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H. End Term Examination **50**

Books and References

1. Fundamental of Ceramics by Michel W. Barsoum, McGraw Hill International edition, 1997
2. Modern Ceramic Engineering by David. W. Richerson, Mercel Dekker, NY 1992
3. Ceramic Processing and Sintering by M. N. Rahman, Mercel Dekker, 2003
4. Introduction to Ceramics by W. David Kingery, H. K. Bowen, Donald R. Uhlmann
5. Physical Ceramics: Principles for Ceramic Science and Engineering by Yet-Ming Chiang, Dunbar P. Birnie, W. David Kingery
6. Handbook of Advanced Ceramics by S. Somiya, Academic Press 2003
7. Handbook of Advanced Ceramics, Parts 1 and 2, S. Somiya, Aacdemic Press, 2006

Links to online references

Link to online references will be provided to students during Lectures.

Course Title	Optical, Electronic and Magnetic Materials
Course Code	MM 522
Course Type	Department Elective A
No of credits	
Semester	
Department	Materials and Metallurgical Engineering
U.G./P.G.	Undergraduate Programme
Programme	Materials and Metallurgical Engineering (MME)
Pre-requisites'	Basic knowledge of Materials Science Crystal Structure
Course Coordinator	Dr. Sanjay Srivastava
Learning Hours	50 Hours

Course Description

Course Objectives

Course Content

Structure of oxides: Ionic diffusion in oxides: Defect structure of non-stoichiometric compounds: Conductivity dependence on partial pressure of oxygen: Macroscopic characterization of dielectric materials: Electronic, atomic dipole, space charge polarization: Relaxation phenomenon-Debye equations: Ferroelectrics: Diamagnetism, paramagnetism and

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ferromagnetism, exchange ferromagnetic domain: Structure and properties of ferrites. Domain and hysteresis, soft and hard magnetic materials, Magnetic storage, superconductivity, Electromagnetic radiation, light interaction with solids, atom and electronic interaction, reflection, refraction, absorption, transmission, luminescence, photoconductivity, laser, optical fibers in communication		
Learning Outcomes		
Teaching Learning Activities	Mostly using White Board, 20% learning through power point, Problem solving activities in tutorial classes, Performing experiments in laboratory	
Course Assessment Methods	A. Assignments and Performance in the class 20 B. Class Test 10 C. Mid Term Examination 20 D. End Term Examination 50	
Books and References		
1	Fundamental of material science and engineering	William D Callister Jr.
2	Fundamental of material science and engineering	David G.Rathwisch
Links to online references		
Link to online references will be provided to students during Lectures.		
Lecture Plan		
S.No.	Course Content	Number of Classes
1	Structure of oxides: Ionic diffusion in oxides:	02
2	Defect structure of non-stoichiometric compounds:	02
3	Conductivity dependence on partial pressure of oxygen:	03
4	Macroscopic characterization of dielectric materials: Electronic, atomic dipole, space charge polarization:	05
5	Relaxation phenomenon-Debye equations: Ferroelectrics: Diamagnetism, paramagnetism and ferromagnetism, exchange ferromagnetic domain:	03
6	Structure and properties of ferrites.	05
7	Domain and hysteresis, soft and hard magnetic materials,.	05
8	Magnetic storage, superconductivity, Electromagnetic radiation,	04
9	light interaction with solids, atom and electronic interaction,	02
10	reflection, refraction, absorption, transmission, luminescence,	04
11	photoconductivity, laser,	06
12	optical fibers in communication	05

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Course Title	Semiconductor Devices and Applications
Course Code	MM 523
Course Type	Department Elective A
No of credits	
Semester	
Department	Materials and Metallurgical Engineering
U.G./P.G.	Undergraduate Programme
Programme	Materials and Metallurgical Engineering (MME)
Pre-requisites'	Basic knowledge of Materials Science Crystal Structure
Course Coordinator	Dr. Sanjay Srivastava
Learning Hours	50 Hours
Course Description	
Course Objectives	
Course Content	
<p>Semiconductor Physics, Semiconductor, Bonds in semiconductor, Energy Band, Effect of temperature on semiconductor, Hole current, Intrinsic & Extrinsic semiconductor, Majority and minority carrier, p-n junction, Fermi energy and Band occupancy, Extrinsic semiconductor: Dopant types and materials conductivity, Fermi energy position, temperature dependence, Metal-semiconductor junction, Schottky Vas Ohmic junction, Band diagram. I-V characteristics, p-n junction, Equilibrium and under bias (forward and reverse) band diagram, I-V characteristics, Junction breakdown. Hetero junction</p> <p>Volt-ampere characteristics of p-n junction, Semiconductor diode, Crystal diode rectifiers, Half wave rectifiers, Efficiency of half wave rectifier, Full wave rectifier, Centre tap full wave rectifier, Ripple factor, Filter circuits, Voltage stabilization, Zener diode, Zener diode as Voltage stabilizers, Transistor, Transistors, Transistors Connections, Common base connection, Common emitter connection, Common collector connection, Comparison base connection< transistor as amplifier in CE arrangements, Transistor load tome analysis, Operating Point, Cut off and saturation points, Application of common base amplifiers , Bioplar junction transistor, Field effect Transistor : JFET/MESFET, MOSFET, Unipolar Devices</p>	
Learning Outcomes	
Teaching Learning	Mostly using White Board, 20% learning through power point, Problem solving activities

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Activities	in tutorial classes, Performing experiments in laboratory
Course Assessment Methods	<p>A. Assignments and Performance in the class 20</p> <p>B. Class Test 10</p> <p>C. Mid Term Examination 20</p> <p>D. End Term Examination 50</p>

Books and References

1	Semiconductor devices: Physics and Technology	S.M.Size, 2 nd edition, Wiley, 2008
2	Introduction to solid state physics	C.Kittle
3	Principle of Electronics, Materials and Devices,	S.O. Kasap, 3 rd edition McGraw-Hill Education (India) Pvt.Ltd. 2007
4	Physics of Solids,	C. A. Wert and R.M. Thomson, McGraw-Hill Book Company, 1970 or later

Links to online references

Link to online references will be provided to students during Lectures.

Lecture Plan

S.No.	Course Content	Number of Classes
1	Semiconductor Physics, Semiconductor,	02
2	Bonds in semiconductor, Energy Band, Effect of temperature on semiconductor,	02
3	Hole current, Intrinsic & Extrinsic semiconductor, Majority and minority carrier,	03
4	p-n junction, Fermi energy and Band occupancy	05
5	Extrinsic semiconductor: Dopant types and materials conductivity, Fermi energy position, temperature dependence,	03
6	Metal-semiconductor junction, Schottky Vas Ohmic junction, Band diagram.	03
7	I-V characteristics, p-n junction, Equilibrium and under bias (forward and reverse) band diagram, I-V characteristics,	03
8	Junction breakdown. Hetero junction	04
9	Volt-ampere characteristics of p-n junction,	02
10	Semiconductor diode, Crystal diode rectifiers, Half wave rectifiers,	04
11	Efficiency of half wave rectifier, Full wave rectifier, Centre tap full wave rectifier,	02
12	Ripple factor, Filter circuits, Voltage stabilization, Zener diode, Zener diode as Voltage stabilizers,	05
13	Transistor, Transistors, Transistors Connections, Common base connection, Common emitter connection, Common collector connection, Comparison base connection,	04
14	transistor as amplifier in CE arrangements, Transistor load tome analysis,	03
15	Operating Point, Cut off and saturation points, Application of common base	03

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	amplifiers ,	
16	Bioplar junction transistor, Field effect Transistor : JFET/MESFET, MOSFET, Unipolar Devices	05

Group –C Open Electives (for other departments)

Name of Program	B.Tech (MME)		Session-2021-22
Course Title	Materials Characterization		
Course Code	MM 701		
Course Type	Open Elective		
No of credits			
Semester			
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme			
Pre-requisites'			
Course Coordinator	Dr. Mangesh Lodhe		
Learning Hours	50 Hours		

Course Description

This course is designed for undergraduate students of Materials And Metallurgical Engineering (MME) programme. It provides the fundamental understanding of characterization of engineering materials. The course enhances the understanding of complexities in processing/characterization and their solutions through analytical/experiments/interpretation of data.

Course Objectives

The objective of this course is to teach the students the importance of materials characterization and its correlation through structure-property polyhedra. Students will able to understand the various techniques like Optical microscopy, X-ray diffraction, Scanning electron microscopy, Transmission electron microscopy, etc.

Course Content

Scope of optical metallographic studies: Image formation, resolving power, numerical aperture, empty magnification, depth of focus, components of microscopes, important lens defects and their correction, principles of phase contrast, interference and polarized light microscopy, elements of quantitative metallography and image processing, sample preparation techniques

X-Ray diffraction and their applications: Production and properties of X-ray, absorption of X-rays and filters, X-ray-diffraction directions, diffraction methods. X-ray - diffraction intensities, factors affecting intensity, 'structure factor' calculations for simple, body centered, face centered, diamond cubic and hexagonal crystal structures. Working principles

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of diffractometer, counters and cameras. Indexing of XRD patterns. Precise lattice parameter determination, determination of particle size

Scanning electron microscope: construction, interaction of electrons with matter, modes of operation, image formation of plane and fractured surfaces.

Transmission electron microscopes: Construction and working principles, Image formation, resolving power, magnification, depth of focus, Bright field and dark field images. Stereographic projection and their applications. Formation of selected area diffraction patterns, indexing of diffraction patterns, sample preparation techniques.

Learning Outcomes

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

- 11) Characterize the various type of materials
- 12) Index the X-ray diffraction pattern, and calculate the particle size
- 13) Differentiate the various phases and determine their phase fraction

Teaching Learning Activities	Mostly using White Board, 20% learning through power point, Problem solving activities in tutorial classes, Performing experiments in laboratory
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Course Assessment Methods	E. Assignments and Performance in the class 20 F. Class Test 10 G. Mid Term Examination 20 H. End Term Examination 50
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Books and References

1. Spencer, Michael, Fundamentals of Light Microscopy, Cambridge University Press, 1982.
2. David B. Williams, C. Barry Carter, "Transmission Electron Microscopy: A Textbook for Materials Science", Springer, pub. 2009.
3. B.D. Cullity and S.R. Stock, "Elements of X-Ray Diffraction" Third edition, Prentice Hall, NJ, 2001.
4. 'Fundamentals of light microscopy and electronic imaging' Douglas B. Murphy, 2001, Wiley-Liss, Inc. USA
5. Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, by Yang Leng
6. X-Ray Diffraction: A Practical Approach, C. Suryanarayana and M. Grant Norton
7. 'Encyclopedia of Materials Characterization, Surfaces, Interfaces, Thin Films,' Editors C. Richard Brundle, Charles A. Evans, Jr., Shaun Wilson, Butterworth-Heinemann, Boston London Oxford Singapore Sydney Toronto Wellington

Links to online references	www.microscopyu.com Other Link to online references will be provided to students during Lectures.
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Name of Program	B.Tech (MME)		Session-2021-22
Course Title	Welding and Joining Technology		
Course Code	MM 702		
Course Type	Open Elective		
No of credits			
Semester			
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme			
Pre-requisites'			
Course Coordinator	Dr. Ramkishor Anant		
Learning Hours	50 Hours		
Course Description			
<p>This course is designed for undergraduate students of materials and metallurgical engineering. It provides the fundamental understanding of processing/characterization/design of engineering materials. This course is discussed about wide variety of processes and materials from the viewpoint of their fundamental physical and chemical properties. Specific topics: cold welding, adhesive bonding, diffusion bonding, soldering, brazing, flames, arcs, high-energy density heat sources, solidification, cracking resistance, shielding methods, and electric contacts. Emphasis on underlying science of a given process rather than a detailed description of the technique or equipment.</p>			
Course Objectives			
<p>Materials and Metallurgical engineers need to know different types of metal joining processes for production of intricate part in combination with the accuracy, tolerance & surface finish. The present course intends to give the exposure of various joining processes for a product whose scale ranges from miniature to extra-large. Since joining of metals is an important manufacturing route to fabricate bulk storage and processing equipment's. The subject focuses on knowledge and understanding of various joining process and equipment's, the underlying principles and their relative merits and demerits. Basic understanding regarding weldability of different metals and alloys is also duly emphasized. It also helps them to understand the advancement of technology in manufacturing.</p>			
Course Content			
Metal Joining Processes		No of hours: 6	
<p>Introduction, classification of welding processes as per AWS, commonly welded base metals, advantages and disadvantages of welding. Welding as compared to riveting and casting. Soldering, brazing, adhesive bonding processes, welding of dissimilar metals.</p>			
Gas Welding Processes		No of hours: 8	
<p>Introduction, oxy-acetylene welding, oxy-hydrogen, air-acetylene welding. Principle of operation, types of welding flames, Lighting the torch, flame adjustment, gas welding techniques .welding techniques- leftward & rightward. Filler metals and fluxes, gas welding</p>			

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equipments, applications.

Arc Welding Processes

No of hours:10

Introduction, Principle, Working, Specifications, Equipments, Merits and demerits, applications of Carbon arc welding, Flux Shielded Metal arc Welding, Gravity Welding, Sub Merged Arc Welding, GTAW Welding, GMAW Welding, CO2 Welding, Flux Cored Arc Welding(FCAW),Electro Slag welding, Electro Gas welding, Plasma Arc Welding. Source of Power Supply: AC/DC & their characteristics

Resistance Welding Processes

No of hours: 6

Introduction, Principle, Working, Specifications, Equipments, Merits and demerits, applications of Spot welding, Seam welding, Projection Welding, Upset welding, Flash Butt welding, Percussion Welding.

Solid State and Thermo Chemical Joining Processes

No of hours: 6

Introduction, Principle, Working, Specifications, Equipments, Merits and demerits, applications of Solid State welding Processes like Cold (or pressure welding), Diffusion(Bonding), Explosive welding, Friction ,Inertia and forged welding. Thermo chemical welding processes like thermit welding, atomic hydrogen welding.

Automation in Welding

No of hours: 6

Welding sequence and classification of processes, manual and semi-automatic, automatic, automated welding- adaptive controls- remote welding, robotic welding- selecting welding system, gravity welding and fire cracker welding, under water welding- wet and dry.

Weld Defects & Tests

No of hours: 4

Introduction, type of defects in weldments, causes and remedies of defects. Repair of defective welds, Visual examination of welding, Fabrication Weldability tests , Hydrostatic Pressure testing and Hydraulic or Gas Pressure testing for leakage, Use of NDT for weldments, Pre and post weld heat treatment, safety standards

Weld Joints & Metallurgy

No of hours: 4

Various types of weld joints & weld symbols, Standard location of elements of welding symbols. Heat affected zone and its properties.

Learning Outcomes

After learning the course the students should be able to:

Indicate which types of Welding Processes are suited for production.

Determine various gas, arc, solid state, thermo chemical welding processes with their process parameters.

Identify various advances welding processes.

Determine various Nondestructive testing for weldaments.

Identify the various types of electrodes used for welding processes

Identify the various Weld Joints & Metallurgy

Teaching Learning

Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, interactive teaching, educational visits, small

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Activities	projects.
Course Assessment Methods	E. Assignments and Performance in the class 20 F. Class Test 10 G. Mid Term Examination 20 H. End Term Examination 50
Books and References	
<ol style="list-style-type: none"> 1. Metallurgy of Welding: Lancaster J 2. Welding Processes and Technology: R.S.Parmar 3. Welding, Brazing and Soldering ASM Metals Hand Book, Vol. 6 4. Welding Metallurgy: Linnert G E 5. AWS Welding Handbook: Materials and Applications - Part 1 Vol.3:, AWS 6. Welding Metallurgy: Sindo Kou 	
Links to online references	

Course Title	Introduction to Materials	
Course Code	MM 703	
Course Type	Open Elective C	
No of credits		
Semester		
Department	Materials and Metallurgical Engineering	
U.G./P.G.	Undergraduate Programme	
Programme)	
Pre-requisites'		
Course Coordinator	Dr. Sanjay Srivastava	
Learning Hours	50 Hours	
Course Description		
Course Objectives		
Course Content		
Introduction and basic crystallographic, symmetry, Symmetry, Crystal Systems, Bravais Lattices and Miller Indices, Interstices, Structure of Metals and Alloys, Structure of Ceramics, Structure of Polymers, Structure Determination: X-ray diffraction, Defects in Materials, Gibbs energy-composition diagrams. Solution models. Isomorphous systems. Calculation of		

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liquidus and solidus in ideal systems. Lever rule. Iso-Gibbs energy curves. Equilibrium diagrams for systems exhibiting moderate departures from ideal behavior. Congruent minimum and congruent maximum. Equilibrium and quasi-equilibrium solidification in isomorphous systems and corresponding microstructures. Stability of a phase. Stability function. Miscibility gap and chemical spinodal boundaries. Thermodynamic conditions and determination of miscibility gap, spinodal boundaries and consolute point. Decomposition inside and outside spinodal boundary and the microstructural features. Illustrative examples

Learning Outcomes

Teaching Learning Activities

Mostly using White Board, 20% learning through power point, Problem solving activities
in tutorial classes, Performing experiments in laboratory

Course Assessment Methods

- A. Assignments and Performance in the class **20**
- B. Class Test **10**
- C. Mid Term Examination **20**
- D. End Term Examination **50**

Books and References

1. Raghavan, Materials Science and Engineering: A First Course, Prentice Hall of India.
2. W.D. Callister, Materials Science and Engineering: A Introduction, Wiley
3. J. Wulff, The Structure and Properties of Materials, Wiley (Vol 1: Structure, Vol 2: Thermodynamics of Structure, Vol 3: Mechanical Behaviour, Vol 4: Electronic Properties)

Links to online references

Link to online references will be provided to students during Lectures.

Lecture Plan

S.No.	Course Content	Number of Classes
1	Fundamentals of Material Properties and the importance of Ceramic materials;	02
2	crystal structure, defect in crystalline solids, dislocation	02
3	Glass and glass-ceramic; Processing and properties of different ceramic monoliths-	03
4	Fundamental Sintering mechanisms, various advanced sintering techniques (e.g. Hot Isostatic Pressing, Spark Plasma Sintering, Microwave sintering), two and three dimensional defect	04
5	Electrical conduction in ceramic, electrical phenomenon in ceramic ferroelectric,	03
6	piezoelectric and pyroelectric ceramic, Relaxor ferroelectric, super	07

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	conductivity, ceramic gas sensor, solid oxides fuel cell, hydrogen generation through MIEC reactor, lithium ion battery, magnetic ceramic ,	
7	sintering off ceramic	03
8	Mechanical behavior of Structural ceramics-Brittleness of ceramics,	04
9	Concept of fracture toughness and different toughness measurement techniques,	02
10	Elastic modulus, Strength measurement and Weibull theory of strength variability,	04
11	Concept of various toughening mechanisms.	04
12	Processing and Properties of ceramic composites- Examples of toughened particle reinforced composites,	04
13	Whisker reinforced composites, and Fiber reinforced composites.	03
14	Structural ceramic materials,	03
15	Bioceramics	03

Name of Program	B.Tech (MME)	Semester	Session-2021-22
Course Title	Corrosion and Surface Engineering		
Course Code	MM-704		
Course Type	Open Elective		
No of credits			
Semester			
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme			
Pre-requisites'	Nil		
Course Coordinator	Dr. Ramesh Kumar Nayak		
Learning Hours	50 Hours		

Course Description

This course is designed for undergraduate students of materials and metallurgical engineering. It provides the fundamental understanding of processing / characterization / design of engineering materials. The course enhances the understanding of complexities in processing / characterization /designing and their solutions through numerical /analytical / modeling / experiments/proto-type designs/interpretation of data. The students will be able to handle the modern equipments in processing industries/design/process novel materials based on this knowledge.

Course Objectives

The course will enable the students to understand the corrosion losses, possible failure in service and necessary remedial measures. It will also be helpful in design and selection of material

Course Content

Corrosion Principle

08 Hrs

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Corrosion, Corrosion due to Electrochemical and thermodynamic principles, Nernst equation and electrode potentials of metals, EMF and galvanic series, merits and demerits; Applications.

Corrosion Type and its Prevention

18 Hrs

Polarization - concentration, activation and resistance, Tafel equation; origin of Pourbaix diagram and its importance to iron, aluminium and magnesium metals, Exchange current density, passivity, electrochemical behaviour of active/passive metals, theories of passivity Atmospheric, pitting, de-alloying, stress corrosion cracking, inter-granular corrosion, corrosion fatigue, fretting corrosion and high temperature oxidation; causes and remedial measures,

Measurement of Corrosion

08 Hrs

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,

Design Aspect of Corrosion

08 Hrs

Corrosion prevention by design improvements, anodic and cathodic protection, metallic, non-metallic and inorganic coatings, mechanical and chemical methods and various corrosion inhibitors

Surface Engineering

08 Hrs

Improvement of surface properties by heat treatment, mechanical and coating methods, Evaluation of surface modified properties.

Learning Outcomes

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

- Understand different types of corrosion and its causes.
- Determine the corrosion rate by weight loss method, electrical resistance method and salt spray test.
- Protect the corrosion by electro and electro-less plating of different alloys.
- Analyze galvanic corrosion, pitting corrosion and stress corrosion cracking.
- Design the product to prevent corrosion through different surface treatment.

Teaching Learning Activities

Class room Lectures, Assignment, Tutorials, case studies, quiz, group discussion, ppt presentation, micro projects.

Course Assessment Methods

- A. Assignments and Performance in the class 20
- B. Class Test 10
- C. Mid Term Examination 20
- D. End Term Examination 50

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Books and References

Text Books

1. Fontana M. G., Greene N. D., 'Corrosion Engineering', 2nd Edition, McGraw Hill, 1983
2. J.C. Scully: the Fundamentals of Corrosion, Pergamon.
3. S. Glasstone: An Introduction to Electrochemistry, Van Nostrand

Reference Books

4. F.A.Lovenheim: Electroplating, McGraw-Hill.
5. SatyaNarain and R. Saran: An Introducton to Electrometallurgy, Standard Publishers.
6. C C.L. Mantell: Electrochemical Engineering, McGraw-Hill.
7. Denny Jones, "Principles and Prevention of Corrosion", Prentice Hall of India, 1996.

Links to online references

<https://nptel.ac.in/courses/113/104/113104082/>

<https://nptel.ac.in/courses/113/108/113108051/>

<https://nptel.ac.in/courses/113/105/113105086/>

Name of Program	B.Tech (MME)	Semester	Session-2021-22
Course Title	Fracture and Failure Analysis		
Course Code	MM 705		
Course Type	Open Elective		
No of credits			
Semester			
Department	Materials and Metallurgical Engineering		
U.G./P.G.	Undergraduate Programme		
Programme			
Pre-requisites			
Course Coordinator	Dr. Jayashree Baral		
Learning Hours	50 Hours		

Course Description

Failure, Failure Analysis, various modes of failure, types of failure and case study. Fracture Mechanics, Linear elastic fracture mechanics. Procedural steps for investigation: Nondestructive testing,

Course Objectives

- To understand about various modes of failure of engineering components, this leads to safe design.
- To expose to fracture mechanics and failure analysis tools

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Course Content	
Introduction	(3hr)
Phenomenological description of various modes of failure and fracture, an overview of the basic problems and concepts of fracture in structural materials, Failure Analysis Methodology, Tools and Techniques of Failure Analysis	
Fundamentals of fracture mechanics:	17hrs
Linear elastic fracture mechanics, Crack-tip plastic zone and the elastic plastic fracture Mechanics, Fracture toughness testing, Microstructural aspect of fracture toughness, and the fracture toughness approach for toughening of structural materials.	
Non-destructive testing of defects:	5hrs
Visual inspection, liquid penetration inspection, magnetic particle inspection, eddy current inspection, ultrasonic testing, radiographic inspection.	
Failure mode and effect analysis:	4hrs
Phenomenological description of various modes of failure, fracture, fractography	
Different failures:	10hrs
Fatigue failure, creep and stress rupture failures, environment-assisted failures, wear failures, common failures in castings, weldments, gears, shafts and springs, failures of composites	
Analyses of engineering failures:	10hrs
Typical defects, macroscopic fracture surface examination, metallographic and fractographic examination, steps in failure analysis, case histories	
Learning Outcomes	
On completion of the course, students should:	
Understand and be able to identify the common modes of failure of engineering components and making recommendations on failure prevention.	
Understand the process of materials selection and be able to use available tools for making decisions on materials selection for engineering applications	
To be able to write a professional engineering failure analysis report	
Teaching Learning Activities	Teaching and learning modes for this course are through contact lectures, tutorials, and case studies. The lectures provide the background theory for the subject, while the tutorial and case studies give students hands-on experience on materials selection and failure analysis. The numerical questions are expected to be answered by the students before the tutorial sessions (all marked as part of assignment) where the answers and explanations will be provided by the subject coordinator.
Course Assessment	I. Assignments and Performance in the class 20

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Methods	J. Class Test 10 K. Mid Term Examination 20 L. End Term Examination 50
Books and References	
G.E. Dieter: Mechanical Metallurgy, McGraw- Hill, 1988 Deformation and fracture mechanics of engineering materials, R. W. Hertzberg Elementary engineering fracture mechanics, D. Broek Fundamental of fracture mechanics, J. F. Knott Metallurgy of Failure Analysis. A.K. Das	
Links to online references	
Anderson, T. L. (2017). <i>Fracture mechanics: fundamentals and applications</i> . CRC press Becker, W. T., & Shipley, R. J. (Eds.). (1990). <i>ASM Handbook</i> (Vol. 11). ASM international. Handbook, M. (1987). vol. 12 Fractography. <i>ASM International Metals Park, Ohio, USA</i>	

Course Title	Advanced Ceramic Materials	
Course Code	MM 706	
Course Type	Open Elective C	
No of credits		
Semester		
Department	Materials and Metallurgical Engineering	
U.G./P.G.	Undergraduate Programme	
Programme		
Pre-requisites'	Basic knowledge of Materials Science Crystal Structure	
Course Coordinator	Dr. Mangesh Lodhe	
Learning Hours	50 Hours	
Course Description		
This course is designed for undergraduate students of Materials and Metallurgical Engineering (MME) programme. It provides the fundamental understanding of science and applications of ceramic materials. The course enhances the understanding of complexities in crystal structure /processing/characterization of ceramic materials		
Course Objectives		
The objective of this course is to teach the students the what is ceramic materials and how it is different from other class of materials. Students will be introduced to the science, crystal structure, processing and applications of ceramic materials		

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Course Content

Traditional ceramics and advanced ceramics, ceramic crystal structures, defect reactions, silicate glass formation and glass formation, Techniques for preparing advanced ceramic powders, Biomimetic processing, Advanced densification techniques, Pressure assisted sintering, Ceramic coatings, Joining of ceramics, Advanced ceramics including fiber glass, machinable ceramics, functional ceramics and functionally grade ceramics, refractories, abrasives and structural ceramics. Microstructural characterization

Engineering applications: at room and high temperatures (including armour application), Electrical behaviour: insulating (dielectric, ferroelectric, piezoelectric, pyroelectric) semiconducting, conducting, superconducting and ionically conducting,

specific materials and their applications. Magnetic behaviour: basic principles, materials and their applications. Transparent ceramics, coatings and films: preparation

and applications, Porous ceramics and ceramic membrane: fabrication techniques and applications in separation technology, Bio-medical applications of ceramic materials, Ceramics for energy and environment technologies (fuel cell, lithium battery, gas sensor and catalytic support), Ceramics matrix composites: different types, their

preparation and properties (including nanocomposites),

Learning Outcomes

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

- 4) Differentiate the different types of ceramics
- 5) Understand the science and processing of ceramic materials.
- 6) Know the various application of these materials

Teaching Learning Activities

Mostly using White Board, 20% learning through power point, Problem solving activities

in tutorial classes, Performing experiments in laboratory

Course Assessment Methods

I. Assignments and Performance in the class **20**

J. Class Test **10**

K. Mid Term Examination **20**

L. End Term Examination **50**

Books and References

1. Fundamental of Ceramics by Michel W. Barsoum, McGraw Hill International edition, 1997
2. Modern Ceramic Engineering by David. W. Richerson, Mercel Dekker, NY 1992
3. Ceramic Processing and Sintering by M. N. Rahman, Mercel Dekker, 2003

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<p>4. Introduction to Ceramics by W. David Kingery, H. K. Bowen, Donald R. Uhlmann</p> <p>5. Physical Ceramics: Principles for Ceramic Science and Engineering by Yet-Ming Chiang, Dunbar P. Birnie, W. David Kingery</p> <p>6. Handbook of Advanced Ceramics by S. Somiya, Academic Press 2003</p> <p>7. Handbook of Advanced Ceramics, Parts 1 and 2, S. Somiya, Academic Press, 2006</p>
<p>Links to online references</p> <p>Link to online references will be provided to students during Lectures.</p>

Course Title	Welding Metallurgy
Course Code	MM 707
Course Type	Open Elective C
No of credits	
Semester	
Department	Materials and Metallurgical Engineering
U.G./P.G.	Undergraduate Programme
Programme	
Pre-requisites'	Introduction to courses such as Welding processes, Materials science etc.
Course Coordinator	Dr. Ramkishor Anant
Learning Hours	50 Hours
Course Description	
<p>This course is designed for undergraduate students of materials and metallurgical engineering. The course focuses on understanding the metallurgy and solidification of weldments. The course will make the students aware with the metallurgical aspects of welding. For getting a sound weld, the students are required to be aware of the science behind the welding phenomena, especially in the domain of weld metal solidification, heat transfer, heat treatment processes, strengthening mechanisms etc. The course will be useful for engineering graduates as well as professionals working in the area of welding.</p>	
Course Objectives	
<p>To provide knowledge about the physical metallurgy of welding.</p> <p>To acquire essential significance of thermal effects of welding and subsequent remedial measures to reduce residual stresses and distortion in weldments.</p> <p>To gain knowledge about the Weldability of different commercially available materials, their corresponding weld joints design and automation of welding processes.</p>	
Course Content	

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Introduction to Welding Metallurgy

No of hours: 8

Welding arc, Heat flow in and around weld metal, Metallurgical effects of welding, Weld metal solidification, Absorption of gases by weld, Gas metal reactions, Porosity in weld, Fe-C, T.T.T. and C.C.T. diagrams, Thermal effects of welding on parent metal and its mechanical properties, Effect of welding parameter on weld quality, Hydrogen embrittlement and cracking, Grain size control, Weld cracking, Corrosion of weld, Weld decay, Dilution

Weld Joint Microstructure

No of hours: 8

Introduction, Weld metal zone, General theory of solidification of metal and alloys, Effect of welding speed on grain structure, Properties of weld metals, Fusion boundary zone, Heat affected zone, Properties of HAZ, Microstructural products in weldments, Microstructure of multi-run welds, Effect of alloying elements on microstructure, Delta and sigma phase in welds.

Welding of Carbon Steel

No of hours: 5

Types of carbon steel, Weldability of carbon steel, Weldability of low carbon steel, Weldability of medium carbon steel, Weldability of high carbon steel, Weldability of high strength low alloy (HSLA) steels, Weldability of low alloy steel, WPS & PQR preparation as per ASME SEC-IX (SMAW Process).

Welding of Stainless Steel

No of hours: 5

Types of stainless steel, Welding of Austenitic stainless steel, Schaeffler diagram, DeLong diagram, Problems associated with welding of Austenitic stainless steel, Ferrite and Sigma phase formation, Carbide precipitation, Knife edge attack, Stress corrosion cracking, PWHT of Austenitic stainless steel weldments, Weldability of Ferritic stainless steel, PWHT of Ferritic stainless steel weldments, Weldability of Martenitic stainless steel, Preheating and PWHT of MSS weldments, Weldability of PH stainless steel, Weldability of DSS, WPS & PQR preparation as per ASME SEC-IX (GTAW Process).

Welding of Aluminium and its Alloys

No of hours: 5

Characteristics and application of Aluminium, Welding characteristics of Al & its alloys, Processes used for welding Aluminium & its alloys, Problems encountered in welding of Aluminium.

Welding of Titanium and its Alloys

No of hours: 5

Characteristics of Titanium, Titanium alloys, Welding of Titanium and its alloys, Welding processes and procedure used for Titanium welding, Joint design selection, preheating, selection of preheat and interpass temperature, Protection during Titanium welding, Welding process selection, PWHT, Problems associated with welding of Titanium.

Welding of Other Ferrous and Non-ferrous Alloys

No of hours: 4

Weldability of cast irons, copper and its alloys, Magnesium and its alloys, Nickel and its alloys, weldability tests.

Residual Stresses and Distortion in Weldments

No of hours: 10

Definition and concept of residual stresses, Types of residual stresses, Residual stresses in welds, Effects of thermal stresses, Control of residual stresses, Need for residual stress

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relieving, Methods of residual stress relieving 1) Design consideration 2) Material selection 3) Preheating 4) Welding procedure 5) Welding sequence 6) PWHT 7) Natural ageing 8) Peening 9) Vibratory stress relieving (VSR), Concept of distortion, Types of distortion, Control of welding distortion, Minimizing distortion in repair work, Effect of properties on welding distortion

Learning Outcomes

On the completion of this course the students can have the ability:

To select suitable welding process and technique to join a given material.

To identify and minimize the distortion and residual stresses induced in weldments.

To evolve better design for both static and fatigue loading conditions.

Teaching Learning Activities

Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, interactive teaching, educational visits, small projects.

Course Assessment Methods

- A. Assignments and Performance in the class **20**
- B. Class Test **10**
- C. Mid Term Examination **20**
- D. End Term Examination **50**

Books and References

1. Welding Technology by O.P.Khanna Dhanpat
2. Welding Engineering & Technology by Dr. R.S.Parmar
3. Welding Metallurgy by Sindo Kou
4. Fundamentals of welding metallurgy, Abington in association with the Welding Institute, 1991 – Henry Granjon
5. Metallurgy of Welding, Woodhead Publishing Limited, 1999 – J.F. Lancaster

Links to online references

Course Title	Advanced Manufacturing Processes
Course Code	MM 708
Course Type	Open Elective C
No of credits	
Semester	
Department	Materials and Metallurgical Engineering
U.G./P.G.	Undergraduate Programme

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Programme	
Pre-requisites'	Unconventional sources of material processing
Course Coordinator	Dr. Ramkishor Anant
Learning Hours	50 Hours
Course Description	
<p>This course is designed for undergraduate students of materials and metallurgical engineering. The course covers the details of the advanced manufacturing technology and practices, advanced manufacturing processes, advanced metal forming processes, advanced welding processes and advanced foundry processes.. The students will be able to handle the modern equipments in processing industries/design/process novel materials based on this knowledge.</p>	
Course Objectives	
<p>To aid students involved in the manufacturing of commercial products to design them to be easily made.</p> <p>To enable students to take advantage of all the inherent cost benefits available in the manufacturing process which will be used.</p> <p>To know about properties, processing and applications of materials.</p> <p>To acquire the essential knowledge about the selection of different latest materials for various applications.</p>	
Course Content	
Metal Casting	No of hours: 12
<p>Patterns and moulds including mould design involving feeding, gating and risering, melting, casting practices in sand casting, permanent mould casting, investment casting and shell moulding, casting defects and repair; Hot, warm and cold working of metals.</p>	
Metal Forming	No of hours: 12
<p>Fundamentals of metal forming processes of rolling, forging, extrusion, wire drawing and sheet metal forming, stretch forming, bending, defects in forming; High energy rate forming (HERF).</p>	
Powder Metallurgy	No of hours: 6
<p>Production of powders, compaction and sintering; 3-D Printing of metals (additive manufacturing).</p>	
Metal Joining	No of hours: 15
<p>Soldering, brazing and welding, common welding processes of shielded metal arc welding, gas metal arc welding, gas tungsten arc welding and submerged arc welding; Welding metallurgy, problems associated with welding of steels and aluminium alloys, defects in welded joints, additive manufacturing by arc welding.</p>	
Non-destructive Testing	No of hours: 5

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NDT using dyepenetrant, ultrasonic, radiography, eddy current, acoustic emission and magnetic particle methods.

Learning Outcomes

Have in-depth knowledge about manufacturing technologies along with recent trends in advanced manufacturing.

In manufacturing industries, the engineers would be benefited after having learnt the concepts of how the products are manufactured.

They would be able to apply the cost reduction techniques of forming design, casting design and welding structural design and solve technical problems related to the above field.

Teaching Learning Activities

Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, interactive teaching, educational visits, small projects.

Course Assessment Methods

- A. Assignments and Performance in the class **20**
- B. Class Test **10**
- C. Mid Term Examination **20**
- D. End Term Examination **50**

Books and References

1. Principles of Metal Casting R. W. Hein, C. R. Loper, P. C. Rosenthal
2. *Welding* Engineering and Technology: R. S. Parmar
3. Manufacturing Engineering & Materials Processing: Robert C. Creese
4. Materials Science and Engineering: William D. Callister Jr., David G. Rethwisch.
6. Additive Manufacturing Technologies: Gibson, Ian, Rosen, David, Stucker, Brent

Links to online references