ANNA UNIVERSITY, CHENNAI

UNDERGRADUATE CURRICULUM (UNIVERSITY DEPARTMENTS)

Campus: College of Engineering

Department: Mechanical Engineering

Programme: B.E. Materials Science and Engineering

Regulations: 2023 (Revised 2024), with effect from the AY 2024 – 25 to all the students of UG Programme.

OVERVIEW OF CREDITS

Sem	PCC	PEC	ESC	HSMC	ETC	ED&S	SDC	OEC	UC	SLC	Total
I	-	-	7	11	-	-	4	-	1	-	**23**
II	-	-	7	11	-	-	3	-	1	-	**22**
III	11	-	7	4	-	-	2	-	-	-	**24**
IV	22	-	-	-	-	-	2	-	3	1	**28**
V	18	-	3	-	3	-	3	-	-	-	**27**
VI	-	9	-	-	3	3	1	3	-	-	**19**
VII	8	9	-	-	-	3	2	3	-	-	**25**
VIII	-	-	-	-	-	-	8	-	-	-	**8**
Total	**59**	**18**	**24**	**26**	**6**	**6**	**25**	**6**	**7**	**1**	**176**
% of Category	**33.14**	**10.11**	**13.48**	**14.6**	**3.37**	**3.37**	**14.0**	**3.37**	**3.9**	**0.56**	

CATEGORY OF COURSES

PCC – Professional Core Course
PEC – Professional Elective Course
ETC – Emerging Technology Course
OEC – Open Elective Course
SLC – Self Learning Course
ESC – Engineering Science Course
HSMC – Humanities Science and Management Course
SDC – Skill Development Course
UC – University Course
ED&S - Entrepreneurship Development

For Honors'& Minor Degree, please refer the Regulations 2023 (Revised 2024).

Semester – I							
S. No.	Course Code	Course Name	Course Type#	Periods / Week		Credits	Category
				L-T-P	TCP*		
1	EN23C01	Foundation English	LIT	2-0-2	4	3	HSMC
2	MA23C01	Matrices and Calculus	T	3-1-0	4	4	HSMC
3	CY23C01	Engineering Chemistry	LIT	3-0-2	5	4	HSMC
4	ME23C01	Engineering Drawing and 3D Modelling	LIT	2-0-4	6	4	SDC
5	EE23C03	Basics of Electrical and Electronics Engineering	LIT	2-0-2	4	3	ESC
6	CS23C02	Computer Programming in Python	LIT	3-0-2	5	4	ESC
7	UC23H01	தமிழர் மரபு/Heritage of Tamils	T	1-0-0	1	1	UC
8	-	NCC/NSS/NSO/YRC	-	0-0-2	2	-	UC
9	-	Audit Course–I	-	-	-	-	UC
					Total Credits	**23**	

***TCP** **–** Total Contact Period(s)

#**TYPE OF COURSE**

LIT –Laboratory Integrated Theory
T – Theory
L – Laboratory Course
IPW – Internship cum Project Work
PW – Project Work
CDP – Capstone Design Project

Semester – II							
S. No.	Course Code	Course Name	Course Type#	Periods / Week		Credits	Category
				L-T-P	TCP*		
1	EN23C02	Professional Communication	LIT	2-0-2	4	3	HSMC
2	MA23C02	Ordinary Differential Equations and Transform Techniques	T	3-1-0	4	4	HSMC
3	PH23C01	Engineering Physics	LIT	3-0-2	5	4	HSMC
4	ME23C04	Makerspace	LIT	1-0-4	5	3	SDC
5	ME23C03	Engineering Mechanics	T	3-1-0	4	4	ESC
6	MS23201	Reaction Kinetics and Dynamics	T	3-0-0	3	3	ESC
7	UC23H02	தமிழரும் தொழில் நுட்பமும் /Tamils and Technology	T	1-0-0	1	1	UC
					Total Credits	**22**	

Semester – III							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1	MA23C06	Partial Differential Equations and Complex Functions	T	3-1-0	4	4	HSMC
2	CY23C02	Polymers, Bio-materials and Ceramics	T	3-0-0	3	3	ESC
3	CE23C01	Mechanics of Materials	LIT	3-0-2	5	4	ESC
4	MS23301	Structure and properties of Materials	T	3-0-0	3	3	PCC
5	MS23302	Metallurgical Thermodynamics	T	3-1-0	4	4	PCC
6	MS23303	Physical Metallurgy	LIT	3-0-2	5	4	PCC
7		Skill Development Course – I	-	-	-	2	SDC
8	**-**	Audit Course–II	-	-	-	-	UC
					Total Credits	**24**	

Semester – IV							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1	MS23401	Heat Treatment of Materials	LIT	3-0-2	5	4	PCC
2	MS23402	Casting and Welding Metallurgy	LIT	3-0-2	5	4	PCC
3	MS23403	Mechanical Metallurgy	T	3-0-0	3	3	PCC
4	MS23404	Powder Metallurgy	LIT	3-0-2	5	4	PCC
5	MS23405	Characterization of Materials	LIT	3-0-2	5	4	PCC
6	MS23406	Iron and Steel Making	T	3-0-0	3	3	PCC
7	MS23U01	Standards for Materials and Testing	T	1-0-0	1	1	UC
8		Skill Development Course - II	-	-	-	2	SDC
9	MS23L01	Self-learning Course (minimum duration of 15 hrs)	-	1-0-0	1	1	SLC
10	UC23U01	Universal Human Values	LIT	1-0-2	3	2	UC
					Total Credits	**28**	

Semester – V							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1	MS23501	Transport phenomena in Metallurgical Processes	T	3-0-0	3	3	PCC
2	MS23502	Theory and Applications of Material Forming	LIT	3-0-2	5	4	PCC
3	MS23503	Surface Engineering	LIT	3-0-2	5	4	PCC
4	MS23504	Composite Materials and Mechanics	LIT	3-0-2	5	4	PCC
5	MS23505	Introduction to Electronic Materials	T	3-0-0	3	3	PCC
6	MS23506	Analytical Instrumentation Techniques	T	3-0-0	3	3	ESC
7		Emerging Technology Course - I	T	-	-	3	ETC
8		Skill Development Course - III	-	-	-	2	SDC
9		Industry Oriented Course – I	-	-	-	1	SDC
				Total Credits		**27**	

Courses for Honors Degree							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1.	**MS23D01**	Capstone Design Project – Level I	CDP	0-0-12	12	6	SDC
(OR)							
1.		Honors' Elective-I	T	3-0-0	3	3	
2.		Honors' Elective -II	T	3-0-0	3	3	
Courses for Minor Degree							
1.		Minor Elective – I	T	3-0-0	3	3	
2.		Minor Elective – II	T	3-0-0	3	3	

Semester – VI (Preference for Foreign Exchange)							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1		Emerging Technology Course – II	LIT	2-0-2	4	3	ETC
2		Professional Elective I	T	3-0-0	3	3	PEC
3		Professional Elective II	T	3-0-0	3	3	PEC
4		Professional Elective III	T	3-0-0	3	3	PEC
5		Industry Oriented Course – II	-	-	-	1	SDC
6		Open Elective I	T	3-0-0	3	3	OEC
7	MS23U02	Perspectives of Sustainable Development	T	3-0-0	3	3	ED&S
					Total Credits	**19**	

Courses for Honors Degree							
1.	**MS23D02**	Capstone Design Project – Level II	CDP	0-0-12	12	6	SDC
(OR)							
1.		Honors' Elective-III	T	3-0-0	3	3	
2.		Honors' Elective -IV	T	3-0-0	3	3	
Courses for Minor Degree							
1		Minor Elective - III	T	3-0-0	3	3	
2		Minor Elective - IV	T	3-0-0	3	3	

Semester – VII							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1	MS23701	Computational Materials Engineering	LIT	3-0-2	5	4	PCC
2	MS23702	Non-Destructive Testing and Evaluation	LIT	3-0-2	5	4	PCC
3	UC23E01	Engineering Entrepreneurship Development	T	2-0-2	4	3	ED&S
4		Professional Elective IV	T	3-0-0	3	3	PEC
5		Professional Elective V	T	3-0-0	3	3	PEC
6		Professional Elective VI	T	3-0-0	3	3	PEC

Semester – VII							
S. No.	Course Code	Course Name	Course Type#	Periods / Week		Credits	Category
				L-T-P	TCP*		
7		Industry Oriented Course – III	-	-	-	1	SDC
8		Open Elective II	T	3-0-0	3	3	OEC
9	MS23703	Mini Project / Summer internship	PW	0-0-2	2	1	SDC
					Total Credits	**25**	

S. No.	Course Code	Course Name	Course Type#	Periods / Week		Credits	Category
				L-T-P	TCP*		
1	MS23D03	Capstone Design (Skill Development Level – IV) – First phase in the development of product	CDP	0-0-12	12	6	SDC
(OR)							
1		Honors Elective – V	T	3-0-0	3	3	
2		Honors Elective – VI	T	3-0-0	3	3	
Courses for Minor Degree							
S. No.	Course Code	Course Name	Course Type#	Periods / Week		Credits	Category
				L-T-P	TCP*		
1.		Minor Elective - V	T	3-0-0	3	3	
2.		Minor Elective - VI	T	3-0-0	3	3	

Semester – VIII							
S. No.	Course Code	Course Name	Course Type#	Periods / Week		Credits	Category
				L-T-P	TCP*		
1	MS23801	Project Work / Internship cum Project Work	PW/IPW	0-0-16	16	8	SDC
					Total Credits	**8**	

PROFESSIONAL ELECTIVE COURSES (PEC)

PEC	Vertical I (Mechanical Behaviour& Materials Characterization)	Vertical II (Advanced Materials & Processing)	Vertical III (Materials For Electrical & Optoelectronic Applications)	Vertical IV (Non-Destructive Testing Techniques)	Vertical V (Materials For High-Temperature Applications)	Vertical VI (Diversified Group)
1.	Fracture Mechanics and Failure Analysis	Nano Structured & Quantum Materials	Smart Materials	Surface NDE Techniques	Fuels, Refractories and Furnaces	Materials selection and design
2.	Creep and Fatigue Behaviour of Materials	Micro and Nano-Manufacturing Processes	Energy Storage Devices	Ultrasonic Testing	Ceramic processing	Metallurgy of Tool Materials and Special Steels
3.	Electron Microscopy	Automotive and Aerospace Materials	Fuel Cell Technology	Radiography Testing and Radiation safety	Mechanical performance of Ceramics	Laser Processing of Materials
4.	X-ray Diffraction techniques	Additive Manufacturing	Semiconductors optoelectronic materials and devices	Advancements in Ultrasonic Technique	Glass Science technology	Making and Metallurgy of Stainless Steels
5.	Advanced Metallographic techniques	Cryogenic Treatment of Materials	Thin film Technology	Eddy current Testing	Abrasives and Cutting Tools	Non-ferrous Metallurgy
6.	Phase Transformations	Materials for Defense and Nuclear Applications	MEMS and Nanotechnology	Advanced NDE Techniques	Metals & Alloys for High Temperature applications	Manufacturing Processes

VERTICAL I: MECHANICAL BEHAVIOUR & MATERIALS CHARACTERIZATION

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MS23001	Fracture Mechanics and Failure Analysis	PEC	3	0	0	3	3
2.	MS23002	Creep and Fatigue Behaviour of Materials	PEC	3	0	0	3	3
3.	MS23003	Electron Microscopy	PEC	3	0	0	3	3
4.	MS23004	X-ray Diffraction techniques	PEC	3	0	0	3	3
5.	MS23005	Advanced Metallographic techniques	PEC	3	0	0	3	3
6.	MS23006	Phase Transformations	PEC	3	0	0	3	3

VERTICAL II: ADVANCED MATERIALS AND PROCESSING

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MS23007	Nano Structured & Quantum Materials	PEC	3	0	0	3	3
2.	MS23008	Micro and Nano-Manufacturing Processes	PEC	3	0	0	3	3
3.	MS23009	Automotive and Aerospace Materials	PEC	3	0	0	3	3
4.	MF23C01	Additive Manufacturing	PEC	3	0	0	3	3
5.	MS23010	Cryogenic Treatment of Materials	PEC	3	0	0	3	3
6.	MS23011	Materials for Defense and Nuclear Applications	PEC	3	0	0	3	3

VERTICAL III: MATERIALS FOR ELECTRICAL AND OPTOELECTRONIC APPLICATIONS

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MS23012	Smart Materials	PEC	3	0	0	3	3
2.	MS23013	Energy Storage Devices	PEC	3	0	0	3	3
3.	MS23014	Fuel Cell Technology	PEC	3	0	0	3	3
4.	PH23C12	Semiconductors, optoelectronic materials and devices	PEC	3	0	0	3	3
5.	MS23015	Thin film Technology	PEC	3	0	0	3	3
6.	MS23016	MEMS and Nanotechnology	PEC	3	0	0	3	3

VERTICAL IV: NON-DESTRUCTIVE TESTING TECHNIQUES

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MS23017	Surface NDE Techniques	PEC	3	0	0	3	3
2.	MS23018	Ultrasonic Testing	PEC	3	0	0	3	3
3.	MS23019	Radiography Testing and Radiation safety	PEC	3	0	0	3	3
4.	MS23020	Advancements in Ultrasonic Technique	PEC	3	0	0	3	3
5.	MS23021	Eddy current Testing	PEC	3	0	0	3	3
6.	MS23022	Advanced NDE Techniques	PEC	3	0	0	3	3

*** Additional lab classes need to be undergone for certification**

VERTICAL V: MATERIALS FOR HIGH-TEMPERATURE APPLICATIONS

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MS23023	Fuels, Refractories and Furnaces	PEC	3	0	0	3	3
2.	MS23024	Ceramic Processing	PEC	3	0	0	3	3
3.	MS23025	Mechanical performance of Ceramics	PEC	3	0	0	3	3
4.	MS23026	Glass Science technology	PEC	3	0	0	3	3
5.	MS23027	Abrasives and Cutting Tools	PEC	3	0	0	3	3
6.	MS23028	Metals and Alloys for High Temperature applications	PEC	3	0	0	3	3

VERTICAL VI: DIVERSIFIED GROUP

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MS23029	Material Selection & Design	PEC	3	0	0	3	3
2.	MS23030	Metallurgy of Tool Materials and Special Steels	PEC	3	0	0	3	3
3.	MS23031	Laser Processing of Materials	PEC	3	0	0	3	3
4.	MS23032	Making and Metallurgy of Stainless Steels	PEC	3	0	0	3	3
5.	MS23033	Non-ferrous Metallurgy	PEC	3	0	0	3	3
6.	MS23034	Manufacturing Processes	PEC	3	0	0	3	3

Courses for Honours Degree							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1	MS23035	Energy Absorbing Mechanisms and Materials	T	3-0-0	3	3	
2	ME23C09	Modelling and Simulation in Materials Engineering	T	3-0-0	3	3	
3	MS23036	Finite Element Analysis	T	3-0-0	3	3	
4	MS23037	Materials for Additive Manufacturing	T	3-0-0	3	3	
5	MS23038	Product Design and Development	T	2-0-2	4	3	
6	ME23C18	Green Hydrogen Production storage and transportation	T	3-0-0	3	3	
Courses for Minor Degree (Materials Engineering)							
1.	MS23039	Introduction to Materials Science	T	3-0-0	3	3	
2.	MS23040	Physics of Materials	T	3-0-0	3	3	
3.	MS23041	Introduction to Mechanical Metallurgy	T	3-0-0	3	3	
4.	MS23042	Semiconductors, optoelectronic materials and devices	T	3-0-0	3	3	
5.	MS23043	Materials Characterization	T	3-0-0	3	3	
6.	MS23044	Materials in Industrial Applications	T	3-0-0	3	3	

Emerging Technology Courses							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
Semester - V							
1	MS23E01	Advanced Sintering technology	T	3-0-0	3	3	ETC
2	MS23E02	Industrial 5.0 & IOT	T	3-0-0	3	3	ETC
Semester - VI							
3	MS23E03	Machine Learning in Materials Science	LIT	2-0-2	3	3	ETC
4	MS23E04	Atomistic Modelling of Materials	LIT	2-0-2	3	3	ETC
Open Elective Courses							
5	MS23901	Introduction to Non-destructive testing	T	3-0-0	3	3	OEC
6	MS23902	Materials Characterization Techniques	T	3-0-0	3	3	OEC
	MS23903	Functional Materials & Devices	T	3-0-0	3	3	OEC
Skill Development Courses							
Semester - IV							
7	MS23S01	Fundamentals of Practical Manufacturing Skills	L	0-0-4	4	2	SDC
Semester - V							
8	MS23S02	Practical Skills on Advanced Materials Processing & Testing Techniques	L	0-0-4	4	2	SDC

EN23C01 **FOUNDATION ENGLISH** **L T P C**
2 0 2 3

COURSE OBJECTIVES:

- To develop students' foundational skills in reading, writing, grammar and vocabulary to enable them to understand and produce various forms of communication.
- To enhance students' proficiency in reading comprehension, narrative and comparative writing.
- To comprehend and analyse descriptive texts and visual images
- To articulate similarities and differences in oral and written forms.
- To improve students' proficiency in reading and writing formal letters and emails.

UNIT I BASICS OF COMMUNICATION 6

Reading - Telephone message, bio-note; Writing – Personal profile; Grammar – Simple present tense, Present continuous tense, wh-questions, indirect questions; Vocabulary – Word formation (Prefix and Suffix).

LAB ACTIVITY: 6

Listening – Telephone conversation; Speaking Self-introduction; Telephone conversation – Video conferencing etiquette

UNIT II NARRATION 6

Reading – Comprehension strategies - Newspaper Report, An excerpt from an autobiography; Writing – Narrative Paragraph writing (Event, personal experience etc.); Grammar – Subject-verb agreement, Simple past, Past continuous Tenses; Vocabulary – One-word substitution

LAB ACTIVITY: 6

Listening – Travel podcast; Speaking – Narrating and sharing personal experiences through a podcast

UNIT III DESCRIPTION 6

Reading – A tourist brochure, Travel blogs, descriptive article/excerpt from literature, visual images; Writing –Descriptive Paragraph writing, Grammar – Future tense, Perfect tenses, Preposition; Vocabulary – Descriptive vocabulary

LAB ACTIVITY: 6

Listening – Railway / Airport Announcements, Travel Vlogs; Speaking – Describing a place or picture description

UNIT IV COMPARE AND CONTRAST 6

Reading – Reading and comparing different product specifications - Writing – Compare and Contrast Essay, Coherence and cohesion; Grammar – Degrees of Comparison; Vocabulary – Transition words (relevant to compare and contrast)

LAB ACTIVITY: 6

Listening – Product reviews, Speaking – Product comparison based on product reviews - similarities and differences

UNIT V EXPRESSION OF VIEWS **6**

Reading – Formal letters, Letters to Editor ; Writing – Letter writing/ Email writing (Enquiry / Permission, Letter to Editor); Grammar – Compound nouns, Vocabulary – Synonyms, Antonyms

LAB ACTIVITY: **6**

Listening – Short speeches; Speaking – Making short presentations (JAM)

TOTAL: 60 PERIODS

TEACHING METHODOLOGY

Interactive lectures, role plays, group discussions, listening and speaking labs, technology enabled language teaching, flipped classroom.

EVALUATION PATTERN

Internal Assessment
Written assessments
Assignment

Lab assessment
Listening
Speaking

External Assessment
End Semester Examination

LEARNING OUTCOMES

By the end of the courses, students will be able to

- Use appropriate grammar and vocabulary to read different types of text and converse appropriately.
- Write coherent and engaging descriptive and comparative essay writing.
- Comprehend and interpret different kinds of texts and audio visual materials
- Critically evaluate reviews and articulate similarities and differences
- Write formal letters and emails using appropriate language structure and format

TEXT BOOKS:

1. “English for Engineers and Technologists” Volume I by Orient Blackswan, 2022

2. “English for Science & Technology - I” by Cambridge University Press, 2023

REFERENCES

1. “Interchange” by Jack C.Richards, Fifth Edition, Cambridge University Press, 2017.
2. “English for Academic Correspondence and Socializing” by Adrian Wallwork, Springer, 2011.
3. “The Study Skills Handbook” by Stella Cortrell, Red Globe Press, 2019
4. www.uefap.com

MA23C01	MATRICES AND CALCULUS	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To develop the use of matrix algebra techniques in solving practical problems.
- To familiarize the student with functions of several variables.
- To solve integrals by using Beta and Gamma functions.
- To acquaint the student with mathematical tools needed in evaluating multiple integrals.
- To acquaint the students with the concepts of vector calculus which naturally arise in many engineering problems.

UNIT I MATRICES 9+3

Eigenvalues and Eigenvectors of a real matrix – Properties of Eigenvalues and Eigenvectors- Cayley-Hamilton theorem (excluding proof) – Diagonalization of matrices - Reduction of Quadratic form to canonical form by using orthogonal transformation - Nature of a Quadratic form.

UNIT II FUNCTIONS OF SEVERAL VARIABLES 9+3

Limit, continuity, partial derivatives – Homogeneous functions and Euler's theorem - Total derivative – Differentiation of implicit functions – Jacobians -Taylor's formula for two variables - Errors and approximations – Maxima and Minima of functions of two variables – Lagrange's method of undermined multipliers.

UNIT III INTEGRAL CALCULUS 9+3

Improper integrals of the first and second kind and their convergence – Differentiation under integrals - Evaluation of integrals involving a parameter by Leibnitz rule – Beta and Gamma functions-Properties – Evaluation of single integrals by using Beta and Gamma functions..

UNIT IV MULTIPLE INTEGRALS 9+3

Double integrals – Change of order of integration – Double integrals in polar coordinates – Area enclosed by plane curves – Triple integrals – Volume of Solids – Change of variables in double and triple integrals-

Evaluation of double and triple integrals by using Beta and Gamma functions.

UNIT V VECTOR CALCULUS 9+3

Gradient of a scalar field, directional derivative – Divergence and Curl – Solenoidal and Irrotational vector fields - Line integrals over a plane curve - Surface integrals – Area of a curved surface – Volume Integral - Green's theorem, Stoke's and Gauss divergence theorems (without proofs)– Verification and applications in evaluating line, surface and volume integrals.

TOTAL: 60 PERIODS

Laboratory based exercises / assignments / assessments will be given to students wherever applicable from the content of the course.

General engineering applications / branch specific applications from the content of each units wherever possible will be introduced to students.

Suggested Laboratory based exercises / assignments / assessments :

Matrices

1. Finding eigenvalues and eigenvectors
2. Verification of Cayley-Hamilton theorem
3. Eigenvalues and Eigenvectors of similar matrices
4. Eigenvalues and Eigenvectors of a symmetric matrix
5. Finding the powers of a matrix
6. Quadratic forms

Functions of Several Variables

1. Plotting of curves and surfaces
2. Symbolic computation of partial and total derivatives of functions

Integral Calculus

1. Evaluation of beta and gamma functions
2. Computation of error function and its complement

Multiple Integrals

1. Plotting of 3D surfaces in Cartesian and Polar forms

Vector Calculus

1. Computation of Directional derivatives
2. Computation of normal and tangent to the given surface

OUTCOMES:

CO 1 :Use the matrix algebra methods for solving practical problems.
CO 2 :Use differential calculus ideas on several variable functions.
CO 3 :Apply different methods of integration in solving practical problems by using Beta and Gamma functions.
CO 4 :Apply multiple integral ideas in solving areas and volumes problems.
CO 5 :Apply the concept of vectors in solving practical problems.

TEXT BOOKS:

1. Joel Hass, Christopher Heil, Maurice D.Weir "'Thomas' Calculus", Pearson Education., New Delhi, 2018.
2. Grewal B.S., "Higher Engineering Mathematics", Khanna Publishers, 45th Edition, New Delhi, 2020.
3. James Stewart, Daniel K Clegg & Saleem Watson "Calculus with Early Transcendental Functions", Cengage Learning, 6th Edition, New Delhi,2023.

REFERENCES:

1. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India Pvt Ltd., New Delhi, 2018.
2. Greenberg M.D., "Advanced Engineering Mathematics", Pearson Education2nd Edition,

5th Reprint, Delhi, 2009.
3. Jain R.K. and Iyengar S.R.K., “Advanced Engineering Mathematics”,Narosa Publications, 5th Edition, New Delhi, 2017.
4. Narayanan S. and Manicavachagom Pillai T. K., “Calculus" Volume I and II, S. Viswanathan Publishers Pvt. Ltd., Chennai, 2009.
5. Peter V.O’Neil, “Advanced Engineering Mathematics”, Cengage Learning India Pvt., Ltd, 7 th Edition, New Delhi , 2012.
6. Ramana B.V., “Higher Engineering Mathematics”, Tata McGraw Hill Co. Ltd., 11th Reprint, New Delhi, 2010.

TEXT BOOKS:

1. Joel Hass, Christopher Heil, Maurice D.Weir "‘Thomas‘ Calculus", Pearson Education., New Delhi, 2018.
2. Grewal B.S., “Higher Engineering Mathematics”, Khanna Publishers, 45th Edition, New Delhi, 2020.
3. James Stewart, Daniel K Clegg & Saleem Watson "Calculus with Early Transcendental Functions", Cengage Learning, 6th Edition, New Delhi,2023.

REFERENCES:

1. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India Pvt Ltd., New Delhi, 2018.
2. Greenberg M.D., “Advanced Engineering Mathematics”, Pearson Education2nd Edition, 5th Reprint, Delhi, 2009.
3. Jain R.K. and Iyengar S.R.K., “Advanced Engineering Mathematics”,Narosa Publications, 5th Edition, New Delhi, 2017.
4. Narayanan S. and Manicavachagom Pillai T. K., “Calculus" Volume I and II, S. Viswanathan Publishers Pvt. Ltd., Chennai, 2009.
5. Peter V.O’Neil, “Advanced Engineering Mathematics”, Cengage Learning India Pvt., Ltd, 7 th Edition, New Delhi , 2012.
6. Ramana B.V., “Higher Engineering Mathematics”, Tata McGraw Hill Co. Ltd., 11th Reprint, New Delhi, 2010.

CO – PO MAPPING:

Course Outcomes	PROGRAMME OUTCOMES											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**P10**	**P11**	**P12**
CO1 :	3	3	2	3	1	2	1	1	1	1	1	3
CO2 :	3	3	2	3	1	2	1	1	1	1	1	3
CO3 :	3	3	2	3	1	2	1	1	1	1	1	3
CO4 :	3	3	2	3	1	2	1	1	1	1	1	3
CO5 :	3	3	2	3	1	2	1	1	1	1	1	3

CY23C01 **ENGINEERING CHEMISTRY** **L T P C**

3 0 2 4

UNIT I WATER TECHNOLOGY

Water – sources and impurities – water quality parameters: colour, odour, pH, hardness, alkalinity, TDS, COD, BOD, and heavy metals. Boiler feed water – requirement – troubles (scale & sludge, caustic embrittlement, boiler corrosion and priming & foaming. Internal conditioning – phosphate, Calgon, and carbonate treatment. External conditioning – demineralization. Municipal water treatment (screening, sedimentation, coagulation, filtration, disinfection-ozonolysis, UV treatment, chlorination), Reverse Osmosis – desalination.

PRACTICAL:

- Estimation of HCl using Na_2CO_3 as the primary standard
- Determination of alkalinity in the water sample.
- Determination of hardness of water by EDTA method.
- Determination of DO content of water sample by Winkler's method.

UNIT II NANOCHEMISTRY

Basics-distinction between molecules, nanomaterials and bulk materials; size-dependent properties (optical, electrical, mechanical, magnetic and catalytic). Types –nanoparticle, nanocluster, nanorod, nanowire and nanotube. Preparation of nanomaterials: sol-gel, solvothermal, laser ablation, chemical vapour deposition, electrochemical deposition and electro-spinning. Characterization - Scanning Electron Microscope and Transmission Electron Microscope - Principle and instrumentation (block diagram). Applications of nanomaterials – medicine including AYUSH, automobiles, electronics, and cosmetics.

PRACTICAL:

- Preparation of nanoparticles by Sol-Gel method/sonication method.
- Preparation of nanowire by Electrospinning.
- Study of morphology of nanomaterials by scanning electron microscopy

UNIT III CORROSION SCIENCE

Introduction to corrosion – chemical and electrochemical corrosions – mechanism of electrochemical and galvanic corrosions – concentration cell corrosion-soil, pitting, inter-granular, water line, stress and microbiological corrosions-galvanic series-factors influencing corrosion- measurement of corrosion rate. Electrochemical protection – sacrificial anodic protection and impressed current cathodic protection. Protective coatings-metallic coatings (galvanizing, tinning), organic coatings (paints). Paints: Constituents and functions.

PRACTICAL:

- Corrosion experiment-weight loss method.
- Salt spray test for corrosion study.
- Corrosion prevention by electroplating.
- Estimation of corroded Iron by Potentiometry/UV-visible spectrophotometer

UNIT IV ENERGY SOURCES

Electrochemical cell, redox reaction, electrode potential – oxidation and reduction potential. Batteries – Characteristics; types of batteries; primary battery (dry cell), secondary battery (lead acid, lithium-ion battery) and their applications. Emerging energy sources – metal hydride battery, hydrogen energy, Fuel cells – H_2-O_2 fuel cell. Supercapacitors –Types and Applications, Renewable Energy: solar heating and solar cells. Recycling and disposal of batteries.

PRACTICAL:

- Study of components of Lead acid battery.
- Measurement of voltage in a photovoltaic cell.
- Working of $H_2 – O_2$ fuel cell

UNIT V POLYMER CHEMISTRY

Introduction: Functionality-degree of polymerization. Classification of polymers (Source, Structure, Synthesis and Intermolecular forces). Mechanism of free radical addition polymerization. Properties of polymers: Tg, tacticity, molecular weight-number average, weight average, viscosity average and polydispersity index (Problems). Techniques of polymerization: Bulk, emulsion, solution and suspension. Compounding and Fabrication Techniques: Injection, Extrusion, Blow and Calendaring. Polyamides, Polycarbonates and Polyurethanes – structure and applications. Recycling of polymers.

PRACTICAL:

- Determination of molecular weight of a polymer using Ostwald viscometer.
- Preparation of a polymer.
- Determination of molecular weight by Gel Permeation Chromatography.

TOTAL: 75 PERIODS

COURSE OUTCOMES:

CO1: To demonstrate knowledge of water quality in various industries and develop skills in analyzing water quality parameters for both domestic and industrial purposes.

CO2: To identify and apply fundamental concepts of nanoscience and nanotechnology for engineering and technology applications, and to develop skills in synthesizing nanomaterials and studying their morphology.

CO3: To apply fundamental knowledge of corrosion protection techniques and develop skills to conduct experiments for measuring and preventing corrosion.

CO4: To study the fundamentals of energy storage devices and develop skills in constructing and experimenting with batteries.

CO5: To recognize and apply basic knowledge of different types of polymeric materials and develop skills in preparing and determining their applications for futuristic material fabrication needs.

TEXT BOOKS:

1. Jain P. C. & Monica Jain., “Engineering Chemistry”, 17th Edition, Dhanpat Rai Publishing Company (P) Ltd, New Delhi, 2015.
2. Sivasankar B., “Engineering Chemistry”, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 2012.
3. Dara S.S., “A Textbook of Engineering Chemistry”, Chand Publications, 2004.

4. Laboratory Manual - Department of Chemistry, CEGC, Anna University (2023).

REFERENCES:

1. Schdeva M.V., “Basics of Nano Chemistry”, Anmol Publications Pvt Ltd, 2011.
2. Friedrich Emich, “Engineering Chemistry”, Medtech, 2014.
3. Gowariker V.R., Viswanathan N.V. and Jayadev Sreedhar, “Polymer Science” New AGE International Publishers, 2009.
4. Vogel’s Textbook of Quantitative Chemical Analysis (8th edition, 2014).

CO - PO Mapping

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

1’ = Low; ‘2’ = Medium; ‘3’ = High

ME23C01 **ENGINEERING DRAWING AND 3D MODELING**

L	T	P	C
2	0	4	4

INTRODUCTION

Manual drawing tools (Mini Drafter, Set Squares, Protractor, Compass, and different grades of pencil). **'**BIS' specifications and rules of Engineering Drawing – Arrows (2H thin line body, HB Filled head and L:W = 3:1 ratio), lettering (Digital fonts, font sizes pertaining to usage and representation), types of line and their syntax (Drawing based – Continuous thin & thick, dashed, dashed dotted and Application based – extension, dimensioning, construction, projection, reference, axis, section, hatching, and break lines), scaling (up, down and equal), and dimensioning. Placing and positioning the 'A3' size drawing sheet over the drawing table. Principal planes and projection, Division of line and circle in to equal parts, and construction of polygons

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UNIT 1: ENGINEERING CURVES, PROJECTION OF POINTS AND LINES

Construction of conic curves with their tangent and normal – ellipse, parabola, and hyperbola by eccentricity method

Construction of special curves with their tangent and normal – cycloid, epicycloid, and involute

Projection of points and I angle projection of lines inclined to both principal planes by rotating line method and trapezoidal rule – marking their traces.

Lab exercises: Study exercise – Introduction to Sketching (or) Drawing, and modification tools in CAD software (AutoCAD, CREO, CATIA, Solid Works, Inventor, Fusion 360)

(6+12 = 18 Hours)

Activities based learning: Identification of the curves used in the application given in the flash card, demonstration of the instantaneous centre of rotation of governors with respect to angle of inclination of the arms of the governors

UNIT 2: PROJECTION OF SURFACES & SOLIDS, AND 2D MODELING

Projection of surfaces inclined to both the principal planes – polygonal, trapezoidal, rhomboidal and circular

Projection of solids – prisms, pyramids, and axisymmetric solids when the axis inclined to both the principal planes – freely hanging – contour resting condition on either of the planes by rotating object method

Lab exercises: Construction of basic sketches – lines, circle, polygon, spline curves, coils, along with dimensioning. Familiarizing with geometric constraints and their types

(6+12 = 18 Hours)

Activities based learning: Making the solids using cardboards, shadow mapping and contour drawing at different orientation of the solids using torches

UNIT 3: 3D PROJECTION OF SOLIDS AND 3D MODELING OF SIMPLE PARTS

Free hand sketching – I & III angle projections of engineering parts and components

Isometric projection of combination of solids – prisms, pyramids, axisymmetric solids, frustum

Perspective projection of prisms, pyramids and axisymmetric solids by visual ray method

Lab exercises: 3D Modeling and 2D drafting of machine parts

(6+12 = 18 Hours)

Activities based learning: Flipped classroom for Free hand sketching, Jig saw activity for Isometric projection, arts and crafts for perspective view

UNIT 4: SECTION OF SOLIDS AND SECTIONED DRAFTING OF ASSEMBLED COMPONENTS

Section of simple and hollow solids – prisms, pyramids and axisymmetric solids, solids with holes/ slots when the section plane perpendicular to one principal plane and inclined to other principal plane ('On the axis' and 'from the axis' conditions)

Application based – section of beams (I, T, L, and C), section of pipe bracket, wood joints, composite walls, shells, flange of a coupling and other similar applications

Lab exercises: Assembly of parts with respect to engineering constraints, and sectioned drafting of assembled components

(6+12 = 18 Hours)

Activities based learning: Making of mitered joint in wood, sectioning the beams in different angles of orientation and identifying the true shape

UNIT 5: LATERAL SURFACE DEVELOPMENT AND SHEET METAL DESIGN

Lateral surface development of sectioned solids when the section plane perpendicular to VP and inclined to HP.

Application based – construction of funnel, chimney, dish antenna, door latch, trays, AC vents, lamp shade, commercial packaging boxes with respect to sectioning conditions and other similar applications

Lab exercises: Sheet metal design and drafting, drafting of coils, springs and screw threads

(6+12 = 18 Hours)

Activities based learning: Fabrication of funnels, chimney, lamp shade, boxes using card boards, ply woods, acrylics

Total: 90 Hours

Note: Activities based learning should not be covered in the regular class hours. It should be given as assignments to the group of maximum 3 members

COURSE OBJECTIVES

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

1. Understand and use the engineering curves in engineering applications and projection techniques to construct conic curves, points and lines.
2. Develop skills in projecting surfaces and solids and create 2D models using CAD software.
3. Develop skills in 3D projection and 3D modeling of simple parts manually as well as using CAD software.
4. Understand and apply sectioning techniques to solids and assemble components.
5. Develop skills in lateral surface development and sheet metal design.

COURSE OUTCOMES

After successful completion of the course, the students will be able to:

CO1: Construct and identify different types of conic curves and special curves, and project the points and lines pertaining to engineering applications

CO2: Project and visualize surfaces and solids in different orientations and utilize the CAD tools for designing.

CO3: Create and draft accurate 3D models and 2D drawings of machine parts manually as well as using CAD software

CO4: Determine the true shape of a sectioned solid and draft the assembled parts accordingly

CO5: Develop lateral surfaces of sectioned solids and design sheet metal components

Text book

1. “Engineering Drawing” by N S Parthasarathy and Vela Murali, Oxford University Press; UK ed. Edition, 2015.
2. “Engineering Drawing + Auto CAD” by Venugopal K, V. Prabhu Raja, New Age International Publishers, Sixth edition (1 January 2022).

References

1. "Basic Engineering Drawing: Mechanical Semester Pattern" by Mehta and Gupta, Charotar Publishing House, 2nd edition, 2018.
2. "Engineering Drawing" by Basant Agrawal and C M Agrawal, Vikas Publishing House, 3rd edition, 2020.

3. "Engineering Drawing With Auto CAD" by B V R Gupta, McGraw Hill Education, 4th edition, 2019.
4. "Engineering Drawing" by P S Gill, Tata McGraw Hill Education, 5th edition, 2018.
5. "Engineering Drawing with an Introduction to AutoCAD" by Dhananjay Jolhe, Cengage Learning, 2nd edition, 2020.
6. "Engineering Drawing" by M B Shah, Charotar Publishing House, 3rd edition, 2019
7. "Fundamentals of Engineering Drawing" by Imtiaz Hashmi, Pearson Education, 2nd edition, 2018.
8. "Computer Aided Engineering Drawing" by S Trymbaka Murthy, Scitech Publications, 3rd edition, 2020.
9. "CAED: Computer Aided Engineering Drawing for I/II Semester BE/Btech Courses" by Reddy K B, CBS Publishers & Distributors, 2nd, 2019.
10. "Computer-Aided Engineering Drawing" by Subrata Pal, Oxford University Press, 2nd, 2020.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	2		1				3	1		3	3	3	2
2	3	3	2		2				3	2		3	3	3	2
3	3	3	3	1	2				3	3		3	3	3	2
4	3	3	3	1	3				3	3		3	3	3	2
5	3	3	3	1	3				3	3		3	3	3	2

EE23C03	BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING	L	T	P	C
		2	0	2	3

UNIT-I BASIC ELECTRICAL CIRCUITS 6

Basic Elements: R,L,C- DC Circuits: Ohm's Law - Kirchhoff's Laws –Mesh and Nodal Analysis(Only Independent Sources). AC Circuits: Average Value, RMS Value, Impedance Instantaneous Power, Real Power, Reactive Power and Apparent Power, Power Factor-Steady state Analysis of RL,RC and RLC circuits.

UNIT II AC AND DC MACHINES 6

Magnetic Circuit Fundamentals -DC Machines - Construction and Working Principle, Types and Application of DC generator and Motor, EMF and Torque Equation.

AC Machines: Principle, Construction, Working and Applications of Transformer -Three phase Alternator - Three Phase Induction Motor.

UNIT III ANALOG AND DIGITAL ELECTRONICS 6

Operation and Characteristics of electronic devices: PN Junction Diodes, Zener Diode and BJT Applications: Diode Bridge Rectifier and Shunt Regulator.

Introduction to Digital Electronics: Basics Logic Gates-Flip Flops.

UNIT IV SENSORS AND TRANSDUCERS 6

Solenoids, electro-pneumatic systems, proximity sensors, limit switches, Strain gauge, LVDT, Piezo electric transducer, optical and digital transducers, Smart sensors, Thermal Imagers.

UNIT V MEASUREMENTS AND INSTRUMENTATION 6

Functional Elements of an Instrument, Operating Principle of Moving Coil and Moving Iron Instruments, Power Measurement, Energy Meter, Instrument Transformers - CT and PT, Multimeter-DSO - Block Diagram Approach.

TOTAL:30 PERIODS

LAB COMPONENET:

1. Verification of ohms and Kirchhoff's Laws.
2. Load test on DC Shunt Motor.
3. Load test on Single Phase Transformer.
4. Load test on 3 Phase Induction Motor.
5. Uncontrolled diode bridge Rectifiers.
6. Application of Zener diode as shunt regulator.
7. Verification of truth table of logic gates and flip flops.
8. Characteristics of LVDT.
9. Three phase power measurement using two wattmeter method.
10. Study of DSO.

CO1 Compute the electric circuit parameters for simple circuits.
CO2 Understand the working principles and characteristics of electrical machines.
CO3 Understand the basic electronic devices.
CO4 Understand the basic operating principles of sensors and transducer.
CO5 Understand the operating principles measuring devices

COURSE OUTCOMES: Students will be able to

TEXT BOOKS:

1. Kotharai DP and Nagarath IJ, “Basic Electrical and Electronics Enigneering”, McGraw Hill Education, Second Edition, 2020.
2. Bhattacharya SK, “Basic Electrical and Electronics Engineering”, Pearson Education, Second Edition, 2017.

REFERENCES:

1. Mehta V.K. & Mehta Rohit, “Principles of Electrical Engineering and Electronics”, McGraw Hill Education, Second Edition, 2020.
2. Mehta V.K. & Mehta Rohit, “Principles of Electrical Machines”, S. Chand Publishing, second edition 2006.
3. Albert Malvino & David Bates, “Electronic principles”, McGraw Hill Education, Seventh Edition, 2017.

Mapping COs and POs:																
COs	**Pos**												**PSOs**			
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	2	1														
CO2	2	1														
CO3	2	1														
CO4	2	1														
CO5	2	1														
Avg	2	1														

ME23C04	MAKERSPACE	L	T	P	C
		1	0	4	3

COURSE OBJECTIVES:

1. To practice the usage of various tools towards assembly and dis-assembly of different items / equipment.
2. To make simple part / component using welding processes.
3. To train on the basic wiring practices of boards, machines, etc.
4. To provide a hands-on experience on the use of electronic components, equipment, sensors and actuators.
5. To expose to modern computer tools and advanced manufacturing / fabrication processes.

LIST OF ACTIVITIES **1L,4P**

(A). Dis-assembly & Assembly Practices

i. Tools and its handling techniques.
ii. Dis-assembly and assembly of home appliances – Grinder Mixer Grinder, Ceiling Fan, Table Fan & Washing Machine.
iii. Dis-assembly and assembly of Air-Conditioners & Refrigerators.
iv. Dis-assembly and assembly of a Bicycle.

(B). Welding Practices

i. Welding Procedure, Selection & Safety Measures.
ii. Power source of Arc Welding – Gas Metal Arc Welding & Gas Tungsten Arc Welding processes.
iii. Hands-on session of preparing base material & Joint groove for welding.
iv. Hands-on session of MAW, GMAW, GTAW, on Carbon Steel & Stainless Stell plates / pipes, for fabrication of a simple part.

(C). Electrical Wiring Practices

i. Electrical Installation tools, equipment & safety measures.
ii. Hands-on session of basic electrical connections for Fuses, Miniature Circuit Breakers and Distribution Box,
iii. Hands-on session of electrical connections for Lightings, Fans, Calling Bells.
iv. Hands-on session of electrical connections for Motors & Uninterruptible Power Supply.

(D). Electronics Components / Equipment Practices

i. Electronic components, equipment & safety measures.
ii. Dis-assembly and assembly of Computers.
iii. Hands-on session of Soldering Practices in a Printed Circuit Breaker.

iv. Hands-on session of Bridge Rectifier, Op-Amp and Transimpedance amplifier.
v. Hands-on session of integration of sensors and actuators with a Microcontroller.
vi. Demonstration of Programmable Logic Control Circuit.

(E).Contemporary Systems

i. Demonstration of Solid Modelling of components.
ii. Demonstration of Assembly Modelling of components.
iii. Fabrication of simple components / parts using 3D Printers.
iv. Demonstration of cutting of wood / metal in different complex shapes using Laser Cutting Machine.

TOTAL: 75 Periods (15 Lecture + 60 Practical)

COURSE OUTCOMES:

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

CO1: Assemble and dis-assemble various items / equipment.

CO2: Make simple parts using suitable welding processes.

CO3: Setup wiring of distribution boards, machines, etc.

CO4: Utilise the electronic components to fabricate a simple equipment, aided with sensors and actuators.

CO5: Take advantage of modern manufacturing practices.

REFERENCES:

1. Stephen Christena, Learn to Weld: Beginning MIG Welding and Metal Fabrication Basics, Crestline Books, 2014.
2. H. Lipson, Fabricated - The New World of 3D Printing, Wiley, 1st edition, 2013.
3. Code of Practice for Electrical Wiring Installations (IS 732:2019)
4. A.S. Sedra and K.C. Smith, Microelectronic Circuits, Oxford University Press, 7th ed. (Indian edition), 2017.
5. Mazidi, Naimi, Naimi, AVR Microcontroller and Embedded Systems: Using Assembly and C, Pearson India, 1st edition 2013.
6. Visualization, Modeling, and Graphics for Engineering Design, D.K. Lieu, S.A. Sorby, Cengage Learning; 2nd edition.

UC23H01 **தமிழர் மரபு** **L T P C**

1 0 0 1

அலகு I **மொழி மற்றும் இலக்கியம்**: **3**

இந்திய மொழிக் குடும்பங்கள் – திராவிட மொழிகள் – தமிழ் ஒரு செம்மொழி – தமிழ் செவ்விலக்கியங்கள் - சங்க இலக்கியத்தின் சமயச் சார்பற்ற தன்மை – சங்க இலக்கியத்தில் பகிர்தல் அறம் – திருக்குறளில் மேலாண்மைக் கருத்துக்கள் – தமிழ்க் காப்பியங்கள், தமிழகத்தில் சமண பௌத்த சமயங்களின் தாக்கம் - பக்தி இலக்கியம், ஆழ்வார்கள் மற்றும் நாயன்மார்கள் – சிற்றிலக்கியங்கள் – தமிழில் நவீன இலக்கியத்தின் வளர்ச்சி – தமிழ் இலக்கிய வளர்ச்சியில் பாரதியார் மற்றும் பாரதிதாசன் ஆகியோரின் பங்களிப்பு.

அலகு II மரபு – பாறை ஓவியங்கள் முதல் நவீன ஓவியங்கள் வரை – சிற்பக் கலை: **3**

நடுகல் முதல் நவீன சிற்பங்கள் வரை – ஐம்பொன் சிலைகள்– பழங்குடியினர் மற்றும் அவர்கள் தயாரிக்கும் கைவினைப் பொருட்கள், பொம்மைகள் – தேர் செய்யும் கலை – சுடுமண் சிற்பங்கள் – நாட்டுப்புறத் தெய்வங்கள் – குமரிமுனையில் திருவள்ளுவர் சிலை – இசைக் கருவிகள் – மிருதங்கம், பறை, வீணை, யாழ், நாதஸ்வரம் – தமிழர்களின் சமூக பொருளாதார வாழ்வில் கோவில்களின் பங்கு.

அலகு III **நாட்டுப்புறக் கலைகள் மற்றும் வீர விளையாட்டுகள்**: **3**

தெருக்கூத்து, கரகாட்டம், வில்லுப்பாட்டு, கணியான் கூத்து, ஒயிலாட்டம், தோல்பாவைக் கூத்து, சிலம்பாட்டம், வளரி, புலியாட்டம், தமிழர்களின் விளையாட்டுகள்.

அலகு IV **தமிழர்களின் திணைக் கோட்பாடுகள்**: **3**

தமிழகத்தின் தாவரங்களும், விலங்குகளும் – தொல்காப்பியம் மற்றும் சங்க இலக்கியத்தில் அகம் மற்றும் புறக் கோட்பாடுகள் – தமிழர்கள் போற்றிய அறக்கோட்பாடு – சங்ககாலத்தில் தமிழகத்தில் எழுத்தறிவும், கல்வியும் – சங்ககால நகரங்களும் துறை முகங்களும் – சங்ககாலத்தில் ஏற்றுமதி மற்றும் இறக்குமதி – கடல்கடந்த நாடுகளில் சோழர்களின் வெற்றி.

அலகு V **இந்திய தேசிய இயக்கம் மற்றும் இந்திய பண்பாட்டிற்குத்தமிழர்களின் பங்களிப்பு**: **3**

இந்திய விடுதலைப்போரில் தமிழர்களின் பங்கு – இந்தியாவின் பிறப்பகுதிகளில் தமிழ்ப் பண்பாட்டின் தாக்கம் – சுயமரியாதை இயக்கம் – இந்திய மருத்துவத்தில், சித்த மருத்துவத்தின் பங்கு – கல்வெட்டுகள், கையெழுத்துப்படிகள் - தமிழ்ப் புத்தகங்களின் அச்சு வரலாறு.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).

2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi - 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

UC23H01 HERITAGE OF TAMILS L T P C
1 0 0 1

UNIT I LANGUAGE AND LITERATURE 3

Language Families in India - Dravidian Languages – Tamil as a Classical Language - Classical Literature in Tamil – Secular Nature of Sangam Literature – Distributive Justice in Sangam Literature - Management Principles in Thirukural - Tamil Epics and Impact of Buddhism & Jainism in Tamil Land - Bakthi Literature Azhwars and Nayanmars - Forms of minor Poetry - Development of Modern literature in Tamil - Contribution of Bharathiyar and Bharathidhasan.

UNIT II HERITAGE - ROCK ART PAINTINGS TO MODERN ART – SCULPTURE 3

Hero stone to modern sculpture - Bronze icons - Tribes and their handicrafts - Art of temple car making - - Massive Terracotta sculptures, Village deities, Thiruvalluvar Statue at Kanyakumari, Making of musical instruments - Mridhangam, Parai, Veenai, Yazh and Nadhaswaram - Role of Temples in Social and Economic Life of Tamils.

UNIT III FOLK AND MARTIAL ARTS 3

Therukoothu, Karagattam, Villu Pattu, Kaniyan Koothu, Oyillattam, Leather puppetry, Silambattam, Valari, Tiger dance - Sports and Games of Tamils.

UNIT IV THINAI CONCEPT OF TAMILS 3

Flora and Fauna of Tamils & Aham and Puram Concept from Tholkappiyam and Sangam Literature - Aram Concept of Tamils - Education and Literacy during Sangam Age - Ancient Cities and Ports of Sangam Age - Export and Import during Sangam Age - Overseas Conquest of Cholas.

UNIT V CONTRIBUTION OF TAMILS TO INDIAN NATIONAL MOVEMENT AND INDIAN CULTURE 3

Contribution of Tamils to Indian Freedom Struggle - The Cultural Influence of Tamils over the other parts of India – Self-Respect Movement - Role of Siddha Medicine in Indigenous Systems of Medicine – Inscriptions & Manuscripts – Print History of Tamil Books.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi - 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by: Department ofArchaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

NCC Credit Course Level 1*

UC23P01	(ARMY WING) NCC Credit Course Level - I	L T P C 2 0 0 2

NCC GENERAL		**6**
NCC 1	Aims, Objectives & Organization of NCC	1
NCC 2	Incentives	2
NCC 3	Duties of NCC Cadet	1
NCC 4	NCC Camps: Types & Conduct	2
NATIONAL INTEGRATION AND AWARENESS		**4**
NI 1	National Integration: Importance & Necessity	1
NI 2	Factors Affecting National Integration	1
NI 3	Unity in Diversity & Role of NCC in Nation Building	1
NI 4	Threats to National Security	1
PERSONALITY DEVELOPMENT		**7**
PD 1	Self-Awareness, Empathy, Critical & Creative Thinking, Decision Making and Problem Solving	2
PD 2	Communication Skills	3
PD 3	Group Discussion: Stress & Emotions	2
LEADERSHIP		**5**
L 1	Leadership Capsule: Traits, Indicators, Motivation, Moral Values, Honour 'Code	3
L 2	Case Studies: Shivaji, Jhasi Ki Rani	2
SOCIAL SERVICE AND COMMUNITY DEVELOPMENT		**8**
SS 1	Basics, Rural Development Programmes, NGOs, Contribution of Youth	3
SS 4	Protection of Children and Women Safety	1
SS 5	Road / Rail Travel Safety	1
SS 6	New Initiatives	2
SS 7	Cyber and Mobile Security Awareness	1

TOTAL : 30 PERIODS

NCC Credit Course Level 1*

UC23P02	**(NAVAL WING) NCC Credit Course Level – I**	**L T P C** **2 0 0 2**
NCC GENERAL		**6**
NCC 1	Aims, Objectives & Organization of NCC	1
NCC 2	Incentives	2
NCC 3	Duties of NCC Cadet	1
NCC 4	NCC Camps: Types & Conduct	2
NATIONAL INTEGRATION AND AWARENESS		**4**
NI 1	National Integration: Importance & Necessity	1
NI 2	Factors Affecting National Integration	1
NI 3	Unity in Diversity & Role of NCC in Nation Building	1
NI 4	Threats to National Security	1
PERSONALITY DEVELOPMENT		**7**
PD 1	Self-Awareness, Empathy, Critical & Creative Thinking, Decision Making and Problem Solving	2
PD 2	Communication Skills	3
PD 3	Group Discussion: Stress & Emotions	2
LEADERSHIP		**5**
L 1	Leadership Capsule: Traits, Indicators, Motivation, Moral Values, Honour Code	3
L 2	Case Studies: Shivaji, Jhasi Ki Rani	2
SOCIAL SERVICE AND COMMUNITY DEVELOPMENT		**8**
SS 1	Basics, Rural Development Programmes, NGOs, Contribution of Youth	3
SS 4	Protection of Children and Women Safety	1
SS 5	Road / Rail Travel Safety	1
SS 6	New Initiatives	2
SS 7	Cyber and Mobile Security Awareness	1

TOTAL : 30 PERIODS

NCC Credit Course Level 1*

UC23P03	(AIR FORCE WING) NCC Credit Course Level – I	L T P C 2 0 0 2

NCC GENERAL		**6**
NCC 1	Aims, Objectives & Organization of NCC	1
NCC 2	Incentives	2
NCC 3	Duties of NCC Cadet	1
NCC 4	NCC Camps: Types & Conduct	2
NATIONAL INTEGRATION AND AWARENESS		**4**
NI 1	National Integration: Importance & Necessity	1
NI 2	Factors Affecting National Integration	1
NI 3	Unity in Diversity & Role of NCC in Nation Building	1
NI 4	Threats to National Security	1
PERSONALITY DEVELOPMENT		**7**
PD 1	Self-Awareness, Empathy, Critical & Creative Thinking, Decision Making and Problem Solving	2
PD 2	Communication Skills	3
PD 3	Group Discussion: Stress & Emotions	2
LEADERSHIP		**5**
L 1	Leadership Capsule: Traits, Indicators, Motivation, Moral Values, Honour Code	3
L 2	Case Studies: Shivaji, Jhasi Ki Rani	2
SOCIAL SERVICE AND COMMUNITY DEVELOPMENT		**8**
SS 1	Basics, Rural Development Programmes, NGOs, Contribution of Youth	3
SS 4	Protection of Children and Women Safety	1
SS 5	Road / Rail Travel Safety	1
SS 6	New Initiatives	2
SS 7	Cyber and Mobile Security Awareness	1

TOTAL : 30 PERIODS

EN23C02	PROFESSIONAL COMMUNICATION	L T P C 2 0 2 3

COURSE OBJECTIVES:

- To read and comprehend different forms of official texts.
- To develop students' writing skills in professional context.
- To actively listen, read and understand written and oral communication in a professional context.
- To comprehend and analyse the visual content in authentic context.
- To write professional documents with clarity and precision

UNIT I CAUSE AND EFFECT 6

Reading – Newspaper articles on Social and Environmental issues; Writing – Instructions, Cause and effect essay; Grammar - Modal verbs; Vocabulary – Cause and effect, Idioms

LAB ACTIVITY: 6

Listening and Speaking – Listen to news reports and summarise in oral form.

UNIT II CLASSIFICATION 6

Reading – An article, social media posts and classifying based on the content; Writing – Definition, Note making, Note taking (Cornell notes etc.) and Summarising; Grammar – Connectives; Vocabulary – Phrasal verbs

LAB ACTIVITY: 6

Listening and speaking: Social interaction (Conversation including small talk)

UNIT III PROBLEM AND SOLUTION 6

Reading – Visual content (Tables/charts/graphs) for comprehension; Writing - Problem and Solution Essay; Grammar – If conditionals; Vocabulary – Sequential words.

LAB ACTIVITY: 6

Listening – Group discussion; Speaking – Participating in a group discussion

UNIT IV REPORT 6

Reading – Formal report on accidents (industrial/engineering); Writing – Industrial Accident report; Grammar – Active and passive voice, Direct and Indirect speech; Vocabulary – Numerical adjectives.

LAB ACTIVITY: 6

Listening / watching – Television documentary and discussing its content, purpose etc.

UNIT V JOB APPLICATION AND INTERVIEW 6

Reading - Job advertisement and company profile; Writing – Job application (cover letter and CV) Grammar – Mixed Tenses; Vocabulary – Collocations related to work environment

LAB ACTIVITY: 6

Listening – Job interview; Speaking – Mock interviews

TOTAL: 60 PERIODS

TEACHING METHODOLOGY

Interactive lectures, role plays, group discussions, listening and speaking labs, technology enabled language teaching, flipped classroom.

EVALUATION PATTERN

Internal Assessment
Written assessments
Assignment
Lab Assessment
Group discussion (Peer assessment)
Listening
External Assessment
End Semester Examination

LEARNING OUTCOMES

By the end of the courses, students will be able to

- To apply appropriate language structure and vocabulary to enhance both spoken and written communication in formal contexts.
- Comprehend different forms of official documents
- Write professional documents coherently and cohesively.
- Interpret verbal and graphic content in authentic context
- Analyse and evaluate verbal and audio visual materials.

TEXT BOOKS:

1. "English for Engineers and Technologists" Volume 2 by Orient Blackswan, 2022
2. "English for Science & Technology - II" by Cambridge University Press, 2023.

REFERENCES:

1. "Communicative English for Engineers and Professionals" by Bhatnagar Nitin, Pearson India, 2010.
2. "Take Off – Technical English for Engineering" by David Morgan, Garnet Education, 2008.
3. "Advanced Communication Skills" by Mathew Richardson, Charlie Creative Lab, 2020.
4. www.uefap.com

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										√		√
CO2										√		√
CO3										√		√
CO4										√		√
CO5										√		√

MA23C02	ORDINARY DIFFERENTIAL EQUATIONS AND TRANSFORM TECHNIQUES	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To acquaint the students with Differential Equations which are significantly used in engineering problems.
- To make the students to understand the Laplace transforms techniques.
- To develop the analytic solutions for partial differential equations used in engineering by Fourier series.
- To acquaint the student with Fourier transform techniques used in wide variety of situations in which the functions used are not periodic.
- To develop Z- transform techniques in solving difference equations.

UNIT I ORDINARY DIFFERENTIAL EQUATIONS 9+3

Homogeneous linear ordinary differential equations of second order -superposition principle - general solution- Particular integral - Operator method - Solution by variation of parameters - Method of undetermined coefficients - Homogeneous equations of Euler–Cauchy and Legendre's type – System of simultaneous linear differential equations with constant coefficients.

UNIT II LAPLACE TRANSFORMS 9+3

Existence theorem - Transform of standard functions – Transform of Unit step function and Dirac delta function – Basic properties - Shifting theorems - Transforms of derivatives and integrals – Transform of periodic functions - Initial and Final value theorem - Inverse Laplace transforms- Convolution theorem (without proof) – Solving Initial value problems by using Laplace Transform techniques.

UNIT III FOURIER SERIES 9+3

Dirichlet's conditions – General Fourier series – Odd and even functions – Half-range Sine and Cosine series – Complex form of Fourier series – Parseval's identity – Computation of harmonics.

UNIT IV FOURIER TRANSFORMS 9+3

Fourier integral theorem – Fourier transform pair - Fourier sine and cosine transforms – Properties – Transform of elementary functions – Inverse Fourier Transforms - Convolution theorem (without proof) – Parsevals's identity.

UNIT V Z – TRANSFORM AND DIFFERENCE EQUATIONS 9+3

Z-transform – Properties of Z-transform – Inverse Z-transform – Convolution theorem – Evaluation of Inverse Z transform using partial fraction method and convolution theorem - Initial and final value theorems – Formation of difference equations – Solution of difference equations using Z - transform.

TOTAL: 60 PERIODS

Laboratory based exercises / assignments / assessments will be given to students from the content of the course wherever applicable.
Branch specific / General Engineering applications based on the content of each units will be introduced to students wherever possible.

Suggested Laboratory based exercises / assignments / assessments :

Ordinary differential equations

1. Symbolic computation of linear ordinary differential equations
2. Solving System of simultaneous linear differential equations using ODE SOLVER

Laplace transforms

1. Symbolic computation of Laplace transform and Inverse Laplace transform
2. Plotting Laplace transforms

Fourier Series

1. Symbolic computation of Fourier Coefficients
2. Computation of harmonics
3. Plotting truncated Fourier Series

Fourier Transform

1. Symbolic computation of Fourier Transforms
2. Plotting truncated Fourier Transforms

Z – transform

1. Symbolic computation of Z-Transforms

OUTCOMES:

CO1 :Solve higher order ordinary differential equations which arise in engineering applications.
CO2 :Apply Laplace transform techniques in solving linear differential equations.
CO3 :Apply Fourier series techniques in engineering applications.
CO4 :Understand the Fourier transforms techniques in solving engineering problems.
CO5 :Understand the Z-transforms techniques in solving difference equations.

TEXT BOOKS:

1. Grewal B.S., “Higher Engineering Mathematics”, Khanna Publishers, 45th Edition, New Delhi, 2020.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India Pvt Ltd., New Delhi, 2018.

REFERENCES:

1. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008
2. Greenberg M.D., “Advanced Engineering Mathematics”, Pearson Education2nd Edition, 5th Reprint, Delhi, 2009.
3. Jain R.K. and Iyengar S.R.K., “Advanced Engineering Mathematics”,Narosa Publications, 5 th Edition, New Delhi, 2017.
4. Peter V.O’Neil, “Advanced Engineering Mathematics”, Cengage Learning India Pvt., Ltd, 7 th Edition, New Delhi , 2012.
5. Ramana B.V., “Higher Engineering Mathematics”, Tata McGraw Hill Co. Ltd., 11th Reprint, New Delhi, 2010.

CO – PO Mapping:

Course Outcomes	PROGRAMME OUTCOMES											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**P10**	**P11**	**P12**
CO 1	3	3	2	3	1	2	1	1	1	1	1	3
CO 2	3	3	2	3	1	2	1	1	1	1	1	3
CO 3	3	3	2	3	1	2	1	1	1	1	1	3
CO 4	3	3	2	3	1	2	1	1	1	1	1	3
CO 5	3	3	2	3	1	2	1	1	1	1	1	3

PH23C01	ENGINEERING PHYSICS	L	T	P	C
	(Common to all branches of B.E/B.Tech Programmes)	3	0	2	4

COURSE OBJECTIVES

- To familiarize with crystal structure, bonding and crystal growth.
- To impart knowledge on Mechanics of Materials.
- To impart knowledge of oscillations, sound and Thermal Physics
- To facilitate understanding of optics and its applications, different types of Lasers and fiber optics.
- To introduce the basics of Quantum Mechanics and its importance.

UNIT I CRYSTAL PHYSICS 9+6

Crystal Bonding – Ionic – covalent – metallic and van der Walls's/ molecular bonding. Crystal systems - unit cell, Bravais lattices, Miller indices - Crystal structures - atomic packing density of BCC, FCC and HCP structures. NaCl, Diamond, Graphite, Graphene, Zincblende and Wurtzite structures - crystal imperfections- point defects - edge and screw dislocations – grain boundaries. Crystal Growth – Czocharalski method – vapor phase epitaxy – Molecular beam epitaxy- Introduction to X-Ray Diffractometer.

1. Determination of Lattice parameters for crystal systems.
2. Crystal Growth – Slow Evaporation method
3. Crystal Growth Sol – Gel Method

UNIT II MECHANICS OF MATERIALS 9+6

Rigid Body – Centre of mass – Rotational Energy - Moment of inertia (M.I)- Moment of Inertia for uniform objects with various geometrical shapes. Elasticity –Hooke's law - Poisson's ratio - stress-strain diagram for ductile and brittle materials – uses- Bending of beams – Cantilever - Simply supported beams - uniform and non-uniform bending - Young's modulus determination - I shaped girders –Twisting couple – Shafts. Viscosity – Viscous drag – Surface Tension.

1. Non-uniform bending -Determination of Young's modulus of the material of the beam.
2. Uniform bending -Determination of Young's modulus of the material of the beam
3. Viscosity – Determination of Viscosity of liquids.

UNIT III OSCILLATIONS, SOUND AND THERMAL PHYSICS 9+6

Simple harmonic motion - Torsional pendulum –- Damped oscillations –Shock Absorber -Forced oscillations and Resonance –Applications of resonance.- Waves and Energy Transport –Sound waves – Intensity level – Standing Waves - Doppler effect and its applications - Speed of blood flow. Ultrasound – applications - Echolocation and Medical Imaging. Thermal Expansion – Expansion joints – Bimetallic strip – Seebeck effect – thermocouple -Heat Transfer Rate – Conduction – Convection and Radiation.

1. Torsional pendulum-Determination of rigidity modulus of wire and moment of inertia of the disc
2. Melde's string experiment - Standing waves.
3. Ultrasonic interferometer – determination of sound velocity and liquids compressibility

UNIT IV OPTICS AND LASERS 9+6

Interference - Thin film interference - Air wedge- Applications -Interferometers–Michelson Interferometer -– Diffraction - CD as diffraction grating – Diffraction by crystals -Polarization - polarizers -– Laser – characteristics – Spontaneous and Stimulated emission- population – inversion - Metastable states - optical feedback - Nd-YAG laser, CO_2 laser, Semiconductor laser - Industrial and medical applications - Optical Fibers – Total internal reflection – Numerical aperture and acceptance angle – Fiber optic communication – Fiber sensors – Fiber lasers.

1. Laser - Determination of the width of the groove of the compact disc using laser.
   Laser Parameters
   Determination of the wavelength of the laser using grating
2. Air wedge -Determination of the thickness of a thin sheet/wire
3. Optical fibre - Determination of Numerical Aperture and acceptance angle
   -Determination of bending loss of fibre.
4. Michelson Interferometer (Demonstration)

UNIT V QUANTUM MECHANICS 9+6

Black body radiation (Qualitative) – Planck's hypothesis – Einstein's theory of Radiation - Matter waves–de Broglie hypothesis - Electron microscope – Uncertainty Principle – The Schrodinger Wave equation (time-independent and time-dependent) – Meaning and Physical significance of wave function - Normalization - Particle in an infinite potential well-particle in a three-dimensional box - Degenerate energy states - Barrier penetration and quantum tunneling - Tunneling microscope.

1. Photoelectric effect – Determination of Planck's constant.
2. Black Body Radiation (Demonstration)
3. Electron Microscope (Demonstration)

TOTAL: 75 PERIODS

COURSE OUTCOMES:

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

CO1: erstand the significance of crystal structure and bonding. Learn to grow crystals.

CO2: ain knowledge on important mechanical and thermal properties of materials determine them through experiments.

CO3: ceptualize and visualize the oscillations and sound.

CO4: sp optical phenomenon and their applications in real life.

CO5: reciate and evaluate the quantum phenomenon.

CO6 elop skill set to solve engineering problems and design experiments.

TEXT BOOKS:

1. Raymond A. Serway, John W. Jewett, Physics for Scientists and Engineers, Thomson Brooks/Cole, 2013.
2. D. Halliday, R. Resnick and J. Walker, Principles of Physics. John Wiley & Sons, 10th Edition, 2015.
3. N. Garcia, A. Damask and S. Schwarz, Physics for Computer Science Students, Springer-Verlag, 2012.
4. Alan Giambattista, Betty McCarthy Richardson and Robert C. Richardson, College Physics, McGraw-Hill Higher Education, 2012.

REFERENCES:

1. R. Wolfson, Essential University Physics. Volume 1 & 2. Pearson, 2016.
2. D. Kleppner and R. Kolenkow. An Introduction to Mechanics, McGraw Hill Education, 2017.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1		1							
CO2	3	2	1	1								
CO3	3	2	1	1								
CO4	3	2	1	1	1							
CO5	3	2	1	1	1							
CO6	3	2	1	2								

CS23C02 COMPUTER PROGRAMMING IN PYTHON

L	T	P	C
3	0	2	4

COURSE OBJECTIVES:

- To understand fundamental structural programming concepts and problem-solving process.
- To solve problems using modular programming and decomposition techniques.
- To solve problems using data structures and abstraction techniques.
- To create programming solutions using libraries and packages.
- To design solutions to domain problems using programming problem-solving techniques.

UNIT I – STRUCTURED PROGRAMMING 9+6

Problem-Solving Strategies. Basic Problem-Solving Tools: Flowcharts, Pseudocode. Introduction to Programming Languages and Development Environments. Programming. Basic Concepts and Syntax: Variables, Identifiers, Data Types: Primitive Types and Strings, Statements, Operators, Expressions and its evaluation, Operator Precedence, Basic Arithmetic Operations. Principles of Structured Programming – Control Structures: Sequence, Selection, Iteration and Branching.

PRACTICALS:

- Design algorithms for simple computational problems
- Create Pseudo-code and Flow charts for simple computational problems
- Create Python programs using simple and nested selective control statements
- Create Python programs using simple and nested sequence & iterative control statements
- Create Python programs to generate series/patterns using control statements

UNIT II – MODULARITY AND DECOMPOSITION 9+6

Principles of Modular and Decomposition. Functions: Defining functions –Argument types – Function Name-spaces – Scoping: Global and Non-local. Principles of Recursion: Base case and Recursive cases – Develop and Analyze Recursive functions: Factorial, Fibonacci. Principles of First-Class and Higher-Order functions: Lambda functions – Functions as arguments.

PRACTICALS:

- Create Python programs using functions
- Create python program using recursion
- Create Python programs using lambda functions
- Create Python programs using first-class functions
- Create Python programs using higher-order functions

UNIT Ill – DATA STRUCTURES AND ABSTRACTIONS 9+6

Principles of Data Structures and Abstractions. String Methods and Manipulations,.Lists: List Operations and Methods, List comprehensions, Nested List comprehensions, Matrix operations using Lists. Tuples and sequences. Sets and Operations. Dictionaries: Dictionary operations, Dictionary comprehensions, Nested Dictionary comprehensions. Comparing Data Structures. Search and Sort Data Structures. Principle of Functional Programming and Tools : map, filter, and reduce.

PRACTICALS:

- Create Python programs for strings manipulations.
- Design Python programs using Lists, Nested Lists and Lists comprehensions
- Create Python programs using Tuples, Nested Tuples, and Tuple comprehensions
- Create Python programs creating Sets and performing set operations
- Create Python programs using Dictionary, Nested Dictionary and comprehensions
- Create Python programs by applying functional programming concepts

UNIT IV – LIBRARIES AND MODULES 9+6

Exceptions: Syntax errors, Exceptions, Exception types, Handling exceptions, Raising exceptions. Files: File Path, Type of files, opening modes, Reading and Writing text files, Handling other format Data files. Modules: Creating Modules, import and from statements, Executing modules as scripts, Standard modules. Packages and Importing from packages

PRACTICALS:

- Design Python programs to handle errors and exceptions
- Create, import, and use pre-defined modules and packages
- Create, import, and use user-defined modules and packages
- Create Python programs to perform various operations on text files
- Create Python programs to perform various operations on other data file formats.

UNIT V – SIMPLE PROBLEM SOLVING TECHNIQUES IN PROGRAMMING 9+6

Data Structures for Problem Solving: Stack, Queue. Principles of Divide and Conquer: Binary Search. Principles of Greedy Algorithms: Minimum Coin Change Problem. Case studies on programming application of problem-solving techniques in different fields of engineering.

PRACTICALS:

- Create python programs to implement stack and queue.
- Create python programs to implement binary search.
- Create python programs to solve minimum coin change problem.
- Case study on developing python solution to a domain specific problems.

TOTAL = 45 + 30 = 75 PERIODS

COURSE OUTCOMES

1. Understand fundamental structural programming concepts and problem-solving process.
2. Solve problems using modular programming and decomposition techniques.
3. Solve problems using data structures and abstraction techniques.
4. Create programming solutions using libraries and packages.
5. Design solutions to domain problems using programming problem-solving techniques.

TEXT BOOKS

1. Reema Thareja, Python Programming using Problem Solving Approach, Oxford University Press, First Edition, 2017.
2. S. Sridhar, J. Indumathi, V. M. Hariharan, Python Programming, Pearson Education, First Edition, 2023

REFERENCE BOOKS

1. Paul Deitel, Harvey Deitel, Python for Programmers, Pearson Education, 2020.
2. John V Guttag. Introduction to Computation and Programming Using Python, With
3. Application to Computational Modeling and Understanding Data. Third Edition, The MIT
4. Press, 2021
5. Mark Lutz, Learning Python, 5th Edition, O'Reilly Media, Inc.
6. Python official documentation and tutorial, https://docs.python.org/3/
7. Numerical Python official documentation and tutorial, https://numpy.org/

CO's-PO's & PSO's MAPPING

CO	PO1	PO2	PO3	PO4	POS	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2		2		1								1	1	
2	2		2		1								1	1	
3	2	1	2		1								1	1	
4	2	1	2	1	1								1	1	
5	2	1	2	1	1								1	1	
Avg	2	1	2	1	1								1	1	

1 - low, 2 - medium, 3 - **high,** '-' - **no correlation**

ME23C03	ENGINEERING MECHANICS	L T P C 3 1 0 4

COURSE OBJECTIVES:

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

- Determining the resultant forces acting on a particle in 2D and 3D and for applying methods of equilibrium on a particle in 2D and 3D.
- Evaluating the reaction forces for bodies under equilibrium, for determining the moment of a force, moment of a couple, for resolving force into a force-couple system and for analyzing trusses
- Assessing the centroids of 2D sections / center of gravity of volumes and for calculating area moments of inertia for the sections and mass moment of inertia of solids.
- Evaluating the frictional forces acting at the contact surfaces of various engineering systems and for applying the work-energy principles on a particle.
- Determining kinetic and kinematic parameters of the rigid bodies subjected to concurrent coplanar forces.

UNIT I STATICS OF PARTICLES 9+3

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

UNIT II EQUILIBRIUM OF RIGID BODIES AND TRUSSES 9+3

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

UNIT III DISTRIBUTED FORCES 9+3

Centroids of lines and areas – symmetrical and unsymmetrical shapes, Determination of Centroids by Integration, Theorems of Pappus-Guldinus, Distributed Loads on Beams, Centre of Gravity of a Three-Dimensional Body, Centroid of a Volume, Composite Bodies, Determination of Centroids of Volumes by Integration.

Moments of Inertia of Areas and Mass - Determination of the Moment of Inertia of an Area by Integration , Polar Moment of Inertia , Radius of Gyration of an Area , Parallel-Axis Theorem , Moments of Inertia of Composite Areas, Moments of Inertia of a Mass - Moments of Inertia of Thin Plates , Determination of the Moment of Inertia of a Three-Dimensional Body by Integration.

UNIT IV FRICTION AND WORK PRINCIPLES 9+3

The Laws of Dry Friction. Coefficients of Friction, Angles of Friction, Wedges, Wheel Friction. Rolling Resistance, Ladder friction. Work of a Force, Kinetic Energy of a Particle, Principle of Work and Energy, Principle of Impulse and Momentum, Impact, Method of Virtual Work - Work of a Force, Potential Energy, Potential Energy and Equilibrium.

UNIT V DYNAMICS OF PARTICLES AND RIGID BODIES 9+3

Kinematics - Rectilinear Motion and Curvilinear Motion of Particles. Kinetics- Newton's Second Law of Motion -Equations of Motions, Dynamic Equilibrium, Energy and Momentum Methods – Kinematics of Rigid Bodies and Plane Kinetics.

TOTAL : 60 Periods

COURSE OUTCOMES:

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

1. To determine the resultant forces acting on a particle in 2D and 3D and to apply methods of equilibrium on a particle in 2D and 3D.
2. Evaluate the reaction forces for bodies under equilibrium, to determine moment of a force, moment of a couple, to resolve force into a force-couple system and to analyze trusses
3. Assess the centroids of 2D sections / center of gravity of volumes and to calculate area moments of inertia for the sections and mass moment of inertia of solids.
4. Evaluate the frictional forces acting at the contact surfaces of various engineering systems and apply the work-energy principles on a particle. evaluate the kinetic and kinematic parameters of a particle.
5. Determine kinetic and kinematic parameters of the rigid bodies subjected to concurrent coplanar forces.

TEXT BOOKS:

1. Beer Ferdinand P, Russel Johnston Jr., David F Mazurek, Philip J Cornwell, Sanjeev Sanghi, Vector Mechanics for Engineers: Statics and Dynamics, McGraw Higher Education., 12th Edition, 2019.

2. Vela Murali, "Engineering Mechanics-Statics and Dynamics", Oxford University Press, 2018.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	2	3									3		
2	3	3	2	3									3		
3	3	3	2	3									3		
4	3	3	2	3									3		
5	3	3	2	3									3		
Avg	3	3	2	3									3		

MS23201	REACTION KINETICS AND DYNAMICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

The main objective of the course is to make the students to understand and apply the basic principles of chemical reaction kinetics and dynamics, theoretical models of molecular collisions, reaction dynamics and microscopic kinetics and theoretically derive rate law equations and solve simple numerical problems.

UNIT – I SOLID STATE CHEMISTRY 9

Solids - Types - Crystalline, Amorphous and Polycrystalline properties. Isotropy and anisotropy-interfacial angles - symmetry in crystal systems - elements of symmetry, - space lattice and unit cell, Bravias lattices - seven crystal systems. Bond types - molecular, covalent, metallic and ionic. Born-Haber Cycle, Lattice energy, Imperfections in crystal- Stoichiometric defects - Schottky, Frenkel. Non-stoichiometric defects – Colour Centre, F-Centre.

UNIT – II REACTION KINETICS IN SOLUTIONS 9

Chemical kinetics – rate equation, order of reaction and rate law determination: Integral, Isolation, half-life and differential methods; comparison of different techniques. Kinetic equations for complex reactions-chain, parallel, opposing and consecutive reactions; Theory of reaction rates; Temperature effect on reaction rates; Rate constant for simple bimolecular reactions; Collision theory; Activated complex theory. Reactions in solutions: Diffusion controlled and activation controlled reactions; Thermodynamic formulation of rate constant: effect of pressure and ionic strength.

UNIT – III REACTION KINETICS ON SURFACES 9

Adsorption: Physisorption and chemisorptiion – Monolayer and multilayer adsorption - Adsorption of gases on solids - factors influencing adsorption - Langmuir adsorption; Adsorption of solutes from solutions - Freundlich adsorption. Applications - Adsorption Chromatography (Column Chromatography). kinetics of surface catalyzed unimolecular and bimolecular reactions; Applications. Surface characterization techniques – BET equation – XPS, AES, SEM and TEM.

UNIT – IV KINETICS OF SOLID STATE REACTIONS 9

Sintering, Nucleation; Factors influencing the reactivity of solids; Precursors to solid state reactions; Tammann and Hedvall mechanism; Wagner's diffusion theory, Material transport in solid state reaction-counter diffusion, Kirkendall effect; Huttig's mechanism; Kinetic model-Reaction in powder compact, Atomic theory of diffusion- self diffusion mechanism.

UNIT – V SYNTHETIC METHODS 9

Thin film - Electrochemical methods, PVD and CVD; Crystal growth- Thermal methods – Bridgman, Stockbarger and Zone refining, High Temperature Ceramic Methods, Particle size reduction, Precursor method, Co-precipitation, Sol-gel, Microwave Synthesis, Combustion Synthesis, High Pressure Methods, preparing single crystals - Czochralski, Molecular beam epitaxy - Flame and plasma fusion, Solution methods, Intercalated compounds.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Remember and explain the basic concepts of solid state chemistry.
CO2: Understand and apply the basic principles of chemical reaction kinetics and dynamics.
CO3: To analyse the theoretical models of molecular collisions, reaction dynamics and microscopic kinetics.
CO4: To derive and evaluate rate law equations and solve simple numerical problems.
CO5: To develop suitable experimental methods for material preparations.

TEXT BOOKS:

1. Laidler, Keith J. Chemical Kinetics, 4th Edn. Pearson Educations, New Delhi, 2007.
2. West, Anthony R. Solid State Chemistry and its Applications, 1st Edn. John Wiley & Sons, Singapore, 2003;

REFERENCES:

1. Leslie E. Smart and Elaine A. Moore “Solid State Chemistry: An Introduction”, 3rd Edn. Taylor & Francis, New York, 2005.
2. Sandra E. Dann, “Reactions and Characterization of Solids”, 1st Edn. The Royal Society of Chemistry, Cambridge, 2000.
3. Pilling M.J. and Seakins P. W., “Reaction Kinetics” 1st Edn. Oxford University Press, London, 1995.

COs- POs & PSOs MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2			1							2	3	1	1
CO2	3	2	1		1							2	2	1	1
CO3	3	2	1		1							2	2	1	1
CO4	3	2	1		1							2	2	1	1
CO5	3	2		1	2							2	2	1	3
Avg.	3	2	1	1	1.2							2	2.2	1	1.4

UC23H02 தமிழரும் தொழில்நுட்பமும்/Tamils and Technology L T P C

1 0 0 1

அலகு I <u>நெசவு மற்றும் பானைத் தொழில்நுட்பம்</u>: 3

சங்க காலத்தில் நெசவுத் தொழில் – பானைத் தொழில்நுட்பம் – கருப்பு சிவப்பு பாண்டங்கள் – பாண்டங்களில் கீறல் குறியீடுகள்.

அலகு II <u>வடிவமைப்பு மற்றும் கட்டிடத் தொழில்நுட்பம்</u>: 3

சங்க காலத்தில் வடிவமைப்பு மற்றும் கட்டுமானங்கள் & சங்க காலத்தில் வீட்டுப் பொருட்களில் வடிவமைப்பு- சங்க காலத்தில் கட்டுமான பொருட்களும் நடுகல்லும் – சிலப்பதிகாரத்தில் மேடை அமைப்பு பற்றிய விவரங்கள் – மாமல்லபுரச் சிற்பங்களும், கோவில்களும் – சோழர் காலத்துப் பெருங்கோயில்கள் மற்றும் பிற வழிபாட்டுத் தலங்கள் – நாயக்கர் காலக் கோயில்கள் - மாதிரி கட்டமைப்புகள் பற்றி அறிதல், மதுரை மீனாட்சி அம்மன் ஆலயம் மற்றும் திருமலை நாயக்கர் மஹால் – செட்டிநாட்டு வீடுகள் – பிரிட்டிஷ் காலத்தில் சென்னையில் இந்தோ-சாரோசெனிக் கட்டிடக் கலை.

அலகு III <u>உற்பத்தித் தொழில் நுட்பம்</u>: 3

கப்பல் கட்டும் கலை – உலோகவியல் – இரும்புத் தொழிற்சாலை – இரும்பை உருக்குதல், எஃகு – வரலாற்றுச் சான்றுகளாக செம்பு மற்றும் தங்க நாணயங்கள் – நாணயங்கள் அச்சடித்தல் – மணி உருவாக்கும் தொழிற்சாலைகள் – கல்மணிகள், கண்ணாடி மணிகள் – சுடுமண் மணிகள் – சங்கு மணிகள் – எலும்புத்துண்டுகள் – தொல்லியல் சான்றுகள் – சிலப்பதிகாரத்தில் மணிகளின் வகைகள்.

அலகு IV <u>வேளாண்மை மற்றும் நீர்ப்பாசனத் தொழில் நுட்பம்</u>: 3

அணை, ஏரி, குளங்கள், மதகு – சோழர்காலக் குமுழித் தூம்பின் முக்கியத்துவம் – கால்நடை பராமரிப்பு – கால்நடைகளுக்காக வடிவமைக்கப்பட்ட கிணறுகள் – வேளாண்மை மற்றும் வேளாண்மைச் சார்ந்த செயல்பாடுகள் – கடல்சார் அறிவு – மீன்வளம் – முத்து மற்றும் முத்துக்குளித்தல் – பெருங்கடல் குறித்த பண்டைய அறிவு – அறிவுசார் சமூகம்.

அலகு V <u>அறிவியல் தமிழ் மற்றும் கணித்தமிழ்</u>: 3

அறிவியல் தமிழின் வளர்ச்சி –கணித்தமிழ் வளர்ச்சி – தமிழ் நூல்களை மின்பதிப்பு செய்தல் – தமிழ் மென்பொருட்கள் உருவாக்கம் – தமிழ் இணையக் கல்விக்கழகம் – தமிழ் மின் நூலகம் – இணையத்தில் தமிழ் அகராதிகள் – சொற்குவைத் திட்டம்.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல்

துறை வெளியீடு)

4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils – The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi – 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by: Department ofArchaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

UC23H02 TAMILS AND TECHNOLOGY L T P C
1 0 0 1

UNIT I WEAVING AND CERAMIC TECHNOLOGY 3

Weaving Industry during Sangam Age – Ceramic technology – Black and Red Ware Potteries (BRW) – Graffiti on Potteries.

UNIT II DESIGN AND CONSTRUCTION TECHNOLOGY 3

Designing and Structural construction House & Designs in household materials during Sangam Age -Building materials and Hero stones of Sangam age – Details of Stage Constructions in Silappathikaram - Sculptures and Temples of Mamallapuram - Great Temples of Cholas and other worship places - Temples of Nayaka Period -Type study (Madurai Meenakshi Temple)- Thirumalai NayakarMahal -ChettiNadu Houses, Indo-Saracenic architecture at Madras during British Period.

UNIT III MANUFACTURING TECHNOLOGY 3

Art of Ship Building - Metallurgical studies -Iron industry - Iron smelting, steel -Copper and gold-Coins as source of history - Minting of Coins – Beads making-industries Stonebeads -Glass beads - Terracotta beads -Shell beads/ bone beats - Archeological evidences - Gem stone types described in Silappathikaram.

UNIT IV AGRICULTURE ANDIRRIGATION TECHNOLOGY 3

Dam, Tank, ponds, Sluice, Significance of KumizhiThoompuof Chola Period,Animal Husbandry - Wells designed for cattle use - Agriculture and Agro Processing -KnowledgeofSea -Fisheries – Pearl - Conche diving - Ancient Knowledge ofOcean -KnowledgeSpecificSociety.

UNIT V SCIENTIFIC TAMIL & TAMIL COMPUTING 3

Development of Scientific Tamil - Tamil computing – Digitalization of Tamil Books – Development of Tamil Software – Tamil Virtual Academy – Tamil Digital Library – Online Tamil Dictionaries – Sorkuvai Project.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCEBOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும்
   கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils – The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi – 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by: Department ofArchaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

MA23C06	PARTIAL DIFFERENTIAL EQUATIONS AND COMPLEX FUNCTIONS	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To familiarize the students to solve of partial differential equations.
- To familiarize the students in solving boundary value problems.
- To understand the concepts of Complex functions.
- To familiarize complex mappings and its property.
- To familiarize the students with integration of complex functions.

UNIT I PARTIAL DIFFERENTIAL EQUATIONS 9+3

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

UNIT II APPLICATIONS OF FOURIER SERIES TO PARTIAL DIFFERENTIAL EQUATION 9+3

Classification of partial differential equations- Method of separation of variables – Solutions of one dimensional wave equation and one-dimensional heat equation – Steady state solution of two dimensional heat equation – Fourier series solutions in Cartesian coordinates.

UNIT III ANALYTIC FUNCTIONS 9+3

Limit, Continuity and Differentiation of Complex functions - Analytic functions – Necessary and sufficient conditions for analyticity - Properties of analytic functions – Harmonic conjugates – Construction of analytic function – elementary analytic functions (exponential, trigonometric, logarithm) and their properties.

UNIT IV CONFORMAL MAPPING 9+3

Introduction to complex mapping - Conformal mapping – Condition for conformality – Standard mappings: a+z, az, az+b, $\frac{1}{z}, z^2, e^z$ - Bilinear transformations – Physical applications: Fluid flow and heat flow problems.

UNIT V INTEGRATION OF COMPLEX FUNCTIONS 9+3

Line integral - Cauchy's integral theorem – Cauchy's integral formula – Taylor's and Laurent's series – Singularities – Residues – Cauchy's Residue theorem – Application of residue theorem for evaluation of real integrals – Use of circular contour and semicircular contours (excluding poles on real lines).

TOTAL: 60 PERIODS

Laboratory based exercises / assignments / assessments will be given to students from the content of the course wherever applicable.

Branch specific / General Engineering applications based on the content of each units will be introduced to students wherever possible.

Suggested Laboratory based exercises / assignments / assessments :

1. Symbolic computation of solution to PDE using PDE Solver
2. Conformal mapping can be done by plotting the curves and surfaces

OUTCOMES:

CO1 :Understand the concepts of partial differential equations in practical situations.
CO2 :Obtain the solutions of the partial differential equations using Fourier series.
CO3 :Understand the Concepts of complex functions in practical situations.
CO4 :Understand the conformal mapping and its applications.
CO5 :Apply the complex integrations in engineering problems.

TEXT BOOKS:

1. Erwin Kreyszig "Advanced Engineering Mathematics", John Wiley & Sons., New Delhi, 2015.
2. Wylie C. R. and Barrett L. C "Advanced Engineering Mathematics", Tata McGraw-Hill., New Delhi, 2019.
3. Grewal B.S., “Higher Engineering Mathematics”, Khanna Publishers, 44th Edition, New Delhi, 2017.

REFERENCES:

1. Mathews J. H. and Howell R. W "Complex Analysis for Mathematics and Engineering", Narosa Publishing House. New Delhi, 2012.
2. Peter V.O Neil "Advanced Engineering Mathematics", Cengage., New Delhi, 2016.
3. Dennis G Zill "Advanced Engineering Mathematics", Jones & Bartlett India P Ltd., New Delhi, 2017.
4. Dean G Duffy "Advanced Engineering Mathematics with MATLAB", CRC., USA, 2010.
5. Spiegel, M.R., Theory and Problems of Complex Variables and its Application (Schaum’s Outline Series), McGraw Hill Book Co., Singapore (1981).

COs- POs & PSOs MAPPING

Course Outcomes	PROGRAMME OUTCOMES											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**P10**	**P11**	**P12**
CO1 :	3	3	2	3	1	2	1	1	1	1	1	3
CO2 :	3	3	2	3	1	2	1	1	1	1	1	3
CO3 :	3	3	2	3	1	2	1	1	1	1	1	3
CO4 :	3	3	2	3	1	2	1	1	1	1	1	3
CO5 :	3	3	2	3	1	2	1	1	1	1	1	3

CY23C02	POLYMERS, BIO-MATERIALS AND CERAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main objective of the course is to impart knowledge on processing, characteristics, and applications of polymers and biomaterials

UNIT I INTRODUCTION TO POLYMERS **9**

Polymers – Basics - Structural properties of Polymers, Molecular mass heterogeneity, Thermal Transitions - Polymer solutions - thermodynamics of dissolution, Crystallinity in Polymers - Structure, Property and Uses of PP, LDPE, HDPE, LLDPE, PS, HIPS, ABS, SAN, PVA, PVC, PVF, PVB, CPVC, PVAc, Phenolic resins, Cellulosic Polymers - Copolymers. Elastomers - Requirements of polymers to be elastomers - Structure, Property and Uses of NR, BR, SBR, Butyl, SBS block copolymers, EPR and EPDM, Neoprene and Silicone Rubber - Vulcanization and Compounding.

UNIT II ENGINEERING AND SPECIALITY POLYMERS **9**

PAM, Polyesters, PC, PAN, PMMA, Polyacetals, PTFE, Polyurethanes, TPUs, Polymer Blends and Alloys, Polymer Composites, Hydrogels, Shape Memory Polymers and Smart Polymers, LCP, Conducting Polymers, IPNs, Polymers for Fuel Cells and Energy Storage Devices.

UNIT III PROCESSING OF POLYMERS AND BIOMATERIALS **9**

Compounding - Role of Additives - Tg, VST, HDT and MFI - Processing - Single screw and twin screw Extrusion –Tubular blown film process - Co-extrusion Injection Moulding – Compression & Transfer Moulding - Blow Moulding – Rotational Moulding – Thermoforming -Calendering – Fiber Spinning - Electrospinning – RIM.Introduction to Additive Manufacturing of Biomaterials.

UNIT IV BIOMATERIALS IN ENGINEERING APPLICATIONS **9**

Properties - Requirements - Classification - Implants - Metallic (SS, Co & Ti alloys) – Shape Memory alloys. Ceramic (Bio inert: Alumina, Zirconia, Bio-resorbable: HAP, TCP, Bio active: glass ceramics) - Polymeric (Polyolefins, PAMs, fluoropolymers, acrylic polymers) - Other applications-heart valve, stent, vascular tubing, knee & hip replacement, suture, dental, wound dressing, dialysis, drug delivery, contact lens, syringes & plastic surgery.

UNIT V CERAMICS AND THEIR APPLICATIONS **9**

Types - Crystal Structures - Silicate Ceramics - Glasses – Glass Ceramics – Advanced Ceramics. Functional properties and applications of ceramic materials-Al_2O_3, SiC, Si_3N_4,B_4C,TiN, PSZ and SIALON– Super hard materials- Tungsten carbide and Boron nitrides-Cermets.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1: Explain the basics concepts of general polymers and describe their composition, properties and uses.
CO2: Discuss the properties and uses of engineering and speciality polymers in various applications.
CO3: Illustrate the common polymer processing techniques and explore the use of AM methods for processing polymers, metals and ceramics.
CO4: Apply the knowledge of biomaterials for implants and other medical applications.
CO5: Discuss the properties and uses of engineering ceramics and their applications in various fields.

TEXT BOOKS:

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

REFERENCES:

1. Ian Gibson, David W Rosen and Brent Stucker, “Additive Manufacturing Technologies: 3D-Printing, Rapid Prototyping and Direct Digital Manufacturing”, Springer, 2015.
2. Billmeyer Jr. and Fred. W., “Textbook of Polymer Science”, WileyTappers, 1965.
3. Gowarikar, “Polymer Science”, Johan Wiley and Sons, 1986.
4. Ghosh P., “Polymer Science and Technology of Plastics and Rubbers”, Tata McGraw-Hill Publishing Co., 1990.
5. Fredrick H. Silver, “Biomaterials, Medical Devices and Tissue Engineering”, Chapman and Hall, 1994.Park J. B., “Biomaterials Science and Engineering”, Plenum Press, 1984.
6. William D. Callister, Jr., “Materials Science and Engineering an Introduction”, 9/e Edition, John Wiley & Sons, Inc., 2014.

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3						2					2	3	3	3
2	3						2					2	3	3	3
3	3					2	2					2	3	3	3
4	3	2	2			2	2					2	3	3	3
5	3	2	2	2			2					2	3	3	3
Avg.	**3**	**2**	**2**	**2**		**2**	**2**					**2**	**3**	**3**	**3**

CE23C01 **MECHANICS OF MATERIALS** **L T P C**
3 0 2 4

COURSE OBJECTIVES:

1. To develop the understanding of the principle concepts of stress, strain and deformation of solids for various engineering applications.
2. To analyse the flexural and shear stresses induced in beams due to different loading conditions
3. To analyse the effect of torsion on shafts and springs.
4. To understand and analyse the deflection of beams for different support and loading conditions
5. To examine the stresses induced in thin and thick shells.

UNIT I STRESS, STRAIN AND DEFORMATION OF SOLIDS 9

Rigid bodies and deformable solids –Stresses and strains: Tension, Compression and Shear - Elastic constants – Relationships – Compound bars – Thermal stresses –Volumetric strains – Stress on inclined planes – Principal stresses and principal planes – Mohr's circle of stress.

PRACTICALS

1. Tension test on mild steel rod

UNIT II TRANSVERSE LOADING ON BEAMS AND STRESSES IN BEAM 9

Beams – Types - Transverse loading on beams – Shear force and bending moment in beams – Cantilevers – Simply supported beams and over hanging beams - Theory of simple bending – Bending stress distribution - Load carrying capacity - Proportioning of sections –Flitched beams –Carriage springs – Shear stress distribution- Shear Centre.

PRACTICALS

1. Deflection test on carriage spring

UNIT III TORSION 9

Theory of Pure Torsion- Stresses and deformation in circular and hollows shafts – Transmission of power through hollow & solid shafts – Stepped shafts –Shafts fixed at the both ends – Stresses in helical springs – Deflection of helical springs.

PRACTICALS

1. Torsion test on mild steel rod

UNIT IV DEFLECTION OF BEAMS 9

Double Integration method – Macaulay's method – Area moment method - Conjugate beam method - Strain energy method - computation of slopes and deflections in beams- Maxwell's reciprocal theorem.

PRACTICALS

1. Compression test on helical spring

UNIT V THIN &THICK SHELLS, THEORIES OF FAILURE 9

Stresses and deformations in thin cylindrical shells and spherical shells subjected to internal pressure – Stresses in thick cylinders – Lame's theory – Application of theories of failure- Euler's buckling theory.

PRACTICALS

1. Hardness test on metal beam

(Rockwell and Brinell hardness test)

TOTAL: 45L+30P =75 PERIODS

COURSE OUTCOMES:

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

CO1	Have thorough understanding of the fundamental concepts of stress and strains and understand the mechanical behaviour of materials such as tension, compression and hardness.
CO2	Understand the bending and shear stress distribution in beams.
CO3	Have sufficient knowledge on designing shafts to transmit power and understand the behaviour of helical springs
CO4	Have the ability to determine the deflection of beams and carriage springs
CO5	Have the knowledge of behaviour of cylindrical and spherical shells.

TEXT BOOKS:

1. Bansal, R.K., Strength of Materials, Laxmi Publications (P) Ltd., 2018
2. Rajput, R.K., Strength of Materials, S Chand And Company Ltd., New Delhi, 2018

REFERENCES:

1. Strength of Materials Laboratory Manual, Anna University, Chennai - 600025.
2. IS 432 (art I) -1992, Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement.
3. Egor. P.Popov “Engineering Mechanics of Solids” Prentice Hall of India, New Delhi, 2015.
4. Ferdinand P. Beer, Russell Johnson, Jr. and John J. Dewole Mechanics of Materials, 7 th Edition, Tata McGraw Hill publishing ‘co. Ltd., New Delhi, 2014.
5. Hibbeler, R.C., Mechanics of Materials, Pearson Education, 10th Edition, 2022.
6. Subramanian R., Strength of Materials, Oxford University Press, Oxford Higher Education Series, 2007

CO-PO-PSO MAPPING: MECHANICS OF MATERIALS

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	2	3	2	2	2	3	3	1	1	2	3	3	2
2	3	3	3	3	2	3	2	3	1	1	1	2	3	2	2
3	3	3	3	3	2	3	2	3	3	1	1	2	3	3	2
4	3	3	3	3	2	2	2	2	3	1	1	2	3	2	2
5	3	3	3	3	2	3	2	3	1	1	1	2	3	3	2
Avg.	**3**	**3**	**3**	**3**	**2**	**3**	**2**	**3**	**3**	**1**	**1**	**2**	**3**	**3**	**2**

MS23301	STRUCTURE AND PROPERTIES OF MATERIALS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main objective of the course is to impart knowledge on the correlation of the structure and the properties of materials

UNIT I ENGINEERING MATERIALS & BONDING IN SOLIDS 9

Classification of engineering materials, differences between metals, ceramics, polymers and composites with respect to the basic structure and applications. Structure at different length scales, correlation between structure, bonding and properties of materials (through examples), Atomic structure of solids: bonding—bonding forces and energies, primary bonding and secondary bonding, band structure.

UNIT II STRUCTURE OF SOLIDS 9

Difference between crystalline (monocrystals, polycrystals) and amorphous solids with examples. Generation of orderly patterns by symmetry operations, concept of lattice, concept of unit cell, Bravais lattices, crystal systems, Basics of point groups and space groups and their visualization, Pearson and Strukturbericht notations, Miller indices for crystallographic positions, planes and directions. Stereographic projection: concept and application.

UNIT III CRYSTAL IMPERFECTIONS & THEIR SIGNIFICANCE 9

Atomic Hard sphere models, close packing, voids, allotropy and polymorphism. Origin and importance of defects in solids: Crystal Imperfections & their influence on the properties - Metals – point defects (vacancies, interstitials), dislocations, grain boundaries & grain size, stacking faults, twinning.

UNIT IV SOLID SOLUTIONS 9

Introduction to Quasi-crystals. Introduction to microstructures. Theory of alloying: substitutional solid solutions, Hume- Rothery rules, interstitial solid solutions, ordering in solids. Introduction to strengthening mechanisms.

UNIT V STRUCTURE OF POLYMERS 9

Polymers – Chain alignment, tacticity, polydispersity, molecular weight, thermoplastics and thermosets; Ceramics – Schottky and Frenkel defects, non-stoichiometric defect, Silicate structures, radius ratio and electroneutrality rules. Functional properties of ceramics.

TOTAL :45 PERIODS

COURSE OUTCOMES:

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

CO1: Relate the connection between structure and properties of materials and explain different types of chemical bonds and their influence on properties

CO2: Discuss on the similarities and differences in the symmetries of different crystal systems and Bravais lattices and index different planes and directions in crystals

CO3: Explain the various defects in metals, ceramics, and polymers

CO4: Elaborate on the different types of Solid solutions and gives an overview of Strengthening mechanisms

CO5: Summarize the fundamental differences between metals, polymers and ceramics.

TEXT BOOKS:

1. Materials Science and Engineering:a First Course, V.Raghavan, PHI Learning, New Delhi, 2004.
2. William D. Callister, Jr., Materials Science and Engineering an Introduction‖, 2/e Edition, John Wiley & Sons, Inc., 2007

REFERENCES

1. Physical Foundations of Materials Science, G.Gottstein, Springer-Verlag,Germany, 2004.
2. Crystallography and Crystal Defects, A.Kelley, K.M.Knowles,Wiley,2012.
3. Introduction to Crystallography, Frank Hoffmann, Springer Nature,2020.
4. Materials Science and Engineering: an Introduction, William D. Callister Jr., David, G.Rethwisch, Wiely, 2014.

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2	1	2							2	3	2	2
2	3	3	2	3	2							2	3	3	2
3	3	1	1	3	2							1	3	3	2
4	3	2	2	2	2							1	3	3	
5	3	2	3	1	2							2	3	1	3
Avg.	3	2	2	2	2							1.6	3	2.2	2.25

MS23302	METALLURGICAL THERMODYNAMICS	L	T	P	C
		3	1	0	4

COURSE OBJECTIVES:

- To Impart knowledge on state functions, law's on thermodynamics, Auxillary functions, thermodynamic potentials, thermodynamic behavior of solutions and reactions

UNIT – I FUNDAMENTAL CONCEPTS 12

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

UNIT – II INTERNAL ENERGY AND ENTROPY 12

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

UNIT – III AUXILLARY FUNCTIONS AND THERMODYNAMIC POTENTIALS 12

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

UNIT – IV THERMODYNAMICS OF SOLUTIONS 12

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

UNIT – V THERMODYNAMICS OF REACTIONS 12

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

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

1. Identify the nature of the system and properties.
2. Explain the concept of internal energy, entropy and criteria for equilibrium.
3. Appraise the importance of auxilliary functions and thermodynamic potentials
4. Apply the concepts of thermodynamics in the behavior of solutions.
5. Perceive the thermodynamic approaches towards electrochemical cells, surfaces and defects.

TEXT BOOKS:

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

REFERENCES:

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

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	3	3									3	1	
2	3	3	3	3									3	3	
3	3	3	3	3									3	3	
4	3	3	3	3									3	2	
5	3	3	3	3									3	2	
Avg.	3	3	3	3									3	2.2	

MS23303	PHYSICAL METALLURGY	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

- The main objective of the course is to impart knowledge on the Solidification in pure metal and alloy systems and interpret the microstructural changes that occur in systems at different temperatures and composition and to gain hands on experience on the metallographic specimen preparation, and microstructural analysis of ferrous & non-ferrous alloys.

UNIT I SOLIDIFICATION OF METALS & PHASE DIAGRAMS 9

Introduction-Cooling curve-Gibb's phase rule, Gibb's Free energy, Phase diagram of Pure metal- Iron, water, undercooling, Concept of nucleation and growth, homogeneous & heterogeneous nucleation, Directional Solidification. Diffusion in solids -Types of diffusion-Laws of Diffusion. Solid Solutions- Limits of solubility, Equillibrium cooling, Binary isomorphous system, Free energy composition diagram, Lever rule, Eutectic, Peritectic & peritectoid systems, Ternary diagram, Non-Equilibrium cooling.

UNIT II IRON-CARBON SYSTEM & OTHER COMMON ALLOY SYSTEMS 9

Solidification of pure iron, Solubility of carbon in BCC & FCC iron, Phases in iron – carbon binary system, Classification of steels & cast irons, Estimation of the amount of micro-constituents in steel, Phase transformations, Mechanical properties of iron – carbon alloys.

Examples of binary isomorphous system- Cu-Ni, Ge-Si, Au-Cu systems. Binary eutectic-Pb-Sn, Al-Si, Ni-Cr Systems, Phase diagrams having intermediate phases-C-Zn, Cu-Sn, Mg-Sn, Ti-Al, Ti-V systems, Interpretation of microstructure & properties.

UNIT III DEFORMATION OF PURE METAL 9

Elastic Deformation, representation of stresses & strains at a point. Stress- strain relationship, Plastic deformation, Deformation of single crystal-Slip &Twin, Numbers of independent slip systems, Critical resolve shear stress (CRSS), Theoretical strength of ideal crystal. Deformation of poly crystalline material.

UNIT IV COLD WORKING, ANNEALING AND STRENGTHENING 9

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

Thermodynamics & kinetics of precipitation, precipitation hardening.

Need for Heat treatments. Introduction to various Heat treatment processes.

Strengthening mechanism, strength vs. toughness (ductility), thermomechanical processing, micro alloyed steel, ultra high strength steel, superalloys, control of texture.

UNIT V INTRODUCTION TO METALLOGRAPHY 9

Optical microscopy-Metallurgical microscope - construction and principle of working, sectioning and cutting of samples-mounting-hot and cold- mounting resins- Grinding parameters- pressure , velocity and direction, Rough polishing, Emery grades, Fine polishing, Etching- chemical, electrolytic, thermal, plasma etching – metallographic analysis.

LAB EXPERIMENTS **30**

1. Mounting of Metallurgical samples.
2. Quantitative Metallography & image analysis.
3. Electrolytic Etching and Polishing of metallurgical samples
4. Microscopic examination of cast irons - Grey, White, Malleable and Nodular.
5. Microscopic examination of Plain carbon steels
6. Microscopic examination of Austenitic Stainless steels and High Speed Steels.
7. Microscopic examination of Copper/Aluminum/Titanium alloys
8. Quantitative metallography to evaluate ceramics, inclusion count, case depth and reinforcement in composites.
9. Construction of ismorphous phase equilibrium diagram and study of phases, invariant points, and invariant reactions.
10. Construction of eutectic phase equilibrium diagrams and study of phases, invariant points, and invariant reactions.

TOTAL :75 PERIODS

COURSE OUTCOMES:

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

CO1: Explain the concepts of nucleation and growth of solids upon solidification

CO2: Interpret the microstructural changes that takes place in the alloy systems and perform microstructural analysis of ferrous and non-ferrous materials

CO3: Discuss on the mechanisms of deformation and the theoretical strength of crystals.

CO4: Elaborate the various strengthening mechanisms and the basics of the Heat treatments adopted to get the desired properties

CO5: Select suitable ferrous and non-ferrous materials for engineering applications & Interpret the microstructures of various materials and also understand the effect of the various phase constituents on the properties of the materials.

TEXT BOOKS:

1. Physical Metallurgy: Principles and Practice,V.Raghavan,PHILearning,Delhi,2008.
2. Introduction to Physical Metallurgy , Sydney H.Avner,McGraw-Hill Companies,June 1990

REFERENCES

1. Physical Metallurgy Principles, R. Abbaschian, R. E. Reed-Hill, Cengage Learning, 2009.
2. Steels: Microstructure and Properties, 3rd edition, H.K.D.H. Bhadeshia and R. Honey combe, Butterworth-Heinemann, 2006.
3. Microstructure of Steels and Cast Irons, M. Durand-Charre, 1st edition, Springer-Verlag, 2004.

4. Physical Metallurgy Vols. I,II,III,R. W.Cahnand P.Haasen, North Holland,1996.
5. Light Metals, I. J. Polmear, Elsevier, 2005.
6. Steels: Processing, Structure, and Performance, G.Krauss, ASM International, 2005.

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	3	3					2				3	1	1
2	3	3	3	3	2				2				3	3	1
3	3	3	3	3					2				3	3	1
4	3	3	3	3					2				3	2	1
5	3	3	3	3					2				3	2	1
Avg.	3	3	3	3	2				2				3	2.2	1

MS23401	HEAT TREATMENT OF MATERIALS	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

- The main objective of the course is to prepare the students to have a comprehensive understanding of the various transformation reactions associated with the changes in microstructures and properties that occur due to various heat treatments and gain hands on experience in performing various heat treatments on the ferrous and non-ferrous alloys and interpret the results obtained.

UNIT I TRANSFORMATIONS IN STEELS 9

Allotropic changes in Iron, Iron-Iron carbide equilibrium diagram – transformations on heating and cooling - influence of alloying elements – isothermal and continuous cooling transformations in steels – Time-Temperature-Transformation curves (TTT-diagrams), continuous cooling transformations – CCT-diagrams– effect of alloying additions on TTT diagrams, Kinetics of formation of austenite- Austenite grain size-mechanism and kinetics of pearlitic, bainitic and martensitic transformations, Interlameller spacing – habit plane – Bain distortion model

UNIT II HEAT TREATMENT PROCESSES 9

Annealing- Types, Normalising, Hardening & Quenching –Mechanisms-tempering – Hollomon& Jaffe tempering correlations, retained austenite, tempering – Stages – effects of alloying elements on tempering, hardenability studies–Grossman's experiments, Jominy end-quench test, Use/Significance ofHardenability data, Effect of grain size and composition, Residual stresses, Quench cracking.austempering and martempering, precipitation hardening, thermo-mechanical treatment, intercritical heat treatment, sub-zero treatment – cryogenic quenching, patenting, Vibratory heat treatment.

UNIT III CASE HARDENING 9

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

UNIT IV FURNACES, ATMOSPHERE AND PROCESS CONTROL 9

Various heating atmosphere used for heat treatment, temperature and atmosphere control– carburising atmosphere and carbon potential measurement, Temperature Measurement Control devices – Nitriding gas atmospheres, quenching media and their characteristics, Stages of Quenching, polymer quenching, Various Heat Treatment furnaces- Roller and Mesh type

continuous furnaces- fluidised bed furnaces, cryo-chamber, cryo-treatment of steels, sealed quench furnace, Vacuum furnace, Plasma equipment-Elements of Process control systems-PLC ,PID controllers and continuous monitoring systems.

UNIT V HEAT TREATMENT OF SPECIFIC ALLOYS 9

Heat treatment of special purpose steels – tool steels, high speed steels, maraging steels, HSLA steels and die steels, heat treatment of cast irons – gray cast irons, white cast irons and S.G.irons, austempering of S.G.Iron, heat treatment of non-ferrous alloys –hardening - aluminium alloys, copper alloys, nickel alloys and titanium alloys, Concept of Precipitation hardening, defects in heat treated parts – causes and remedies. Heat treatment system assessment, Introduction to CQI-9.

30

LAB EXPERIMENTS

1. Hardening and tempering of High carbon steels
2. Annealing and normalizing of hardened steels
3. Study of Microstructure and hardness of steel at different rates ofcooling.
4. Effect of tempering temperature and time on tempering of steel
5. Effect of carbon percentage on the hardening of steel
6. Surface hardening by thermo-chemical treatments (carburizing/ boronising)
7. Case hardness depth measurements and verification of Harris equation.
8. Determination of Hardenability of steel by Jominy End Quench Test
9. Heat treatment of cast iron
10. Heat treatment of Stainless Steels and High speed steels
11. Heat treatment of non-ferrous alloys
12. Use of Heat treatment apps for designing the heat treatment process for a given material.

TOTAL : 75 PERIODS

COURSE OUTCOMES:

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

1. Discuss the various transformation reactions that occur due to various heat treatments.
2. Explain and perform the suitable heat treatment processes for different ferrous and non-ferrous alloys.
3. Analyze the effect of various case hardening treatments on the properties of metals and alloys and execute the carburizing treatment on low carbon steels
4. Analyze the advantages and limitations of various heat treatment furnaces, quenching media and furnace atmospheres.

5. Interpret the results of heat treatments on the various non-ferrous materials, alloy steels and cast irons and also the effect of quenching media and the carbon percentage on the hardening of steel

TEXT BOOKS:

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

REFERENCES

1. Engineering Physical Metallurgy and Heat Treatment by Yu. M. Lakhtin, MIR Publishers, Central Books Ltd, 1980.
2. ASM Hand book "Heat Treating", Vol.4., ASM International, 1999.
3. I. Novikov, "Theory of Heat Treatment of Metals", MIR Publishers, Moscow, 1978
4. Prabhudev. K. H. "Handbook of Heat Treatment of Steels", Tata McGraw-Hill, Publishing Co., New Delhi, 1988.
5. Sydney H. Avner, "Introduction to Physical Metallurgy", Tata McGraw Hill, New Delhi, 1997.

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2	3	1	2	2	1					2	3	2	3
2	3	2	2	1	2	2	1		2	1		2	3	2	3
3	2	2	2	2	2	2	1		2	1		2	3	2	3
4	2	2	2	2	2	2	1		2	1		2	3	2	3
5	3	2	2	1	2	2	1		2	1		2	3	2	3
Avg.	2.6	2	2.2	1.4	2	2	1		2	1		2	3	2	3

MS23402	CASTING AND WELDING METALLURGY	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

- The main learning objective of this course is to impart knowledge on the metallurgical aspects of ferrous & nonferrous cast and welded alloys and to acquire skills on estimation of molding sand properties and understand the metallurgical aspects of the cast & welded specimens.

UNIT I FERROUS CAST ALLOYS 9

Solidification of pure metals and alloys and eutectics -Nucleation - Growth Process, Critical nucleus size- Super cooling- Niyama Criterion -G/R ratio- Cell- Dendritic - Random dendritic structure-Segregation and Coring- Eutectics-Compositions and alloys in Cast Irons, FG-CGISG structures, Metallic Glass- Mold dilation, Mold metal reactions- Structure and Section sensitivity Cast irons- family & microstructures-Alloying effects- Malleable Iron, ADI, Charge calculations- Effect of normal elements and alloying elements in steels- Compositional aspects and properties of alloy steels- melting procedure and composition control for carbon steels- low alloy steels - stainless steels- composition control- slag-metal reactions- desulphurization, dephosphorisation, specifications for carbon steels- low alloy steels and stainless steels

UNIT II NON FERROUS CAST ALLOYS 9

Copper- Aluminium- Magnesium- zinc - Nickel base alloys- melting practices - Al alloys, Mg alloys, Nickel alloys, Zinc alloys and copper alloys-modification and grain refinement of Al alloys- problems in composition control- degassing techniques -Heat Treatment of Aluminium alloys – Basics of Solution and Precipitation process. - Applications of Aluminium Alloy castings in various fields. Residual Stresses- defects in castings–Inspection. Introduction to casting simulation softwares.

UNIT III WELDING METALLURGY PRINCIPLES 9

Thermal cycles in welding: basic heat transfer equations, temperature distributions and cooling curves, dependence of cooling rate on heat input, joint geometry, preheat and other factors. Comparison of welding processes based on these considerations. Robotic welding.

UNIT IV PHYSICAL METALLURGY OF WELDING 9

Welding of ferrous materials: Iron- Iron carbide diagram, TTT and CCT diagrams, effects of steel composition, formation of different microstructural zones in welded plain-carbon steels. Welding of C-Mn and low-alloy steels, phase transformations in weld and heat - affected zones, cold cracking, role of hydrogen and carbon equivalent, formation of acicular ferrite and effect on weld metal toughness

UNIT V WELDING OF ALLOY STEELS AND NON-FERROUS METALS 9

Welding of stainless steels, types of stainless steels, overview of joining ferritic and martensitic types, welding of austenitic stainless steels, Sensitization, hot cracking, sigma phase and chromium carbide formation, ways of overcoming these difficulties, welding of cast iron. Welding of non-ferrous materials: Joining of aluminum, copper, nickel and titanium alloys, problems encountered and solutions. Introduction to welding simulation softwares.

LAB EXPERIMENTS

30

1. Determination of Average Sand grain fineness number.
2. Determination of Permeability of green sand.
3. Determination of moisture content in green sand.
4. Estimation of compactability of system sand.
5. Estimation of Active clay content in green sand
6. Loss of Ignition Test for green sand.
7. Determination of green compression and shear Strength of green sand.
8. Determination of Dry Compression Strength of system sand.
9. Casting simple geometrical shapes by using green sand and full mold process.
10. Effect of welding parameters on the bead geometry of Shielded metal arc welded (SMAW) plates
11. Effect of welding parameters on the hardness of SMAW plates.
12. Effect of welding parameters on grain size of Shielded metal arc welded carbon steel, Stainless steel, aluminum and titanium alloy.
13. Fabrication of any structure using SMAW process.
14. Demo on Gas Tungsten Arc welding (GTAW) process.
15. Microstructural analysis of cast and welded components.

TOTAL :75 PERIODS

COURSE OUTCOMES:

CO1: Select suitable casting process for application requirement and demonstrate the sand casting and fabrication of complex welded structures

CO2: Apply gating design and mould design knowledge to overcome defects in casting and determine the various properties of moulding sand

CO3: Select suitable welding process according to the requirements and apply metallurgical aspects of welding to overcome defects in welding and analyse the effect of welding parameters on bead geometry, the grain size and hardness

CO4:Discuss on the physical metallurgy of welding and the interpret the phase transformations in the different zones of welding

CO5: Explain the weldability of alloy steels and non-ferrous materials

TEXTBOOKS:

1. A.K.Chakrabarthi, ‘Casting Technology and Cast Alloys,Prentice Hall, 2005.
2. 2. R.S.Parmar, ‘Welding Engineering and Technology’, Khanna Publishers, 2003

REFERENCES:

1. ASM International. Handbook Committee, ASM Handbook: Casting. Volume 15, ASM International, 2008.

2. Baldev Raj, Shankar V, Bhaduri A K, “Welding Technology for Engineers”, Narosa Publications, 2009.
3. Beeley P, “Foundry Technology" Butterworth-Heinemann, 2001.
4. John Brown, Foseco Ferrous Foundryman's Handbook, Butterworth-Heinemann, 2000.
5. John Campbell, “Casting", Butterworth-Heinemann, 2003.
6. Sind kou, ‘Welding metallurgy’ ,Wiley publications, 2016.

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	**3**	**2**	1	1					**2**	**1**		**2**	**2**	**1**	
2	3	2	1	1	**3**				**2**	**1**		2	2	1	
3	3	2	1	1	**3**				**2**	**1**		2	2	1	
4	3	2	1	1	**3**							2	2	1	
5	3	2	1	1	**3**				**1**	**2**		2	2	1	
Avg.	3	2	1	1	**3**				**1.8**	**1.2**		2	2	1	

MS23403	MECHANICAL METALLURGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To impart knowledge on Dislocations & mechanisms of plastic deformation, various strengthening mechanisms, Fracture mechanics and Creep & Fatigue behavior of materials.

UNIT – I ELASTIC AND PLASTIC BEHAVIOUR 9

Elastic behaviour of materials - Hooke's law, Plastic behaviour: Types of Dislocation, Dislocation characteristics- Burger's vector and dislocation loops, Strength of a perfect crystal, observation of dislocations, Lattice resistance to dislocations, stress fields and energies of dislocations, Partial dislocations, influence of stacking fault energy, intersections of dislocations, multiplication of dislocations, Mechanism of plastic deformation: Slip and twinning.

UNIT – II STRENGTHENING MECHANISMS 9

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

UNIT – III FRACTURE AND FRACTURE MECHANICS 9

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

UNIT – IV FATIGUE BEHAVIOUR AND TESTING 9

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

UNIT – V CREEP BEHAVIOUR AND TESTING 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Identify the role of dislocations and the mechanisms of plastic deformation.

CO2: Explain the strengthening mechanisms of polycrystalline and composite materials.

CO3: Analyze the nature of fracture and its underlying mechanism.

CO4: Appraise the micro-mechanics, factors and life predictions of components under fatigue loading.

CO5: Assess the behavior of materials under high temperature, metallurgical factors and life prediction of high temperature materials.

TEXT BOOKS:

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

REFERENCES:

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

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	3										3	3	
2	3	3	3										3	3	2
3	3	3	3	3									3	3	
4	3	3	3	3									3	3	2
5	3	3	3	2									3	3	
Avg.	3	3	3	2.67									3	3	2

MS23404	POWDER METALLURGY	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

- The main objective of the course is to prepare the students in gaining essential knowledge on powder preparation, characterization, compaction and sintering techniques and to gain hands on experience on various powder metallurgical techniques.

UNIT I POWDER MANUFACTURE AND CONDITIONING 9

Mechanical methods: Machine milling, ball milling, shotting- Chemical methods, condensation, thermal decomposition, Reduction, electrodeposition, precipitation from aqueous solution and fused salts, hydrometallurgical method. Physical methods: Electrolysis and atomisation processes, types of equipment, factors affecting these processes, examples of powders produced by these methods, Comparison of atomization methods. applications, Powder conditioning- blending and mixing, equipment, Self-propagating high-temperature synthesis (SHS), sol-gel synthesis-Nanopowder production methods.

UNIT II CHARACTERISTICS AND TESTING OF METAL POWDERS 9

Sampling, chemical composition, Particle Size and its measurement- Sieve analysis-Principle and procedure, Effect of particle size on the microstructure, Dynamic Light Scattering sedimentation, elutriation & permeability, Particle size Topography, Surface area, BET surface area analysis, True, Apparent and Tap Density, Flow rate, Compressibility, Green Strength, Pyrophoricity and Toxicity, particle shape, classifications

UNIT III POWDER COMPACTION 9

Pressureless compaction: Loose Shaping, slip casting and slurry casting. Pressure compaction-Die compaction, Role of lubrication, single ended and double ended compaction, isostatic pressing, powder rolling, Vibratory Compaction, Centrifugal compaction, explosive forming.

UNIT IV SINTERING 9

Stages of sintering, Mechanisms of sintering, liquid phase sintering and infiltration, Full density Processing-Activated sintering, Hot pressing and Hot Isostatic Pressing (HIP), Vacuum sintering, Sintering furnaces-batch and continuous-sintering atmosphere, Finishing operations – Heat treatment, Surface treatments, Impregnation, sizing, coining, Special sintering processes - Microwave sintering, Spark plasma sintering, Field assisted sintering, Reactive sintering, Sintering of nanostructured materials.

UNIT V APPLICATIONS of P/M COMPONENTS **9**

Major applications in Aerospace, Nuclear and Automobile industries- Bearing Materials-types, Self-lubrication and other types, Methods of production, Properties, Applications. Sintered Friction Materials-Clutches, Brake linings, Tool Materials- Cemented carbides, Oxide ceramics, Cermets- Dispersion strengthened materials.

30

LAB EXPERIMENTS

1. Powder Production by wet chemical synthesis
2. Powder size reduction by Ball Milling
3. Sieve Analysis Particle size distribution
4. Measurement of Apparent and Tap Density of Powders
5. Measurement of Flow Rate of Powders
6. Determination of optimum compaction pressure.
7. Density determination of sintered product.
8. Hardness of sintered product.
9. Preparation of porous ceramic product.

TOTAL :75 PERIODS

COURSE OUTCOMES:

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

CO1: Classify the various powder production methods and the Powder conditioning treatments.

CO2: Synthesize and correlate the characteristics of metal powders with that of the size, shape and nature of the powders.

CO3: Compare the different compaction processes and identify a suitable compaction methodology for a component meant for specific application

CO4: Explain the sintering mechanisms and the various types of Sintering processes as well as the finishing processes and evaluate the quality of formed and sintered components

CO5: Discuss the applications of various powder metallurgy components.

TEXT BOOKS:

1. Anish Upadhya and G S Upadhaya, “Powder Metallurgy: Science, Technology and Materials, Universities Press, 2011
2. P.C.Angelo and R.Subramanian.,“ Powder Metallurgy: Science, Technology and Applications” Prentice Hall, 2008

REFERENCES:

1. ASM Handbook. Vol. 7, “Powder Metallurgy”, Metals Park, Ohio, USA, 1990.
2. Kempton. H Roll, “Powder Metallurgy”, Metallurgical Society of AMIE, 1988.
3. Ramakrishnan. P., “Powder Metallurgy-Opportunities for Engineering Industries”, Oxford and IBH Publishing Co., Pvt. Ltd, New Delhi, 1987.
4. Sands. R. L. and Shakespeare. C. R. “Powder Metallurgy”, George Newes Ltd. London, 1966
5. Sinha A. K., “Powder Metallurgy”, Dhanpat Rai & Sons. New Delhi, 1982

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3		1		2							2	3	**1**	**2**
2	3		1	**2**	2				**2**	**2**		2	3	**2**	
3	3		2		2							2	3	**1**	2
4	3		2		2				**2**	**2**		2	3	**1**	2
5	3								**2**	**2**		2	3	**1**	
Avg.	**3**		**1.5**	**2**	**2**				**2**	**2**		**2**	**3**	**1.2**	**2**

MS23405	CHARACTERISATION OF MATERIALS	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

- The main objective of this course is to acquire knowledge on various microscopic, XRD, SEM and TEM techniques used for structural characterization of materials and to acquire skills on metallurgical characterization using sophisticated instruments.

UNIT I PRINCIPLE OF METALLOGRAPHY 9

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

UNIT II X-RAY DIFFRACTION TECHNIQUES 9

Basics of X-ray emission from source, electron excitation and X-ray interaction with materials, Properties of X-rays, Bragg's law, Ewald's Sphere, Diffraction methods – Laue, rotating crystal, and powder methods. Intensity of diffracted beams –structure factor calculations and other factors. Diffractometer – General features and optics, Counters - Proportional, Scintillating, Geiger counters and semiconductor based.

UNIT III ANALYSIS OF X-RAY DIFFRACTION 9

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

UNIT IV SCANNING ELECTRON MICROSCOPY(SEM) **9**

Components of SEM- Construction, and operation of Scanning electron microscope, Specimen preparation techniques, Electron specimen interaction, Contrast formation in SEM, Imaging with SEM, Microchemical analysis, Specialised SEM techniques.

UNIT V ADVANCED ELECTRON MICROSCOPY 9

Construction and operation of Transmission electron microscope(TEM),Energy Dispersion Spectroscopy, Electron Backscatter Diffraction, Basics of Field ion microscopy (FIB), Scanning Tunneling Microscope (STM) and Atomic Force Microscope(AFM) – Case studies.

LAB EXPERIMENTS 30

1. Verification of Beer Lambert's law using Absorption Spectrophotometer.

2. Determination of concentration of metal ions using UV Visible spectrophotometer.
3. Determination of thermal coefficient using dilatometer.
4. Functional group identification of samples using FTIR.
5. Quantitative analysis using column chromatography.
6. Qualitative identification of species using TLC.
7. Thermal analysis of samples using DSC, TGA and DMA.
8. Surface and elemental composition analysis of materials using SEM-EDS.
9. Surface topographic analysis of samples using AFM.
10. XRD pattern analysis of crystalline and amorphous samples.
11. Analysis of TEM – SAED pattern

TOTAL :75 PERIODS

COURSE OUTCOMES:

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

CO1 Analyze the microstructure using optical Microscope
CO2 Discuss the fundamentals of XRD Diffraction
CO3 Analyse and Interpret the XRD results
CO4 Summarize the electron microscopy techniques and their application.
CO5 Discuss and demonstrate the surface and Thermal analysis techniques and characterise the samples using spectrophotometer.

TEXTBOOKS:

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

REFERENCES:

1. Brandon D. G, “Modern Techniques in Metallography”, Von Nostrand Inc. NJ, USA, 1986.
2. D. A. Skoog, F. James Leary and T. A. Nieman, “Principles of Instrumental Analysis”, 7thedition, Cengage Learning, 2017.
3. Thomas G., “Transmission electron microscopy of metals”, John Wiley, 1996.
4.R.F. Speyer, Thermal Analysis of Materials, Marcel Decker, 1994
5. Materials characterization, Vol. 10, ASM hand book, 1997.

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2	1	2	2							2	2	3	
2	3	2	1	2	2							2	2	3	
3	3	2	1	2	2			2	2			2	2	3	
4	3	2	1	2	2							2	2	3	
5	3	2	1	2	2			2	2			2	2	3	
Avg.	3	2	1	2	2			2	2			2	2	3	

MS23406	IRON AND STEEL MAKING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main objective of the course is to prepare the students for acquiring basic knowledge on the need for the beneficiation of iron ores and the primary processing of iron and steel making.

UNIT I RAW MATERIALS AND BURDEN PREPARATION 9

Iron ore classification, Occurrence and distribution of iron ore and limestone in India., problems associated with Indian raw materials, Classification of iron-making methods. Iron ore beneficiation and agglomeration, Briquetting, sintering, Nodulising and pelletizing, testing of burden materials, burden distribution on blast furnace performance.

UNIT II PRINCIPLES AND PROCESSES OF IRON MAKING 9

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

Reduction of iron ores and oxides of iron by solid and gaseous reductions-thermodynamics and kinetics study of direct and indirect reduction, Gruner's theorem, Blast furnace slag and slag metal reactions; Fe-O, C-O, Fe-C-O, & Fe-C-O-H phase equilibria., Rist diagrams, Ellingham diagram, material and heat balance- Sponge Iron making. Combustion zone, RAFT, deadman's zone, cohesive zone- size and shape.

UNIT III PRINCIPLES OF STEEL MAKING 9

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

UNIT IV STEEL MAKING PROCESSES 9

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

UNIT V LADLE METALLURGY 9

Production practice for plain carbon steels, stainless steels, tool steels and special steels, Secondary steel making processes, continuous steel casting process – Deoxidation and

teeming practice. Principle, methods and their comparison, Killed, Rimmed and Capped steels, Degassing practices, Injection Metallurgy, Cored wire injection, Tundish metallurgy &design, ingot production, ingot defects and remedies. Recent trends in steel making technology, Green Steel making.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

1. Identify suitable preliminary treatments for the beneficiation of iron ores.
2. Explain the construction of Blast furnace, its operation and the various reactions in the various zones of blast furnace.
3. Discuss the slag theories and slag functions in the steel making processes.
4. Analyze the various steel making processes, their advantages and limitations
5. Identify suitable secondary refining processes for producing good quality steels.

TEXT BOOKS:

1. Dipak Mazumdar, “A First Course in Iron and Steel Making”, Universities press – IIM, Series in Metallurgy and Materials Science, India, 2015.
2. Tupkary, R. H.&Tupkary V.R., “An Introduction to Modern Iron Making”, Khanna Publishers, 4th edition, 2017& “An Introduction to Modern Steel Making”, Khanna Publishers, New Delhi, 2000.

REFERENCES

1. Sujay Kumar Dutta, Yakshil B. Chokshi, ”Basic Concepts of Iron and Steel Making”, Springer Nature Singapore, 2020.
2. AhindraGhosh and Amitchatterjee, “Iron Making and Steel Making – Theory and Practice”, Prentice Hall of India Private Ltd., New Delhi 2008.
3. Biswas, A. K., “Principles of blast furnace iron making: theory and practice”, SBA Publications, Kolkata, 1994.
4. Bashforth, G. R., “Manufacture of Iron and Steel”, Vol. I, Chapman and Hall London, 1964.Bashforth, G. R., “Manufacture of Iron and Steel”, Vol.2, 3rd Edition, Chapman &Hall,London, 1964.
5. “Making, Shaping and Treating of Steel”, US Steel Corporation, 11th edition, 1994.

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2	3	1	2	2	1					2	3	2	1
2	3	1	2	1	2	2	1					2	3	2	1
3	2	2	2	2	2	2	2	2				2	3	2	1
4	2	1	2	2	2	2	1	2				2	3	2	1
5	3	2	2	1	2	2	1	1				2	3	2	1
Avg.	**2.6**	**1.6**	**2.2**	**1.4**	**2**	**2**	**1.2**	**1.7**				**2**	**3**	**2**	**1**

MS23U01 STANDARDS FOR MATERIALS AND TESTING L T P C

1 0 0 1

COURSE OBJECTIVES:

- The main objective of the course is to prepare the students to gain required knowledge the various Indian and International standards used for Materials and performing mechanical and other testing.

MODULE I OVERVIEW OF STANDARDS 6

Basic concepts of standardization; Purpose of Standardization, marking and certification of articles and processes; Importance of standards to industry, policy makers, trade, sustainability and innovation. Objectives, roles and functions of BIS, Bureau of Indian Standards Act, ISO/IEC Directives; WTO Good Practices for Standardization. Important Indian and International Standards.

MODULE II MATERIALS AND TESTING 9

System of designation of iron and steel, Indian standards, AISI, SAE specifications, ASTM standards. Standards for steel and cast iron castings. System of designation of Non-ferrous alloys, copper, aluminium, magnesium, Titanium, Nickel, Zinc and Tin alloys.

Materials testing Standards- ASTM and ISO standards, ASTM standards for Specimen preparation, testing methods and calculation methods. Standards for testing of metals, alloys, plastics and composites.

COURSE OUTCOMES:

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

CO1: Recollect the various standards used for the materials and testing
CO2: Perform testing as per standards

REFERENCES:

1. https://www.services.bis.gov.in/php/BIS_2.0/dgdashboard/Published_Standards_new/new_standards
2. https://www.astm.org/products-services/standards-and-publications.html
3. Jutz-Scharkus,"Westermann tables" New Age International publishers,3rd edition, 2024

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	1	1	2	2								2	1	2	2
2	1	1	2	2								2	1	2	2

UC23U01 **UNIVERSAL HUMAN VALUES** **L T P C**
1 0 2 2

COURSE OBJECTIVE:

The objective of the course is four-fold:

1. Development of a holistic perspective based on self-exploration about themselves (human being), family, society and nature/existence.
2. Understanding (or developing clarity) of the harmony in the human being, family, society and nature/existence
3. Strengthening of self-reflection.
4. Development of commitment and courage to act.

MODULE I: INTRODUCTION (3L,6P)

Purpose and motivation for the course, recapitulation from Universal Human Values-I, Self-Exploration– Its content and process; 'Natural acceptance' and Experiential Validation- as the process for self-exploration Continuous Happiness and Prosperity- A look at basic Human Aspirations Right understanding, Relationship and Physical Facility- the basic requirements for fulfilment of aspirations of every human being with their correct priority Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario, Method to fulfil the above human aspirations: understanding and living in harmony at various levels.

Practical Session: *Include sessions to discuss natural acceptance in human being as the innate acceptance for living with responsibility (living in relationship, harmony and co-existence) rather than as arbitrariness in choice based on liking-disliking*

MODULE II: HARMONY IN THE HUMAN BEING (3L,6P)

Understanding human being as a co-existence of the sentient 'I' and the material 'Body', Understanding the needs of Self ('I') and 'Body' - happiness and physical facility, Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer), Understanding the characteristics and activities of 'I' and harmony in 'I', Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail, Programs to ensure Sanyam and Health.

Practical Session: *Include sessions to discuss the role others have played in making material goods available to me. Identifying from one's own life. Differentiate between prosperity and accumulation. Discuss program for ensuring health vs dealing with disease.*

MODULE III: HARMONY IN THE FAMILY AND SOCIETY (3L,6P)

Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship, Understanding the meaning of Trust; Difference between intention and competence, Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship, Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals, Visualizing a universal harmonious order in society- Undivided Society, Universal Order- from family to world family.

Practical Session*: Include sessions to reflect on relationships in family, hostel and institute as extended family, real life examples, teacher-student relationship, goal of education etc.*

Gratitude as a universal value in relationships. Discuss with scenarios. Elicit examples from students' lives

MODULE IV: HARMONY IN THE NATURE AND EXISTENCE (3L,6P)

Understanding the harmony in the Nature, Interconnectedness and mutual fulfilment among the four orders of nature- recyclability and self regulation in nature, Understanding Existence as Co-existence of mutually interacting units in all- pervasive space, Holistic perception of harmony at all levels of existence.

Practical Session: *Include sessions to discuss human being as cause of imbalance in nature (film "Home" can be used), pollution, depletion of resources and role of technology etc.*

MODULE V: IMPLICATIONS OF HARMONY ON PROFESSIONAL ETHICS (3L,6P)

Natural acceptance of human values, Definitiveness of Ethical Human Conduct, Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order, Competence in professional ethics: a. Ability to utilize the professional competence for augmenting universal human order b. Ability to identify the scope and characteristics of people friendly and eco-friendly production systems, c. Ability to identify and develop appropriate technologies and management patterns for above production systems. Case studies of typical holistic technologies, management models and production systems, Strategy for transition from the present state to Universal Human Order: a. At the level of individual: as socially and ecologically responsible engineers, technologists and managers b. At the level of society: as mutually enriching institutions and organizations, Sum up.

Practical Session: *Include Exercises and Case Studies will be taken up in Sessions E.g. To discuss the conduct as an engineer or scientist etc.*

TOTAL: 45 (15 Lectures + 30 Practicals) PERIODS

COURSE OUTCOME:

By the end of the course, the students will be able to:

1. Become more aware of themselves, and their surroundings (family, society, nature);
2. Have more responsible in life, and in handling problems with sustainable solutions, while keeping human relationships and human nature in mind.
3. Have better critical ability.
4. Become sensitive to their commitment towards what they have understood (human values, human relationship and human society).
5. Apply what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction.

REFERENCES:

1. Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 3rd revised edition, 2023.
2. Jeevan Vidya: Ek Parichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
3. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
4. The Story of Stuff (Book).

5. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi
6. Small is Beautiful - E. F Schumacher.
7. Slow is Beautiful - Cecile Andrews.
8. Economy of Permanence - J C Kumarappa
9. Bharat Mein Angreji Raj - PanditSunderlal
10. Rediscovering India - by Dharampal
11. Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
12. India Wins Freedom - Maulana Abdul Kalam Azad
13. Vivekananda - Romain Rolland (English)
14. Gandhi - Romain Rolland (English)

Web URLs:

1. Class preparations: https://fdp-si.aicte-india.org/UHV-II%20Class%20Note.php
2. Lecture presentations: https://fdp-si.aicte-india.org/UHV-II_Lectures_PPTs.php
3. Practice and Tutorial Sessions: https://fdp-si.aicte-india.org/UHV-II%20Practice%20Sessions.php

Articulation Matrix:

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

MS23501 TRANSPORT PHENOMENA IN METALLURGICAL PROCESSES

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- The main objective of the course is to prepare the students to gain required knowledge on fluid mechanics specific to materials processing and getting acquainted with heat transfer concepts

UNIT I FLUID MECHANICS **9**

Fluid properties - density, viscosity, and specific weight. Fluid statics - Pressure at a point - Pressure variations in horizontal and vertical directions - Concept of gauge and absolute pressure. Use of manometer for pressure measurements. Energy Balance in Fluid Flow: Types of flow - continuity equation - Application to one dimensional problems, The Navier-Stokes equations. Derivation of Bernoulli's equation and Euler's equation – Examples illustrating the use of energy equation in metallurgical processes.

UNIT II INTERNAL AND EXTERNAL FLOW **9**

Types of flow - Reynolds number - Laminar flow between parallel plates and circular pipes -Numerical, Shell momentum balance, Pressure in Fluid Flow: Head loss due to friction -Darcy - Weisbach equation - flow through pipes - use of Moody diagram - Minor losses – Numerical problems.

UNIT III CONDUCTION HEAT TRANSFER **9**

Steady state heat conduction, Transient heat conduction - Systems with negligible internal resistance - Lumped heat analysis - Response time of a temperature measuring instrument - System with negligible surface resistance- heat flow in an infinitely thin plate (Semi-infinite body) - System with finite surface and internal resistance - Chart solutions of transient heat conduction problems – Examples on Heat Treatment

UNIT IV CONVECTIVE HEAT TRANSFER **9**

Forced and free convention - Boundary layer concept -velocity and thermal boundary layers (no derivation) - Simple problems - Flow over flat plate - laminar and turbulent boundary layers (no derivation) - Simple problems – Boundary layer development in a circular duct (no derivation) - Flow over cylinders and Spheres- Simple problem- applications in metallurgical processes.

UNIT V RADIATION HEAT TRANSFER AND DIFFUSION **9**

Nature of thermal radiation, Concept of Black body, Emissive power – Gray body - Shape factor- Simple problems on radiation heat transfer between surfaces.

Mass Transfer: Diffusion mass transfer. Simple problems using Fick's law of diffusion, Diffusivity in gases, liquids, solids, Introduction to convective mass

transfer-Introduction to computational fluid dynamics- software

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1: Summarize the fundamentals related to fluid mechanics.
CO2: Discuss the internal and External flow
CO3: Analyze conduction heat transfer
CO4: Interpret convective heat transfer
CO5: Analyze Radiation and diffusion

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2	2								2	3	2	
2	3	2	2	2								2	3	2	
3	3	2	2	2								2	3	2	
4	3	2	2	2								2	3	2	
5	3	2	2	2								2	3	2	
Avg.	**3**	**2**	**2**	**2**								**2**	**3**	**2**	

MS23502 THEORY AND APPLICATIONS OF MATERIAL FORMING

L	T	P	C
3	0	2	4

COURSE OBJECTIVES:

- The main objective of the course is to make the students to learn about stress strain concepts in materials during plastic deformation, theory of plasticity of materials, forging , rolling ,extrusion, drawing, sheet metal forming methods and their applications and to gain hands on experience on various metal forming techniques.

UNIT I STRESS - STRAIN TENSOR **9**

State of stress, components of stress, Theory of plasticity, Stress-strain relationship, symmetry of stress tensor, principle stresses, stress deviator, Von Mises, Tresca, Yield criteria, Strain hardening, Material incompressibility, Work hardening, comparison of yield criteria, Octahedral shear stress and shear strain, Slip, twinning, Forming load calculations, Strain Rate Tensor**.**

UNIT II FUNDAMENTALS OF METAL FORMING **9**

Classification of forming process- Mechanics of metal working, Flow rule for Anisotropic material, Initiation and extent of plastic flow- Problems, Flow stress determination, Effect of temperature, strain rate and metallurgical structure on metal working, Friction and lubrication. Deformation zone geometry, Workability, Residual stresses.

UNIT III FORGING AND ROLLING **9**

Forging-Hot, Cold and Warm Forging – types of presses and hammers. Classification, Open die forging and Closed die forging, coining, nosing, upsetting, heading, die design, Orbital forging, forging in plane strain, calculation of forging loads, use of software for analysis - forging defects – causes and remedies, residual stresses in forging. Post-forge heat treatment. Rolling: Classification of rolling processes, types of rolling mills, hot and cold rolling, flat rolling, shape rolling, rolling of bars and shapes, forces and geometrical relationship in rolling, analysis of rolling load, torque and power, rolling mill control, rolling defects- causes and remedies.

UNIT IV EXTRUSION, DRAWING AND ADVANCES IN MATERIAL PROCESSING **9**

Direct and indirect extrusion, Hot extrusion and cold extrusion, Impact extrusion, helical extrusion and its characteristics, variables affecting extrusion, deformation pattern, equipment's, port – hole extrusion die, hydrostatic extrusion, defects and remedies, simple analysis of extrusion, tube extrusion and production of seamless pipe and tube. Drawing of rod, wires and tubes, Mechanical working- Processes involving Progressive deformation- Ring rolling, Rotary piercing, Rotary swaging, Orbital forging, Composite forming- cut extruder, Roll extruder.

UNIT V SHEET METAL FORMING AND OTHER PROCESSES **9**

Forming methods – Shearing, Fine and Adiabatic blanking, bending, stretch forming,

super plastic forming, deep drawing, defects in formed part, sheet metal formability, forming limit diagram. High velocity forming, Comparison with conventional forming, Explosive forming, Electro hydraulic, Electro Magnetic forming, Dynapark and petroforge forming, rubber-pad forming, Water Hammer Forming. Introduction to simulation software.

LAB EXPERIMENTS **30**

1. Formability of sheet metal by Ericsson cupping test
2. Thickness reduction in sheet metal rolling
3. Deep drawing for simple cup shape
4. Diameter reduction in wire drawing
5. Extrusion of cylindrical component
6. Non-destructive test of metal formed components

TOTAL :75 PERIODS

COURSE OUTCOMES:

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

CO1: Explain the plastic deformation of metals in terms of stress-strain tensor.

CO2: Discuss the fundamentals and various factors influencing metal forming.

CO3: Describe about various forging and rolling process and Identify the root causes and remedies of defects in extruded and drawn components

CO4: Differentiate the conventional and un-conventional metal forming techniques.

CO5: Discuss on the Sheet metal forming operations and perform various metal forming processes.

TEXT BOOKS:

1. Dieter.G.E., “Mechanical Metallurgy”, McGraw – Hill Co., SI Edition, 2007.
2. Surender Kumar, “Technology of Metal Forming Processes”, PHI, New Delhi, 2008.

REFERENCES

1. Henry S. Valberg, Applied Metal Forming - Including FEM Analysis, Cambridge University Press, 2010.
2. Z. R. Wang, Weilong Hu, S. J. Yuan, Xiaosong Wang, Engineering Plasticity: Theory and Applications in Metal Forming, 2018.
3. Sheet Metal Forming Processes and Applications, T. Altan and Tekkaya, ASM, 2012.
4. Nagpal G. R., “Metal Forming Processes”, Khanna Pub., New Delhi, 2000.
5. Sadhu Singh, “Theory of plasticity and Metal Forming Processes”, Khanna Publishers, 2005.

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2	2	2							2	2	1	2
2	3	2	1	2	2							2	2	1	2
3	3	2	2	2	2							2	2	1	2
4	3	2	1	2	2				1	2		2	2	1	2
5	3	2	2	2	2				1	2		2	2	1	2
Avg	**3**	**2**	**1.6**	**2**	**2**				**1**	**2**		**2**	**2**	**1**	**2**

MS23503	SURFACE ENGINEERING	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

- The main learning objective of this course is to prepare the students to acquire essential knowledge on the wear and corrosion of the industrial components and the ways to overcome these problems and to gain hands on experience on different coating techniques employed in industries and demonstrate the corrosion test and evaluate the corrosion resistance of different materials.

UNIT I SURFACES & FRICTION 9

Basics of surfaces features – Roughness parameters – surface measurement - Cause of friction Laws of friction – Static friction – Rolling Friction – Stick-slip Phenomenon - Friction properties of metal and nonmetals – Friction in extreme conditions – Thermal considerations in sliding contact. Contact mechanics.

UNIT II WEAR & CORROSION 9

Types of Wear, Adhesive, Abrasive, Oxidative, Corrosive, Erosive and Fretting Wear, Roles of Friction and Lubrication, Wear-debris analysis, Theoretical wear models, Standards,

Expressions for Corrosion Rate. Pourbaix Diagram, Forms of Corrosion – Uniform, Pitting, Intergranular, Stress Corrosion. Corrosion Fatigue. Dezincification. Erosion Corrosion, Crevice Corrosion – Cause and Remedial Measures – Pilling Bed-worth Ratio – High Temperature Oxidation-Hydrogen Embrittlement – Remedial Measures. Standards.

UNIT III CORROSION OF INDUSTRIAL COMPONENTS& TESTING 9

Corrosion in Fossil Fuel Power Plants, Automotive Industry, Chemical Processing Industries, Corrosion in Petroleum Production Operations and Refining, Corrosion of Pipelines, Wear of Industrial Components.

Purpose of Corrosion Testing – Classification – Susceptibility Tests for Intergranular Corrosion Stress Corrosion Test. Salt Spray Test Humidity and Porosity Tests, Accelerated Weathering Tests. ASTM Standards for Corrosion Testing and Tests for Assessment of Wear.

UNIT IV PLATING & COATINGS 9

Surface properties – Hydrophobic – Super hydrophobic – Hydrophilic - surface metallurgy, Fundamentals of electroplating, Electrodeposition from plating baths, Electroless plating, Metalliding, Selective plating, CLC, Hard anodizing. Thermal evaporation, Powder coating, PVD and CVD, Sputter coating, Ion plating, Thin film for wear application, Coating specifications. Cathodic Electro Deposition(CED), Phosphating & Paintings.Introduction to CQI-11.

UNIT V HARD FACING PROCESSES AND APPLICATIONS 9

Thermal spray processes and their applications, Hardfacing transformation, Fusion alloys, Non - fusion materials. Hard facing for repairs, Hardfacing with fusion processes, Non-fusion deposits, Weldability Considerations, Finishing considerations.

LAB EXPERIMENTS: 30

1. Estimation of corrosion rate of mild steel by weight loss method and determination of inhibitor efficiency in acid and neutral media.
2. Electroplating of Cu and Ni
3. Electroless nickel coating
4. Oxalic acid etch test for Intergranular corrosion (Streicher test)
5. Evaluation of corrosion characteristics by potentiostatic /galvanostatic polarization techniques - Study of passivation characteristics of MS and SS steels in acid media
6. Evaluation of corrosion characteristics by potentiostatic/galvanostatic polarization techniques - Determination of pitting potential of various steels
7. Evaluation of corrosion characteristics by potentiostatic /galvanostatic polarization techniques – Potentiostatic investigation of the effectiveness of inhibitors
8. Determination of wear, wear rate and wear characteristics pin on disc wear testing.
9. Experiments on Electrochemistry

TOTAL: 75 PERIODS

COURSE OUTCOMES:

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

CO1: Explain the different failures that occur on the surface of the engineering components.

CO2: Discuss on the kinetic aspects and the effect of various parameters on the rate of corrosion.

CO3: Conduct corrosion testing for a given material and interpret the corrosion failures that occur in different industrial components and articulate the results obtained from the corrosion testing.

CO4: Discuss on the various plating techniques and thin film coatings and demonstrate the electroplating and electroless Ni coating on various substrate materials

CO5: Explain the different hard facing processes and their applications

TEXTBOOKS:

1. Mars Guy Fontana, Corrosion Engineering, Tata McGraw-Hill, 2005.
2. Dheerendra Kumar Dwivedi, Surface Engineering -Enhancing Life of Tribological Component, Springer India, 2018.

REFERENCES:

1. Gabe. D.R., “Principles Of Metal Surface Treatment And Protection”, Pergamon, 1990
2. P. K. Dutta & I. S. Gray, Surface Engineering, Vol. I - III, Royal Society of Chemistry, 1993
3. Kenneth G. Budinski, Surface Engineering for wear resistance, Prentice Hall, NJ 1988
4. Stand Grainger Engineering Coatings – Design and Application Jaico Publishing House, 1994.
5. Parthasarathy. N.V., Electroplating Handbooks, Prentice Hall, 1992

COs – POs & PSOs MAPPING

COs	POs												PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	3	1	3	3	3	2				2	3	2	1
2	3	1	1	3	2	2	2	1				2	3	1	1
3	3	1	1	2	2	2	2	1	2	2		2	3	1	1
4	3	2	1	3	2	2	2	1	2	2		2	3	1	1
5	3	2	1	3	2	2	2	1	2	2		2	3	1	1
Avg.	**3**	**1.8**	**1.4**	**2.4**	**2.2**	**2.2**	**2.2**	**1.2**	**2**	**2**		**2**	**3**	**1.2**	**1**

MS23504	COMPOSITE MATERIALS AND MECHANICS	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

- The main learning objective of this course is to prepare the students to understand the processing methods of different composites and critical issues with processing routes and use of constitutive equation to design the laminates with the understanding on failure criterion and to gain hands on experience on fabricating and testing of composites.

UNIT I POLYMER MATRIX COMPOSITES 9

Fundamentals of composites - classification of composites – Matrix-Reinforcement selection- Polymer resins –– reinforcement fibres – Fiber production techniques for glass, carbon and ceramic fibers – fibre terminologies. PMC processes - hand lay-up processes – spray up processes – compression moulding – reinforced reaction injection moulding - resin transfer moulding – Pultrusion – Filament winding – Injection moulding-Laminates-applications of PMC in aerospace, automotive Industries-Demonstration of Preparation of composite laminates by simple methods.

UNIT II METAL MATRIX COMPOSITES 9

Characteristics of MMC-Reinforcements – particles – fibres. Effect of reinforcement - volume fraction – rule of mixtures. Processing of MMC – powder metallurgy process - diffusion bonding – stir casting – squeeze casting, In-situ reactions-Interface/interphase-measurement of interface properties- interface strengthening- applications of MMC in aerospace, automotive industries

UNIT III CERAMIC MATRIX COMPOSITES AND SPECIAL COMPOSITES 9

Engineering ceramic materials – properties - need for CMC –matrix – reinforcements – particles- fibres- whiskers. Sintering - Hot pressing – Cold isostatic pressing (CIPing) – Hot isostatic pressing (HIPing). applications of CMC in aerospace, automotive industries-Carbon /carbon composites – advantages of carbon matrix – limitations of carbon matrix carbon fibre – chemical vapour deposition of carbon on carbon fibre perform. Sol-gel technique

UNIT IV LAMINA CONSTITUTIVE EQUATIONS 9

Lamina Constitutive Equations: Lamina Assumptions – Macroscopic Viewpoint. Generalized Hooke's Law. Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix (Q_{ij}), Definition of stress and Moment Resultants. Strain Displacement relations. Basic Assumptions of Laminated anisotropic plates. Laminate Constitutive Equations – Coupling Interactions, Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli. Evaluation of Lamina Properties from Laminate Tests. Quasi-Isotropic Laminates.

UNIT V ANALYSIS OF LAMINA 9

Determination of Lamina stresses within Laminates. Maximum Stress and Strain Criteria. Von-Misses Yield criterion for Isotropic Materials. Generalized Hill's Crite*rion for Anisotropic materials. Tsai-Hill's Failure Criterion for Composites. Tensor Polynomial (Tsai-Wu) Failure criterion. Prediction of laminate Failure.

LAB EXPERIMENTS: 30

1. Preparation of Continuous Fiber reinforced Polymer Composites
2. Study of Tensile strength and young's modulus of FRP composites
3. Study of Flexural strength of FRP composites
4. Study of fracture toughness of the PMC by drop weight impact testing
5. Preparation of Al-TiB2 composite by in-situ reaction
6. Study of Microstructure, hardness and density of Al-TiB2 composites
7. Preparation of Al-SiC composites by stir casting method
8. Study of microstructure, hardness and density of Al-SiC composite
9. Study of Tensile strength of Al-SiC composites
10. Study of interface bonding strength of glass fiber reinforced polymer composite
11. Environmental Testing (Humidity and temperature)

TOTAL: 75 PERIODS

COURSE OUTCOMES:

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

CO1: Select and use appropriate matrix and reinforcement materials for developing PMC,MMC and CMC

CO2: Design and develop polymer matrix, metal-matrix and in-situ composites with suitable reinforcements and examine the effect of humidity and temperature on the performance of composites.

CO3: Select suitable reinforcement for ceramic matrix composites and develop the composites and evaluate their microstructure and mechanical properties

CO4: Apply the constitutive equations to predict the stress in the laminate

CO5: Apply proper failure theories to analyze the failure of the composite

TEXT BOOKS:

1. Chawla K. K., "Composite materials", Springer – Verlag, Second Edition, 1998.
2. Mathews F. L. and Rawlings R. D., "Composite Materials: Engineering and Science", Chapman and Hall, London, England, 1st edition, 1994.

REFERENCES:

1. Mathews F. L. and Rawlings R. D., "Composite Materials: Engineering and Science", Chapman and Hall, London, England, 1st edition, 1994.
2. Chawla K. K., "Composite materials", Springer – Verlag, Second Edition, 1998.

3. Clyne, T. W. and Withers, P. J., “Introduction to Metal Matrix Composites”, Cambridge University Press, 1993.
4. Strong, A.B., “Fundamentals of Composite Manufacturing”, SME, 1989.
5. Sharma, S.C., “Composite materials”, Narosa Publications, 2000.

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	1	1	1	1	2	1					2	3	2	1
2	3	1	2	1	1	1	1					2	3	3	2
3	3	1	2	1	1	1	1					2	3	3	2
4	3	1	2	1	1	1	1		2	2		2	3	3	2
5	3	1	2	1	1	1			2	2		2	3	3	3
Avg.	**3**	**1**	**1.8**	**1**	**1**	**1.2**	**1**		**2**	**2**		**2**	**3**	**2.8**	**2**

MS23505	INTRODUCTION TO ELECTRONIC MATERIALS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main objective of the course is to prepare the students for understanding the electrical, magnetic and optical properties of materials and selecting suitable materials for different engineering applications.

UNIT – I ELECTRICAL AND DIELECTRIC MATERIALS 9

Electrical conduction in materials -resistivity – conducting materials (OFHC Copper, Al alloys, Fe-Si alloys, amorphous metals) –thermoelectricity – thermoelectric materials –Applications-dielectric phenomena - concept of polarization - effects of composition, frequency and temperature - dielectrics (ceramics and polymers) - dielectric loss, dielectric breakdown - ferro electricity piezo and pyro electricity – Applications

UNIT – II SEMICONDUCTING AND SUPERCONDUCTING MATERIALS 9

semiconductors – concept of doping-N-type & P-type - simple and compound semiconductors – Direct and indirect bandgap semiconductors- amorphous silicon, oxide semiconductors; amorphous semiconductors - FER, MOSFET and CMOS –ohmic contacts, schottky diode – hall probe & hall sensor - Concept of superconductivity-properties – superconducting magnets – applications.

UNIT – III OPTICAL PROPERTIES OF MATERIALS 9

Introduction to electromagnetic radiation, atomic and electronic interactions with electromagnetic radiation, optical properties of metals, optical properties of nonmetals, opacity and translucency in insulators, color of materials, applications of optical phenomena-luminescence, photoconductivity, lasers, optical fibers in communications – photochromic & electrochromic materials – applications.

UNIT – IV PREPARATION OF ELECTRONIC MATERIALS 9

Electronic materials - methods of crystal growth for bulk single crystals - zone melting-refining, leveling - synthesis of epitaxial films by VPE, PVD, MBE and MOCVD techniques - lithography; production of silicon - starting applications.

UNIT – V MAGNETIC MATERIALS 9

Introduction to dia, para, ferro, antiferro and ferri magnetism - hard and soft magnetic materials - iron- silicon alloys – iron- nickel alloys - ferrites and garnets - (Ag - Mn - Al) alloys - (Cu - Ni- Co) alloy - fine particle magnets - applications of hard and soft magnetic materials - Giant magneto resistance- GMR Sensors- spintronic devices.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Understand the conducting, semiconducting, superconducting, dielectric, ferro-electric and piezoelectric behavior of materials

CO2: Differentiate between diamagnetic, paramagnetic, ferromagnetic, ferromagnetic, and anti-ferromagnetic behavior of materials

CO3: Synthesis and processing of semi-conducting materials for engineering applications

CO4: Study the effect of composition, structure and temperature on the properties of the materials.

CO5: Describe the interactions of light with materials and its effects at the interface

TEXT BOOKS:

1. Raghavan V, Materials Science and Engineering, 4th Edition, Prentice Hall of India, 1998.
2. Pradeep fuley, Electrical, magnetic, and Optical Materials, 1st edition, CRC press, 2010

REFERENCES:

1. Kittel C, Introduction to Solid State Physics, 6th Edition, Wiley Eastern, New
2. International Publishers, 1997.
3. S. O. Pillai,“ Solid state physics”, New age International Pvt Ltd, 6th edition, 2005
4. Wahab, M. A.,“ Solid State Physics”, Narosa Publishing, 2nd Edition, 2005
5. Ibach, Harald, Lüth, Hans,“ An Introduction to principles of Materials Science”, Springer, 2003.

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2	1								2	3	1	2
2	3	2	1	1								2	3	1	1
3	3	2	1	1								2	3	1	
4	3	2	2	1								2	3	1	2
5	3	2	1	1								2	3	1	1
Avg.	**3**	**2**	**1.4**	**1**								**2**	**3**	**1**	**1.5**

MS23506 ANALYTICAL INSTRUMENTATION TECHNIQUES

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- The main objective of the course is to prepare the students to acquire essential knowledge on theory, instrumentation and working of various analytical instrumentation techniques

UNIT I INTRODUCTION TO SPECTROSCOPY 9

EMR - properties - interaction of EMR with matter - Atomic and Molecular spectroscopy – Energy levels in atoms and molecules – Absorption and Emission techniques – Fluorescence, Phosphorescence and Chemiluminescence – Beer Lambert's law – Qualitative and Quantitative analyses – limitations – Visible absorption spectroscopy.

UNIT II UV-VISIBLE, IR, NMR, RAMAN AND ATOMIC SPECTROSCOPY 9

Transitions - Principle, theory, instrumentation, working and uses of UV-Visible spectrophotometer - Single beam and double beam instruments– Photometric titration – FTIR Spectroscopy - ^{1}H and ^{13}C NMR Spectroscopy - Raman Spectroscopy - AAS, FES, ICP-AES.

UNIT III ELECTROCHEMICAL METHODS AND GAS ANALYZERS 9

Theory, principle, working and applications of Potentiometry - Conductometry - Coulometry, Amperometry - Voltammetry - CV and LSV - Industrial Gas Analyzer H_2, O_2, NO_2, H_2S - IR Analyzer - Thermal Conductivity Analyzer - Air pollution monitoring instruments - CO, hydrocarbons, Nitrogen oxides, Sulphur oxides, dust and smoke measurements.

UNIT IV SEPARATION METHODS 9

Chromatography - Liquid Chromatography - Partition Chromatography - Affinity Chromatography - Adsorption Chromatography - Ion exchange Chromatography - Size Exclusion Chromatography – Paper, TLC and Column- GC and HPLC - Capillary Electrophoresis, Membrane Separation Methods - Microfiltration - Ultrafiltration - RO - Dialysis - Electrodialysis.

UNIT V THERMAL AND COMPOSITIONANALYSIS 9

X-ray Analytical methods - Spectral Analysis, Thermal Aanalysis – Dilatometry, DSC, TGA, DTA and DMA – Principle, instrumentation and applications, X-ray emission spectroscopy - Wave Dispersive Spectroscopy- Ultraviolet Photo Electron Spectroscopy (UPS), X-ray Photoelectron Spectroscopy (XPS), Auger Electron Spectroscopy (AES).

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1: Understand the fundamentals of spectroscopic methods.

CO2: Apply UV-visible, IR, NMR, Raman and Atomic spectroscopic techniques for material characterization.

CO3: Evaluate the electrochemical properties of materials and analyze samples using various analyzers.

CO4: Analyze samples qualitatively and quantitatively using separation techniques.

CO5: Analyze, interpret and confirm the thermal and microscopic properties of materials.

TEXT BOOKS:

1. Skoog D.A., James Leary F., and. Nieman T.A., “Principles of instrumental analysis, Fifth Edn., Saunders Publications, 1998.
2. Willard, H. H., Merritt, I. I., Dean J. A. and Settle, F. A., “Instrumental methods of analysis”, CBS publishers, 1986.

REFERENCES

1. Khandpur, R. S., “Handbook of Analytical Instruments”, Tata McGraw Hill Publishing Co., 2003.Sharma B.K., “Instrumental methods of analysis”, Goel Publishing House, 1995.
2. Braun, R. D., “Introduction to Instrumental Analysis”, McGraw Hill, 2008.
3. Erwing, G.W., “Instrumental Methods of Chemical Analysis, McGraw-Hill, 1985.
4. Bagotsky, V. S.,“Fundamentals of Electrochemistry”, A John Wiley & Sons, Inc., Publication, 2005.

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	2	3	3		2	1				2	3	3	1
2	3	3	2	3	3		2	1				2	3	3	1
3	3	3	2	3	3		2	1				2	3	3	1
4	3	3	2	3	3		2	1				2	3	3	1
5	3	3	2	3	3		2	1				2	3	3	1
Avg.	**3**	**3**	**2**	**3**	**3**		**2**	**1**				**2**	**3**	**3**	**1**

MS23U02	PERSPECTIVES OF SUSTAINABLE DEVELOPMENT	L	T	P	C
		2	0	2	3

MODULE I INTRODUCTION 6

Principles & Historical perspectives, Importance and need for sustainability in engineering and technology, impact and implications. United Nations Sustainability Development Goals (SDG), UN summit – Rio & outcome, Sustainability and development indicators.

MODULE II ENVIRONMENTAL SUSTAINABILITY 6

Climate change, Biodiversity loss, Pollution and waste management, Renewable vs. non-renewable resources, Water and energy conservation, Sustainable agriculture and forestry. National and international policies, Environmental regulations and compliance, Ecological Footprint Analysis

MODULE III SOCIAL & ECONOMIC SUSTAINABILITY 9

Equity and justice, Community development, Smart cities and sustainable infrastructure, Cultural heritage and sustainability, Ethical considerations in sustainable development.

Triple bottom line approach, Sustainable economic growth, Corporate social responsibility (CSR), Green marketing and sustainable product design, Circular economy and waste minimization,Green accounting and sustainability reporting.

MODULE IV MATERIALS AND SUSTAINABILITY 9

Sustainability issues in metallic materials usage. Materials for sustainable development. Advancements in materials for net zero carbon emissions targets, critical sustainable materials and manufacturing requirements for emerging power conversion systems, contrasting traditional fossil fuels with renewable energy sources including bio-energy, nuclear, wind, solar, hydroelectric, wave, geothermal and thermoelectric technologies.

MODULE V SUSTAINABILITY PRACTICES 30

Suggested Practices not limited to

- Energy efficiency – how to save energy (energy efficient equipment, energy saving behaviours).
- Chemical use and storage - the choice of chemicals being procured, the safe disposal of leftover chemicals, the impact of chemicals on the environment and long-term health impacts on humans.
- Green building, green building materials, green building certification and rating: green rating for integrated habitat assessment (GRIHA), leadership in energy and environmental design (LEED)
- Tools for Sustainability - Environmental Management System (EMS), ISO14000, life cycle assessment (LCA)
- Ecological footprint assessment using the Global Footprint Network spreadsheet calculator
- National/Sub national Status of Sustainable Development Goals

TOTAL: 60 PERIODS

REFERENCES:

1. Allen, D., &Shonnard, D. R. (2011). Sustainable engineering: Concepts, design and case studies. Prentice Hall.
2. Munier, N. (2005). Introduction to sustainability (pp. 3558-6). Amsterdam, The Netherlands: Springer.
3. Blackburn, W. R. (2012). The sustainability handbook: The complete management guide to achieving social, economic and environmental responsibility. Routledge.
4. Clini, C., Musu, I., &Gullino, M. L. (2008). Sustainable development and environmental management. Published by Springer, PO Box, 17, 3300.
6. Bennett, M., James, P., &Klinkers, L. (Eds.). (2017). Sustainable measures: Evaluation and reporting of environmental and social performance. Routledge.
7. Seliger, G. (2012). Sustainable manufacturing for global value creation (pp. 3-8). Springer Berlin Heidelberg.
8. Stark, R., Seliger, G., & Bonvoisin, J. (2017). Sustainable manufacturing: Challenges, solutions and implementation perspectives. Springer Nature.
9. Davim, J. P. (Ed.). (2013). Sustainable manufacturing. John Wiley & Sons.

MS23701	COMPUTATIONAL MATERIALS ENGINEERING	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

- The main learning objective of this course is to import knowledge on the modeling of microstructure and ICME tools and to gain hands-on computing experience in using computational tools to gain an understanding into the structure – property correlations in metallurgical and materials engineering.

UNIT I THERMODYNAMIC BASIS OF PHASE TRANSFORMATIONS AND MONTE CARLO POTTS MODEL 9

Reversible and Irreversible Thermodynamics - Solution Thermodynamics -Two-State Potts Model (Ising Model)- Q-State Potts Model- Speed-Up Algorithms- Applications of the Potts Model-Cellular Automata -A One-Dimensional Introduction - +2D CA Modelling of Recrystallization - +2D CA Modelling of Recrystallization- +2D CA Modelling of Grain Growth-Microstructure Evolution Modelling.

UNIT II MODELING SOLID-STATE DIFFUSION 9

Diffusion Mechanisms in Crystalline Solids- Microscopic Diffusion- Macroscopic Diffusion-Numerical Solution of the Diffusion Equation- Statistical Theory of Phase Transformation- Solid-State Nucleation- Diffusion-Controlled Precipitate Growth- Multiparticle Precipitation Kinetics

UNIT III PHASE-FIELD MODELING 9

Phase-Field Model for Pure Substances- Case Study- Phase-Field Equation- Model for Multiple Components and Phases- Model Formulation- Simulations of Phase Transitions and Microstructure Evolution-Image analysis.

UNIT IV MACROSCALE CONTINUUM INTERNAL STATE VARIABLE (ISV) PLASTICITY 9

History of Multiscale Modelling- ICME for Design- Stress- Kinematics of Deformation and Strain-Continuum Theory Constitutive Equations- Multistage Fatigue (MSF) Modelling- Bridging Strategies for the Macroscale and the Mesoscale-

UNIT V MESOSCALE ANALYSIS: CONTINUUM THEORY METHODS WITH DISCRETE FEATURES/METHODS 9

Kinematics of Crystal Plasticity- Kinetics of Crystal Plasticity- Crystal Orientations and Elasticity-Upscaling: Bridging the Crystal Level to the Polycrystalline Continuum Level- Downscaling from Crystal Plasticity to Dislocation Dynamics- Experimental Exploration, Calibration, and Validation at the Mesoscale- Metal Plasticity Modelling- Dislocation Mechanics Basics- Modelling Discrete Dislocations- Upscaling for Plasticity.

LAB EXPERIMENTS **30**

1. Fitting and visualization of multidimensional data;
2. Quantification of experimental microstructures using programs as well as software tools;
3. Application of linear algebra towards solution to a system of linear linear equations;
4. Application of linear algebra towards solution to a system of non-linear equations; Numerical solution of diffusion equation
5. Computational techniques such as phase field method and Monte Carlo towards evolution of synthetic microstructures;
6. evaluation of properties from the computed microstructures using mean field and full field approaches;
7. data analytics using principal component analysis;
8. ICME approach

TOTAL: 75 PERIODS

COURSE OUTCOMES:

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

CO1 Develop models based on first principles and use computational methods such as phase field method and Monte Carlo towards evolution of synthetic microstructures

CO2 Model the diffusion assisted phase transformation and quantify of experimental microstructures using programs as well as software tools

CO3 explain phase field simulation techniques

CO4 Use continuum theory constitutive Equations

CO5 Use principles to model plasticity and perform data analytics using principal component analysis

TEXT BOOKS:

1. Koenraad G. F. Janssens, Dierk Raabe, Ernst Kozeschnik, Mark A. Miodownik, Britta Nestler, Computational Materials Engineering-An Introduction To Microstructure Evolution, Elsevier Academic Press, 2007.
2. Mark F. Horstemeyer, Integrated Computational Materials Engineering (Icme) For Metals, Wiley, 2012.

REFERENCES :

1. Maciej Pietrzyk, Lukasz Madej,Lukasz Rauch, Danuta Szeliga, Computational Materials Engineering, Elsevier, 2016.
2. Georg J. Schmitz and Ulrich Prahl, Integrative ComputationalMaterials Engineering, Wiley-VCH, 2012.
3. June Gunn Lee, Computational Materials Science: An Introduction, CRC press, 2012.
4. Kaoru Ohno, KeivanEsfarjani, Yoshiyuki Kawazoe, Computational Materials Science, Springer,2018.

5. Somnath Ghosh, Christopher Woodward, Craig Przybyla, Integrated Computational Materials Engineering (ICME), Springer,2020
6. Introduction to Computational Materials Science – Richard LeSar, Cambridge University Press (2013). ISBN: 9781316614877
7. Mathematical Methods for Physics and Engineering, 3rd Edition – R.F. Riley, M.P. Hobson, S.J. Bence, Cambridge University Press (2012). ISBN: 9780521139878
8. Integrated Computational Materials Engineering (ICME) for Metals – Mark F. Horstemeyer, TMS (2012). ISBN: 9781118022528
9. Integrative Computational Materials Engineering: Concepts and Applications of a Modular Simulation Platform – Georg J. Schmitz and Ulrich Prahl, Wiley-VCH Verlag GmbH & Co (2012). ISBN: 9783527330812
10. Numerical Modeling in Materials Science and Engineering - Michel Rappaz, Michel Bellet, Michel Deville, Springer (2003). ISBN : 978-3-642-11820-3

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	3	3	2				2			3	3	3	3
2	3	3	3	3	2				2			3	3	3	3
3	3	3	3	3	2				2			3	3	3	3
4	3	3	3	3	2				2			3	3	3	3
5	3	3	3	3	2				2			3	3	3	3
Avg.	3	3	3	3	2				2			3	3	3	3

MS23702 NON-DESTRUCTIVE TESTING AND EVALUATION L T P C

3 0 2 4

COURSE OBJECTIVES:

- The main objective of the course is to prepare the students to acquire essential knowledge on the basic principles of various NDT techniques, its applications, limitations, codes and standards and to gain hands on experience in performing the various NDT and acquainted with the testing procedures.

UNIT I INTRODUCTION & VISUAL INSPECTION METHODS 9

NDT versus Mechanical testing, Need for NDT, Relative merits and limitations, Material response to external stimulus, Overview of the Non-Destructive Testing Methods for detection of manufacturing, processing and service defects as well as material characterization.

Visual Inspection -Direct and Indirect VT, Unaided, Aided- Borescopes -Videoscopes, Special features in Borescopes, Selection of borescopes, Optical sensors, Microscopes & replication Microscopy Technique and applications, Holography, Welding Gages for VT• Case study.

UNIT II SURFACE NDT TECHNIQUES 9

LPT - Principle, types, Procedures, Penetrants and their characteristics, Emulsifiers, Solvent Cleaners / Removers, Developers- properties and their forms, Equipments, Advantages and limitations, Inspection and Interpretation, Applications and case study.

MPT-Principle, Theory of Magnetism, Magnetising current, Magnetisation methods, Magnetic particles, Procedure, Interpretation, Relevant and Non-relevant indications, Residual magnetism, Demagnetisation – need, methods, Advantages and Limitations, Applications, Magnetic Rubber Inspection, Magnetic Printing, Magnetic Painting, Case study.

UNIT III THERMOGRAPHY & EDDY CURRENT TESTING 9

Thermography – Introduction, Principle, Contact & Non-Contact inspection methods, Active & Passive methods, Techniques for applying liquid crystals, – Concept, example, advantages & limitations. Electromagnetic spectrum, infrared thermography- approaches, infrared radiation and infrared detectors,, Instrumentation and methods and applications, Case study.

Eddy current Testing – Principle, properties of eddy currents, Eddy current sensing elements, probes, Instrumentation, Types of arrangement, Advantages & Limitations, Interpretation of Results& applications, Case study.

UNIT IV ULTRASONIC TESTING & ACOUSTIC EMISSION TESTING 9

Ultrasonic Testing-Principle, Basic Equipment, Transducers, couplants, Ultrasonic wave, Variables in UT, Transmission and Pulse-echo method, Straight beam and angle beam, A-Scan, B-Scan & C-Scan, Phased Array Ultrasound& Time of Flight

Diffraction, UT calibration, Advantages & Limitations, Interpretation of Results& Applications, Case study

Acoustic Emission Technique – Introduction, Types of AE signal, AE wave propagation, Source location, Kaiser effect, AE transducers, Principle, AE parameters, AE instrumentation, Advantages & Limitations, Interpretation of Results, Applications, Case study.

UNIT V RADIOGRAPHY 9

Introduction, Principle, X-ray Production, Gamma ray sources, tubing materials, X-ray tubing characteristics, Interaction of X-ray with matter, Imaging, Film techniques, Filmless techniques, Types and uses of filters and screens, Real time radiography, geometric factors, inverse square law, characteristics of film, graininess, density, speed, contrast, characteristic curves, Penetrameters, Exposure charts, Radiographic equivalence. Fluoroscopy- Xero-Radiography, Digital Radiography – Film Digitisation, Direct Radiography & Computed Radiography, Computed Tomography, Gamma ray Radiography, Safety in X- ray and Gamma Ray radiography, Case study.

LAB EXPERIMENTS 30

1. Macrostructural analysis of Mounted samples with various defects
2. Visual inspection of welded tubes using Boroscope.
3. Inspection of welds using solvent removable visible dye penetrant test (PT)
4. Inspection of welds using solvent removable fluorescent dye penetrant test.
5. Inspection of welds by Magnetic Particle Testing - Dry method.
6. Inspection of welds by Magnetic Particle Testing- Wet method.
7. Detection of sub-surface flaws using Ultrasonic testing in weld component
8. Thickness measurements using Ultrasonic technique
9. Calibration of Ultrasonic Flaw Detector using standard IIW Type US-1calibration block
10. Calibration of Ultrasonic testing equipment using Miniature Angle-Beam calibration Block
11. Infrared Thermography for Temperature Measurement on weld specimen to measure the peak temperature.
12. Study of Radiographic film for flaw detection

TOTAL :75 PERIODS

COURSE OUTCOMES:

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

CO1: Compare the differences between the various visual inspection techniques and apply the techniques for the components to be inspected.

CO2: Recognise the importance of Penetrant testing in NDT with the understanding of the procedures involved in the Penetration methods

CO3: Interpret the images and the results obtained from Thermographic technique and Eddy current testing

CO4: Evaluate and interpret the results obtained in the Ultrasonic inspection, Radiography and Acoustic Emission technique

CO5: Perform suitable NDT technique to detect the flaws or discontinuities in engineering components and interpret the results.

TEXT BOOKS:

1. ASM Metals Handbook, “Non-Destructive Evaluation and Quality Control”, American Society of Metals, Metals Park, Ohio, USA, 200, Volume-17.
2. Paul E Mix, “Introduction to Non-destructive testing: a training guide”, Wiley, 2nd edition New Jersey, 2005

REFERENCES

1. Robert C. McMaster , Nondestructive testing hand books , Ronald Press Company , 1991
2. ASNT, American Society for Non Destructive Testing, Columbus, Ohio, NDT Handbook,Vol. 1, Leak Testing, Vol. 2, Liquid Penetrant Testing, Vol. 3, Infrared and Thermal Testing Vol. 4, Radiographic Testing, Vol. 5, Electromagnetic Testing, Vol. 6, Acoustic Emission Testing, Vol. 7, Ultrasonic Testing.
3. Baldev Raj, T.Jayakumar, M.Thavasimuthu “Practical Non-Destructive Testing”, Narosa Publishing House, 2009.
4. Charles, J. Hellier,“ Handbook of Non-destructive evaluation”, McGraw Hill, New York 2001.
5. G. Gaussorgues, “Infrared Thermography”, Chapman & Hall, University Press, Cambridge, 1994.

CO’s- PO’s & PSO’s MAPPING

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2	2	1		3	3					2	3	2	3
2	3	2	2	1		3	3					2	3	2	3
3	3	2	2	1		3	3		2	2		2	3	2	3
4	3	2	2	1		3	3		2	2		2	3	2	3
5	3	2	2	1		3	3		2	2		2	3	2	3
Avg.	3	2	2	1		3	3		2	2		2	3	2	3

PROFESSIONAL ELECTIVE COURSES

MS23001	FRACTURE MECHANICS AND FAILURE ANALYSIS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main objective of the course is to equip the students with essential knowledge on fracture and its mechanics under different loading conditions and analyze the various failure mechanisms.

UNIT I BASIC CONCEPTS IN FRACTURE MECHANICS 9

Introduction to fracture- elastic deformation, plastic and elasto-plastic deformation, Brittle fracture: Griffiths theory, Ductile fracture, Inglis solution-LEFM-EPFM- Different modes of fracture- photo elastic fringes- characteristics-crack emanating from inner and outer boundaries of cylinder

UNIT II MECHANICS OF FRACTURE- STATIC LOADING 9

Strain energy- strain energy in the presence of crack- energy release rate- fracture criteria- crack branching based on energy approach- Analytical solutions yielding near a crack front –westergaads stress function- plastic zone size – Dugdaale model – J integral and its relation to crack opening displacement. Strain energy release and stress intensity factor. Evaluation of fracture Toughness of different materials: size effect & control.

UNITIII FAILURE ANALYSIS OF FATIGUE FRACTURE 9

Fundamental sources of failures- Deficiency in design, Empirical Relation describing crack growth by fatigue – Life calculations for a given load amplitude. Introduction to Weibull Distribution & B10 life. Effects of changing the load spectrum – Effects of Environment. Micro-structural analysis of fatigue failures, some case studies in analysis of fatigue failures

UNIT IV FAILURE ANALYSIS OF CREEP RUPTURE 9

Fracture at elevated temperature: Time dependent mechanical behavior, stress rupture, Microstructural changes during creep, Mechanism of creep deformation and Creep deformation maps, Prediction of time to rupture, Creep-fatigue interaction. Some case studies in analysis of creep failures.

UNIT V FAILURE ANALYSIS OF CORROSION AND WEAR 9

Types of corrosion, Corrosion stress, corrosion cracking, Analysis of corrosion failure. Procedure for analysis of stress corrosion cracking. Effect of Environment. Analysis of corrosion characteristics of metals and alloys in different environment. Types of wear, Role of friction, Interaction of corrosion and wear. Analysis of wear failure.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1: Design structure to prevent failure from the internal defect that unit within the structure

CO2: Derive the stress field solutions for fracture problems

CO3: Design structure to prevent fatigue and creep

CO4: Define different deformation and related theories

CO5: Analyse the corrosion and wear failure and system methods to prevent corrosion and wear

TEXT BOOKS:

1. Hertz berg R W, “Deformation and fracture mechanics of Engineering materials” second edition John Wiley sons inc, New York 1983.
2. Knott. J.F, “Fundamentals of Fracture Mechanics” Butterworth London, 1973.

REFERENCES

1. Campbel J E, Underwood J H, and Gerberich W W., “Applications of Fracture Mechanics for the selection of Materials “, American Society for Metals, Metals Park Ohio, 1982.
2. Evalds H L and RJH Warnhil, ”Fracture Mechanics”, Edward Arnold Ltd, Baltimore,1984.
3. Fracture Mechanics Metals Handbook, ninth edition, vol. 8 437-491, American Society of Metals Metal Park ohio, 1985
4. Kare Hellan,“Introduction of Fracture Mechanics”, McGraw-Hill Book Company, 1985.
5. Prashant Kumar, “Elements of Fracture Mechanics”, Wheeler Publishing,1999 3.

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	1	2	2	1							2	1	1	2
2	2	3	1	2	3							2	2	3	1
3	3	2	2	3	2							2	2	2	1
4	2	2	2	3	2							2	2	1	1
5	3	3	3	2	3							2	1	3	3
Avg.	**2.6**	**2.2**	**2**	**2.4**	**2.2**							**2**	**1.6**	**2**	**1.6**

MS23002	CREEP AND FATIGUE BEHAVIOUR OF MATERIALS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To impart knowledge on mechanisms, governing variables and methods of predicting creep and fatigue life along with an insight of performing failure analysis.

UNIT – I CREEP 9

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

UNIT – II HIGH – TEMPERATURE DEFORMATION RESPONSE 9

Deformation mechanism, deformation mechanism maps, Creep and stress rupture test, Generation and analysis of creep and creep-rupture data, Parametric methods for prediction of long time properties data, materials for elevated temperature. Super plasticity: Strain rate sensitivity, Experimental observation and mechanism.

UNIT – III CYCLIC STRESS AND STRAIN FATIGUE 9

Macro fractography of fatigue failures , Characteristics of fatigue failure, Stress cycles, Fatigue tests, fatigue limit and fatigue strength, S-N curves, types of stress variations, terminology, High cycle and low cycle fatigue , Effect of mean stress on fatigue, Soderberg, Goodman and Gerber equations, stress raisers, stress concentration factor, notch sensitivity factor, factors affecting fatigue limit, finite life, equivalent stress, combined variable stress

UNIT – IV FATIGUE CRACK INITIATION PROPAGATION 9

Mechanisms of fatigue crack nucleation and propagation, Effect of metallurgical variables on fatigue, effect of overloading pulse, variable stress amplitude, crack closure, Stress and crack lengths correlations with FCP, Fracture modes in Fatigue ,Micro structural aspects of FCP in metal alloys. Thermo-mechanical fatigue, cumulative damage- Miner law, corrosion fatigue, case studies.

UNIT – V ANALYSIS OF ENGINEERING FAILURES 9

Typical defects, Microscopic surface examination, metallographic and fractographic examination, Fracture surface preservation – Cleaning and replication techniques and image interpretation, failure data retrieval, Component failure analysis : procedural steps for investigation of a failure for failure analysis, Preparation of failure analysis report.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Discuss the metallurgical factors and temperature – strain influence on creep behavior of materials

2. Describe the mechanism of creep, method of predicting creep life and super plasticity.
3. Differentiate the characteristics, factors and method of life prediction in the stress and strain controlled fatigue.
4. Explain the micro-mechanics and micro-structural aspects of fatigue.
5. Perform failure analysis in methodical way and generate a report.

TEXT BOOKS:

1. Richard. W. Hertzberg ," Deformation and Fracture Mechanism of Engineering Materials", John Willey and Sons, 5th edition, 2012.
2. Thomas H Courtney," Mechanical Behaviour of Materials", Waveland press, 2005.

REFERENCES:

1. Norman E Dowling, "Mechanical Behavior of Materials: Engineering Methods for Deformation, Fracture and Fatigue" Pearson. 2013.
2. Suresh S, " Fatigue of materials", Cambridge University press, 1998.
3. William T Becker, Failure analysis and Prevention, ASM international, 2002.
4. Josef Cadek, .," Creep in Metallic Materials", Elsevier,1988.
5. Prashant Kumar," Elements of Fracture Mechanics", Tata McGraw-Hill,2009.

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2										1	3	1	
2	3	3	2	3								1	3	3	
3	3	2	3	2								1	3	3	
4	3	3	3	3								1	3	2	
5	3	3	2	3								1	3	2	
Avg.	3	2.6	2.5	2.75								1	3	2.2	

MS23003	ELECTRON MICROSCOPY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main objective of the course is to impart knowledge on the construction, working principles, instrumentation and application of Scanning Electron Microscope, Transmission Electron Microscope.

UNIT I BASICS OF ELECTRON MICROSCOPYAND ELECTRON OPTICS 9

Introduction to electron microscopy - History of electron microscopy – Comparison of optical and electron microscopy - Scanning Electron Microscope (SEM) - Transmission Electron Microscope (TEM) - Electron Optics – Concept of resolution – interaction of electrons with matter – depth of field and depth of focus.

UNIT II INTRODUCTION TO SEM OPERATION 9

Introduction to SEM - Major Components - Electron optical column - Vacuum system - Signal detection and Display - Lens Aberration - Object Resolution - Image quality, Working principles of SEM - SEM modes of operation- effect of aperture, working distance, condenser lens - probe current, probe diameter.

UNIT III SEM ANALYSIS 9

Sample Preparation - Iinteraction volume, factors affecting interaction volume - Structural analysis and elemental analysis - Image formation and interpretation - SE, BSE – Imaging – EDS, WDS, ECCI, STEM - EBSD - Orientation Imaging.

UNIT IV INTRODUCTION TO TEM OPERATION 9

Instrument - Major parts - Illumination System: Electron gun and Condenser - Vacuum system - Image forming system - Projection system - Aperture - Electromagnetic lens and Optics - Probe used - Working principle of TEM – important aspects of microscope operation and alignment – aberration correction – Resolution, Calibration

UNIT V TEM ANALYSIS 9

Material specimen preparation - Electron source - Beam-specimen interaction -Imaging and interpretation - Electron tomography - TEM imaging modes - imaging principles, Resolution, Diffraction, formation of diffraction patterns and images – SAED – bright and dark field images – Centered dark field images - weak beam images – HR-TEM.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1: Discuss the fundamentals of electron microscopy.
CO2: Explain the instrumentation and operation of TEM and their capabilities.
CO3: Interpret the TEM images to derive useful information.
CO4: Explain the basic operation principle of SEM and their capabilities,
CO5:Interpret the SEM Image.

TEXT BOOKS:

1. Peter J. Goodhew, John Humphreys, Richard Beanland, “Electron Microscopy and Analysis”, 3rd Edition, CRC Press, 2000.
2. David B. Williams and C. Barry Carter, “Transmission Electron Microscopy: A Text Book for Materials Science”, Springer, 2009.

REFERENCES

1. Dale E. Newbury, David C. Joy and E.Charles, “Scanning Electron Microscopy and X-ray Microanalysis”, Springer Science, New York, 2003.
2. Edington, J. W., “Electron Diffraction in the Electron Microscope”, N. V.Philips’ Gloeilampenfabrieken, Eindhoven, 1975.
3. Marc De Graef, “Introduction to Conventional Transmission Electron Microscopy”, Cambridge University Press, UK, 2003.
4. Goldstein, J. I., Newbury, D. E., Echlin, P., Joy, D. E., Romig A. D., Lyman, C. E., Fiori, C and Lifshin, E., “Scanning Electron Microscopy and X-ray Microanalysis”, Springer, 1992.

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	2	2	2							2	3	3	1
2	3	3	2	2	2							2	3	3	1
3	3	3	2	3	2							2	3	3	3
4	3	3	2	3	2							2	3	3	3
5	3	3	2	3	2							2	3	3	3
Avg.	**3**	**3**	**2**	**2.6**	**2**							**2**	**3**	**3**	**2.2**

MS23004	X-RAY DIFFRACTION TECHNIQUES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main objective of the course is to impart knowledge on the generation of X-rays**,** their interaction with materials and interpretation of cell parameters, phase quantification and residual stresses.

UNIT I X-RAY GENERATION AND INTERACTION WITH MATERIALS 9

X-ray – generation – soft and hard x–ray – shortest wavelength – characteristic x –ray – continuous x-ray – absorption - absorption edges – elastic scattering – by an electron, electrons of an atom and atomic arrangements – x-ray fluorescence – elemental identification – collimators – detectors – precautions

UNIT II BASICS OF X-RAY DIFFRACTION (XRD) 9

Bragg's law, Diffraction methods – Laue, rotating crystal and powder methods- Reciprocal lattice- Ewald's Sphere - Stereographic projection – texture and orientation- Intensity of diffracted beams –structure factor calculations

UNIT III DETERMINATION OF CELL PARAMETERS AND IDENTIFICATION OF PHASES 9

Crystallite size – Scherrer - Stokes and Wilson - Importance of Rietveld refinement in XRD (fundamental) Precise parameter measurement - Phase identification –ASTM catalogue of Materials identification – Grazing incidence XRD

UNIT IV QUANTIFICATION OF PHASES 9

Internal standard – External standard – Direct comparison – single phase quantification – calibration – correction factor - practical difficulties.

UNIT V RESIDUAL STRESS MEASUREMENT 9

Warrens Method, lattice strain calculation – double exposure method – powder diffraction and diffractometer - $\sin^2 \psi$ technique.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1: Discuss the generation of x-rays and their interaction with materials.
CO2: Compare the methods of X-ray diffraction and
CO3: Analyze the XRD pattern for cell parameters precisely and identify the phases.
CO4: Identify the phases based on XRD.
CO5: Explain the procedure of determination of residual stress based on XRD.

TEXT BOOKS:

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

REFERENCES

1. Whan R E (Ed), ASM Handbook, Volume 10, Materials Characterisation “, Ninth Edition, ASM international, USA, 1986.
2. Yang Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia) Pte Ltd. 2010.
3. Khangaonkar, P. R., An Introduction to Materials Characterization, Penram Publishers, 2010
4. Suryanarayana, C., Norton, M.G., 1998. X-rays and Diffraction. Springer US.
5. Shih, K., 2013. X-ray diffraction: Structure, principles and applications. Nova Science Publishers, Inc..

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	1	3	3							2	2	3	2
2	3	2	1	3	3							2	2	3	2
3	3	2	1	3	3							2	2	3	2
4	3	2	1	3	3							2	2	3	2
5	3	2	1	3	3							2	2	3	2
Avg.	**3**	**2**	**1**	**3**	**3**							**2**	**2**	**3**	**2**

MS23005	ADVANCED METALLOGRAPHIC TECHNIQUES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main objective of the course is to impart knowledge on basics, instrumentation and principles of advanced metallographic techniques

UNIT I PHASE CONTRAST AND POLARIZATION MICROSCOPY 9

Path- Phase difference – intensity difference – Zernike – negative and positive phase plate – Halo- shade off effect – Phase Contrast Microscope – Polarization – slow- fast axis – polarizer- analyzer – Retardation plates – compensators - Polarization microscope-ploechroism- Examples.

UNIT II INTEFERENCE AND DIFFERENTIAL INTERFERENCE CONTRAST (DIC) MICROSCOPY 9

Walloston Prism- Nomarski Prism – ordinary and extra ordinary rays – bias retardation – DIC microscope - modulated contrast DIC- Double beam interference microscope - examples

UNIT III HOT MICROSCOPY 9

Lens – illumination – hot stage- melting range - crystal nucleation - crystal growth - transformations and interactions between the compound and excipients of polymers – Instrumentation of Hot stage microscopy- Examples.

UNIT IV LASER SCANNING CONFOCAL MICROSCOPY(LSCM) 9

Laser- pin hole aperture – galvano mirror- scanning – confocal images - Marvin Minsky– spatial and lateral resolution- photomultiplier tube detector - 3D images- Dynamic range – Instrumentation of LSCM – Examples

UNIT V OREINTATION IMAGING MICROSCOPY(OIM) 9

Electron backscattered diffraction – Backscattered electrons – Scanning electron microscope- kikuchi lines - texture – orientation - pole figures, inverse pole figures, Euler space, and Rodrigues space – OIM instrumentation. mis-orientations, grain boundaries, inter-grain mis-orientation, twin boundaries, Grain analysis for the determination of grain size- grain shape-Taylor Factors, Schmid Factors, Elastic Modulus- Dislocation Density

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

1. Explain the working principles of phase contrast and polarization microscopes.
2. Compare the advantages of differential interference contrast with other

microscopes.

3. Discuss the applications of hot stage microscope for polymeric materials.
4. Explain the various components and steps involved in 3D image formation from laser scanning confocal imaging.
5. Interpret electron backscattered diffraction images.

TEXT BOOKS:

1. Angelo, P.C., “Materials Characterisation”, Cengage Publication, 1st Edition, 2016.
2. Murphy, Douglas B., Fundamentals of light Fundamentals of light Microscopy and electronic imaging, John-Wiley, 2001

REFERENCES

1. Whan R E (Ed), ASM Handbook, Volume 10, Materials Characterisation “, Ninth Edition, ASM international, USA, 1986.
2. Yang Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, 2nd Edition., Wiley, 2013.
3. André Luiz V. da Costa e Silva, “Metallography of Steels: Interpretation of Structure and the Effects of Processing”, ASM International, 2018.
4. R. E. Smallman, K. H. G. Ashbee, “Modern Metallography: The Commonwealth and International Library: Metallurgy Division”, Elsevier Science, 2013.

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	1	3	3							2	2	3	2
2	3	2	1	3	3							2	2	3	2
3	3	2	1	3	3							2	2	3	2
4	3	2	1	3	3							2	2	3	2
5	3	2	1	3	3							2	2	3	2
Avg.	**3**	**2**	**1**	**3**	**3**							**2**	**2**	**3**	**2**

MS23006	PHASE TRANSFORMATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main objective of the course is to impart knowledge on the diffusion mechanisms, diffusionless transformations, precipitation reactions and Understanding the significance and importance of phase transformations and its influence on the mechanical behavior.

UNIT I DIFFUSION MECHANISMS 9

Basics of thermodynamic & kinetics: equilibrium - configurational entropy - free energy of mixing - miscibility gap – chemical potential. Diffusion – uphill diffusion – downhill diffusion – atomic mechanisms of diffusion, Fick's 1^{st} and 2^{nd} law – solution to the diffusion equation – error functions – application of the non-steady state diffusion, spinodal decomposition, Classifications of Phase transformations based on thermodynamics, mechanisms, kinetics.

UNIT II DIFFUSION CONTROLLED PHASE TRANSFORMATIONS 9

Nucleation and growth - types of nucleation – concept of free energy during solidification – thermodynamics and kinetics of homogeneous and heterogenous nucleation – critical nucleus size and critical free energy change – nucleation rate and growth rate – overall transformation rate, concept of activation energy – Arrhenius equation – Johnson-Mehl-Avrami equation, Examples of Diffusion controlled transformations

UNIT III PRECIPITATION REACTIONS 9

Precipitation reaction – thermodynamic considerations, structure and property during ageing– sequence of ageing – formation of G-P zones and intermediate precipitates, theories of precipitation hardening – effect of time, temperature and alloy compositions – precipitation free zones, crystallographic aspects of transformation, coarsening kinetics. Precipitation in Al-Cu alloys and Al-Ag alloys.

UNIT IV RECOVERY, RECRYSTALLISATION AND GRAIN GROWTH 9

Cold working and hot working, recovery – polygonisation and dislocation movements in polygonisation, recrystallisation – effect of time, temperature, strain and other variables – Mechanism of nucleation and growth, grain growth – grain growth law, geometrical collisions, preferred orientation, secondary recrystallisation.

UNIT V DIFFUSIONLESS PHASE TRANSFORMATIONS 9

Martensite transformation – definition – characteristic features of Martensitic transformation in steels – morphology of Martensite – lath and acicular martensite – crystallography of martensitic transformation – martensite in non-ferrous systems – thermoelastic martensite – shape memory effect, crystallography, Reversion stress in shape memory alloys – examples and applications of shape memory alloys

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

1. Explain the various diffusion mechanisms and the thermodynamic and kinetic principles involved in it.
2. Classify the various diffusion controlled transformations and understand the effect of various parameters on the kinetics and growth of nucleation
3. Compare the differences between the diffusion controlled and diffusionless transformations and explain the diffusionless transformations in steels and non-ferrous alloys.
4. Interpret the effect of time, temperature and composition during precipitation hardening.
5. Discuss the concept of recovery, recrystallization and grain growth that occur during annealing of cold worked steels.

TEXT BOOKS:

1. David A. Porter, Kenneth E. Easterling, Mohamed Y. Sherif, “Phase Transformations in Metals and Alloys”, CRC Press, New York, 3rd edition, 2009.
2. Jena, A.K., and Chaturvedi, M., “Phase Transformations in Materials”, Prentice-Hall, 1993.

REFERENCES

1. Anil Sinha, “Physical Metallurgy Handbook”, McGraw-Hill Professional; 1st edition, 2002.
2. Reed Hill. R. E., “Physical Metallurgy Principles”, Affiliated East West Press, New Delhi, 1992.
3. Romesh C. Sharma, “Phase Transformation in Materials”, CBS Publishers & Distributors, New Delhi, 2002.
4. David V Edmonds, Elena Pereloma, “Phase Transformations in Steels: Fundamentals and Diffusion-Controlled Transformations”, Elsevier Science, 2012.
5. G. Kostorz, “Phase Transformations in Materials”, Wiley, University of Michigan, 2007.

CO’s- PO’s & PSO’s MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2	2	2	1							2	2	1	
2	3	2	2	2	1							2	2	1	
3	3	2	2		1							2	2	1	
4	3	2	2		1							2	2	1	
5	3	2	2									2	2	1	
Avg.	3	2	2	2	1							2	2	1	

MS23007 NANOSTRUCTURED AND QUANTUM MATERIALS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- The main learning objective of this course is to prepare the students to understand different classes of nanostructured materials, their processing and growth mechanisms.

UNIT I INTRODUCTION TO NANOMATERIALS **9**

Amorphous, Crystalline, microcrystalline, quasicrystalline and nanocrystalline materials- historical development of nanomaterials – Nanomaterials classification (Gleiter's Classification) – properly changes done to size effects, Hall – petch, inverse Hall- petch effects - polymeric nanostructures

UNIT II ZERO DIMENSIONAL NANOMATERIALS **9**

Nanoparticles – Properties – Processing – Liquid state processing - Sol-gel process, wet chemical synthesis – Vapor state processing – PVD, CVD, Aerosol processing, solid state processing – mechanical, mechanochemical synthesis – Application of nanoparticle.
Quailing Dots – Quantum confinement – Pauli Exclusion Principle – Processing – Optical lithography – MOCVD – Droplet epitaxy - Applications.

UNIT III ONE DIMENSIONAL NANOMATERIALS **9**

Graphene, Carbon nanotubes – Old and new forms of carbon – Structure of CNT and classification – Processing – Solid carbon based production techniques – Gaseous carbon based production technique - growth mechanisms – Applications.

Nanowire – processing – Laser ablation – Oxide assisted growth – carbo thermal reactions – Thermal evaporation – Temperature based synthesis – Electro spinning –Vapour–Solid growth (VS growth) - vapor – liquid – solid growth (VLS technique) – Applications.

UNIT IV SUPER HARD COATINGS,BULK NANOSTRUCTURES& QUANTUM MATERIALS **9**

Superhard coating – types – characteristics – thermal stability – case studies
(nc-TiN/a-Si_3N_4 coating) – Applications. Nano hardness Measurement.
Bulk nanostructure formation – PM Route-severe plastic deformation- Techniques- Grain refinement mechanisms, Instability due to size effect- thermodynamic stability and atomic mobility-stability in corrosive environment-stability in fatigue environment
Quantum Materials:
Quantum dots- properties and synthesis, novel types- 2D quantum materials and sensor devices, Superconducting quantum magnetic sensing,

UNIT V APPLICATIONS **9**

Nanocrystalline Solar Cells- semiconductor-sensitized solar cells. Nanoscale Materials for Hydrogen and Energy Storage- Energy Storage in Super capacitors and Batteries-

challenges in materials development- Nanoporous Inorganic Materials- Transition metal-based structures- chemisorption materials- Optical Applications, Functionally graded materials.Quantum materials for emerging applications

TOTAL:45 PERIODS

COURSE OUTCOMES:

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

CO1 Identify different classes of nanostructured materials
CO2 Select and use different processes employed to produce nanostructures
CO3 Demonstrate and explain the growth mechanisms of nanostructures
CO4 Explain the change in properties for each of the nanostructures and their instability and discuss on the quantum materials
CO5 Suggest suitable nanomaterial and quantum material for certain applications

TEXT BOOKS

1. Carl C. Koch (ed.), Nanostructured Materials, Processing, Properties And Potential Applications, Noyes Publications, Norwich, New York, U.S.A, 2002.
2. Bhusan, Bharat (Ed), “Springer Handbook of Nanotechnology”, 2nd edition, 2007.

REFERENCE BOOKS

1. Mark Ratner and Daniel Ratner, “Nano Technology”, Pearson Education, New Delhi, 2003.
2. G. Wilde, “Nanostructured Materials’, Elsevier, 2008.
3. Bamberg, D., Grundman, M. and Ledentsov, N.N., “Quantum Dot Heterostructures”, Wiley, 1999.
4. G Timp (ed), “Nanotechnology”, AIP press/Springer, 1999.
5. K.A. Padmanabhan and S. Balasivanandha Prabu, ‘On the Origins of Conflict in the Experimental Results Concerning the Mechanical Properties of Ultra-Fine Grained and Nanostructured Materials: Effects of Processing Routes and Experimental Conditions ‘, Adv.Mech.Properties and Deform. Mechanism of Bulk Nanostr.Mat, Trans Tech Publication,UK, ISBN-13::978-3-03785-105-0, pp.3-54,

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3											2	3	3	3
2	3	1	1									2	3	3	3
3	3	1	1									2	3	3	3
4	3	1	1		3		3					2	3	3	3
5	3	1	1				3					2	3	3	3
Avg.	**3**	**1**	**1**		**3**		**3**					**2**	**3**	**3**	**3**

MS23008	MICRO AND NANO-MANUFACTURINING PROCESSES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main learning objective of this course is to impart knowledge on the basics of micro and Nano manufacturing concepts, mechanical and high energy assisted machining and finishing processes, and characterization of micro – Nano finished surfaces.

UNIT I INTRODUCTION 9

Micro products and design considerations for manufacturing, Material factors, Consideration on manufacturing methods, Manufacturing methods and processes, Assembly and Packaging, Process chains and hybrid processes, miniature manufacturing systems and bench top machines, Supporting Technologies/Devices/ Systems for Micro-manufacturing.

UNIT II MICRO/NANO MACHINING THROUGH MECHANICAL CUTTING 9

Fundamentals of Micro and Nano cutting processes – Specific energy and cutting force, Minimum chip thickness and chip formation, Ductile mode cutting, Effect of workpiece material microstructure, Modelling the micro/nano cutting processes, Precision machines for micro or nanocutting – ultra precision machine tools, Micro and Meso machines, Micro tooling, Ultra precision diamond turning, Applications, Economic considerations.

UNIT III MICRO EDM AND LASER ASSISTED MICRO MANUFACTURING 9

Micro EDM – Working principle, Process variants, Process parameters and process capabilities, Micro wire EDM, Micro die sinking EDM, Micro electrical discharge drilling, Micro electrical discharge contouring, Electrical discharge machine design, Materials selection, Electrodes for Micro EDM, Applications.
Basic properties of Laser Ablation, Process principles of laser ablation, Laser micro texturing and micro drilling.

UNIT IV NANOFINISHING PROCESSES 9

Need for Nanofinishing, Honing, Lapping, Advanced Nanofinishing processes – Abrasive flow finishing, Elastic emission machining, Elasto abrasive finishing, Focused Ion Beam () Nano finishing, Magnetic abrasive finishing, Magneto rheological finishing, Hybrid Nano Finishing processes.

UNIT V CHARACTERIZATION OF MICRO/NANO FINISHED SURFACES 9

Challenges in micro/Nano scale measurements, Paradigm shift in surface metrology, 2D and 3D surface roughness parameters, Stylus based instruments, Non-contacting optical measurements – Optical interferometry, Confocal laser scanning microscopy, scanning electron microscope, Scanning probe microscopy, Atomic Force Microscopy.

TOTAL :45 PERIODS

COURSE OUTCOMES:

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

CO1: Explain the need for micro/Nano products and their manufacturing challenges.
CO2: Classify the various mechanical micromachining methods.
CO3: Summarize the various thermal energy-based micromachining processes.
CO4: Discuss the Nano-finishing processes.
CO5: Select the suitable characterization techniques for micro/Nano finished surfaces.

TEXTBOOKS:

1. QinY., "Micromanufacturing engineering and technology," William Andrew, 2010.
2. Jain V.K., "Nanofinishing science and technology: Basic and advanced finishing and polishing processes", CRC Press, 2016.

REFERENCES:

1. J. Paulo Davim, Mark J. Jackson, "Nano and Micromachining", Wiley: Germany, 2013.
2. Kapil Gupta, "Micro and Precision Manufacturing", Springer International Publishing: Germany, 2017.
3. Kang S., "Micro/Nano Replication: Processes and Applications", John Wiley & Sons, 2012.
4. Zindani D., Bhowmik S. "Hybrid Micro-Machining Processes", Germany: Springer International Publishing. 2019.

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	1	1									1	3		
2	3	2	2		2							1	3		3
3	3	2	2		2							1	3	2	3
4	3	2	2		2							1	3	2	3
5	3	3	3	3	2							1	3	3	3
Avg.	3	2	2	3	2							1	3	2.3	3

MS23009	AUTOMOTIVE AND AEROSPACE MATERIALS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main objective of the course is to acquire knowledge about various automotive components and the methodical selection of materials for automotive components.

UNIT I INTRODUCTION 9

Classification of Vehicles, Layout of an automobile chassis, Components, Functions of major components of an automobile, Requirements of materials in automotive applications, Material selection and Design, Materials and the Environment, Properties of materials, Economic considerations. Introduction to VAVE concept.

UNIT II MATERIALS FOR ICE & TRANSMISSION SYSTEMS 9

Materials for Cylinder head, Inlet Manifold, Crankcase, Sump, Cylinder liners, Piston, Piston ring, Crankshaft, Connecting rod, Cam shaft, Flywheel, Inlet, Exhaust valves and valve seats, Piston ring coatings, Ceramic usage with pistons. Materials for Disc Brake, Brake drum, Clutch plate, Propeller shaft, Differential, Springs, Gears and gear box housings, Seals for static, rotating and round components, Wheels, Axles.

UNIT III MATERIALS FOR AUTOMOTIVE STRUCTURES 9

Introduction to body architecture and terminology, Body zones and terminology, Body-on-chassis and unitary architecture, Structural dynamics, Design for static stiffness, Crashworthiness, Weight efficiency, Hybrid Materials design – Aluminium and steel, Carbon Fiber Reinforced Plastics (CFRP) in body construction, Combining aluminium and CFRP, Material candidates and selection criteria, Materials used for protection of the body structure, Wheels and tyres.

UNIT IV MATERIALS FOR BATTERIES AND SENSORS 9

Vehicle Batteries – Requirements, Selection, Lead acid, Alkaline, sodium-nickel-chloride, Sodium sulphur, Swing Batteries, Fuel cells, Super capacitors.
Thermistors, Thermocouples, Hall effect, Thin film air flow sensor, Optical sensors, Light sensors, Thick film air temperature sensor, Rain sensors, Oxygen sensors, Methanol sensors, Dynamic vehicle position sensors.

UNIT V MATERIALS FOR AEROSPACE APPLICATIONS 9

Introduction to Aerospace materials, Material requirements for aerospace structures and engines, Aluminium, Titanium and Magnesium alloys for Aerospace structures, Steels for aircraft structures, superalloys for gas turbine engines, Polymers and composites for aerospace applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1 Explain the importance of material properties for automotive applications.
CO2 Evaluate the materials for internal combustion engine components.
CO3 Analyze the materials employed for automotive transmission elements.

CO4 Distinguish the various materials for automotive structural applications.
CO5 Select suitable material for automotive batteries and sensors.

TEXT BOOKS:

1. Crane, Fredrick Albert Andrew, James Anthony Charles, and Justin Furness. Selection and use of engineering materials. Elsevier, 1997.
2. Jason Rowe, “Advanced materials in automotive engineering”, 2012, Woodhead Publishing.

REFERENCES:

1. Bhardwaj B. P.,“The Complete Book on Production of Automobile Components & Allied Products”, 2014, NIIR Project Consultancy Services.
2. Lechner Giesbert, and Harald Naunheimer, “Automotive transmissions: fundamentals, selection, design and application”, Springer Science & Business Media, 1999.
3. Davies Geoffrey., “Materials for automobile bodies”, Elsevier, 2012.
4. MallickPankaj K., “Materials, design and manufacturing for lightweight vehicles”, Woodhead publishing, 2020.
5. Denton Tom, “Automobile electrical and electronic systems”, Routledge, 2004.
6. Adrian P. Moritz, “Introduction to Aerospace materials” Woodhead Publishing in Materials, 2012

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	**3**	**1**				**1**						**1**	**3**		
2	**3**	**3**	**3**			**1**					**2**	**1**	3	3	3
3	**3**	**3**	**3**			**1**					**2**	**1**	3	3	3
4	**3**	**3**	**3**			**1**	**2**				**2**	**1**	3	3	3
5	**3**	**3**	**3**			**1**	**2**				**2**	**1**	3	3	3
Avg.	**3**	**2.6**	**3**			**1**	**2**				**2**	**1**	**3**	**3**	**3**

MF23C01 **ADDITIVE MANUFACTURING** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

- To familiarize various design considerations, software tools, processes, and techniques to create physical components using AM.

UNIT I INTRODUCTION **9**

Overview – Distinction between traditional manufacturing and AM – Evolution of Additive Manufacturing (AM) - AM Process workflow - Classification – Benefits. AM Standards - AM Considerations-Business and Societal Implications of AM -Economic aspects.

UNIT II DESIGN FOR ADDITIVE MANUFACTURING (DFAM) **9**

AM Unique Capabilities- Need for DFAM- Design consideration in AM- Part Consolidation - Topology Optimization- Generative Design- Lightweight Structure - DFAM for Part Quality Improvement. CAD Model Preparation - File formats for AM (STL, PLY, VRML, AMF) - Part Orientation and Support Structure Generation - Model Slicing - Tool Path Generation.

UNIT III PHOTO POLYMERIZATION, MATERIAL EXTRUSION, AND POWDER BED FUSION PROCESSES **9**

Photo polymerization: Stereolithography Apparatus (SLA) - Materials - Process - Capabilities - Applications. Digital Light Processing (DLP) - Materials – Process - Capabilities - Applications. Continuous Liquid Interface Production (CLIP) - Materials - Process - Capabilities and Applications. Extrusion Based System: Fused Deposition Modeling (FDM) - Process – Types- Materials - Applications. Powder Bed Fusion: Selective Laser Sintering (SLS): Process – Materials and Application. Multijet fusion. Selective Laser Melting (SLM) and Electron Beam Melting (EBM): Materials – Principle - Process - Capabilities and Applications.

UNIT IV SHEET LAMINATION, DIRECT ENERGY DEPOSITION, BINDER AND MATERIAL JETTING PROCESSES **9**

Sheet Lamination Process: Laminated Object Manufacturing (LOM) - Basic Principle- Mechanism: Gluing or Adhesive Bonding – Thermal Bonding- Materials-Application and Limitation

Direct Energy Deposition Process: Laser Engineered Net Shaping (LENS) and Wire Arc Additive Manufacturing (WAAM) - Process -Material Delivery - Process Parameters -Materials - Capabilities – Industrial Applications. Binder and Material Jetting: Three-Dimensional Printing - Materials - Physics of 3DP – Process- Types of printing – Material - Capabilities and Application.

Hybrid Additive Manufacturing – Need - Principles - Synergy in Hybrid AM Materials - Part Quality and Process Efficiency.

UNIT V APPLICATION OF AM **9**

Rapid tooling - Direct tooling - Indirect tooling – Soft tooling- bridge tooling. Rapid Tooling for Investment Casting, sand casting, Injection molding. Case Studies/Application: Aerospace and automotive industries, Medical and healthcare - Architecture and construction - Food Printing -

Printing Electronics - Consumer products and fashion.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Gain an understanding of Additive Manufacturing and its development and Identify different business opportunities associated with Additive Manufacturing.

CO2: Develop a comprehensive understanding of design considerations specific to Additive Manufacturing and familiarize oneself with a range of software tools used in the design process for Additive Manufacturing.

CO3: Elaborate the photo polymerization, material extrusion processes, powder bed fusion processes and its applications.

CO4: Acquire knowledge on process and applications of sheet lamination, direct energy deposition, Binder and Material Jetting Processes and introduce the concept of hybrid Additive Manufacturing processes that combine multiple techniques to achieve desired outcomes.

CO5: Achieve in-depth knowledge of Rapid Tooling techniques in Additive Manufacturing and explore case studies and industrial applications of AM

TEXT BOOKS:

1. Gibson, Ian, David Rosen, Brent Stucker, MahyarKhorasani, Ian Gibson, David Rosen, Brent Stucker, and MahyarKhorasani. "Design for additive manufacturing." Additive manufacturing technologies (2021), ISBN : 978-3-030-56126-0.
2. Andreas Gebhardt and Jan-Steffen Hötter “Additive Manufacturing: 3D Printing for Prototyping and Manufacturing”, Hanser publications, United States, 2016, ISBN: 978-1-56990-582-1.

REFERENCES:

1. A Practical Guide to Design for Additive Manufacturing, Diegel, Olaf, Axel Nordin, and Damien Motte, Springer, 2020.
2. Additive Manufacturing, Second Edition, Amit BandyopadhyaySusmita Bose, CRC Press Taylor & Francis Group, 2020, ISBN- 978-1-4822-2360-6.
3. The 3D Printing Handbook: Technologies, Design and Applications, Redwood, Ben, FilemonSchoffer, and Brian Garret, 3D Hubs, 2017.
4. Amit Bandyopadhyay and Susmita Bose, “Additive Manufacturing”, Second Edition, CRC Press., United States, 2020, ISBN 9781032238593.
5. Additive Manufacturing: Principles, Technologies and Applications, C.P Paul, A.N Junoop, McGrawHill, 2021.

COs- POs & PSOs MAPPING

Cos	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	1	1	1	1	1	1	1	1	1	2	3	1	1	1
2	3	2	2	1	2	1	3	1	1	1	1	3	2	3	2
3	3	1	1	1	1	1	2	1	1	1	1	3	2	2	1
4	3	1	1	1	1	1	2	1	1	1	1	3	2	2	1
5	3	3	2	1	1	1	2	3	1	1	2	3	3	3	3
Avg.	3	1.6	1.4	1	1.2	1	2	1.4	1	1	1.4	3	2	2.2	1.6

MS23010	CRYOGENIC TREATMENT OF MATERIALS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main objective of the course is to impart knowledge on the basic cycles for subzero treatment of materials and their effects on material characteristics.

UNIT I INTRODUCTION **9**

Insight on Cryogenics-Basics, Properties of Cryogenic fluids, Liquefaction Cycles - Carnot Liquefaction Cycle, F.O.M. and Yield of Liquefaction Cycles. Inversion Curve – Joule Thomson Effect. Linde Hampson Cycle, Precooled Linde Hampson Cycle, Claude Cycle, Dual Cycle

UNIT II CRYOCOOLER **9**

Cryocooler requirement- Satellite communication, Surveillance Imaging, Military applications, Impact of regenerative materials on cooler performance, Impact of material properties on cryocooler Performance-Materials used, Thermal Properties, Electrical Properties, and Mechanical properties.

UNIT III CRYOGENIC PROCESSING **9**

Historical Development of Cryogenic Treatment, Cryogenic for Ferrous Metals, Need for cryogenic treatment, Types of low temperature treatment and processors, Benefits of cryogenic treatment-Wear resistance, Stress Relieving, Hardness Precautions during cryogenic treatment.

UNIT IV MATERIALS ENGINEERING **9**

Desirable qualities for materials used in cryogenic applications, History and applications of metallic / non-metallic materials, properties and fabrication processes of superconducting Nb_3Sn wires, High temperature superconductors. Characterization of cryogenically processed materials.

UNIT V APPLICATIONS **9**

Cryogenic processing of materials for Space applications, Superconductivity, Medical applications, Food Preservation-Individual Quick Freezing, Tool Industry, Automobiles etc, CNG,LNG vehicles.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

1. Identify Suitable cycle for cryogenic treatment of materials
2. Explain the functions, requirements and performance of cryocooler.
3. Select the suitable cryogenic processes for ferrous materials.
4. Discuss the characteristics of cryo -treated materials
5. Summarize the applications of cryogenic materials

TEXT BOOKS:

1. Randall F. Barron, “Cryogenic Systems”, McGraw-Hill, 1985.
2. Jha, A. R., “Cryogenic Technology and Applications”, Butterworth-Heinemann, 2006

REFERENCES

1. Klaus D. Timmerhaus and Richard P. Reed, “Cryogenic Engineering”, Springer, 2007.
2. Scott R. B., “Cryogenic Engineering”, Van Nostrand and Co., 1962.
3. William E. Bryson, “Cryogenics”, HanserGardner Publications,1999.
4. Shao-Yun Fu, Susheel Kalia, “Polymers at Cryogenic Temperatures”, Springer Berlin Heidelberg, 2013.
5. Al Zeller, Bill Burt, Charles Reece, David Glaister, , “Advances in Cryogenic Engineering”, Volume-45, Springer US, 2000

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	**3**	2	2			2						2	**3**	2	2
2	3	2	2			2						2	3	2	2
3	3	2	2			2						2	3	2	2
4	3	2	2			2						2	3	2	2
5	3	2	2			2						2	3	2	2
AVG.	3	2	2			2						2	3	2	2

MS23011	MATERIALS FOR DEFENSE AND NUCLEAR APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main objective of the course is to impart knowledge on the materials used for defence, aerospace, naval and nuclear applications**.**

UNIT I MATERIALS FOR DEFENCE 9

Brief on Indian Defence services – army, navy and air force. Introduction to Ballistics – Internal, External and Terminal. Overview of metallic materials for defence application, needs of complex metals, alloys and composite materials required for modern and sophisticated warfare equipments and weapons systems with less weight. Sensors and vision devises, periscopes, IR, NIR camera. Camouflage and materials used for different spectrum of electromagnetic radiation. Radar application in Defense

UNIT II MATERIALS FOR ARMOUR APPLICATIONS 9

Kinetic Energy attenuating and Shock attenuating materials technologies. Special Alloys for Armour applications: Rolled Homogeneous steels, Steel casting and steel forging for armour applications, Aluminium, titanium, magnesium alloys and composite armour for light armoured vehicles. Personal body Armour.

UNIT III MATERIALS FOR AMMUNITION APPLICATIONS 9

Alloys and materials for ammunition applications: Explosive materials used in ammunition-mines-smart munitions. Ferrous fragmenting projectile materials: Cast iron for ammunition casing, Shaped charge weapon system and its lining materials, Tungsten heavy alloys long rod penetrators of kinetic energy ammunitions and other components of the ammunition, Recent development

UNIT IV MATERIALS FOR AEROSPACE AND NAVAL APPLICATIONS 9

Alloys for aerospace applications: Materials required for engine parts, Super alloys for high temperature applications, Single crystal blades made of Ni based super alloys, Aerospace grade low density high strength Ti and Al alloys, Ultra-high strength steel with the toughness for missile applications, composite materials.
Special alloys for naval applications: Corrosion resistive materials, Advanced magnetic materials - Ultra high energy product permanent magnets, emerging materials such as nano-materials, smart materials and composite materials

UNIT V MATERIALS FOR NUCLEAR APPLICATIONS 9

Brief on Nuclear reaction, controlled and uncontrolled Nuclear reactions and their applications, Nuclear reaction products, TNT and TNT equivalents, Nuclear

radiation effect on human beings and electronics and other equipment's, Safety against Nuclear radiation and disposal of Nuclear wastes.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO-1: suggest suitable criteria for selecting the materials for defence applications.
CO-2: Discuss the materials, properties and processes for armour applications.
CO-3: summarize the materials, properties and processes for ammunition applications.
CO-4: Discuss the materials, properties and processes for aerospace, naval applications.
CO-5: Illustrate the various nuclear reactions, shielding materials and disposal of nuclear wastes

TEXT BOOKS:

1. Alistair Doig, Military metallurgy, Maney publishing, 2002.
2. Robert Odette, Steven Zinkle, "Structural Alloys for Nuclear Energy Applications", Elsevier Science, 2019.

REFERENCES:

1. Roy Johnson, Yashwant R. Mahajan, "Handbook of Advanced Ceramics and Composites: Defense, Security, Aerospace and Energy Applications" Springer International Publishing, 2020.
2. National Research Council (U.S.). Committee on Materials Research for Defense After Next, "Materials Research to Meet 21st Century Defense Needs", National Academies Press, 2003.
3. Raul Fangueiro, Sohel Rana, "Advanced Materials for Defense", Trans Tech Publications Limited, 2019.
4. Pavel V. Tsvetkov, "Nuclear Materials", Intech Open, 2021.
5. Ioan Ursu, "Physics and Technology of Nuclear Materials", Elsevier Science, 2015

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	3			2	2					1	3	3	3
2	3	3	3			2	2				2	1	3	3	3
3	3	3	3			2	2				2	1	3	3	3
4	3	3	3			2	2	3				1	3	3	3
5	3	3	3			2	3	3				1	3	3	3
Avg.	**3**	**3**	**3**			**2**	**2.2**	**3**			**2**	**1**	**3**	**3**	**3**

MS23012	SMART MATERIALS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main objective of this course is to impart knowledge on the properties, applications of magnetostrictive, electro-rheological, piezoelectric, shape memory alloys, smart and hybrid composites**.**

UNIT I INTRODUCTION TO SMART MATERIALS AND MAGNETOSTRICTIVE MATERIALS 9

Classification of materials, Demand for New Materials, Smart materials, classifications of smart materials, Introduction, Materials Overview, physical Overview of magnetostriction, Materials behavior, magnetostrictive Effects, magnetostrictive transducers, Magneto rheological Fluids properties and applications.

UNIT II ELECTRO-RHEOLOGICAL AND PIEZO ELECTRIC MATERIALS 9

Introduction, Background, Materials, Mechanical Properties of Electro-rheological materials, theories of Electro-rheological materials, application, piezo electric materials, properties, and applications.

UNIT III SHAPE MEMORY ALLOYS 9

Shape memory alloys, NiTinol, NiTinol Material properties, NiTinol Phase Diagram, Shape memory effect – one way, two shape memory effect, Pseudoplasticity or super elasticity, NiTinol applications: Biomedical industries, Aerospace, automobile, Robotics. High temperature shape memory alloys, Magnetic shape memory alloys, shape memory polymers, applications

UNIT IV SMART COMPOSITES 9

Cement-Matrix Composites for Smart Structures - Cement-Matrix Composites for Strain Sensing, Damage Sensing, Temperature Sensing, and Vibration Reduction. Polymer-Matrix Composites for Smart Structures, Polymer-Matrix Composites for Strain Sensing and Temperature Sensing.

UNIT V HYBRID COMPOSITES 9

Shape Memory Alloy Fiber / Metal Matrix Composites, Shape Memory Alloy Fiber / Polymer Matrix Composites, SMA Particulate / Aluminum Matrix Composites, Magnetic Particulate / SMA Matrix Composites, SMA / Piezoelectric Heterostructures.

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TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1 Classify smart and Magnetostrictive materials.
CO2 Categorize Electro rheological and piezo electric materials
CO3 Discuss the shape memory alloys, their properties and applications
CO4 Summarize the health monitoring of smart structures.
CO5 Explain the various types of hybrid composites.

TEXTBOOKS:

1. Mel schwartz, encyclopedia of smart materials, john wiley& sons, inc, 2002.
2. Gandhi M V and Thompson B S, Smart Materials and Structures, Chapman &Hall, Madras, 1992

REFERENCES:

1. Jani, Jaronie Mohd, et al. "A review of shape memory alloy research, applications and opportunities." Materials & Design (1980-2015) 56 (2014): 1078-1113.
2. Antonio Concilio, Vincenza Antonucci, Ferdinando Auricchio, Leonardo Lecce, Elio Sacco, “Shape Memory Alloy Engineering For Aerospace, Structural, and Biomedical Applications”2nd Edition - January 13, 2021.
3. Cady, W. G., Piezoelectricity, Dover Publication.
4. Brian Culshaw, Smart Structures and Materials, Artech House, 2000

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	3	3								2	3	2	2
2	3	3	3	3								2	3	2	2
3	3	3	3	3								2	3	2	2
4	3	3	3	3								2	3	2	2
5	3	3	3	3								2	3	2	2
Avg.	3	3	3	3								2	3	2	2

MS23013	ENERGY STORAGE DEVICES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main objective of this course is to **inculcate knowledge on the** energy storage technologies and the use of sensible and phase change materials in thermal energy storage systems and the importance of the future prospects of other alternative and hybrid storage systems.

UNIT I OVERVIEW OF ENERGY STORAGE TECHNOLOGIES 9

Need for Energy Storage - Energy Storage Classification - Thermal, Mechanical, Chemical, Electrochemical, Electrical – Comparison

UNIT II MECHANICAL ENERGY STORAGE SYSTEMS 9

Mechanical Storage Systems - Pumped Hydro Energy Storage (PHES), Compressed Air Energy Storage (CAES), Flywheel Energy Storage (FES).

UNIT III ELECTRICAL AND ELECTROCHEMICAL ENERGY STORAGE SYSTEMS 9

Batteries –Types & applications-Flow Batteries, Lithium Ion batteries - Super capacitors - Super conducting Magnetic Energy Storage (SMES)

UNIT IV THERMAL ENERGY STORAGE SYSTEMS 9

Thermal Storage Systems - Sensible Heat Storage Systems - SHS medium - Stratified Systems - Latent Heat Storage Systems - Phase Change Materials (PCM).

UNIT V HYDROGEN, BIOGAS AND OTHER HYBRID SYSTEMS 9

Hydrogen - Storage Methods - Use in Fuel Cells - Biogas Storage methods - Concept of Hybrid Storage Systems - Configuration and Applications

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

1. Discuss the scientific need for energy storage systems.
2. Understand and appreciate the mechanical energy storage systems.
3. Explain the working principles of batteries and supercapacitors.
4. Analyse and describe the methods of energy storage using thermal methods.
5. Explore other effective methods of energy storage for sustainable development and growth.

TEXT BOOKS:

1. Ibrahim Dincer and Mark A. Rosen, “Thermal Energy Storage Systems and Applications”, John Wiley and Sons, 2021.
2. Ru-Shi Liu, Lei Zhang and Xueliang Sun, “Electrochemical Technologies for Energy Storage and Conversion”, Wiley, 2012.

REFERENCES:

1. Lindon David, “Handbook of Batteries”, McGraw Hill, 2002 .
2. Robert A. Huggins, “Energy Storage”, Springer, 2010.
3. Ter-Gazarian, A. G., “Energy Storage for Power Systems”, IET Publications, UK, 2011.
4. James LArminie and Andrew Dicks, “Fuel Cell Systems”, Wiley, 2018.
5. Sukhatme, S. P., “Solar Energy: Principles of Thermal Collection and Storage”, McGraw Hill, 2009.

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2	2					2	2	2						1
2	2	2					2	2	2						1
3	2	2					2	2	2						1
4	2	2					2	2	2						1
5	2	2	2				3	3	2						1
Avg.	**2**	**2**	**2**				**2.2**	**2.2**	**2**						**1**

MS23014	FUEL CELL TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main objective of the course is to introduce and impart knowledge on the basics of fuel cell technology, its types, working principles and to understand the importance of hydrogen as green fuel

UNIT I INTRODUCTION TO FUEL CELLS 9

Introduction to Fuel Cell Technology - Relevance - Importance - History of Fuel Cell - Working principle - Attractive features - Comparison of fuel cell and other electrochemical cells - R&D Challenges.

UNIT II CLASSIFICATION OF FUEL CELLS 9

Types of Fuel Cells - Low and High Temperature Fuel Cells - Description, working principle, component, construction, applications, advantages and limitations of PEMFC, DMFC, PAFC, AMFC, SOFC, MCFC, MFC of alkaline fuel cells, phosphoric acid, solid oxide, molten carbonate, Relative merits and demerits - Recent development in technology.

UNIT III THERMODYNAMICS AND KINETICS OF FUEL CELLS 9

Background theory - thermodynamic aspects of electrochemistry- Energy conversion and its efficiency – factors affecting Fuel Cell efficiency, Fuel Cell Reaction kinetics -electrode kinetics of Fuel Cells - Characterization Techniques - Polarization Curve - Various Losses.

UNIT IV HYDROGEN PRODUCTION AND STORAGE 9

Hydrogen - physical and chemical properties - Unique characteristics of hydrogen - Economy of hydrogen energy - Production of hydrogen: Steam Reoforming - Electrolysis - Gasification - Biomass Conversion -Biological Production - Photodissociation - Photocatalytic - Thermal methods. Storage of hydrogen: Physical (Material based) and Chemical - Compressed Gas - Liquified Hydrogen - Safety and Management. Electrocatalysis.

UNIT V APPLICATION OF FUEL CELLS AND CHALLENGES 9

Fuel cells for domestic, industrial and commercial applications - Large scale power generation - Transportation and other stationary applications - Economic and environmental analysis - Safety and Cost issues - Life cycle analysis of Fuel Cells - Future trends in Fuel Cells.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

1. Understand and appreciate the fuel cell technology as one of the sustainable development.
2. Understand the need for development of various types of fuel cells and their scopes for different uses.
3. Apply the principles of thermodynamics and reaction kinetics of fuel cells and make attempts to improve their efficiencies.
4. Gain knowledge on the hydrogen as a source of green energy and the challenges associated with its production, storage and transport.
5. Analyse the cost effectiveness and eco-friendliness of fuel cell technology and understand the impact of this technology in a global context.

TEXT BOOKS:

1. Aulice Scibioh M.and Viswanathan B, “Fuel Cells – principles and applications’, University Press (India), 2006.
2. Ryan O. H., Suk Won C. and Whiteny C., “Fuel Cell Fundamentals”, John Wiley & Sons, 2016.

REFERENCES

1. James L. and Andrew D., “Fuel Cell Systems Explained”, John Wiley, 2003.
2. O’Hayre, R., Cha S. W., Colella W. and Prinz, B., “Fuel Cell Fundamentals”, John Wiley and Sons, 2005.
3. Barbir F “PEM fuel cells: theory and practice” Elsevier, Burlington, MA 2005.
4. Mench, M. M., “Fuel Cell Engines”, Wiley, 2008.
5. Liu, H., “Principles of Fuel Cells”, Taylor and Francis, 2006.

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2						3		3		1				2
2	2						3		3		1				2
3	2	2			1		3		3		1				2
4	2						3		3		1				2
5	1	2	1			2	3	1	3		2				2
Avg.	**1.8**	**2**	**1**		**1**	**2**	**3**	**1**	**3**		**1.2**				**2**

PH23C12	SEMICONDUCTORS, OPTOELECTRONIC MATERIALS AND DEVICES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main objective of the course is to educate the students on the importance of theory of semiconductors, its optical properties, working and practical applications of modern optoelectronic devices.

UNIT I INTRODUCTION TO SEMICONDUCTORS 9

Classical free electron theory (Qualitative) – Quantum free electron theory : Fermi-Dirac distribution - density of states - Introduction to origin of band gap - E-k diagram - effective mass of an electron - energy bands In solids - Fermi energy level - Equilibrium carrier concentration for Intrinsic and extrinsic semiconductors- conductivity of Intrinsic and extrinsic semiconductors - law of mass action - variation of Fermi level with doping and temperature.

UNIT II OPTICAL PROPERTIES OF SEMICONDUCTORS 9

Direct and indirect band gap semiconductors - electron-hole pair generation and recombination - non-radiative and radiative recombination in semiconductors – Electron –hole injection – Internal Quantum Efficiency – Junctions: P-N junction – Bias – P-I-N junction – Heterojunctions- Quantum wells – work function and Schottky junction –Ohmic contacts – Band to band absorption and Emission - Optical absorption and emission due to defect centers.

UNIT III PHYSICS OF OPTOELECTRONIC MATERIALS 9

Refractive index of semiconductors – Relative permittivity and refractive index – Dispersion – Sellmeier coefficients – Group velocity and Group index – Luminescence: Photoluminescence, cathodoluminescence, electroluminescence and injection luminescence, Light scattering, absorption and attenuation – Growth of optoelectronic materials: Czocharalski method, MBE and MOCVD techniques – Band structure modifications of semiconductor optoelectronic alloys.

UNIT IV SEMICONDUCTOR DEVICES 9

Ideal PN junction – Avalanche and Zener diodes – BJT - JFET –– MOSFET – LEDs – OLEDs - Diode lasers - LCDs – Photodetectors – Phototransistors - Solar cells – CCD sensors – Junction photodiodes - Hall effect and Its Applications

UNIT V MODERN OPTOELECTRONIC DEVICES 9

Optical anisotropy – Birefringent retarding plates – photoelasticity - Optical activity – Electro-optic effects : Pockels effect and Kerr effect – Electro-optic modulator – scanners and directional couplers - Optical switches – Quantum well lasers – Quantum dots – single electron transistor – molecular transistor.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

At the end of the course,

CO1: The students will learn about the basic theories involved in the development of semiconductor physics

CO2:The students will understand the important optical properties of semiconductors.

CO3: The students will gain knowledge about the Physics of optoelectronic materials.

CO4:Thestudents will understand easily the physical principles of various semiconductor devices

CO5:The students will gain knowledge of modern optoelectronic devices.

TEXT BOOKS:

1. Optoelectronics and Photonics : Principles and Practices, S.O.Kasap, Pearson, 2013
2. Wilson, J. and Hawkes, J.F., 1989. Optoelectronics-an introduction. Optoelectronics-An introduction (2nd edition.

REFERENCES

1. Principles of Electronic Materials and Devices, S.O. Kasap, McGraw Hill, 2006.
2. Electronic and Optoelectronic Properties of Semiconductor Structures, Jasprit Singh, Cambridge University Press, 2003.
3. Pierret, R.F., 1996. *Semiconductor device fundamentals*. Pearson Education India.
4. Fundamentals of Photonics, B.E.A. Saleh and M.C. Teich, Wiley Interscience, 2019.
5. Molecular Electronics: An Introduction to Theory and Experiment, Carlos Cuevas, World Scientific, 2017.

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2	1	1	1									3	3	1
2	2	2	1	1	1								3	3	1
3	2	1	1	2	1								3	3	1
4	2	2	2	1	1								3	3	1
5	2	1	2	2	1								3	3	1
Avg.	**2**	**1.4**	**1.4**	**1.4**	**1**								**3**	**3**	**1**

MS23015	THIN FILM TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main learning objective of this course is to inculcate knowledge on the basics involved in thin films and development of thin films and their significance in various applications.

UNIT I BASICS OF THIN FILMS 9

Cosine law of emission. Emission from a point source. Mass of material condensing on the substrate. Chemical methods: Qualitative study of preparation of thin films by Electroplating, vapour phase growth and anodization. Physical methods: Vacuum evaporation

UNIT II PREPARATION OF THIN FILMS 9

Study of thin film vacuum coating unit - Construction and uses of vapour sources-wire, sublimation, crucible and electron bombardment heated sources. Arc and Laser evaporation. Sputtering - Study of glow Discharge - Physical nature of sputtering - Sputtering yield- Experimental set up for DC sputtering, AC sputtering and RF sputtering. Nucleation and growth of thin films (qualitative study only): Four stages of film growth.

UNIT III DEPOSITION MONITORING AND CONTROL 9

Microbalance, Crystal oscillator thickness monitor, optical monitor, Resistance Monitor. Thickness measurement: Multiple Beam Interferometer, Fizeau (Tolansky) technique - Fringes of equal chromatic order (FECO) method - Ellipsometry (qualitative only).

UNIT IV PROPERTIES OF THIN FILM 9

Sheet resistance - size effect - Electrical conduction in thin metallic films. Effect of Ageing and Annealing - Oxidation - agglomeration. Dielectric properties: DC conduction mechanism - Low field and high field conduction. Breakdown mechanism in dielectric films - AC conduction mechanism. Temperature dependence of conductivity. Optical properties: Optical constants and their determination - Spectrophotometer method. Anti-reflection coatings. Interference filters. Thin film Solar Cells CuInSe2 solar cell.

UNIT V APPLICATION OF THIN FILMS 9

Thin film resistors: Materials and Design of thin film resistors (Choice of resistor and shape and area) - Trimming of thin film resistors - sheet resistance control - Individual resistor trimming. Thin film capacitors: Materials - Capacitor structures - Capacitor yield and capacitor stability. Thin film field effect transistors: Fabrication and characteristics - Thin film diodes.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Explain the fundamental principles of Thin film technology.
CO2: Compare the various techniques of preparation of thin films with respect to the processes, advantages, limitations and applications.

CO3: Interpret the results obtained from Microbalance, Crystal oscillator thickness monitor, optical monitor, Resistance Monitor and Thickness measurements.
CO4: Interpret the effect of size of thin films and ageing and annealing on the optical and conductive properties of thin films.
CO5: Identify suitable surface modification technologies of deposition of thin film for different application like optical emission, abrasion resistance, dielectric, electronic applications, energy conversion, etc.

TEXT BOOKS

1. Goswami A, “Thin Film Fundamentals”, New Age International (P) Ltd., 1996.
2. K.L. Chopra, “Thin Film Phenomena”, McGraw-Hill,1983

REFERENCES

1. Aicha Elshabini-Riadaud Fred D Barlow III, “Thin Film Technology Hand book”, Mc Graw Hill Company, 1997.
2. Anders H, “Thin Films in Optics”, Focal press, 1967.
3. Guthrie A, “Vacuum Technology”, John Wiley and Sons, 1963.
4. Maissel L.I and Glang R, “Hand Book of Thin Film Technology”, McGraw Hill, 1970.
5. Rao V V, Ghosh, T.B., Chopra, K.L., “Vacuum Science and Technology”, Allied Publications, 1998
6. Schwartz B and Schwartz N, “Measurement Techniques for Thin Films”, John Wiley & Sons, 1967.

COs-POs & PSOs Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO1	3	2	1	2								2	2	3	1
CO2	3	1	2	1	1							2	2	2	1
CO3	3	2	1	2								2	3	2	1
CO4	3	1	1	2								2	2	2	1
CO5	3	2	1	2								3	3	2	1
Avg	3	1.6	1.2	1.8	1							2.2	2.4	2.2	1

MS23016	MEMS AND NANOTECHNOLOGY	L T P C 3 0 0 3

COURSE OBJECTIVES:

The main learning objective of this course is to impart knowledge on the basics of nanoelectromechanical systems (NEMS) and to develop the skills to utilize MEMS devices in the real-time applications.

UNIT – I MATERIAL ASPECTS OF MEMS AND NEMS **9**

Overview of MEMS and NEMS. Material Aspects – Silicon and its compounds – Thin metal films – semiconductor – optical properties – Polymers – Smart materials.

UNIT – II SENSORS **9**

MEMS Sensors– Mechanical Sensors– Thermal Sensors– Magnetic Sensors– Micro-optoelectromechanical Systems – Radio Frequency (RF) MEMS. Microfluidic Systems; Chemical and Biomedical Microsystems.

UNIT – III ACTUATORS **9**

MEMS Actuators – Mechanical Actuators – Thermal Actuators – Magnetic Actuators – Micro-opto electromechanical Systems – Radio Frequency (RF) MEMS. Microfluidic Systems; Chemical and Biomedical Microsystems.

UNIT – IV MEMS AND NEMS APPLICATIONS-I **9**

Applications in Computer industry – Making of ICs and Microprocessors – Data storage devices. Automobile – Safety and Stability Control. Health care

UNIT – V MEMS AND NEMS APPLICATIONS-II **9**

Lab-on-a-Chip. Consumer Products; Micro reactor; Micro-bots; MOEMS; Molecular machines. Applications of NEMS

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Select suitable material for MEMS and Microsystems,
2. Explain the scaling laws involved in miniaturization.
3. Apply the working principle of electrostatic based MEMS sensors and actuators in the design of MEMS devices.
4. Apply the working principle of thermal based MEMS sensors and actuators in the design of MEMS devices.
5. Design the elements of Micro-fluidic systems, and select suitable MEMS devices for Industrial applications.

TEXT BOOKS:

1. Mark A. Ratner and Daniel Ratner, “Nanotechnology: A Gentle Introduction to the Next Big Idea, Pearson, 2003.

2. Tai-Ran Hsu, “MEMS and Micro systems Design and Manufacture”, McGraw Hill Education, 2015.

REFERENCES:

1. Bharat Bhushan, “Handbook of Nanotechnology”, Springer, 2006.
2. Marc Madou, “Fundamentals of Microfabrication”, CRC Press, 2002.
3. Stephen D Senturia, “Microsystem Design”, Kluwer Academic Publishers, 2002.

COs-POs & PSOs Mapping

	PO1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO1	3	1	2	1								2	2	1	1
CO2	3	1	2	1								2	2	1	1
CO3	3	1	3	1								2	2	1	1
CO4	3	2	1	1								2	3	1	1
CO5	3	1	3	1					2			2	3	1	3
Avg	3	1.2	2.2	1					2			2	2.4	1	1.4

MS23017	SURFACE NDE TECHNIQUES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main learning objective of this course is to impart knowledge on the various NDT inspection method procedures along with the standards and codes.

UNIT I VISUAL INSPECTION 9

Fundamentals of Visual inspection– vision, lighting, material attributes, environmental factors, visual perception, direct and indirect methods, mirrors, magnifiers, borescopes and fibroscopes– light sources and special lighting – calibration- computer enhanced system – Applications - metallic materials, welds, classification of indications for acceptance criteria - Codes, Standards and Specifications (ASME, ASTM, AWS etc.)

UNIT II LIQUID PENETRANT TESTING 9

Principles – types and properties of liquid penetrants – developers – advantages and limitations of various methods - Preparation of test materials – Application of penetrants to parts, removal of excess penetrants, post cleaning – Control and measurement of penetrant process variables – selection of penetrant method – solvent removable, water washable, post emulsifiable – Units and lighting for penetrant testing –calibration, Interpretation - codes and standards.

UNIT III MAGNETIC PARTICLE TESTING 9

Theory of magnetism – ferromagnetic, paramagnetic materials – characteristics of magnetic fields –magnetic hysteresis – magnetization by means of direct and alternating current, Depth of penetration factors – Circular and longitudinal magnetization techniques, current calculation –– field produced by a current in a coil, shape and size of coils, field strength, Magnetic Barkhausen Noise Analysis (MBN) – advantages and limitations.

UNIT IV MAGNETIC PARTICLE TESTING EQUIPMENT 9

Selecting the method of magnetization, inspection materials, wet and dry particles – portable, mobile, and stationary equipment – calibration, capabilities, magnetic particle inspection of castings and welding – Dry continuous method, wet residual method – Interpretation and evaluation of test indications, methods of demagnetization –codes and standards.

UNIT V EDDY CURRENT TESTING 9

Basics of electromagnetics - Generation of eddy currents – effect of change of impedance on instrumentation – properties of eddy currents – eddy current sensing elements, probes, type of coil arrangement – absolute, differential, lift off, operation, applications, advantages, limitations, Interpretation/Evaluation –Applicable codes and standards.

TOTAL:45PERIODS

COURSE OUTCOMES:

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

CO1 Explain the visual inspection methods
CO2 Summarize the types of Liquid penetrant testing
CO3 Discuss the fundamentals of Magnetic particle testing
CO4 Explain the various magnetic particle Testing Equipment
CO5 Summarize the Eddy current testing methods

TEXTBOOKS:

1. Paul E Mix, “Introduction to Non-destructive testing: a training guide”, Wiley, 2nd edition New Jersey, 2005
2. ASM Metals Handbook, “Non-Destructive Evaluation and Quality Control”, American Society of Metals, Metals Park, Ohio, USA, 200, Volume-17

REFERENCES:

1. V. S. Cecco, G. V. Drunen and F. L. Sharp, Eddy current Manual: Test method, Vol.1, Chalk River Nuclear Laboratories (1983).
2. B.P.C. Rao, Practical Eddy Current Testing, Alpha Science International Limited (2006)
3. ASTM/ASME/API standards for Visual, Liquid Penetrant Testing, Magnetic particle Inspection and Eddy Current Testing
4. J. Prasad and C. G. K. Nair, Non-Destructive Test and Evaluation of Materials, Tata McGraw-Hill Education, 2nd edition (2017)
5. CT-5, NDT Handbooks, General Dynamics

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	3	3		2	2					2	3	2	2
2	3	3	3	3		2	2					2	3	2	2
3	3	3	3	3		2	2					2	3	2	2
4	3	3	3	3		2	2					2	3	2	2
5	3	3	3	3		2	2					2	3	2	2
Avg.	3	3	3	3		2	2					2	3	2	2

MS23018	ULTRASONIC TESTING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main learning objective of this course is to inculcate knowledge on the physics of Ultrasonic waves and their generation and their significance in the detection of discontinuities in engineering components.

UNIT I INTRODUCTION TO ULTRASONIC WAVES 9

Nature of sound waves, wave propagation in metals– modes of sound wave generation – longitudinal waves, transverse waves, surface waves, lamb waves –Velocity, frequency and wavelength of ultrasonic waves – Ultrasonic pressure, intensity, and impedance – Attenuation of ultrasonic waves – reflection, refraction, and mode convection – Snell's law and critical angles –Fresnel and Fraunhofer effects.

UNIT II ULTRASONIC WAVE GENERATION 9

Methods of ultrasonic wave generation – piezo electric effect, piezo electric materials, mode of vibration – Ultrasonic search Units (transducers), types (straight, angle, dual) – Construction materials and shapes – Beam intensity, characteristics, sensitivity, resolution, and damping – Transducer operation.

UNIT III INSPECTION METHODS AND EQUIPMENT 9

pulse echo method, resonance method, – contact testing, immersion testing, comparison of contact and immersion method. Pulse Echo instrumentation, controls and circuits, pulse generation, signal detection, display and recording methods, gates, alarms and attenuators, detectability of defects., Total Focussing Method(TFM), Time of Flight Diffraction(ToFD), Sampling Phased Array (SPA), Synthetic Aperture Focussing technique(SAFT).

UNIT IV CALIBRATION 9

Need and importance of calibrating equipment and search units, Basic instrument calibration – calibration blocks (IIW Block, ASTM Blocks, etc.), cables, connectors, test specimens. Reference reflectors for calibration (side drilled holes, notches, etc.) – Inspection calibration, comparison with reference blocks, reference for planned tests (straight beams, angle beam. etc.), transmission factors.

UNIT V TESTING AND INTERPRETATION 9

Codes, Standards (ASME, ASTM, AWS, BS. etc.) Weld body examination with normal and angle beam by DAC and DGS methods, Ultrasonic testing and evaluation of ingot, plate, forgings, and castings. Factors affecting ultrasonic test results, safety precautions, case studies.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1 Explain the fundamentals of ultrasonic waves

CO2 Discuss the ultrasonic wave generation
CO3 Classify the ultrasonic wave inspection methods and equipment.
CO4 Summarize the calibration aspects of ultrasonic testing
CO5 Interpret the results of ultrasonic testing

TEXT BOOKS:

1. J. Krautkramer and H. Krautkramer, Ultrasonic Testing of Materials, Springer, 4th edition(1990).
2. B. Raj, C.V. Subramanian and T. Jayakumar, Non-Destructive Testing of Welds, Woodhead Publishing, 1st edition (2000).

REFERENCES:

1. P. J. Shull, Nondestructive Evaluation: Theory, Techniques, and Applications, CRC Press,1st edition (2002).
2. C.V.Subramanian, Practical Ultrasonics, Alpha Science International, (2006).
3. A.S. Birks and R.E. Green, Ultrasonic Testing, Nondestructive Handbook, Vol. 7, American Society for Nondestructive Testing, 2nd edition (1991).
4. ASME Sec V 2001 (Boiler& Pressure Vessel Code), ASME Intl. (2017).
5. Herbert Krautkrämer, Josef Krautkrämer, Ultrasonic Testing of Materials, Springer Verlag; Revised, Subsequent edition (1 November 1990)

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2	2		2	2	2					2	3	3	3
2	3	2	2		2	2	2					2	3	3	3
3	3	2	2		2	2	2					2	3	3	3
4	3	2	2		2	2	2					2	3	3	3
5	3	2	2		2	2	2					2	3	3	3
Avg.	3	2	2		2	2	2					2	3	3	3

MS23019	RADIOGRAPHY TESTING AND RADIATION SAFETY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main learning objective of this course is to impart knowledge on the fundamental concepts in radiography testing and the interpretation of Radiography results

UNIT I FUNDAMENTALS OF RADIOGRAPHY 9

Geometric exposure principles, shadow formation, shadow sharpness – Radio isotopic sources –types and characteristics – Production and processing of radioisotopes – radiographic cameras -X-ray source generation and properties – industrial X-ray tubes – target materials and characteristics – High energy X-ray sources.

UNIT II FILM & DIGITAL RADIOGRAPHY 9

X-ray film – structure and types for industrial radiography – sensitometric properties – use of film, characteristic curves (H & D curve) – latent image formation on film – radiographic exposure, X-ray, and gamma ray exposure charts – exposure time calculations – film handling and storage – Effect of film processing on film characteristics –Processing defects and their appearance on films – control and collection of unsatisfactory radiographs, Digital radiography, Linear accelerated Computed Radiography(LINAC), Image Analysis-AI & pattern Recognition, Computed Tomography.

UNIT III RADIOGRAPHIC IMAGE QUALITY AND RADIOGRAPHIC TECHNIQUES 9

Radiographic sensitivity – Radiographic Contrast, film Contrast, Subject Contrast, Radiographic density – Image Quality Indicators – Intensifying screens –intensification factor, control of scattered radiation, filters, diaphragms, masks – Radiography of weldments – single and double wall Radiography – panoramic radiography-procedure shooting sketch/technique sheets.

UNIT IV RADIATION DETECTORS AND SAFETY 9

Special and SI Units of radiation – Principle of radiation detectors – ionization chamber, proportional counter, G. M. counters, scintillation counters, solid state detectors – Biological effect of ionizing radiation – Operational limits of exposures – Radiation hazards evaluation and control– Design of radiography installation and shielding calculations. Atomic Energy Regulatory Board(AERB) regulations for industrial Radiography

UNIT V RADIOGRAPHY INTERPRETATION 9

Interpretation of radiographs:- Interpretation for welds, castings etc, applications, various case studies, Inspection standards - applicable codes, standards, and specifications (ASME, ASTM,AWS, BS, IBR etc.).

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1 Discuss the fundamentals of radiography

CO2 Summarize the concepts related to film radiography
CO3 Explain radiographic image quality and radiographic techniques
CO4 Summarize the safety instructions of radiography
CO5 Analyze the results of radiography test

TEXT BOOKS:

1. L. E. Bryant and P. McIntire, Non-Destructive Testing Hand Book: Radiography and Radiation Testing, Vol.3, American Society for Non-Destructive Testing, 2nd edition (1985).
2. Non-Destructive Examination and Quality Control, ASM International, Vol.17, 9th edition (1989).

REFERENCES:

1. R. H. Bossi, F. A. Iddings and G.C. Wheeler, Radiographic Testing, American Society for Nondestructive Testing, 3rd edition (2002).
2. Baldev Raj, T. Jayakumar, and M. Thavasimuthu, Practical Non-Destructive Testing, AlphaScience International Limited, 3rd edition (2002).
3. Eastman Kodak, Radiography in modern industry, Eastman Kodak Co, 3rd edition, (1969).
4. ASME Sec V 2001 (Boiler& Pressure Vessel Code), ASME Intl. (2017).
5. Barry Hull and Vernon John, Non-Destructive Testing, Macmillan Education Ltd, 1988

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	2			2	2					2	3	3	2
2	3	3	2			2	2					2	3	3	2
3	3	3	2			2	2					2	3	3	2
4	3	3	2			2	2					2	3	3	2
5	3	3	2			2	2					2	3	3	2
Avg.	3	3	2			2	2					2	3	3	2

MS23020 ADVANCEMENTS IN ULTRASONIC TECHNIQUE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- The main objective of the course is to equip the students with proper understanding on advanced ultrasonic techniques, guided wave theories and their significance in the ultrasonic inspection process and also to get essential knowledge on the applications of Ultrasonic testing in Structural health monitoring and condition monitoring.

UNIT I PHASED ARRAY TECHNIQUES **9**

Principles of phased array inspection – phased array probes and their characteristics – Phased array wedges – Focal law sequencing – Beam shaping, steering – principles of inspection sensitivity – Scanning with phased array probes- linear, sectorial, C scan mapping –Instrumentation – phased array instruments, calibration methods, checking probe elements –beam angles and beam shape – data collection and data analysis, principles of data analysis –data acquisition, defect detection, sizing, interpretation and characterization – procedures for verification of flaw existence and position, reporting, applications – Case studies.

UNIT II TIME OF FLIGHT DIFFRACTION **9**

Theory and principles of Time of Flight Diffraction (TOFD) – Mathematical model, Data acquisition and interpretation, TCG Plotting– TOFD techniques – selection of probe angle – dynamic depth focusing, Delay Laws applications, optimizing angles – flaw location and sizing – types of scan, equipment requirements – advantages, limitations of detection and resolution – codes and standards –Interpretation, evaluation, applications, case studies.

Synthetic Aperture Focusing Technique (SAFT):- Principles of (SAFT), focusing and reconstruction of images, Signal processing of SAFT data, Advantages, Limitations, Applications, Case studies.

UNIT III ULTRASONIC GUIDED WAVES **9**

Guided waves - types& Generation – Plate theory – Rayleigh-Lamb Equation, Guided waves in Plates, Pipes and rods – Wave structure analysis – Dispersion curves – Modes inguided waves – Air coupled ultrasonic guided waves – advantages and limitations –Applications, case studies.

Electro Magnetic Acoustic Transducer (EMAT)-Basic principles – types of coil and design –

Generation and defect detection of guided waves using EMATS- advantages and limitations, Applications- case studies

UNIT IV OPTICAL METHODS IN ULTRASONICS **9**

Laser Ultrasonics – Laser fundamentals – types of lasers – bulk wave and lamb wave generation mechanisms – optical detection of ultrasound – measurement of in-plane displacement and velocity – holographic NDT – recording and reconstruction of a hologram – Two wave mixing interferometry – Laser shearography – Applications (Laser ultrasonics for flaw detection and material characterization) – Case studies.

UNIT V NON-LINEAR ULTRASONICS AND STRUCTURAL HEALTH MONITORING **9**

Non-Linear Ultrasonics- Higher harmonic generation-Principles of non-linearity in elastic solids– non-linear ultrasonics of fatigue damage – Non-linearity of surface and Lamb waves –applications – case studies.

Structural Heath Monitoring (SHM):- Condition Monitoring (CM)- life and integrity assessment, comparison between SHM and CM.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

1. Have a better knowledge in the field of Phased array techniques for flaw detection in engineering components.
2. Characterise the defects using TOFD technique.
3. Plot dispersion curves and perform long range inspection using guided waves for plates, pipes and rods
4. Carry out examination by optical techniques to measure the in-plane displacement and
   Velocity
5. Explain the Non-linear ultrasonic techniques and their application in structural health monitoring and condition monitoring.

TEXT BOOKS:

1. Introduction to Phased Array Ultrasonic Technology Applications, R/D Tech, (2004)
2. T. Kundu, Ultrasonic Non-Destructive Evaluation: Engineering and Biological Material Characterization, CRC Press, 1st edition, (2003).

REFERENCES

1. L. W. Schmerr, Fundamentals of Ultrasonic Phased Arrays, Springer, (2014)
2. J. L. Rose, Ultrasonic waves in solid media, Cambridge University Press, (2004).
3. J. A. Ogilvy and A.G. Temple, Diffraction of elastic waves by cracks: Application to Timeof Flight Inspection, Ultrasonics, volume 7, 259-269, (1983).
4. Charles, J. Hellier," Handbook of Non-destructive evaluation", McGraw Hill, New York 2001.
5. C. B. Scruby and L. E. Drain, Laser Ultrasonics: Techniques and Applications, CRCPress, (1990).

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2	1	1		2	2					2	3	2	3
2	3	2	2	1		2	2					2	3	2	3
3	3	2	1	2		2	2					2	3	2	3
4	3	2	1	2		2	2					2	3	2	3
5	3	2	2	1		2	2					2	3	2	3
Avg	3	2	1.4	1.4		2	2					2	3	2	3

MS23021	EDDY CURRENT TESTING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main learning objective of this course is to inculcate knowledge on the fundamental concepts and instrumentation aspect of eddy current testing and their codes and standards.

UNIT I INTRODUCTION 9

History of eddy current testing, Different NDT methods, choice of methods, electricity, magnetism, alternating current theory, Eddy current principles, Factors that affect eddy current – test frequency, Effect of lift off or fill factor, Effect of conductivity, Effect of magnetic permeability, Effect of geometry.

UNIT II INSTRUMENTATION 9

Coil, Eddy current generation, Eddy current detection, Coil arrangement, Probes- types of probes - Encircling probes, Internal bobbin probes etc.

UNIT III EDDY CURRENT TECHNIQUES 9

Constant Current drive ECT techniques, scanning probe Technique, Surface defect detection using absolute probe, single frequency ECT system, 3D or Phased Array ECT.

UNIT IV CASE STUDIES AND STANDARDS 9

Eddy current inspection of tubes, cylinders, steel bars, welded tubing, plates and pipes, Remote Field Sensing - Interpretation/Evaluation –Applicable codes and standards.

UNIT V ADVANCED EDDY CURRENT TESTING METHODS 9

Magneto Eddy current imaging (MOI), pulsed Eddy Current Testing, Low frequency Testing, Squid Based Eddy Current testing – applications, advantages, limitations

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1 Discuss the fundamentals of Eddy current.

CO2 Summarize the instrumentation aspect of Eddy current testing

CO3 Discuss the various eddy current techniques

CO4 Explain the Codes and standards of Eddy current testing.

CO5 Summarize the advanced eddy current testing methods

TEXTBOOKS:

1. Baldev Raj, T. Jayakumar, M, Thavasimuthu, ‘Practical Non-Destructive Testing, Narosa publishing house
2. Paul E Mix, “Introduction to Non-destructive testing: a training guide”, Wiley, 2nd edition New Jersey, 2005

REFERENCES:

1. J. Thomas Schmidt, K. Skeie and P. MacIntire, ASNT Non-Destructive Testing Handbook: Magnetic Particle Testing, American Society for Nondestructive Testing, American Society for Metals, 2nd edition (1989).
2. V. S. Cecco, G. V. Drunen and F. L. Sharp, Eddy current Manual: Test method, Vol.1, Chalk River Nuclear Laboratories (1983).
3. B.P.C. Rao, Practical Eddy Current Testing, Alpha Science International Limited (2006)
4. ASM Metals Handbook, "Non-Destructive Evaluation and Quality Control", American Society of Metals, Metals Park, Ohio, USA, 200, Volume-17
5. J. Prasad and C. G. K. Nair, Non-Destructive Test and Evaluation of Materials, Tata McGraw-Hill Education, 2nd edition (2017)

COs- POs & PSOs MAPPING

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	**3**	**2**	2			2	2					**2**	**3**	**2**	**3**
2	**3**	**2**	2			2	2					**2**	**3**	**2**	**3**
3	3	**2**	2			2	2					**2**	**3**	**2**	**3**
4	3	**2**	2			2	2					**2**	**3**	**2**	**3**
5	**3**	**2**	2			2	2					**2**	**3**	**2**	**3**
Avg.	**3**	**2**	2			2	2					**2**	**3**	**2**	**3**

MS23022	ADVANCED NDE TECHNIQUES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main objective of the course is to make the students gain fundamental knowledge on the advanced NDE techniques to control the quality in the engineering components and equip students with proper competencies to locate flaw in various components by Advanced NDT techniques.

UNIT I ACOUSTIC EMISSION INSPECTION 9

Principles and Theory – Signal Propagation – Physical Considerations – The AE Process Chain- Time Considerations – AE Parameters –The AE Measurement Chain – Types of displays –Noise – Location calculation and Clustering – Sensors and Amplifiers, Instrumentation principles, Advantages – Limitations – Relationship to other test methods - inspection of pressure vessels/welds/composite materials – AE testing during grinding – pipelines – steam turbines – AE location of faults in power transformers.

UNIT II LEAK TESTING 9

Introduction to leak testing– objectives – terminologies – measurement of leakage – Types of
leak – Types of flow in leaks – Principles of Fluid dynamics – Leak Testing of Pressure Systems Without and with a Tracer Gas – Halogen diode leak testing – Helium mass spectrometer leak testing and subsystems – Choosing the Optimum Leak Testing Method – System response in leak testing – Measurement of Leak Rate Using Calibrated Leaks –Vacuum leak testing- Common errors in Leak testing- Leak testing for special applications-standards.

UNIT III THERMOGRAPHIC TESTING 9

Introduction and fundamentals to infrared and thermal testing– Heat transfer – Active and passive techniques – Lock in and pulse thermography– Contact and non-contact thermal inspection methods– Heat sensitive paints – Heat sensitive papers –- thermally quenched phosphors liquid crystals – techniques for applying liquid crystals – other temperature sensitive coatings – Inspection methods – Infrared radiation and infrared detectors–thermo mechanical behavior of materials– IR imaging in aerospace applications, electronic components, Honeycomb and sandwich structures– Case studies.

UNIT IV DIGITAL RADIOGRAPHY AND COMPUTED TOMOGRAPHY (CT) 9

Principles of Digital Radiography-Methods of digital radiography – digitization of X-ray films –
Computed radiography (CR) and Digital radiography (DR) – process of image formation in CR–comparison of film, CR and DR Method., Interpretation of the results.
Computed Tomography – CT image reconstruction algorithm – Capabilities, comparison to other NDT methods – industrial CT applications – CT System design and equipment – CT scanning geometries, data acquisition system – Image quality, image artifacts, special features, reconstruction techniques. Interpretation of the images.

UNIT V STRAIN MEASUREMENT AND ANALYSIS 9

Principle - Types of strain gauges- Resistance strain gauge method, Photoelastic coating method, Brittle coating method, Gauge performance, Gauge materials, bridge circuit for measurement – instrumentation.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

1. Interpret the Acoustic Emission signals and correlate with the defects that occur in the engineering components.
2. Gain sufficient knowledge and skill to perform leak testing and visualise the defects and characterise the same.
3. Classify the Thermographic techniques and explain them.
4. Interpret the images obtained from the various advanced radiography testing methods.
5. Discuss the various methods of strain measurements and analyse the results of the strain measurements.

TEXT BOOKS:

1. A.S. Paipetis,T. E Matikas and D. G. Aggelis, Emerging Technologies in Non-DestructiveTesting, CRC Press, (2012).
2. X. P.V. Maldague, Non-Destructive Testing Handbook; Infrared and Thermal Testing,Vol-3, series III, American Society for Non-Destructive Testing, 3rd edition (2001).

REFERENCES

1. ASM Metals Handbook, “Non-Destructive Evaluation and Quality Control”, American Society of Metals, Metals Park, Ohio, USA, 2000, Volume-17.
2. X. P. V. Maldague, Nondestructive evaluation of materials by infrared thermography, Springer-Verlag, 1st edition, (1993).
3. C. U. Grosse, Acoustic Emission Testing, Springer, (2008).
4. Charles, J. Hellier,“ Handbook of Non-destructive evaluation”, McGraw Hill, New York 2001.
5. R. K.Miller and V.K.Hill, Non-Destructive Testing Handbook; Acoustic Emission Testing,Vol-6, series V, American Society for Non-Destructive Testing, 3rd edition, (2005).

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2	2			2	2					2	3	2	3
2	3	2	2			2	2					2	3	2	3
3	2	2	1			2	2					2	3	2	3
4	2	2	3			2	2					2	3	2	3
5	3	2	2			2	2					2	3	2	3
Avg.	2.6	2	2			2	2					2	3	2	3

MS23023	FUELS, REFRACTORIES AND FURNACES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main objective of the course is to impart knowledge on the fuels, refractories and furnaces

UNIT I FUNDAMENTALS 9

Energy, Resources and Environments, Thermal Energy, conversion. Heat Transfer, conduction, radiation, convection. Thermoelectric effect. Thermocouples, Peltier effect. Temperature measurement.

UNIT II FUELS 9

Characterization of Fuels- concepts, Production of secondary fuels-carbonization, Gasification and combustion. Materials and Heat balance in carbonization, Gasification and combustion. Thermal Energy conversion - Fossil fuels, availability, deposits, calorific content. Nuclear Fuels, Solar and geothermal heating.

UNIT III FURNACES 9

Firing, electric Resistance, Radiation, Induction. Temperature control –proportional integral derivative (PID). Multi zone furnaces. Batch and tunnel furnaces. Heat Utilization in furnaces

UNIT IV REFRACTORIES 9

Refractory in furnaces, Heat resistant materials in steel making and non-ferrous production plants. Applications in the power, energy conversion, petroleum and chemical industries.

UNIT V ADVANCED ISSUES 9

Environmental optimization, recycling of thermal energy. Emissions control.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

1. Explain different modes of heat transfer
2. Suggest different fuels for energy generation system
3. Discuss different furnaces and temperature control
4. summarize the applications of Refractories in furnace
5. Discuss issues in environment.

TEXT BOOKS:

1. Gupta. O. P., “Elements of Fuels, Furnaces and Refractories”, 4th edition, Khanna Publishers, New Delhi, 2000.
2. R. C. Gupta, “Fuels, Furnaces and Refractories”, Prentice-Hall of India, 2016

REFERENCES

1. Gilchrist, J. D., “Fuels, Furnaces and Refractories”, Pergamon Press, 1977.
2. Yeshvant V. Deshmukh, “Industrial Heating: Principles, Techniques, Materials, Applications,
3. and Design”, CRC Press, 2005
4. Subir Biswas, Debasish Sarkar, “Introduction to Refractories for Iron- and Steelmaking”, Springer International Publishing, 2020.
5. Charles Schacht, “Refractories Handbook”, CRC Press, 2004.
6. Samir Sarkar, “Fuels and Combustion” (3rdEdition) Orient Black Swan, 2009.

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3						2					2	3	2	3
2	3	3					2					2	3	2	3
3	3		3	2			2					2	3	2	3
4	3			2			2					2	3	2	3
5	3	3	3				2					2	3	2	3
Avg.	3	3	3	2			2					2	3	2	3

MS23024	CERAMIC PROCESSING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. Introduce the methods of material recovery by quarrying
2. Describe the various processes involved in making the quarried raw material into fine, fractioned powders and make students understand the effect of various parameters on size reduction
3. Teach various size separation and mixing techniques
4. Discuss the means of mixing and conveying of the processed raw materials.
5. Discuss the means of storage and testing of the processed raw materials.

UNIT I QUARRYING 9

Winning of clays – china clay and Kaolin; Clay purification methods – Dorr bowl classifier, continuous centrifuge, electro-osmosis and mechanical air separator; Sedimentary clay – British ball clay and fire clay; Weathering of clay; quarrying of non plastic materials; Beneficiation of non plastic materials; machinery used in clay winning.

UNIT II SIZE REDUCTION 9

Laws of size reduction; mechanism of size reduction; principle and working of different crushers and grinders – jaw crusher, gyratory crusher, hammer mill, different types of tumbling mill, jet mill, attrition mill, vibro-energy mill; Closed circuit and open circuit grinding.

UNIT III MECHANICAL SEPARATION 9

Introduction; types of separation; Screening – dry and wet screening, equipments, effectiveness of screen; test sieves - ASTM, BSS, BIS, IS; Filtration – theory of filtration, batch and continuous filters, principles of cake filtration; Separation based on movement through a fluid – sedimentation, cyclone separation, air classification; Magnetic separation; Applications - requirements and market scenario; Industries.

UNIT IV MIXING AND CONVEYING 9

Mixing – mechanism of mixing; batch and continuous solid mixers – pan mixer, shaft mixer, U mixer, muller mixer and other mixers; liquid mixers – mechanism, blungers, agitators; Conveying – solid conveying, types of conveyors, criteria for selecting a conveyor; liquid conveying- condition for liquid conveying, different types of pumps.

UNIT V STORAGEOF MATERIALS AND TESTING 9

Storage methods for different ceramic powders; Problems in bin storage; Coning and quartering of sample; sampling on delivery; measurement of moisture content by IR moisture balance, speedy moisture test; particle size analysis – sieve test, sedimentation method, Stokes, Andreasen Pipette, sedigraph; Determination of surface area by permeametry, adsorption.

TOTAL :45 PERIODS

COURSE OUTCOMES

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

CO1 understand and apply the different quarrying methods to extract clay and non clay materials and its purification process

CO2 understand, apply and analyze Selection of proper size reduction method for the given input size and for the expected final size

CO3 understand and apply and analyze different size separation methods and modes of operation.

CO4 Understand, apply and analyze a suitable method of mixing of raw materials, and conveying for the given material.

CO5 understand and apply and analyze different storage methods and the study of fundamental properties of the powdered materials

TEXT BOOKS

1. Warren L.McCabe, Julian C.Smith and Peter Harriott, Unit Operations of Chemical Engineering, 7thEdn., McGraw Hill International Edition,2013.
2. Charles Burroughs Gill, Materials Beneficiation, Springer Verlag, 1991

REFERENCES

1. Ryan W and Redford C, Whitewares: Production, Testing and Quality Control, Pergamon Press, NY, 1987.
2. Vincenzini P, Fundamentals of Ceramic Engineering, Elsevier Applied Science, London, 1991.
3. Singer F.and Singer S., Industrial Ceramics, Oxford and IBH Publishing Co. 1991.
4. Mohamed N.Rahaman, Ceramic Processing, CRC Press, 2th Edn.,2017.
5. Paul De Garmo E, Black J.J and Ronald A.Kohser, Materials and Processes in KeishiGotoh, Powder Technology Handbook, Marcel Dekker Inc.,1997.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	**2**	**2**	**2**	**2**	**-**	**2**	**2**	**2**	**-**	**-**	**-**	**-**	**3**	**3**	**-**
2	**2**	**3**	**3**	**2**	**-**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**3**	**2**	**-**
3	**2**	**2**	**2**	**2**	**-**	**2**	**2**	**2**	**-**	**-**	**-**	**-**	**2**	**2**	**-**
4	**2**	**3**	**3**	**2**	**-**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
5	**2**	**3**	**3**	**2**	**-**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**2**	**2**	**3**
Avg															

MS23025	MECHANICAL PERFORMANCE OF CERAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1 Elastic behaviour of Ceramic Materials
2 Fracture behaviour, strength , Fatigue and creep behaviour of ceramic materials
3 Toughening techniques and thermal behaviour of ceramic materials.
4 Gain knowledge on the thermal and Mechanical properties of Ceramic Materials
5 Understand the science behind and to interpret the results efficiently.

UNIT I ELASTIC BEHAVIOUR 9

Elastic constants – elastic deformation of isotropic and crystalline materials - effect of lattice constant, Grain size and Temperature- Theoretical strength – Yield criteria - stress – strain relationship - Stiffness measurement – static and dynamic methods – Critical resolved shear stress

UNIT II FRACTURE MECHANICS 9

Types of fracture - ductile and brittle fracture - Linear elastic fracture mechanics, Stress concentration, Griffith theory, stress at crack tip – - Critical stress intensity factor measurement – single edge notched, Chevron notched beam, indentation method – Statistical treatment.

UNIT III STRENGTH 9

Strength reducing mechanisms – subcritical crack propagation, failure under constant stress. Stable crack propagation – R curve, measurement. Fatigue of Ceramics – Testing method, paris theory, Life time prediction, cylindrical Pressure vessel - design of beam and columns.

UNIT IV THERMAL BEHAVIOUR 9

Thermal stress, Eshell by method-Thermal shock resistance, Thermal cycle - measurement, micro cracking of ceramics, thermal tempering. Thermal conductivity - measurement, Creep of Ceramics – mechanisms, measurement types – Diffusion, dislocation, Construction of Deformation Map- safe life design.

UNIT V TOUGHENING AND MECHANICAL PROPERTIES OF CERAMICS9

Toughening mechanisms – crack deflection, crack bowing, crack branching, crack tip shielding by process zone and bridging effect, transformation toughening, wear testing, Mechanical properties of Alumina, Silicon Nitride, Silicon Carbide and Porous ceramics, Selection of Ceramic materials.

TOTAL: 45 PERIODS

COURSE OUTCOMES FOR THEORY

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

CO1 Have a basic understanding about elasticity, deformation point of isotropic and crystalline materials.
CO2 Analyse about various fractures, fracture testing techniques, strength behaviour, thermal shock resistance and creep behaviour
CO3 Understand and evaluate life time prediction and Failure analysis.
CO4 Design ceramic components for safe life and identify suitable ceramic material

for intended application.

CO5 Analyse toughening mechanisms and their properties

TEXT BOOKS

1. Joshua Pelleg, “Mechanical Properties of Ceramics”, springer link, 2014.
2. John B.Watchman, Mechanical Properties of Ceramics, John Wiley and Sons Inc., NY, 2nd edition, 2009.

REFERENCES

1. Jonathan salem et al, “Mechanical Properties and Performance of Engineering Ceramics and Composites VII”,Wiley,2012, Volume 33, Issue 2
2. Barsoum. M.W, Fundamentals of Ceramics, 1 st edition, Taylor & Francis, 2003.
3. R C Bradt et al, “Fracture mechanics of ceramics Volume 8: Microstructure, Methods, Design, and Fatigue” 2013.
2. R C Bradt, D P H Hasselman,“Fracture Mechanics of Ceramics, Composites, R-Curve Behavior, and Fatigue”, Springer, 2012.
3. SastriV.S and Edward Ghalai, Corrosion-prevention and protection, John Willey and Sons, 2007.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2	2	2	2	-	-	-	-	-	-	-	-	-	3
2	3	2	2	2	2	-	-	-	-	-	-	-	2	-	3
3	3	3	3	3	3	-	-	-	-	-	-	-	1	3	3
4	3	3	3	3	3	-	-	-	-	-	-	-	-	-	3
5	3	3	3	3	3	-	-	-	-	-	-	-	-	3	3
Avg	3														

CorrelationLevels:1—low,2—medium, 3—high, -—nocorrelation

MS23026	GLASS SCIENCE TECHNOLOGY	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES

1. Describe the principle behind glass formation and structures of different glasses
2. List about the raw materials for glass making and glass ceramics then describe formation of glass
3. Describe different furnaces used for glass melting, their design and operation
4. Enable students to gain knowledge on different glass compositions and products
5. Enable students to gain knowledge on glaze and enamel over wares
6. Teach techniques for estimation of glass properties

UNIT I GLASS FORMATION 9

Definition; Glass Formation – atomistic hypothesis of glass formation, kinetic approach to glass Formation; Structures of glasses – fundamental laws, elements of structural models for glasses, structural models for silicate glasses; Phase diagrams of glass forming oxide systems – $CaOAl_2O_3$- SiO_2, Na_2O-CaO-SiO_2.

UNIT II RAW MATERIALS AND BATCH PREPARATION 9

Raw materials – Network former, network modifier, intermediate glass former, minor additives, cullet; Handling and storage, problems and remedies; Briquetting and Pelletizing; Glass and glass ceramic compositions, Glass Batch Calculation; Major reactions and physiochemical changes during glass melting.

UNIT III GLASS MELTING FURNACES 9

Construction and operation of pot furnace and day tank furnace; Tank furnace – types, design and construction, Heat recovery systems; Refractories used; Electric tank furnace – design and operation, electrodes used, electric boosting in tank furnace;. Forehearth & Feeder

UNIT IV FORMING AND TREATMENT 9

Hand operations; Flatware – patterned glass, sheet glass, float glass; Hollow ware – press & blow, blow & blow, IS machine, tube making. Annealing – Importance, Strain release, and annealing cycle; coated glasses, laminated glass, tempered glass, micro porous glass, sealing glass, and glass fibers.

UNIT V GLASS CERAMICS 9

Glass ceramic materials – characteristics; phase equilibria in glass forming system; glass crystallization kinetics. melting, forming, heat treatment; Alkali and alkaline earth silicates – SiO_2-Li_2O; Aluminosilicates - SiO_2-Al_2O_3-Li_2O, Flurosilicates - SiO_2-Al_2O_3-MgO-CaO-ZrO_2- F; Silicophosphates - SiO_2-CaO-Na_2O-P_2O_5; applications - Industries - Market Demand

TOTAL : 45 PERIODS

COURSE OUTCOMES

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

CO1	Have thoroughly understood the science behind glass formation
CO2	understand the various raw materials used for glass preparation and the purpose of its usage and apply the batch composition formulation of glass compositions
CO3	different glass melting furnace and explain the operation of different furnaces with

	the means to control its operation
CO4	Understand the different fabrication processes of glass and recognize the importance of annealing a glass ware
CO5	Know fundamentals and preparation and property evaluation of glass ceramics

TEXT BOOKS

1. James E.Shelby, Introduction to Glass Science and Technology, The Royal Society of Chemistry, 1997.
2. Z. Strnad, Glass Ceramics materials, Glass Science and Technology 8, Elsevier 1986

REFERENCES

1. Tooley F.V, Handbook of Glass Manufacture, VolIandII, Ogden Publishing Co., NY, 1960
2. Chapman & Hall, Schott Guide to Glass Second Edition,1996
3. Wolfgang Trier ,Glass Furnaces-Design, Construction and Operation, Society of Glass Technology, 2000.
4. Wolfram Holand and George H. Beall, Glass – Ceramic Technology, second edition,2012.
5. Charles A Harper, Handbook of Ceramic Glasses and Diamonds, McGraw Hill,2001

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	2	2	2	2	-	2	2	2	-	-	-	-	3	3	-
2	2	3	3	2	-	3	3	3	-	-	-	-	2	3	-
3	2	3	3	2	-	3	3	3	-	-	-	-	2	-	-
4	2	3	3	2	-	3	3	3	-	-	-	-	3	-	-
5	2	3	3	2	-	3	3	3	-	-	-	-	-	3	3
Avg	2.0	2.8	2.8	2.0	2.7	2.8	2.8	2.8	3.0	3.0	2.7	3.0	2.5	2.6	2.5

MS23027	ABRASIVES AND CUTTING TOOLS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1 Introduce natural and synthetic raw materials used in abrasives.
2 Impart knowledge on the manufacture of coated and bonded abrasives.
3 Explain the principle, working and applications of grinding, polishing and cutting tools.

UNIT I ABRASIVE RAW MATERIALS AND COATED ABRASIVES 10

Abrasives – definition, classification, applications. Abrasive grains – classification, characteristics like hardness, toughness, bulk density etc. Backings; Binders- temporary and permanent. Selection of abrasives for various processes; Lifecycle and sustainability Manufacturers.

Coated Abrasives - Raw material selection and preliminary treatments, maker coating, abrasive coating, conversions – slitting, belt making, sheet cutting, disc cutting. Individual disc coating process; Applications. Quality control and testing- Manufacturers.

UNIT II BACKUPS 8

Contact wheels – cloth contact wheels, rubber contact wheels, hardness, face serrations, shape, wheel diameter, speed, belt tension, dressing and protection of contact wheels – their characteristics.

Drum, rolls, pads and platens – types, characteristics, choice and uses. Working principle of coated abrasive products.

UNIT III MANUFACTURE OF BONDED ABRASIVES 9

Abrasive grain type and characteristics required for bonded abrasives. Types of bonds – vitrified, silicate, resinoid, shellac, rubber and oxychloride. Bonded wheel manufacture - different bonds, Reaction at temperatures, characteristics. Shapes and sizes of wheels, Applications.

Factors determining grinding action – characteristics of abrasive grain, bond type, structure. Wheel losses- cracks, pin holes, boils. Other types of wheels – Diamond wheels, reinforced wheels, mounted wheels. Selection of appropriate abrasive wheels for grinding metals and non-metals – Industries

UNIT IV BASICS OF GRINDING AND POLISHING 9

Grinding wheel – definition, Nomenclature, grinding chips, G ratio, chemical reactions, grade selection, wheel wear and chemical grinding aids. Safe grinding practices.

Grinding fluids – properties, types and purpose. Types of grinding – cylindrical grinding, center less grinding, surface grinding, internal grinding. Polishing – definition, types.

UNIT V CUTTING TOOLS 9

Introduction, types -Ceramic cutting tools - Oxide ceramics. Whiskered ceramics. Silicon nitrides, carbides. SiAlon –Properties, Parameters.

Drilling cutters, milling cutters, tool inserts, coatings on cutting tools; selection of tool & tool life calculations, cost analysis. Lifecycle and sustainability of abrasive tools.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1	Identify a suitable abrasive for a given process.
CO2	Understand the need / selection for a contact wheel, its storage and protection.
CO3	Recognize an appropriate bonded abrasive product for a given application.
CO4	Apply a suitable grinding/polishing/cutting tool for a selected material to be grinded.
CO5	Evaluate the tool life and cost analysis for cutting tool & inserts.

TEXT BOOKS

1. Alfred Broadhead Searle **, (**2010 **) "**The Manufacture and Uses of Abrasive Materials: A Concise Treatment of the Nature and Preparation of Raw Materials, and the Manufacture of Abrasive Blocks, Wheels, Papers, Cloths, Polishes", sir I. Pitman & Sons, Limited, 1922,
2. Ioan.D.Marinescu et al, "Handbook of machining with grinding wheels" CRC Press,2016**.**

REFERENCES

1. Barbara Linke, "Lifecycle and sustainability of abrasive tools" Springer, 2016.
2. Stephen Malkin, "Grinding technology, Theory and applications of machining with abrasives", Industrial press, 2008.
3. Standards Australia Ltd., Staffs, "Bonded Abrasive Products, Permissible Unbalances of Grinding Wheels as Delivered: Static Testing" Standards Australia & New Zealand publishers 2006.
4. Mark J Jackson, J Paulo Davim, "Machining with abrasives" Springer, 2011.
5. Mark J. Jackson, Michael P. Hitchiner, "High Performance Grinding and Advanced Cutting Tools", Springer, 2012.

COURSE ARTICULATION MATRIX

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	-	3	2	2	3	-	-	-	-	-	-	-	-	3	3
2	-	2	2	2	2	-	-	-	-	-	-	-	-	3	-
3	-	2	3	3	3	-	-	-	-	-	-	-	-	3	-
4	-	3	2	3	2	-	-	-	-	-	-	-	2	3	2
5	-	3	3	3	3	-	-	-	-	-	-	-	2	3	-
Avg	-	2.6	2.4	2.6	2.6	-	-	-	-	-	-	-	2	3	2.5

MS23028	METALS AND ALLOYS FOR HIGH TEMPERATURE APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main objective of the course is to provide a comprehensive foundation in metals and alloys for high temperature applications, covering essential theoretical concepts, practical considerations, and emerging trends in the field.

UNIT I INTRODUCTION TO HIGH TEMPERATURE APPLICATIONS 9

Need of high temperature applications in metallurgy-Importance of high temperature materials in industries (aerospace, power generation, etc.)-Challenges and requirements for materials at high temperatures- Overview of key properties required (high temperature strength, oxidation resistance, creep resistance, etc.)

UNIT II HIGH TEMPERATURE ALLOYS: COMPOSITION AND MICROSTRUCTURE 9

High temperature deformation mechanisms (creep, fatigue, plasticity)-Measurement and evaluation of high temperature mechanical properties-Role of microstructure in mechanical behavior at elevated temperatures-Design considerations for high temperature applications

UNIT III MECHANICAL PROPERTIES AT HIGH TEMPERATURES 9

Abrasive grain type and characteristics required for bonded abrasives. Types of bonds – vitrified, silicate, resinoid, shellac, rubber and oxychloride. Bonded wheel manufacture - different bonds, Reaction at temperatures, characteristics. Shapes and sizes of wheels, Applications.

Factors determining grinding action – characteristics of abrasive grain, bond type, structure. Wheel losses- cracks, pin holes, boils. Other types of wheels – Diamond wheels, reinforced wheels, mounted wheels. Selection of appropriate abrasive wheels for grinding metals and non-metals – Industries

UNIT IV OXIDATION AND CORROSION RESISTANCE 9

Mechanisms of oxidation and corrosion at high temperatures-Factors influencing oxidation and corrosion resistance-Protective coatings and surface treatments-Case studies and examples from industrial applications.

UNIT V EMERGING TRENDS IN HIGH TEMPERATURE MATERIALS 9

Emerging materials for extreme environments (intermetallics, ceramic-metal composites, etc.)-Advances in processing technologies (powder metallurgy, additive manufacturing)-Sustainability and environmental considerations in high temperature materials-Future directions and challenges in the field.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1: Explain the importance of the high temperature materials in industries.
CO2: Interpret the influence of microstructure in mechanical behavior at elevated temperatures.
CO3: Select appropriate abrasive materials for wheels used for grinding metals and non-metals.
CO4: Discuss the effect of the various parameters on oxidation and corrosion resistance.
CO5: Explore the emerging materials for extreme environments.

TEXTBOOKS:

1. William D. Callister Jr. and David G. Rethwisch, “Materials Science and Engineering: An Introduction "John Wiley and Sons, 9th edition, 2013
2. George Y. L. Shen, "High Temperature Alloys for Gas Turbines and Other Applications",Springer Science & Business Media, 1986

REFERENCE BOOKS :

1. G.W. Meetham, M.H. Van de Voorde, "Materials for High-Temperature Engineering Applications" 2000th edition, Springer, 2012.
2. "Mechanical Behavior of Materials at High Temperatures" by C. T. Sims et al.
3. David John Young, "Oxidation of Metals" Elsevier Corrosion Series 1, 2011.
4. "High-Temperature Alloys: Design and Applications" by Chris J. Simkin
5. Fujio Abe, Torsten-Ulf Kern, R Viswanathan, "Creep-Resistant Steels" , Woodhead Publishing in materials, Elsevier, 2008.
6. David John Young,"High-Temperature Oxidation and Corrosion of Metals" Elsevier Science, 2016.

COs- POs & PSOs MAPPING

COs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	2	2	3							2	2	3	3
2	3	2	2	2	2							2	2	3	
3	3	2	3	3	3							2	2	3	
4	3	3	2	3	2							2	2	3	2
5	3	3	3	3	3							2	2	3	
Avg.	**3**	**2.6**	**2.4**	**2.6**	**2.6**							**2**	**2**	**3**	**2.5**

MS23029	MATERIALS SELECTION AND DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To impart knowledge on different criteria of selecting the materials, processes for designing engineering components.

UNIT I MATERIAL SELECTION IN DESIGN 9

Introduction, types of design-**morphology of design process-** relation of materials selection **to design**, general criteria for selection-conceptual design and embodiment design, performance characteristics of materials, materials selection process, design process and materials selection, material property chart, material performance indices, materials selection procedure-**case studies –ethical consideration in design. Compliance & Regulatory requirements.**

UNIT II MATERIALS PROCESSING AND DESIGN 9

Classification of manufacturing processes, types of manufacturing systems, Role of Processing in Design, influence of material on process selection-**case studies**. Design for manufacturability, Design for Assembly, **Design for Environment,-Design for Sustainability-material selection and design-Guidelines**

UNIT III MANUFACTURING CONSIDERATIONS IN DESIGN 9

Surface finish, texture, Standardization, Interchangeable manufacturing, Selective assembly, selection of materials based on mechanical properties - Preferred numbers, Limits, fits and tolerances, Types of fits and tolerances, **Shaft basis system and Hole basis system**-Geometric tolerance, types of form and position tolerances, tolerance and manufacturing methods, selection of fits

UNIT IV MATERIALS PROPERTIES AND DESIGN 9

Stress - Strain diagram, **design for strength, rigidity, stiffness**-design under static loading, stress due to torsion and bending, variable loading, stress concentration, fluctuating stress, eccentric loading – stress concentration. Design examples with shaft design

UNIT V MATERIALS IN DESIGN 9

Design for brittle fracture, **impact of stresses in the design members**-plane strain fracture toughness, fatigue failure, Design criteria, fatigue parameters, infinite, safe life and damage tolerance design –**case studies**, fatigue life prediction, corrosion resistance, forms of corrosion, **materials for corrosion prevention**, Design against wear, types of wear, **materials for wear prevention**, Designing with plastics

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1 Identify criteria for material selection in the engineering design process
CO2 Select the different manufacturing processes in design
CO3 Elucidate the manufacturing considerations in design
CO4 Analyze the influence of material properties and the nature of loading on design

CO5 Develop a design procedure for various types of failures for the different applications

TEXT BOOKS:

1. Dieter George E, Engineering Design, Tata McGraw-Hill education, 1991.
2. Michael F Ashby, Materials selection in Machine Design , Butterworth and Heinemann,2010

REFERENCES:

1. Bhandari V B, Design of Machine Elements, 3rd edition, Tata McGraw-Hill Education, 2010
2. Charles J A & Crane F A A, Selection and Use of Engineering Materials, Elsevier, 2013
3. ASM Handbook: Materials Selection and Design, Volume 20, Taylor & Francis,1997
4. Mahmoud M Farag, Materials and Process Selection for Engineering Design, CRC Press, 2013
5. R.K.Bansal, A Textbook of Strength of Materials Paperback – 1 January 2018,Laxmi Publications.

COs- POs & PSOs MAPPING

Cos	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2	3	2		2		3				2	3	2	3
2	3	2	3	2		2	2					2	3	2	3
3	3	2	3	2								2	3	2	3
4	3	2	3	2								2	3	2	3
5	3	2	3	2			2					2	3	2	3
Avg.	3	2	3	2		2	2	3				2	3	2	3

MS23030	METALLURGY OF TOOL MATERIALS AND SPECIAL STEELS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To make the students to gain knowledge on the various types of tool materials, various heat treatments that can be given to tool steels and its effect on the mechanical properties, various methods of testing tool steels and to understand the need for coating the tool materials and its implications.

UNIT I CLASSIFICATION AND MANUFACTURE OF TOOL STEELS 9

Classification – AISI system, selection of tool steels from the point of view of mechanical properties, Effect of alloying elements such as W, Mo, Ni, V, Ti etc., in Tool steels, Production techniques –problems in melting – powder metallurgy route, Refining methods like VAR, ESR– forming of tool steels.

UNIT II HEAT TREATMENT OF TOOL STEELS AND DEFECTS 9

Heat Treatment and Metallurgy OF W, S, O, A & D type tool steels, Water hardening tool steels, shock resistance tool steels, cold work tool steels-oil hardening, medium alloy and high carbon-high Cr(O,A&D types): Constitution, classification of principal types, heat treatment process, hardenability, distortion characteristics, properties and application. Heat Treatment and Metallurgy Of H, T, M, Special Purpose Tool Steels, Hot work tool steels, high speed tool steels, maraging tool steels, special purpose tool steels: constitution, classification of principal types, heat treatment process, specific requirements and applications.

UNIT III PROPERTIES, TESTING AND FAILURE OF TOOL STEELS 9

Mechanical properties of Tool steels with respect to applications – Elevated temperature properties – Microstructures –Carbide distribution –Coating thickness, micro hardness – Adhesion and Scratch resistance. Tool failures – material heat treatment, manufacturing processes and Operational factors.

UNIT IV ADVANCED TOOL MATERIALS 9

Sintered Tungsten Carbide tools – ISO classification, Uses of P, M, K,H,W, S, O, A ,T grades Cermet – ceramics, mixed and reinforced grades –WC, Al_2O_3, SiC , CBN, PCD, TaC, TiC, Solid Carbide tools – Manufacturing techniques, heat treatment and properties, Stellites, Cemented carbides, ceramic tools, Special purpose tool steels

UNIT V SURFACE TREATMENTS AND COATINGS 9

Sulphidizing of tool steels – TiN coating by PVD, coating of Carbide tools –Mono and multilayer Coatings of TiC, TiN, Alumina and DLC by PVD and CVD processes.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1 To classify the various tool materials that are used for engineering applications and understand the influence of various alloying elements on the properties of tool materials

CO2 To select suitable heat treatment for the different tool materials in order to improve the performance of tools.

CO3 To test the tool materials for various properties and analyse on the various possible failures that occur in tools.

CO4 To explain the need for advanced tool materials and the advantages of various special tool materials over conventional tool materials.

CO5 To infer the effect of coating on the tool materials and are exposed to the various possible coating techniques that are available for tool materials.

TEXT BOOKS:

1. George Roberts, George Krauss, Richard Kennedy, “Tool Steels” 5th edition, ASM International,1998.
2. Payson, Peter – “Metallurgy of Tool Steels” – John Wiley & Sons, New York 1962

REFERENCES:

1. Joseph R. Davies – “Tool Materials”, ASM International, 1995
2. Robert Wilson, “Metallurgy and Heat treatment of Tool Steels, McGraw Hill New York,1975

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	1										2	1		
2		3	1										2		
3	3	1		2									1		
4	3				2									1	
5	3		1												2
Avg.	3	1.67	1	2	2								1.33	1	2

MS23031	LASER PROCESSING OF MATERIALS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The objective of the course is to impart knowledge about the principles of industrial lasers such as laser generation, mode selection, beam mechanisms, modifications and characteristics, types of lasers etc. Also to introduce the concepts of laser processing of materials which includes background of laser systems, process parameters, material considerations and specific applications.

UNIT I PRINCIPLES OF INDUSTRIAL LASERS 9

Principle of laser generation, Simulated and spontaneous emissions, Einstein's coefficients, Population inversion, optical resonators, laser modes- mode selection, laser pumping, Rate equation, line- broadening mechanisms, laser beam modifications, types of industrials lasers, Solid state lasers, Gas lasers and semiconductor laser.

UNIT II THERMAL PROCESS – HEAT AND FLUID FLOW 9

Heat flow in the work piece, Temperature distribution: thick plate with point heat source, thin plate with line heat source, peak temperature, cooling rates and Gaussian heat source. Fluid flow in molten pool: continuity equation, Navier-Stokes equation and surface tension effects.

UNIT III LASER METALLURGY 9

Process microstructure- fusion zone, zone of partial melting, HAZ. discontinuities- porosity, cracking, lack of fusion, incomplete penetration and undercut

UNIT IV LASER WELDING AND SURFACE MODIFICATIONS 9

Laser welding parameters, Laser efficiency, Process mechanisms (Key hole and Plasmas), Material considerations, imperfections and industrial applications. Recent developments Laser surface modifications: Laser surface heat treatment, Laser surface melting- Glazing, Laser direct Metal deposition– Laser surface alloying, Laser surface cladding and Hard coatings, Laser physical vapour deposition and Laser shock peening.

UNIT V LASER MACHINING 9

Laser instrumentation for cutting and drilling, cut quality and process characteristics, methods of cutting material consideration, practical performance, process variations, industrial applications of Laser cutting and drilling. New developments- Micromachining.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1 Apply the Laser principles in the processing of engineering materials
CO2 Explain the heat flow and temperature distribution in the laser processing of materials
CO3 Analyze the influence of metallurgical factors during the laser processing of materials.
CO4 Appraise the laser welding and various surface modification techniques.
CO5 Assess the laser instrumentation and influence of parameters while laser machining.

REFERENCES:

1. Guo Chunlei, and Subhash Chandra Singh.,“Handbook of Laser Technology and Applications: Lasers Applications: Materials Processing and Spectroscopy”, Vol. 3. CRC Press, 2021.
2. Perrière Jacques, Eric Millon and Eric Fogarassy., "Recent advances in laser processing of materials.", European Materials Research Society, 2006.
3. Dahotre Narendra B., and Sandip Harimkar.,“Laser fabrication and machining of materials”, Springer Science & Business Media, 2008.
4. Akinlabi Esther Titilayo, Rasheedat Modupe Mahamood, and Stephen Akinwale Akinlabi., “Advanced manufacturing techniques using laser material processing”, IGI Global, 2016.

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3		3									1	3		3
2	3	3	3									1	3	3	3
3	3	3	3									1	3	3	3
4	3	3	3									1	3	3	3
5	3	3	3									1	3	3	3
Avg.	3	3	3									1	3	3	3

MS23032 MAKING AND METALLURGY OF STAINLESS STEELS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- The main objective of this course is to prepare the students to gain a comprehensive knowledge on various aspects of Stainless steel making, metallurgy, their properties and its applications.

UNIT I HISTORY AND EVOLUTION OF STAINLESS STEEL 9

Essential elements, evolution, Earlier production processes, Wild process, Rustless process, development of alloys, Effect of alloying elements on properties of Stainless Steels. selection of Stainless steels, Recent processing enhancements. Some Metallurgical Principles., Naming and numbering of Stainless steels.

UNIT II CLASSIFICATION AND HEAT TREATMENT 9

Wrought and Cast Stainless steels – Ferritic, Martensitic, Austenitic, Cr-Ni-Mo Stainless steels, Precipitation Hardened, Duplex, Heat Resistant, Abrasive and Wear resistant steels-Composition, Metallurgy, Properties, Phase Diagrams, Fretting and Galling, Welding and Weldability of Stainless steels. Relevance of Nickel equivalent and Chromium equivalent, The Schaeffler–Delong diagram, Role of alloying elements in ferrite and austenite stabilization, Heat treatment of stainless steels-ferritic, martensitic, austenitic, duplex, precipitation hardenable, Ti- and Nb- stabilized grade stainless steels. Precipitation reaction in stainless steels,

UNIT III MELTING AND SECONDARY REFINING OF STAINLESS STEELS 9

Raw Materials selection, Melting Furnaces (EAF, EIF), melt treatment, Laser powder bed fusion of stainless steels, Continuous casting, secondary refining –AOD, VOD, IOC converters processing, advantages and limitations, Final processing of heat treatable and non-heat treatable stainless steel.

UNIT IV CORROSION BEHAVIOUR OF STAINLESS STEELS 9

Microbiologically Induced Corrosion (MIC), Atmospheric, aqueous, stress corrosion, cracking and Hydrogen Embrittlement, High Temperature corrosion, Corrosion of Cast stainless steels, Role of precipitates on corrosion, PREN Index, Corrosion rate estimations- ATM Practices.

UNIT V APPLICATIONS OF STAINLESS STEELS 9

Automotive, Railways & Transport, Architecture, Building & Construction, Reinforcement bars, Roofing sheets, utensils, Furniture, Material Handling applications, Process Industries, Biomedical applications.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

1. Recall the essential elements responsible for the unique properties of stainless steels and the basic metallurgical principles involved.
2. Classify the various types of stainless steels based on the microstructure and the effect of microstructure on the properties of stainless steels.
3. Explain the production methodology of stainless steel making and the influence of the process on the quality of the stainless steel.
4. Interpret the results of corrosion testing and PREN index and understand the influence of the various environmental factors on the corrosion of stainless steels.
5. Identify the suitable stainless steel material for a given application.

TEXT BOOKS:

1. John C. Lippold, Damien J. Kotecki, “Welding Metallurgy and Weldabiiity of Stainless steels”, Wiley and Sons, Edition 2005
2. Jonathan Beddoes, J. Gordon Parr, “Introduction to Stainless Steels”, ASM International, 2000

REFERENCES

1. Donald Peckner, Irving Melvis Bernstein , “Hand Book of Stainless steels”, McGraw Hill, 1977.
2. Joseph R.Davis, “Alloy Digest Source Book: Stainless Steels”, ASM International,2000.
3. Michael F. McGuire , “Stainless steels for Design Engineers”, ASM International,2008
4. R.A. Lula, James Gordon Parr , “Stainless steels”, American Society for Metals, 1996.
5. Source book on Stainless steels, American Society for Metals, 1976.
6. Joseph R. Davis , “Stainless Steels”, ASM International, 3rd print,--1999

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2	2	1	2	2	1					2	3	1	1
2	3	2	2	1	2	2	1					2	3	2	1
3	2	2	1	2	2	1	2					2	3	1	1
4	2	2	2	2	1	2	1					2	3	2	1
5	3	2	2	1	2	2	2					2	3	1	1
Avg.	2.6	2	1.8	1.4	1.8	1.8	1.4					2	3	1.4	1

MS23033	NON-FERROUS METALLURGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main objective of the course is to impart knowledge on the extraction processes, structure, properties and applications of various non-ferrous alloys.

UNIT I COPPER AND COPPER ALLOYS 9

Methods of Extraction of Copper, Properties and applications of metallic copper. Major alloys of copper and designation- Brasses. Phase diagram of industrially relevant portion. Copper, characteristics and uses. Bronzes: Tin bronze. Composition, properties and uses. Other bronzes like Cu-Al, Cu-Si, Cu-Mn and Cu-Be alloys. Cu-Ni alloys. Typical microstructure of copper alloys.

UNIT II ALUMINIUM AND ITS ALLOYS 9

Methods of Extraction of Aluminum- Properties of Pure aluminium. Alloys of aluminium and designation, classification. Wrought and cast alloys. Heat treatable and non-heat treatable alloys. Age hardening of Al-Cu alloy. Al-Mg-Si, Al-Zn-Mg and Al-Li alloys. Typical microstructure of aluminium alloys. Applications of Al alloys in Automobile and Aircraft industries.

UNIT III MAGNESIUM AND TITANIUM ALLOYS 9

Methods of Extraction of Magnesium- properties and uses. Magnesium alloys and designation, Applications. Methods of Extraction of Titanium- unique characteristics of Ti metal- alpha, alpha+beta and beta titanium alloys- major types. Titanium aluminides – their properties and uses. Typical microstructure of magnesium and titanium alloys- Applications of Ti alloys in Aircraft, Chemical and Medical industries.

UNIT IV NICKEL AND ZINC ALLOYS 9

Methods of Extraction of Nickel-Properties and uses of nickel. Nickel alloys and designation– their properties and uses. Nickel aluminides. Methods of Extraction of Zinc-Use of zinc in corrosion protection of ferrous materials. Zinc alloys – properties and uses. Typical microstructure of nickel and zinc alloys, Applications.

UNIT V LEAD, TIN, RE AND PRECIOUS METALS 9

Methods of Extraction of Lead and Tin-Major characteristics and applications of lead and tin and their alloys and designation. Low melting nature of solder alloys. Gold, silver and platinum – nobility of these metals. Engineering properties and applications of these metals and their alloys. Typical microstructure of solder alloys. Rare earth materials-importance, Extraction, applications.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

1. Correlate the structure - property relations of various copper alloys with special emphasis on engineering applications.

2. Compare the various aluminum alloys with respect to their composition, properties and applications.
3. Identify suitable magnesium and titanium alloys fora given application.
4. Classify the different types of Nickel and Zinc alloys.
5. Explain the importance of precious metals, lead and tin alloys, their properties and applications.

TEXT BOOKS:

1. K.G.Budinski and M.K.Budinski," Engineering Materials-- Properties and Selection", PHI Learning Pvt. Ltd., New Delhi, 2010.
2. Sidney H. Avner, "Introduction to Physical Metallurgy", Tata McGraw-Hill, 2nd Edition, 1997

REFERENCES

1. AhindraGhosh, Hem Shanker Ray, "Principles of Extractive Metallurgy", New Age International, Reprint 2001.
2. BalramGupta,"Aerospace Materials", Vol. 1, 2 and 3, S. Chand and Co., New Delhi, 1996.
3. Clark and Varney,"Physical Metallurgy for Engineers", Affiliated East West Press, New Delhi, 1987.
4. W.H. Dennis,"Metallurgy of the Nonferrous Metals", Sir Isaac Pitman and Sons, London,1967
5. William F. Smith,"Structure and Properties of Engineering Alloys", McGraw Hill, USA, 1993

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3		2									2	3	3	3
2	3		2									2	3	3	3
3	3		2									2	3	3	3
4	3		2									2	3	3	3
5	3		2									2	3	3	3
Avg.	3		2									2	3	3	3

MS23034	MANUFACTURING PROCESSES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVE:

- To impart knowledge on metal casting, joining, and forming processes

UNIT I METAL CASTING PROCESSES 9

Sand Casting – Sand Mould – Type of patterns - Pattern Materials – Pattern allowances – Types of sand- sand properties and testing – Cores –Types and applications Basics of gating system – Molding machines – Melting furnaces – Principle of special casting processes- Shell, investment – Ceramic mould–Pressure die casting–Centrifugal Casting- CO_2 casting process Defects in Sand casting process Stir casting– Squeeze casting – Full Moulding –magnetic Moulding- Micro casting -Casting techniques for single crystal components -Casting defects.

UNIT II METAL JOINING PROCESSES 9

Fusion welding processes–Type of Gas welding–Flame characteristics–Filler and Flux materials Arc welding, Electrodes ,Coating and specifications–Principles and types of Resistance welding– Gas Tungsten arc welding- Gas metal arc welding –Cold metal Transfer-Wire arc additive Manufacturing–Thermal spraying- Submerged arc welding – Electro slag welding – Plasma arc welding – Thermit Welding –Electron beam welding -Laser beam welding-Ultrasonic Welding –Friction welding–Friction stir welding–Diffusion bonding Weld defects - Brazing and soldering –– Adhesive bonding.

UNIT III BULK DEFORMATION PROCESSES 9

Hot working and cold working of metals – Forging processes – Open, impression and closed die forging–Characteristics of the processes–Typical forging operations–rolling of metals–Types of Rolling – Flat strip rolling –contour roll forming- shape rolling operations – Defects in rolled parts – Principle of rod and wire drawing–Tube drawing–Principles of Extrusion–Types–Hot and Cold extrusion.

UNIT IV SHEET METAL PROCESSES 9

Sheet metal characteristics–Typical shearing bending and drawing operations–Stretch forming operations – Formability of sheet metal – Test methods –special forming processes – Working principle and applications–Hydro forming–Rubber pad forming– Multi-point Die Forming– Warm/Hot Forming – Solid Granular Medium Forming –Metals pinning-Introduction of Explosive forming magnetic pulse forming, peen-forming, Super plastic-forming –Micro-forming–Incremental forming.

UNIT V MANUFACTURE OF PLASTIC COMPONENTS 9

Types and characteristics of plastics – Molding of thermoplastics – working principles and typical applications – injection molding – Plunger and screw machines – Compression molding transfer molding –Typical industrial applications–introduction to blow-molding–Rotational-molding–Film-blowing– Extrusion–Vacuum bag Forming-Thermo-forming–Bonding of Thermo-plastics.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

- Explain the working principles of various metal casting processes.
- Categorize and select the appropriate metal joining process.
- Compare the working principles of bulk deformation of metals.
- Suggest suitable sheet metal forming processes for production of Engineering Components.
- Explain the manufacturing of plastic components.

TEXTBOOKS:

1. Kalpakjian.S, "Manufacturing Engineering and Technology", Pearson Education India Edition,8th edition 2020.
2. Rao.P.N., Manufacturing Technology Foundry, Forming and Welding,5thEdition.Tata McGraw Hill, 2018.

REFERENCES:

1. Gowri.S, P.Hariharan, A.SureshBabu, Manufacturing Technology, Pearson Education,2008.
2. R.K.Jain Production Technology Manufacturing Systems Vol –I K.hanna Publishers
3. Paul DegarmaE., BlackJ.T.and Ronald A.Kosher, Materials and Processes, in Manufacturing, Eight Edition, Prentice Hall of India,1997.
4. Sharma, P.C.,A Textbook of Production Technology, S.ChandandCo.Ltd.,2006.
5. Roy.A.Lindberg, Processes and materials of manufacture, PHI / Pearson Education,2006.

COs- POs & PSOs MAPPING

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	2	2	-	-	2	1	-	-	-	1	3	2	3
2	3	3	2	2	-	-	2	1	-	-	-	1	3	2	3
3	3	3	2	2	-	-	2	1	-	-	-	1	3	2	3
4	3	3	2	2	-	-	2	1	-	-	-	1	3	2	3
5	3	3	2	2	-	-	2	1	-	-	-	1	3	2	3
Avg.	3	3	2	2	-	-	2	1	-	-	-	1	3	2	3

COURSES FOR HONOUS DEGREE

MS23035	ENERGY ABSORBING MECHANISMS AND MATERIALS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main objective of the course is to impart knowledge on the various mechanisms of energy absorption and the materials that are used in defence for absorption of energies.

UNIT I BALLISTICS **9**

Ballistics – Types of Ballistics, Failure Mechanism, Penetration Analysis, Kinetic Energy calculation of projectile, Types of Armour Materials – Metallic, Composites and Hybrid composites, Ceramic and Transparent Armour, Properties of Armour. Reactive and Active Armour.

UNIT II MINE BLAST AND PROTECTION **9**

Mine Blast and protection – Types of mine blast and it effect on military vehicles and human. Mine blast shock attenuation methods and mechanisms. Types of materials, combination of materials and its structure to attenuate the magnitude of the mine blast shock.

UNIT III ELECTROMAGNETIC SPECTRUM **9**

Introduction to Electromagnetic spectrum, different wave lengths and its application in Military Application. Sound Attenuation – Properties of sound and attenuators, Design variations and Noise Control.

UNIT IV RADAR ABSORBING MATERIALS **9**

Radar Absorbing Materials (RAM) – Introduction, classifications, RAM matrices and Fillers. Radar Cross Section, Reflection coefficient, Transmission Co-efficient. RAM attenuation mechanism, different RAM absorbing materials – Types and structures, Anechoic chamber, shielding materials, Composites, Metal Nano-tubes,

UNIT V ELECTRO MAGNETIC INTERFERENCE / ELECTRO MAGNETIC COMPLIANCE **9**

Electro Magnetic Interference / Electro Magnetic Compliance (EMI/EMC) – Sources of EMI, Design parameters – Trace Spacing and layers, Ground Planes, Shielding, Arrangement of PCB layers, Decoupling capacitors

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1: Differentiate different types of ballistics and armour materials.
CO2: Suggest suitable design for attenuating the magnitude of the mine blast shock.
CO3: Explain the significance of wavelengths and sound attenuation in military applications
CO4: Discuss the radar absorbing materials and their attenuation mechanisms.
CO5: describe the effect of design parameters on the electromagnetic shielding.

TEXT BOOKS:

1. G Lu, T X Yu, Energy Absorption of Structures and Materials, Woodhead Publishing Series

in Metals and Surface Engineering, 2003.
2. Ian Crouch, “The Science of Armour Materials”, Elsevier Science, 2016.

REFERENCES:

1. Valentina Lopresto, Langella Antonio, Abrate Serge, “Dynamic Response and Failure of Composite Materials and Structures”, Elsevier Science, 2017.
2. Thomas H. Courtney, “Mechanical Behaviour of Materials”, second edition, Waveland Press, 2005.
3. Bruno Castanié, Serge Abrate, Yapa D. S. Rajapakse,”Dynamic Failure of Composite and Sandwich Structures”, Springer Netherlands, 2012.

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	3			2	3					1	3	3	3
2	3	3	3			2	3					1	3	3	3
3	3	3	3			2	3	3				1	3	3	3
4	3	3	3			2	3	3				1	3	3	3
5	3	3	3			2	3	3				1	3	3	3
Avg.	**3**	**3**	**3**			**2**	**3**	**3**				**1**	**3**	**3**	**3**

MS23036 **FINITE ELEMENT ANALYSIS** **L T P C**

3 0 0 3

COURSE OBJECTIVE:

To apply the concepts of the finite element analysis to solve multi-dimensional problems in engineering.

:

UNIT I INTRODUCTION **9**

Historical Background – Mathematical Modeling of field problems in Engineering – Governing Equations – Discrete and continuous models – Boundary, Initial and Eigen Value problems– Weighted Residual Methods – Variational Formulation of Boundary Value Problems – Ritz Technique – Basic concepts of the Finite Element Method.

UNIT II ONE-DIMENSIONAL PROBLEMS **9**

One Dimensional Second Order Equations – Discretization – Element types- Linear and Higher order Elements – Derivation of Shape functions and Stiffness matrices and force vectors- Assembly of Matrices - Solution of problems from solid mechanics including thermal stresses- heat transfer. Natural frequencies of longitudinal vibration and mode shapes. Fourth Order Beam Equation – Transverse deflections and Transverse Natural frequencies of beams.

UNIT III TWO DIMENSIONAL SCALAR VARIABLE PROBLEMS **9**

Second Order 2D Equations involving Scalar Variable Functions – Variational formulation –Finite Element formulation – Triangular elements and Quadrilateral elements- Shape functions and element matrices and vectors. Application to Field Problems - Thermal problems – Torsion of Non-circular shafts.

UNIT IV TWO DIMENSIONAL VECTOR VARIABLE PROBLEMS **9**

Equations of elasticity – Plane stress, plane strain and axisymmetric problems– Constitutive matrices and Strain displacement matrices – Stiffness matrix – Stress calculations - Plate and shell elements.

UNIT V ISOPARAMETRIC FORMULATION AND ADVANCED TOPICS **9**

Natural co-ordinate systems – Isoparametric elements – Shape functions for isoparametric elements– One and two dimensions – Serendipity elements – Numerical integration - Meshing techniques - Introduction to Analysis Software-Introduction to Non Linearity.

TOTAL:45 PERIODS

COURSE OUTCOMES:

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

CO1 Develop mathematical models for Boundary Value Problems and their numerical solution

CO2 Formulate the Finite Element methodology to solve the one-dimensional problems.

CO3 Estimate field variables for two-dimensional scalar variable problems

CO4 Determine field variables for two-dimensional vector variable problems

CO5 Apply the Iso-parametric transformation and use the numerical integration technique for engineering problems.

TEXT BOOKS:

1. Rao, S.S., “The Finite Element Method in Engineering”, 6th Edition, Butterworth-Heinemann,2018.

REFERENCES:

1. David Hutton, “Fundamentals of Finite Element Analysis”, Tata McGrawHill, 2005
2. Dhanaraj. R and Prabhakaran Nair. K, “Finite Element Analysis”, Oxford Publications, 2015.
3. Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt, “Concepts and Applications of Finite Element Analysis”, 4th Edition, Wiley Student Edition, 2004.
4. Seshu.P, “Text Book of Finite Element Analysis”, PHI Learning Pvt. Ltd., NewDelhi, 2012.
5. TirupathiR.Chandrupatla and Ashok D. Belegundu, “Introduction to Finite Elements in Engineering”, International Edition, Pearson Education Limited, 2014.

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	2	2	2	-	-	1	-	-	2	1	3	2	2
2	3	3	3	3	2	-	-	1	-	-	1	2	3	2	2
3	3	3	3	2	3	-	-	1	-	-	2	2	3	2	2
4	3	3	3	3	2	-	-	1	-	-	1	2	3	2	2
5	3	3	2	2	3	-	-	1	-	-	2	1	3	2	2
Avg	3	3	2.6	2.4	2.4	-	-		-	-	1.6	1.6	3	2	2

MS23037 MODELLING AND SIMULATION IN MATERIALS ENGINEERING L T P C
3 0 0 3

COURSE OBJECTIVES:

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

1. Getting introduced to the different mathematical concepts related to modeling of materials
2. Acquiring knowledge on solving one dimensional problems related to heat transfer
3. Solving two dimensional problems related to heat transfer
4. Getting introduced to the different software packages and their capabilities in solving material processing problems
5. Understanding the computer applications in physical metallurgy

UNIT I INTRODUCTION TO MODELING AND MATHEMATICAL CONCEPTS 9

Mathematical modeling, physical simulation, advantages and limitations - Review of differential equations, numerical methods, introduction to FEM, FDM- Governing differential equations of elastic, plastic deformation, fluid flow and heat transfer – basic steps in FEM.

UNIT II ONE DIMENSIONAL PROBLEMS 9

Classical Techniques in FEM – Weighted residual method – Galarkin and Ritz method – Coordinates and shape functions- Potential energy approach –– Assembly of stiffness matrix and load vector – Finite element equations – Quadratic shape functions – Applications to elastic deformation of bar, plane trusses and beam – steady state heat transfer.

UNIT III TWO DIMENSIONAL AND AXISYMMETRIC CONTINUUM 9

Triangular and quadrilateral elements – Natural co-ordinates – Isoparametric formulation- 2D shape functions - Element stiffness matrix – Force vector – Solution procedure, Gaussian elimination and Cholskey decomposition techniques - Axisymmetric formulation - Boundary conditions – Applications in 2D elastic deformation and heat transfer problems.

UNIT IV SOFTWARE PACKAGES 9

Introduction to standard software packages – General purpose FEA packages– Special purpose packages for simulation of rolling, forging and casting simulations. - Applications of FEA in simulation of sheet metal and bulk forming, solidification of casting and weldment, Concepts of coupled analysis

UNIT V COMPUTER APPLICATIONS IN PHYSICAL METALLURGY 9

Use of computers for the construction of phase diagrams, Expert system for alloy design and selection of materials – computer applications in crystallography

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Apply numerical techniques to a variety of materials process including solidification, heat treatment, grain from the recovery stabilization
2. Solve one dimensional problems related to heat transfer
3. Solve two dimensional problems related to heat transfer

4. Able to evaluate the capabilities and limitation of commercial software
5. Explain the computer applications in physical metallurgy

TEXT BOOKS

1. AMIE, “Modeling of casting and welding process”, Volume I & II, the Metallurgical society of AMIE, 1981&1983
2. Reddy J. N., “An Introduction to Finite Element Method”, McGraw-Hill International Student Edition, 1985

REFERENCES

1. Cerjak H., “Mathematical Modeling of Weld Phenomenon-2”, The Institute of Materials, 1995
2. Cerjak H., “Mathematical Modeling of Weld Phenomenon-2”, The Institute of Materials, 1995
3. Piwonoka T.S., Vollen V., Katgerman I., “Modeling of Casting, Welding, and Advanced Solidification Process”, 4th edition, TMS-AIME, USA, 1993
4. Stocks G.M., Turchi P.E.A., “Alloy Modeling and Design”, the Metals Society, AMIE, USA, 1994
5. Trivedi R., Sekhar J.A., Majumudar J., “Principles of Solidification and Material Processing”, Volume I&II, Oxford and IBH, New Delhi, 1989

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

MS23037	MATERIALS FOR ADDITIVE MANUFACTURING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The objective of the course is to inculcate knowledge on the working principles of different additive manufacturing processes and various materials used in additive manufacturing.

UNIT I ADDITIVE MANUFACTURING PROCESSES 9

Additive Manufacturing Process Chain - Classification - Application Case Studies:Polymer Powder Material - Polymer Liquid Materials - Metal Powder Materials - Metal Wire Materials - Ceramic Powder Materials

UNIT II POLYMER MATERIALS FOR ADDITIVE MANUFACTURING 9

Powder Materials: Selective Laser Sintering Processing Mechanism of Polymer and its Composite - Preparation, Composition, and Characterization of Polymers and Their Composite and Nylon- Styrene based Amorphous Polymer- Polycarbonate - Acrylonitrile Butadiene Styrene.

Liquid Materials: Stereolithography Apparatus Formed Photopolymer: Stereolithography Apparatus Material - Reaction Mechanism - Characteristic Parameters of Photopolymer and Ultraviolet Light Source - Characteristics of Photopolymer Materials and their Stereolithography Apparatus Formability.

Filament Materials: Fused Deposition Modeling Principle and Process of Polymer Materials - Support Materials: Break-Away Support Materials- Water-Soluble Support Materials.

UNIT III METAL MATERIALS FOR ADDITIVE MANUFACTURING 9

Common Metal and Alloy Powder Materials for Additive Manufacturing - Forming Mechanisms of Metal Materials - Metal Powder for Selective Laser Melting: Effects of Powder Particle Size, Sphericity, Oxygen Content - Formability - Metallurgical Characteristics - Surface Roughness and Dimensional Accuracy of Formed Parts - Microstructure Characteristics and Mechanical Properties.

UNIT IV BIO AND ECO-FRIENDLY MATERIALS IN ADDITIVE MANUFACTRING 9

Introduction to Biomaterials - Metallic Biomaterials - Ceramic Biomaterials - Polymeric Biomaterials - Composite Biomaterials - Biodegradable Polymeric Biomaterials - Tissue-Derived Biomaterials - Materials for Sustainability - Eco-Friendly and New Age Energy Efficient and Smart Materials - Alternative Manufacturing Practices - Materials and Selection of Manufacturing Processes - Control on Use of Renewable Materials - Bio-Degradable Materials Recycling of Materials.

UNIT V CERAMIC MATERIALS AND MATERIALS FOR FOUR-DIMENSIONAL PRINTING 9

Selective Laser Sintering: Forming Mechanism - Preparation of Ceramic Materials: Ceramic Powders and Binders - Composite Ceramic Powders - Properties.

Four-Dimensional Printing : Polymer Based Composites – Metal Based Composites – Ceramic Based Composites, Cu-Al-Ni And Cu-Zn-Al Based Shape Memory Alloys – Double Network Hydrogel Reinforced By Carbon Nanotubes – Acrylate Based Shape Memory Polymer.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1 Discuss on the various additive Manufacturing processes.
CO2 Identify suitable polymeric material for producing 3 D printed products.
CO3 Suggest suitable materials for metal additive manufacturing.
CO4 Select the suitable bio and Eco friendly material for sustainable additive manufacturing
CO5 Explain the concepts and materials involved in 4 D printing.

TEXT BOOKS:

1. Yusheng Shi, Chunze Yan, Yan Zhou, Jiamin Wu, Yan Wang, Chen Ying "Materials for Additive Manufacturing" Academic Press 2021
2. Jing Zhang, Yeon-Gil Jung, “Additive Manufacturing: Materials, Processes, Quantifications and Applications”. Elsevier Science, 2018.

REFERENCES:

1. Li Yang, Keng Hsu, Brian Baughman, Donald Godfrey, Francisco Medina, Mamballykalathil Menon, Soeren Wiener "Additive Manufacturing of Metals: The Technology, Materials, Design and Production" Springer 2017
2. Bandar AlMangour" Additive Manufacturing of Emerging Materials" Springer 2019
3. Kun Zhou " Additive Manufacturing: Materials, Functionalities and Applications " Springer 2022
4. David Ian Wimpenny, L. Jyothish Kumar, Pulak M. Pandey,”3D Printing and Additive Manufacturing Technologies”, Springer Nature Singapore, 2018.
5. Chander Prakash, Seeram Ramakrishna, Sunpreet Singh, “Innovative Processes and Materials in Additive Manufacturing”, Elsevier Science, 2022.

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	1	2	2	2							2	3	2	3
2	3	1			2							2	3	2	3
3	3	1			2							2	3	2	3
4	3	1			2		3					2	3	2	3
5	3	1	2	2	2							2	3	2	3
Avg.	3	1	2	2	2		3					2	3	2	3

MS23038	PRODUCT DESIGN AND DEVELOPMENT	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

1. To understand and apply the principles of generic development process; and understanding the organization structure for new product development.
2. To understand and conduct customer need analysis; and to design and set product specification for new product development.
3. To generate, select, and test the concepts for new product development
4. To understand and apply principles of product architecture and industrial design for new product development.
5. To understand and apply the principles in design for manufacturing and prototyping for new product development.

UNIT I INTRODUCTION TO PRODUCT DEVELOPMENT 9

Introduction – Characteristics of Successful Product Development – Product Development Team – Challenges of Product Development – Duration and Cost of Product Development – Product Development Process – Concept Development: The Front-End Process – Adapting the Generic Product Development Process – Product Development Process Flows – Product Development Organizations

UNIT II CUSTOMER NEEDS IDENTIFICATION & PRODUCT SPECIFICATION 9

Identifying Customer Needs – Importance of Latent Needs – Process of Identifying Customer Needs – Definition of Specifications – Time to Establish Specification – Establishing Target Specifications – Setting the Final Specifications.

UNIT III PRODUCT CONCEPT GENERATION, SELECTION & TESTING 9

Activity of Concept Generation – Concept Selection – Concept Screening – Concept Scoring – Caveats – Concept Testing.

UNIT IV PRODUCT ARCHITECTURE & INDUSTRIAL DESIGN 9

Product Architecture – Definition – Implications – Establishing the Architecture – Delayed Differentiation – Platform Planning – Related System-Level Design Issues – Industrial Design – Assessing the Need for Industrial Design – Impact of Industrial Design – Industrial Design Process – Management of the Industrial Design Process – Assessing the Quality of Industrial Design.

UNIT V DESIGN FOR MANUFACTURING & PROTOTYPING 9

Design for Manufacturing – DFM Process: Estimate the Manufacturing Costs – Reduce the Costs of Components – Reduce the Costs of Assembly – Reduce the Costs of Supporting Production – Consider the Impact of DFM Decisions on Other Factors – Prototyping – Principles of Prototyping – Prototyping Technologies – Planning for Prototypes.

TOTAL:45 PERIODS

LABORATORY

The main objective of this laboratory is to understand and apply the principles and concepts in Product Design and Development for Innovative Product with hands on training.

Each student group (not more than three) have to develop digital and physical prototype models of a new product / existing product with enhanced feature involving the following areas:

- Automotive / Aerospace / Medical / Industrial components.
- Machining / Forming / Casting tool, fixtures, and supplementary components.
- Consumer products

The fabricated models may be in the form of RP models, clay models, sheet metal models or cardboard models etc. The design and development of the product will be reviewed in two stages for awarding internal marks. The end semester examination mark will be based on the project report (Introduction; Literature survey; Methodology; Simulation; Experimentation; Analysis and Discussion; and Conclusion) and their demonstration followed by oral examination of their new product by internal examiner.

TOTAL : 60 PERIODS

COURSE OUTCOMES:

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

CO1 Apply the principles of generic development process; and understanding the organization structure for new product development.

CO2 Conduct customer need analysis; and to design and set product specification for new product development.

CO3 Generate, select, and test the concepts for new product development

CO4 Apply principles of product architecture and industrial design for new product development.

CO5 Apply the principles in design for manufacturing and prototyping for new product development.

TEXT BOOKS:

1. Ulrich K.T., Eppinger S. D. and Anita Goyal, “Product Design and Development “McGraw-Hill Education; 7 edition, 2020.

REFERNCE BOOKS:

1. Belz A., 36-Hour Course: “Product Development” McGraw-Hill, 2010.
2. Rosenthal S.,“Effective Product Design and Development”, Business One Orwin,Homewood,1992,ISBN1-55623-603-4.
3. Pugh.S,“Total Design Integrated Methods for Successful Product Engineering”, Addison Wesley Publishing,1991,ISBN0-202-41639-5.
4. Chitale, A. K. and Gupta, R. C., Product Design and Manufacturing, PHI Learning, 2013.
5. Jamnia, A., Introduction to Product Design and Development for Engineers, CRC Press, 2018.

COs	POs												PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2
2	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2
3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2
4	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2
5	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2

ME23C18 GREEN HYDROGEN PRODUCTION STORAGE AND TRANSPORTATION L T P C
3 0 0 3

COURSE OBJECTIVES:

The main learning objective of this course is

1 To impart knowledge about hydrogen properties and its safety
2 To impart knowledge about green hydrogen production techniques
3 To impart knowledge about storing hydrogen under different conditions in different medium
4 To impart knowledge on methods of hydrogen transportation
5 To impart knowledge on hydrogen utilisation for transportation

UNIT – I INTRODUCTION

Properties of hydrogen, safety and storage aspects of hydrogen, hydrogen leakage detection, regulation - codes – standards**.**

UNIT II GREEN HYDROGEN PRODUCTION

Electrolysis fundamentals and various types of Electrolyzers, Hydrogen production from renewables Fundamentals of electrolysis of water, sizing of electrolyzers, electrolysis parameters – current density, pressure, operating temperature, hydrogen purity

UNIT – III HYDROGEN STORAGE

Hydrogen storage fundamentals, underground hydrogen storage, fundamentals of hydrogen compression and expansion, Mechanical and non-mechanical hydrogen compressors Compressed and liquid state storage of hydrogen- thermodynamics, equipment and processes; compressed hydrogen tank types and design considerations, relevant standards.

UNIT – IV TRANSPORT OF HYDROGEN

Hydrogen Transport - different ways of transporting and distributing hydrogen to the point of utilization, current status

of existing methods globally, hydrogen refueling stations-concepts and components

UNIT – V UTILIZATION OF HYDROGEN FOR TRANSPORTATION

Merits and demerits of hydrogen as a fuel for IC engines, Strategies for using hydrogen as fuel in IC engines, hydrogen fuel supply system, Performance – combustion - emission characteristics. Fuels cells for automotive applications – Sizing - Performance evaluation - Parameters affecting the efficiency

COURSE OUTCOMES

On Completion of the course the student will be able to

CO1 Utilise the advantages of hydrogen and adopt appropriate standards

CO2 Generate green hydrogen under various conditions

CO3 Store hydrogen under various conditions in different phases

CO4 Propose transport of hydrogen using different techniques.

CO5 Utilizing hydrogen as fuel in IC engine and fuel cells

TEXT BOOKS

1. Gupta, R. B., Hydrogen Fuel: Production, Transport and Storage, CRC Press, Taylor & Francis Group, 2009.
2. NPTEL :: Chemical Engineering - NOC: Hydrogen Energy: Production, Storage, Transportation and Safety

REFERENCES

1. Global Hydrogen Review 2021, IEA (2021), Paris, https://www.iea.org/reports/global-hydrogen-review-2021
2. AgataGodula-Jopek, Hydrogen Production by Electrolysis, Wiley-VCH, Germany, 2015
3. Tzimas, E., Filiou, C., Peteves, S.D., &Veyret, J.B. “Hydrogen storage: state-of-the-art andfuture perspective. Netherlands”: European Communities, 2003.
4. Michael Hirscher, “Handbook of Hydrogen Storage”, Wiley-VCH, 2010.

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2	2	1							1	2	1	1
2	3	2	2	2	1							1	2	1	1
3	3	2	2	2	1							1	2	1	1
4	3	2	2	2	1							1	2	1	1
5	3	2	2	2	1							1	2	1	1

COURSES FOR MINOR DEGREE

(MATERIALS ENGINEERING)

MS23039	INTRODUCTION TO MATERIALS SCIENCE	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main objective of the course is to impart essential knowledge on materials and to equip the students to select suitable material for a given application.

UNIT I INTRODUCTION TO MATERIALS 9

Introduction to Materials, Historical perspective, scope of materials science and engineering, materials in everyday life, Classification of materials, Modern materials needs.

UNIT II STRUCTURE OF SOLIDS 9

Atomic structure and interatomic bonding. Lattices, basic idea of symmetry. Bravais lattices, unit cells, crystal systems, crystal structures, planes and directions, co-ordination number, Miller indices, close packed planes and directions. Linear and planar densities, simple calculations

UNITIII CRYSTALLINE AND NON-CRYSTALLINE MATERIALS 9

Structure of Crystalline Solids, Single crystals, polycrystalline, non-crystalline, nano crystalline materials. Anisotropy , Polymorphism and allotropy, Ceramic crystal structures, Radius ratio, Polymer crystallinity.

UNIT IV IMPERFECTIONS IN MATERIALS 9

Imperfections in Solids - point defects, vacancies, self interstitials, imperfections in ceramics, line defects-dislocations-types, Interfacial defects- surface defects. Atomic vibrations, defects in polymers.

UNIT V STRUCTURE AND PROPERTIES OF MATERIALS 9

Structure, properties and applications of different, metals and alloys, ceramics and polymers. Influence of structure on the Electrical, magnetic, optical and thermal properties of materials

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1: Classify different types of engineering materials and explain their importance in engineering applications
CO2: Distinguish different types of crystal structures and their significance on the properties of materials
CO3: Differentiate the crystalline and non-crystalline materials and the influence of crystallinity on the properties of materials
CO4: Discuss on the different types of crystal imperfections and their role on the characteristics of materials
CO5: correlate the structure and property of different materials

TEXT BOOKS:

1. Materials Science and Engineering, an Introduction, William D. Callister. John Willey and Sons Inc. Singapore.
2. Physical Metallurgy: Principle and Practice, V. Raghavan. Prentice Hall India, Pvt Ltd.

REFERENCES:

1. Mechanical Metallurgy, George E Dieter. Mcgraw Hill, London.
2. Physical Metallurgy: Principle and Practice, H Sydney Avner Prentice Hall India Pvt Ltd.
3. Physical Metallurgy Principles, Robert E Rehill, Cengage Learning, 2008
4. Physical Metallurgy by Vijendra Singh, Standard Publishers Distributors,2020
5. Modern Physical Metallurgy, RE Small Man, AHW Ngan, Butterworth Heinemann, 2014

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2	1								2	3	3	2
2	3	2	2	2								2	3	3	2
3	3	2	2	2								2	3	3	2
4	3	2	2	2								2	3	3	2
5	3	2	2	2								2	3	3	2
Avg.	**3**	2	**2**	**1.8**								**2**	3	3	2

MS23040	PHYSICS OF MATERIALS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main objective of the course is to provide an understanding of the various approaches used to understand important properties of materials and the relationships between these properties.

UNIT I **9**

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

UNIT II **9**

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

UNIT III **9**

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

UNIT IV **9**

Direct Band gap, indirect Band gap semiconductors; Magnetic properties; Electron compounds/Hume Rothery phases. Phonons, Optoelectronic properties; Superconductivity, Bose-Einstein Statistics; Physics of nano scale materials.

UNIT V **9**

Principles of photoconductivity, luminescence- - photo detectors – Optical disc and optoelectronic materials –LCD, LED and diode laser materials – electro optic modulators - Kerr and Pockel's effect – $LiNbO_3$.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1: Explain the electrical and thermal conductivity of the materials based on the modular, statistical approach
CO2: Discuss the conduction mechanism exhibited by materials based on band gap theory for conducting, semiconducting and insulating materials
CO3: Describe the theory of superconductivity phenomenon and superconducting materials and their applications along with recent advancements
CO4: discuss about photoconduction phenomenon, optical materials and various optical devices

and their performances

CO5: Explain the principles of photo conductivity, and their applications

TEXT BOOKS:

1. David Jiles, “Introduction to electronic properties of materials”, Chapman and Hall, 1994.
2. S.O. Kasap, “Principles of Electrical Engineering Materials” McGraw Hill, 1977.

REFERENCES:

1. Alan Cottrell, “Introduction to the Modern Theory of Metals”, Ashgate Publishing Company, 1988.
2. Ed. Kasap and Capper, “Handbook of electronic and photonic materials”, Springer, 2006.
3. Ashcroft and Mermin, “Solid State Physics”, Saunders College Publishing, 1976.
4. William D. Callister, Jr., “An introduction to Materials Science and Engineering”, John Wiley & Sons, 2003.
5. David R. Gaskell , “Introduction to Metallurgical Thermodynamics”, Hemisphere Publishing, 1981

COs- POs & PSOs MAPPING

COs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2									2	3	2	2
2	3	2	2									2	3	2	2
3	3	2	2									2	3	2	2
4	3	2	2									2	3	2	2
5	3	2	2									2	3	2	2
Avg.	**3**	2	**2**									**2**	3	2	2

MS23041	INTRODUCTION TO MECHANICAL METALLURGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main objective of the course is to inculcate the fundamental concepts of mechanical behavior of materials and to apply them to design the materials for various load-bearing structural engineering applications.

UNIT I ELASTIC AND PLASTIC BEHAVIOUR 9

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

UNIT II STRENGTHENING MECHANISMS 9

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

UNIT III FRACTURE AND FRACTURE MECHANICS 9

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

UNIT IV FATIGUE BEHAVIOUR AND TESTING 9

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

UNIT V CREEP BEHAVIOUR AND TESTING 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1: Identify the role of dislocations and the mechanisms of plastic deformation.
CO2: Explain the strengthening mechanisms of polycrystalline and composite materials.
CO3: Analyze the nature of fracture and its underlying mechanism.
CO4: Appraise the micro-mechanics, factors and life predictions of components under fatigue loading.
CO5: Assess the behavior of materials under high temperature, metallurgical factors and life prediction of high temperature materials

TEXT BOOKS:

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

REFERENCES:

1. Bhargava A K & Sharma C P, "Mechanical behavior and Testing of materials" PHI learning2011.
2. Norman E Dowling, "Mechanical Behaviour of Materials, Pearson 2013.
3. Prashant Kumar, "Elements of Fracture Mechanics", McGraw-Hilll, 2009.
4. Shetty M N, Dislocations and mechanical behavior of materials", PHI learning 2013.
5. William F.Hosford., "Mechanical behaviour of Materials", Cambridge University press, 2010.

COs- POs & PSOs MAPPING

COs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	1	1								2	3	2	2
2	3	2	1	1								2	3	2	2
3	3	2	2	1								2	3	2	2
4	3	2	2	2								2	3	2	2
5	3	2	2	2								2	3	2	2
Avg.	**3**	2	**1.6**	**1.4**								**2**	3	2	2

MS23043	MATERIALS CHARACTERIZATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main objective of the course is to provide a broad overview about different techniques available for structural characterization of various materials systems and interpret the results of the various characterization processes.

UNIT I INTRODUCTION TO MICROSCOPY 9

Basic principles of image formation, General concepts of microscopy: resolution. Magnification, depth of field, depth of focus etc. Optical microscopy, Image formation, contrast development, Basic components (light sources, specimen stage, lens system, optical train etc.), Various modes of optical microscopy, Bright field mode (transmission vs. reflection), Contrast enhancing modes (dark field, polarized light, interference contrast, fluorescent microscopy etc.)

UNIT II X-RAY AND ITS PRINCIPLES 9

X-ray production, Electromagnetic radiation, continuous spectrum, characteristic spectrum, X-ray absorption (adsorption edge, excitation voltage, Auger effect etc.), X-ray filters, Intensities of diffracted beams, scattering by single electron (Thomson and Crompton scattering), Scattering by single atom: atomic scattering factor, Intensities of diffracted beams, Scattering from unit cell: structure factor calculation for various crystal systems, Multiplicity factor and temperature factor.

UNIT III X-RAY DIFFRACTION 9

X-ray diffraction profile and analysis, FWHM and line broadening, Crystallite size effect and Scherer formula, Effect of strain (tensile vs. compressive, uniform vs. non-uniform), Amorphous vs. crystalline materials

UNIT IV SCANNING ELECTRON MICROSCOPY 9

General concepts of electron microscopy, Basic components of electron microscope (electron gun, electro-magnetic lenses etc.), Aberrations (chromatic, spherical, astigmatism etc.) and their corrections, Electron-materials interaction (elastic vs. inelastic scattering, coherent vs. incoherent scattering, interaction volume), Scanning electron microscopy (SEM), Working principle in scanning mode, Signal generation: Inelastic scattering (Secondary vs. backscattered electron, Auger electrons, characteristic X-ray emission etc.), Basic components of SEM, Detectors: SE (E-T detector), BSE (scintillator vs. solid state), in-lens detector, Optics of SEM (magnification, pixel, resolution, depth of field), Resolution in SEM (minimum probe size, beam current etc.), Chemical analysis in SEM , EDS and WDS detectors, Imaging and contrast generation in SEM, Topographic imaging (in SE & BSE mode), Compositional imaging (BSE mode)

UNIT V TRANSMISSION ELECTRON MICROSCOPY 9

Transmission electron microscopy (TEM), Image formation and contrast generation (mass-thickness contrast, atomic number contrast, diffraction contrast etc.) , Modes of TEM (bright field, dark field, HAADF, STEM), Electron diffraction in TEM, Scattering of electrons in

crystalline material (Braggs law, zone axis, order of diffraction etc.), Electron diffraction in TEM, Concept of reciprocal lattice, Ewald sphere, diffraction from finite crystal, Diffraction pattern (Single crystal vs. polycrystalline diffraction, selected area diffraction etc.), Indexing of diffraction pattern (camera constant, structure, Application of electron diffraction (DF imaging, dislocation contrast, phase identification etc.)

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1: Explain the techniques of the metallography and analysis the microstructure of materials.
CO2: Describe the techniques of XRD and its principles.
CO3: Interpret and analysis the XRD results.
CO4: Discuss the techniques of electron microscopy and their applications.
CO5: illustrate the techniques of elemental chemical composition and structure of surface

TEXT BOOKS:

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

REFERENCES:

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

COs- POs & PSOs MAPPING

COs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2	2	3							2	3	2	3
2	3	2	2	2	3							2	3	2	3
3	3	2	2	2	3							2	3	2	3
4	3	2	2	2	3							2	3	2	3
5	3	2	2	2	3							2	3	2	3
Avg.	**3**	2	**2**	**2**	**3**							**2**	3	2	3

MS23044	MATERIALS IN INDUSTRIAL APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main objective of the course is to impart Knowledge on the properties of engineering materials and enable the students to select suitable materials for engineering components.

UNIT I CLASSES OF ENGINEERING MATERIALS 9

Evolution of engineering materials, Definition of materials properties, Displaying material properties using materials selection charts, Forces for change in materials selection and design, Materials and the environment. Selection of materials for automotive, aerospace, marine and defence applications.

UNIT II MECHANICAL PROPERTIES FOR MATERIALS 9

Properties of Conventional Materials – Linear and Non-Linear Behaviour – Yielding, Strain Hardening and Fracture – Design for Strength –basis of material selection - Selection strategy, Attribute limits and Material indices, structural index Selection procedure- Materials processing and design processes and their influence on design, Material costs, Availability, Recyclability, Environmental consideration. Computer aided selection.

UNIT III MATERIALS FOR AUTOMOTIVE APPLICATIONS 9

Materials selection for engines: Piston, piston rings, cylinder, Engine block, Connecting rod, Crank shaft, Fly wheels, Gear box, Gears, Clutches. Materials selection for bearings, Bumper, shock absorbers, Materials for electronic devices meant for engine control, ABS, Steering, Suspension, Sensors, temperature sensors for climate control, anti-collision, Anti-fog, Head lamps.

UNIT IV MATERIALS FOR HIGH TEMPERATURE APPLICATIONS 9

Shape Memory Alloys - Fundamentals of Shape Memory Alloy (SMA) Behavior – Phase Transformation – Lattice Structure and Deformation Mechanism – Origin of the One-Way Shape Memory Effect – Stress Induced Martensite and Pseudoelasticity – Two-Way Shape Memory Effect.

Carbon/Carbon composites – Properties & Advantages –Super Alloys – Ceramic Material Systems and Their Properties –– Application of High Temperature Materials in an Aircraft.

UNIT V MATERIALS FOR BIO-MEDICAL APPLICATIONS 9

Nickel – Titanium alloy (Nitinol) – Materials characteristics of Nitinol – martensitic transformations – austenitic transformations – thermoelastic martensitic transformations– classification of SMA alloys- mechanism of magnetic SMA – applications of SMA – continuum applications of SMA fasteners – SMA fibers – reaction vessels, nuclear reactors, chemical plant, etc. – micro robot actuated by SMA – SMA memorization process (Satellite Antenna Applications) SMA blood clot filter – Impediments to applications of SMA – Shape memory polymers– mechanism of shape memory-Primary moulding – secondary moulding– types and applications

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1: Classify different types of materials and their applications.
CO2: Explain the importance of Selection criteria for various components
CO3: Discuss on the different materials used for automotive engines and transmission and Select proper material for Automobile applications.
CO4: Describe the state-of-the-art techniques in material characterization.
CO5: Significance of Shape memory alloys in Engineering applications.

TEXT BOOKS:

1. Gladius Lewis, “Selection of Engineering Materials”, Prentice Hall Inc. New Jersey USA, 1995
2. Titterton.G., Aircraft Materials and Processes, V Edition, Pitman Publishing Co., 1995.

REFERENCES:

1. Sujata V., Bhat., “Biomaterials”, Narosa Publication House, New Delhi, 2002
2. ASM Handbook. “Materials Selection and Design”, Vol. 20- ASM Metals Park Ohio.USA, 1997.
3. ASM Handbook, “Selection of Materials Vol. 1 and 2”, ASM Metals Park, Ohio. USA, 1991.
4. Cantor,“ Automotive Engineering: Lightweight, Functional, and Novel Materials”, Taylor & Francis Group, London, 2006
5. Prasad, N. Eswara, Wanhill, R. J. H Aerospace Materials and Material Technologies – Indian Institute of Metals Series, 2017
6. Buddy D. Ratner (Editor), Allan S. Hoffman (Editor), Frederick J. Schoen (Editor), Jack E. Lemons, “Biomaterials Science: An Introduction to Materials in Medicine”, Academic Press,2nd edition, 2004

COs- POs & PSOs MAPPING

COs	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2									2	3	2	
2	3	2	2									2	3	2	
3	3	2	2									2	3	2	
4	3	2	2									2	3	2	
5	3	2	2									2	3	2	
Avg.	**3**	2	**2**									**2**	3	2	

EMERGING TECHNOLOGY COURSES
SEMESTER V

MS23E01	**ADVANCED SINTERING TECHNOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

The main learning objective of this course is to inculcate knowledge on the basic mechanisms of sintering, types of sintering and their applications.

UNIT I FUNDAMENTALS OF SINTERING 9

Basics of sintering processes - Mechanisms of sintering: diffusion, grain growth, and pore evolution – Driving force and basic phenomena, Types of sintering: solid-state, liquid-phase, and vapor-phase sintering. Variables of Sintering. Kinetics and Mechanisms of densification.

UNIT II ADVANCED SINTERING TECHNIQUES 9

Vacuum Sintering, Microwave sintering - Spark plasma sintering (SPS) -High-pressure sintering techniques- Field-assisted sintering techniques (FAST). Selective Laser Sintering.

UNIT III SINTERING OF ADVANCED MATERIALS 9

Sintering of ceramics, metals, and composites - Effects of additives and dopants - Microstructural control in sintering processes, sintering of ionic compounds, Sintering of electronic ceramics, Sintering of non-material, Ultrahard materials, thin films.

UNIT IV MODELING AND SIMULATION OF SINTERING PROCESSES 9

Thermodynamic modeling - Kinetic modeling of sintering - Computational approaches and software tools for sintering simulation - Mathematical modeling of sintering processes- Simulation techniques: FEM and MD - Case studies on model validation and real-world applications.

UNIT V APPLICATIONS AND FUTURE TRENDS IN SINTERING 9

Sintering in aerospace, biomedical, and electronics applications - Sustainability in sintering technology - Emerging trends: 3D printing and additive manufacturing in sintering

COURSE OUTCOMES:

On Completion of the course, the students will be able to
CO1: Explain the basics of Sintering, their mechanisms and kinetics of sintering
CO2: Discuss on the advanced sintering techniques and their applications
CO3: Indentify suitable sintering technique for advanced materials
CO4: Compute and mathematical model the sintering processes
CO5: Explore the applications of sintering and also the future trends in sintering technology

TEXT BOOKS

1. Zhigang Zak Fang ," Sintering of Advanced Materials" , Woodhead publishing in Materials, 2010.
2. Kang, S. L. (2004). Sintering: Densification, Grain Growth and Microstructure. Netherlands: Elsevier Science.

REFERENCES

1. Science of Sintering: New Directions for Materials Processing and Microstructural Control. (2013). Germany: Springer US.
2. Vorst, G. A. L. v. d. (1994). Modelling and Numerical Simulation of Viscous Sintering. Netherlands: Eindhoven University of Technology.
3. German, R. (2014). Sintering: From Empirical Observations to Scientific Principles. Netherlands: Elsevier Science.
4. Spark Plasma Sintering of Materials: Advances in Processing and Applications. (2019). Switzerland: Springer International Publishing.
5. Advances in Sintering Science and Technology. (2010). Germany: Wiley.
6. Yi, M., Wang, W., Xue, M. *et al.* Modeling and Simulation of Sintering Process Across Scales. *Arch Computational Methods Eng*30, 3325–3358 (2023). https://doi.org/10.1007/s11831-023-09905-0
7. Liu, M. (Ed.). (2018). Sintering Technology - Method and Application. InTech. doi: 10.5772/intechopen.75146

COs-POs &PSOs mapping

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2	2	2								2	3	2	
2	3	2	1	2								2	3	2	
3	3	2	1	2								2	3	2	
4	3	2	1	2								2	3	2	
5	3	2	2	2								2	3	2	
Avg.	3	2	1.4	2								2	3	2	

MS23E02	INDUSTRIAL 5.0 AND IOT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

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

1. Understand the fundamental concepts, principles, and technologies underlying Industry 5.0 and IoT.
2. Acquire knowledge of automation and control systems, including sensors, actuators, PLCs, and SCADA systems.
3. Develop proficiency in industrial robotics, including robot anatomy, kinematics, programming, and material handling.
4. Gain expertise in IoT, including its architectures, applications in various sectors, sensor implementation, communication protocols, and security considerations.
5. Explore advanced topics and emerging trends in Industry 5.0 and IoT, such as AI, machine learning, edge computing, cloud integration, and cyber-physical systems.

UNIT – I INTRODUCTION TO AUTOMATION AND CONTROL SYSTEMS 9

Introduction to automated manufacturing systems, Sensors and actuators in automation, Pneumatic and hydraulic systems, Control using PLCs, Introduction to SCADA, Experiments: Logical circuits, pneumatic and electro-pneumatic circuits, study of PLC and PLC-based electro-pneumatic sequencing circuits,

UNIT – II INDUSTRIAL ROBOTICS AND MATERIAL HANDLING 9

Detroit Automation and material handling systems, Mechanization devices and parts handling, Parts feeding and sensing, Automated Guided Vehicles (AGVs), Industrial robotics: anatomy, drive systems, sensors, kinematics, End effectors and robot programming, Experiments: Visual inspection using computer vision technology, robot programming for pick and place, stacking of objects

UNIT – III INTERNET OF THINGS 9

Introduction to Industry 4.0 and IoT, Digitization and drivers of Industry 4.0, End-to-end digital integration in smart factories, Introduction to IoT and its architectures, IoT applications: smart cities, connected vehicles, healthcare, process monitoring, Experiments: Implementation of IoT for temperature-dependent cooling system, engine management system, machine condition monitoring, and healthcare monitoring

UNIT – IV IOT SENSORS AND COMMUNICATION 9

IoT sensors: RF and wireless sensor modules, power management, IoT communication protocols and networks, Data acquisition and transmission in IoT, Security and privacy considerations in IoT, Experiments: Implementation of IoT sensors and communication for specific applications,

UNIT – V ADVANCED TOPICS AND EMERGING TRENDS 9

Industry 5.0: evolution and key principles, Advanced automation technologies: AI, machine learning, and robotics, Edge computing and cloud integration in IoT, Cyber-physical systems

and their applications, Emerging trends in Industry 5.0 and IoT, Experiments: Exploring advanced automation technologies and trends

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

1. Demonstrate a comprehensive understanding of automation and control systems, including their components, operation, and applications in manufacturing systems.
2. Apply the principles of industrial robotics and material handling to design and implement efficient and reliable automated processes.
3. Design and implement Internet of Things (IoT) solutions, including sensor integration, data acquisition, communication protocols, and security considerations, for real-world applications.
4. Analyze and evaluate the impact of Industry 5.0 and IoT on various industries and sectors, including smart factories, connected vehicles, healthcare, and process monitoring.
5. Explore and assess advanced automation technologies and emerging trends in Industry 5.0 and IoT, such as AI, machine learning, edge computing, cloud integration, and cyber-physical systems.

TEXT BOOKS

1. Frank Lamb, "Industrial Automation: Hands-On", McGraw Hill, 2013.
2. William Bolton, "Programmable Logic Controllers", Elsevier Science, 2011. Elsevier Science, 2018.

REFERENCES

1. Stamatio, Nikolakopoulos, "Introduction to Industrial Automation", CRC Press, 2018.
2. B.R. Mehta, Y. Jaganmohan Reddy, "Industrial Process Automation Systems", Elsevier Science,2014.
3. John J. Craig, "Introduction to Robotics: Mechanics and Control", Pearson Education, 2014.
4. Bruno Siciliano and Lorenzo Sciavicco, "Robotics: Modelling, Planning and Control", Springer, 2010.
5. Grossetete, P., Hanes, D., Henry, J., Barton, R., Salgueiro, G., “IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things”, Pearson Education, 2017.

Mapping of COs with POs and PSOs

COs/POs & PSOs	POs												PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	1	1	0	0	0	0	0	0	1	0	1	1	0	1
CO2	2	1	1	0	0	0	0	0	0	1	0	1	1	0	2
CO3	2	1	1	0	1	0	0	0	0	1	0	1	1	0	2
CO4	2	1	1	0	1	0	0	0	0	1	0	1	1	0	2
CO5	2	1	1	0	2	0	0	0	0	1	0	1	1	0	2
CO/PO & PSO Average	2.0	1.0	1.0	0	1.3	0	0	0	0	1.0	0	1.0	1.0	0	1.8

MS23E03	MACHINE LEARNING IN MATERIALS SCIENCE	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

The main learning objective of this course is to impart knowledge on the various machine learning methods, model assessment techniques, and their applications and case studies in materials science.

UNIT– I FOUNDATIONS OF MACHINE LEARNING IN MATERIALS SCIENCE 9

Basics of linear algebra and probability theory- Overview of machine learning methods: supervised, unsupervised, reinforcement learning - Strengths, and limitations of ML methods in materials science.

UNIT– II LINEAR REGRESSION AND PREDICTIVE MODELING 9

Linear regression for material property prediction - Model assessment techniques: learning curves, error metrics -Normalization, regularization, cross-validation, and over-fitting concepts in ML- Advanced regression techniques: Gaussian process regression.

UNIT–III ADVANCED REGRESSION TECHNIQUES AND OPTIMIZATION 9

Model assessment techniques: learning curves, parity plots, error metrics - Non-linear regression: Gaussian process regression - Bayesian optimization for materials screening and model improvement- Active learning strategies for materials discovery.

UNIT– IV ADVANCED ML METHODS IN MATERIALS SCIENCE 9

Ensemble learning methods (e.g., random forests, gradient boosting) for materials problems-Deep learning applications in materials science: CNNs, RNNs -Evolutionary algorithms and Monte Carlo tree search for materials optimization-Symbolic regression techniques

UNIT– V APPLICATIONS AND CASE STUDIES IN MATERIALS SCIENCE 9

Levels of materials fingerprints: coarse, medium, and fine representations- Efficient design of materials experiments using sampling methods - Case studies illustrating the application of ML in materials science

COURSE OUTCOMES

On Completion of the course the student will be able to

CO1 **Understand the basics of machine learning in materials science**

CO2 Explain the model assessment techniques and their applications

CO3 Optimize materials by using advanced regression techniques

CO4 Discuss on the various advanced methods of machine learning in materials science

CO5 Identify suitable modeling technique for providing solutions for materials design.

TEXT BOOKS

1. "Machine Learning: A Probabilistic Perspective" by Kevin P. Murphy
2. "Introduction to Machine Learning with Python: A Guide for Data Scientists" by Andreas C. Müller and Sarah Guido

REFERENCES:

1. "Pattern Recognition and Machine Learning" by Christopher M. Bishop
2. "Applied Predictive Modeling" by Max Kuhn and Kjell Johnson
3. "Gaussian Processes for Machine Learning" by Carl Edward Rasmussen and Christopher K. I. Williams
4. "Bayesian Data Analysis" by Andrew Gelman et al.
5. "Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville
6. "Ensemble Methods in Data Mining: Improving Accuracy Through Combining Predictions" by Seni and Elder
7. "Materials Informatics: Principles and Applications" edited by Krishna Rajan and James R. Elliott
8. "Introduction to Linear Algebra" by Gilbert Strang
9. "Probability and Statistics for Engineering and the Sciences" by Jay L. Devore
10. "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow" by Aurélien Géron

COs-POs &PSOs mapping

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	2	2	2							3	3	2	
2	3	3	2	2	2							3	3	2	
3	3	3	2	2	2							3	3	2	3
4	3	3	2	2	2							3	3	2	3
5	3	3	2	2	2							3	3	2	3
Avg.	3	3	2	2	2							3	3	2	3

MS23E04	ATOMISTIC MODELING OF MATERIALS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- **The main learning objective of this course is to provide a deep understanding of atomistic modelling techniques and their applications in predicting and understanding the properties of materials at the atomic level, preparing students for advanced research and development in materials science.**

UNIT– I INTRODUCTION TO COMPUTER SIMULATION OF MATERIALS 9

Rational design of materials through simulations- Importance of predicting materials properties from first-principles-Representation of materials in computers using supercells.

UNIT– II ATOMISTIC MODELLING TOOLS 9

Electronic structure modelling tools: Hartree-Fock method and Density Functional Theory (DFT) - Potentials for different materials classes: pair potentials, many-body potentials (e.g., EAM, Tersoff)

UNIT–III ATOMISTIC MODELLING METHODS 9

Machine learning approaches in atomistic modelling-Molecular dynamics simulation methods-Hyperdynamics and accelerated molecular dynamics -Monte Carlo methods and free energy calculations.

UNIT– IV APPLICATIONS TO MATERIALS 9

Calculation of mechanical properties (e.g., elasticity, strength)-Electronic properties (e.g., band structure, electronic density of states)-Optical properties (e.g., absorption spectra, optical constants)-Magnetic properties (e.g., magnetic susceptibility, spin configurations)

UNIT– V ADVANCED TECHNIQUES AND CASE STUDIES 9

Advanced simulation techniques for complex materials (e.g., alloys, nanostructures)-Integration of simulations with experimental data-Case studies demonstrating the application of atomistic modelling to real-world materials problems.

Hands-on Projects: Include practical assignments using simulation software (e.g., VASP, Quantum ESPRESSO, LAMMPS) for students to implement and analyze atomistic models.

COURSE OUTCOMES:

On Completion of the course the student will be able to

CO1: **Give an insight on the computer simulation of materials**
CO2: Elaborate the tools used for electronic structure modelling
CO3: Discuss on the molecular dynamics simulation methods
CO4: Calculate the mechanical, optical, electronic and magnetic properties of materials.
CO5: Implement and analyse the atomistic models.

TEXT BOOKS :

1. "Introduction to Computational Materials Science: Fundamentals to Applications" by Richard LeSar.
2. "Computational Materials Science: An Introduction" by June Gunn Lee and Haeng-Ki Lee

REFERENCES :

1. Density Functional Theory: A Practical Introduction" by David Sholl and Janice A. Steckel
2. "Electronic Structure: Basic Theory and Practical Methods" by Richard M. Martin"Machine Learning for Materials Scientists and Engineers" by Carlos F. Jové Navarro and Ignacio E. Grossmann
3. "Understanding Molecular Simulation: From Algorithms to Applications" by Daan Frenkel and Berend Smit
4. "Computational Materials Science: An Introduction" by June Gunn Lee and Haeng-Ki Lee
5. "Electronic Structure Calculations for Solids and Molecules: Theory and Computational Methods" by Jorge Kohanoff
6. "Simulation and Modeling of Materials" by E. L. Wolf
7. "Computational Approaches in Condensed-Matter Physics and Materials Science" by Richard M. Martin.

COs-POs &PSOs mapping

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	2	2	2							3	3	2	1
2	3	3	2	2	2							3	3	2	1
3	3	3	2	2	2							3	3	2	3
4	3	3	2	2	2							3	3	2	3
5	3	3	2	2	2							3	3	2	3
Avg.	3	3	2	2	2							3	3	2	2.6

OPEN ELECTIVE COURSES

MS23901	INTRODUCTION TO NON-DESTRUCTIVE TESTING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main objective of the course is to inculcate knowledge on the basic principles of various NDT techniques, its applications, limitations, codes and standard and to equip the students with proper competencies to locate a flaw in various materials, products.

UNIT I	INTRODUCTION TO NDT & VISUAL TESTING	9

Concepts of Non-destructive testing-relative merits and limitations-NDT Versus mechanical testing, Fundamentals of Visual Testing – vision, lighting, material attributes, environmental factors, visual perception, direct and indirect methods – mirrors, magnifiers, boroscopes and fibroscopes – light sources and special lighting.

UNIT II	LIQUID PENETRANT TESTING& MAGNETIC PARTICLE TESTING	9

LPT - Principle, types, Procedures, Penetrants and their characteristics, Emulsifiers, Solvent Cleaners / Removers, Developers- properties and their forms, Equipments, Advantages and limitations, Inspection and Interpretation, Applications.

MPT-Principle, Theory of Magnetism, Magnetising current, Magnetisation methods, Magnetic particles, Procedure, Interpretation, Relevant, Demagnetisation – need, methods, Advantages and Limitations, Applications.

UNIT III	EDDY CURRENT TESTING & THERMOGRAPHY	9

Eddy Current Testing: Generation of eddy currents- properties- eddy current sensing elements, probes, Instrumentation, Types of arrangement, applications, advantages, limitations – Factors affecting sensing elements and coil impedance, calibration, Interpretation/Evaluation. Thermography- Principle, Contact & Non-Contact inspection methods, Active & Passive methods, Liquid Crystal – Concept, example, advantages & limitations. Electromagnetic spectrum, infrared thermography- approaches, IR detectors, Instrumentation and methods, applications.

UNIT IV	ULTRASONIC TESTING & ACOUSTIC EMISSION TESTING	9

Ultrasonic Testing-Principle, Basic Equipment, Transducers, Ultrasonic wave, Transmission and Pulse-echo method, Straight beam and angle beam, A-Scan, B-Scan & C-Scan, Advantages& Limitations, Interpretation of Results& Applications, Case study

Acoustic Emission Technique – Introduction, Types of AE signal, AE wave propagation, Source location, Kaiser effect, AE transducers, Principle, AE parameters, AE instrumentation, Advantages & Limitations, Applications.

UNIT V	RADIOGRAPHY TESTING	9

Sources-X-rays and Gamma rays and their characteristics-absorption, scattering. Filters and screens, Imaging modalities-film radiography and digital radiography (Computed, Direct, Real Time, CT scan). Problems in shadow formation, exposure factors, inverse square law, exposure

charts, Penetrameters, safety in radiography.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1: Compare the differences between the various visual inspection techniques and apply the same to the components to be inspected.
CO2: Recognize the importance of Penetrant testing in NDT with the understanding of the procedures involved in the Penetration methods
CO3: Interpret the images and the results obtained from the Thermo graphic technique and the Eddy current testing
CO4: Evaluate and interpret the results obtained in the Ultrasonic inspection and Acoustic Emission technique
CO5:Explain the techniques involved in the Radiographic testing and the various advancements in Radiography.

TEXT BOOKS:

1. Paul E Mix, “Introduction to Non-destructive testing: a training guide”, Wiley, 2nd edition New Jersey, 2005
2. Baldev Raj, T.Jayakumar, M.Thavasimuthu “Practical Non-Destructive Testing”, Narosa Publishing House, 2009.

REFERENCES

1. ASM Metals Handbook, “Non-Destructive Evaluation and Quality Control”, American Society of Metals, Metals Park, Ohio, USA, 2000, Volume-17.
2. Ravi Prakash, “Non-Destructive Testing Techniques”, New Age International Publishers, 1st revised edition, 2010.
3. B. HULL, Vernon John, “Non-Destructive Testing”, Springer New York, 2012
4. Nathan Ida, Norbert Meyendorf, “Handbook of Advanced Nondestructive Evaluation”, Springer International Publishing,2019.

COs- POs & PSOs MAPPING

COs	PO’s												PSO’s		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2	3		2	2	1		1			2	3	2	3
2	3	2	2		2	2	1		1			2	3	2	3
3	2	2	3	2	2	2	2	2	1	2		2	3	2	3
4	2	2	3	2	2	2	1	2	1	2		2	3	2	3
5	3	2	2		2	2	3	3	1	2		2	3	2	3
Avg.	2.6	2	2.6	2	2	2	1.6	2.3	1	2		2	3	2	3

MS23902 MATERIALS CHARACTERIZATION TECHNIQUES

L	T	P	C
3	0	0	3

OBJECTIVES:

- The main objective of this course is to impart knowledge on the various characterization techniques and their importance in materials technology.

UNIT I METALLOGRAPHIC TECHNIQUES 9

Metallurgical microscope - construction and principle of working, specimen preparation, light material interaction, magnification, numerical aperture, resolving power, depth of focus, depth of field, different light sources; lenses aberrations and their remedial measures, Principles of microscopy, Quantitative metallography – Image analysis for grain size distribution and grain/precipitate shape.

UNIT II X-RAY DIFFRACTION TECHNIQUES 9

Basics of X-ray emission from source, electron excitation and X-ray interaction with materials, Properties of X-rays, Bragg's law, Diffraction methods – Laue, rotating crystal, and powder methods. Estimation of crystallite size and strain; residual stress measurement

UNIT III SURFACE ANALYSIS 9

X- ray emission spectroscopy- working, applications, X-ray Photoelectron Spectroscopy (XPS)- working, applications, Auger Electron Spectroscopy (AES)- working, applications.

UNIT IV ELECTRON MICROSCOPY 9

Scanning Electron microscopy - Construction, operation, sample preparations and applications, EDS, transmission electron microscope (TEM), operation, sample Preparations and applications of TEM.

UNIT V THERMAL ANALYSIS 9

DTA – working Principles and applications, DSC – working Principle and application, TGA-working principle and application, TMA –working principle and applications.

TOTAL :45 PERIODS

OUTCOMES:

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

CO1 Analyze the microstructure using optical Microscope
CO2 Discuss the fundamentals of XRD Diffraction
CO3 Explain the various surface analysis Techniques
CO4 Summarize the electron microscopy techniques and their application.
CO5 Discuss the thermal analysis techniques.

TEXTBOOKS:

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

REFERENCES:

1. Brandon D. G, “Modern Techniques in Metallography”, Von Nostrand Inc. NJ, USA, 1986.
2. D. A. Skoog, F. James Leary and T. A. Nieman, “Principles of Instrumental Analysis”, 7thedition, Cengage Learning, 2017.
3. Thomas G., “Transmission electron microscopy of metals”, John Wiley, 1996.
4. Whan R E (Ed), ASM Handbook, Volume 10, Materials Characterisation “, NinethEdition, ASM international, USA, 1986.
5. Yang Leng, Materials Characterization: Introduction to Microscopic and SpectroscopicMethods, Hong Kong University Of Science And Technology, John Wiley & Sons (Asia)Pte Ltd. 2010.
6. Materials characterization, Vol. 10, ASM hand book, 1997.

COs- POs & PSOs MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	**3**	**2**	**2**									2	**2**	**3**	**1**
2	3	**2**	2									2	**2**	**3**	**2**
3	3	**2**	2									2	**2**	**3**	**2**
4	3	**2**	2									2	**2**	**3**	**2**
5	3	**2**	2									2	**2**	**3**	**2**
Avg.	3	**2**	2									2	**2**	**3**	**1.8**

MS23903	FUNCTIONAL MATERIALS AND DEVICES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The main objective of the course is to make the students to gain knowledge on the various functional materials and their application in a broad range of technological devices such as memory cards, displays and telecommunication.

UNIT I BASICS FOR FUNCTIONAL MATERIALS 9

Atomic structure; Order and disorder, Lattices and unit cells, Crystal directions and planes, Non-crystalline structures, Interatomic bonding, Van der Waals solids, Metallic solids, Ionic solids, Covalent solids, Symmetry, Reciprocal space, Structure determination. Lattice vibrations; The continuum approximation, Vibrations of periodic systems, Quantization of vibrational modes: Phonons, Crystal momentum, Heat capacity, Anharmonicity. Static electron systems; Free electron gas, Fermi-Dirac distribution, Electrons in periodic solids, Nearly-free-electron model, Brillouin zones and energy bands, Tight-binding approximation. Dynamic electron systems; Free-electron gas, Periodic solids, Intrinsic semiconductors, Extrinsic semiconductors. Dia- and paramagnetism, ferro- and antiferromagnetism.

UNIT II HOMOGENEOUS REACTIONS AND DIFFUSION 9

Diffusion mechanisms - Mechanical properties of solids - Thermal properties of solids - Heat Capacity - Introduction to thermal properties of solids -Expansion in solids -Negative and zero expansion ceramics – Their applications - Elasticity and compressibility - Viscosity

UNIT III FUNCTIONAL MATERIALS AND MAGNETISM 9

Semiconductor devices – Optical active materials: theory, examples of materials and applications – Dielectrics, piezo- and ferroelectrics: theory, examples of materials and applications

Introduction to magnetism : Magnetic properties of solids - Magnetism at nanoscale - Bulk and man-sized magnetic materials -Characterization of structure and properties of magnetic materials - Giant and Colossal Magnetoresistance - GMR and CMR materials -Spintronics - Spin diode and filters - Spintronics for data storage and energy

UNIT IV FUNCTIONAL DEVICES I 9

Sensors and detectors – Magnetic ,Sensors – Optical and Electrical , Sensors – Thermal , Sensors – VOCs and electrochemical

UNIT V FUNCTIONAL DEVICES II 9

Energy Devices – batteries, Energy devices – supercapacitors, Energy devices – solar cells, Piezoelectric devices

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1: Explain the importance of functional materials.
CO2: Relate properties of functional materials to crystal structure.
CO3: Apply symmetry to explain, classify, and together with tensor description calculate directional properties of materials.
CO4: Explain electronic properties of materials by using band structure analysis.
CO5: contribute to new applications of functional materials

TEXT BOOKS:

1. R. Balasubramaniam ," Callister's Materials Science and Engineering ", Wiley India Pvt. Ltd, 2nd edition, 2014.
2. Chetan Singh Solanki," Solar Photovoltaics: Fundamentals, Technologies And Applications" 3rd Edition, PHI Learning, 2015.

REFERENCES:

1. Hasse Fredriksson, Ulla Åkerlind, "Physics of Functional Materials", Wiley, 2008
2. Charles Kittel,"Introduction to Solid State Physics", Eighth Edition, John Wiley & Sons,2005
3. B D Cullity, "Elements of X Ray Diffraction", Creative Media Partners, LLC, 2018.
4. Neil Ashcroft , N. Mermin, "Solid State Physics", Saunders Collage Publishing, 1976.
5. Anjali Sharma Kaushik , Anjani Kumar Singh, Saluru Baba Krupanidhi, Vinay Gupta, "Advanced Functional Materials and Devices: Select Proceedings of AFMD 2021: 14 (Springer Proceedings in Materials) , 2021.

MS23S01 FUNDAMENTALS OF PRACTICAL MANUFACTURING SKILLS **L T P C**

0 0 4 2

OBJECTIVE

- This course focuses on developing practical skills in key manufacturing processes, including welding, casting, rolling, and drawing.

Lab Exercise

1. **Introduction and Safety Protocols**
   - Introduction to manufacturing processes
   - Lab safety training
   - Overview of lab equipment and tools
2. **Basics of Gas Metal Arc Welding (GMAW) & GAS Tungsten Arc Welding (GTAW)**
   - Principles of GMAW & GTAW
   - Equipment setup and electrode selection
   - Basic welding practice
3. **Welding Techniques and Joint Fabrication**
   - Types of welding joints (butt, lap, T-joints)
   - Hands-on practice welding different joints
4. **Sand Casting**
   - Introduction to sand casting
   - Common casting defects
   - Inspection and testing methods
5. **Rolling Process Fundamentals**
   - Basics of rolling (hot vs. cold rolling)
   - Rolling machine setup and operation
   - Hands-on practice reducing plate thickness
6. **Drawing Process Fundamentals**
   - Fundamentals of wire and rod drawing
   - Drawing machine setup and operation
   - Hands-on practice with metal rods
7. **Integration of Manufacturing Processes**
   - Demonstrate different geometrical shapes using sheet metal
   - Fabricate any complicated structures using different welding processes.
   - Make various mould shapes for the sand casting process.

Lab Equipment and Materials:

- GMAW and GTAW machine
- Sand moulding equipment
- Stir casting machine
- Rolling machine
- Drawing machine
- Safety gear (gloves, goggles, aprons)

TOTAL: 30 PERIODS

OUTCOME

Upon completing of the course students will be able to:

- Demonstrate GMAW and GTAW process
- Analyse casting defects
- Apply Metal forming process

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	2	1			2		1	1	3		3	3	2	2	2
2	2	1			2		1	1	3		3	3	2	2	2
3	2	1			2		1	1	3		3	3	2	2	2
Avg	2	1			2		1	1	3		3	3	2	2	2

MS23S02 PRACTICAL SKILLS ON ADVANCED MATERIALS L T P C

PROCESSING & TESTING TECHNIQUES 0 0 4 2

OBJECTIVE

This course focuses on developing practical skills in advanced materials processing and testing techniques.

Lab Exercise

1. **Advanced Processing Techniques**
    - *Additive Manufacturing*
        - Fundamentals of AM Technology
        - Design-CAD Model preparation
        - Set-up & Operation
    - *Friction Stir processing*
        - Principles of Friction Stir processing
        - Equipment setup and tool selection
        - Hands-on practice for processing
    - *Electromagnetic Forming*
        - Principles of electromagnetic Forming
        - Equipment setup and selection of process parameters
        - Hands-on practice for Forming
    - *Laser Cladding of Materials*
        - Fundamentals of laser deposition
        - Equipment Operation
        - Hands-on-experience on cladding of materials on a substrate
2. **Advanced testing Techniques**
    - *Differential Scanning Calorimetry / Thermogravimetry Analysis*
        - Basics principles of DSC/TGA
        - Instrument set-up and operation
    - *Quantitative Metallography*
        - Quantification of micrographs using Image analysis software
    - *Scanning Electron microscope*
        - Basics principles of SEM
        - Sample preparation technique
        - Instrument set-up and operation
    - *Fatigue testing*
        - Knowledge on fatigue failures
        - Sample preparation
        - Instrument set-up and operation

TOTAL: 30 PERIODS

OUTCOMES

Upon completing of the course students will be able to:

- Demonstrate the advanced manufacturing processes such as AM,FSP,EMF & LC

- Perform microstructural characterisation
- Conduct fatigue testing and thermal analysis of materials

CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	2	1	2	2	3				2		2	3	2	2	2
2	2	1	2	2	3				2		2	3	2	2	2
3	2	1	2	2	3				2		2	3	2	2	2
Avg	2	1	2	2	3				2		2	3	2	2	2

UC23E01 ENGINEERING ENTREPRENEURSHIP DEVELOPMENT

L	T	P	C
2	0	2	3

COURSE OBJECTIVES:

1. Learn basic concepts in entrepreneurship, develop mind-set and skills necessary to explore entrepreneurship
2. Apply process of problem - opportunity identification and validation through human centred approach to design thinking in building solutions as part of engineering projects
3. Analyse market types, conduct market estimation, identify customers, create customer persona, develop the skills to create a compelling value proposition and build a Minimum Viable Product
4. Explore business models, create business plan, conduct financial analysis and feasibility analysis to assess the financial viability of a venture ideas & solutions built with domain expertise
5. Prepare and present an investible pitch deck of their practice venture to attract stakeholders

MODULE – I: ENTREPRENEURIAL MINDSET **4L,8P**

Introduction to Entrepreneurship: Definition – Types of Entrepreneurs – Emerging Economies – Developing and Understanding an Entrepreneurial Mindset – Importance of Technology Entrepreneurship – Benefits to the Society.

Case Analysis: Study cases of successful & failed engineering entrepreneurs - Foster Creative Thinking: Engage in a series of Problem-Identification and Problem-Solving tasks

MODULE – II: OPPORTUNITIES **4L,8P**

Problems and Opportunities – Ideas and Opportunities – Identifying problems in society – Creation of opportunities – Exploring Market Types – Estimating the Market Size, - Knowing the Customer and Consumer - Customer Segmentation - Identifying niche markets – Customer discovery and validation; Market research techniques, tools for validation of ideas and opportunities

Activity Session: Identify emerging sectors / potential opportunities in existing markets - Customer Interviews: Conduct preliminary interviews with potential customers for Opportunity Validation - Analyse feedback to refine the opportunity.

MODULE – III: PROTOTYPING & ITERATION **4L,8P**

Prototyping – Importance in entrepreneurial process – Types of Prototypes - Different methods – Tools & Techniques.

Hands-on sessions on prototyping tools (3D printing, electronics, software), Develop a prototype based on identified opportunities; Receive feedback and iterate on the prototypes.

MODULE – IV: BUSINESS MODELS & PITCHING **4L,8P**

Business Model and Types - Lean Approach - 9 block Lean Canvas Model - Riskiest Assumptions in Business Model Design – Using Business Model Canvas as a Tool – Pitching Techniques: Importance of pitching - Types of pitches - crafting a compelling pitch – pitch presentation skills - using storytelling to gain investor/customer attention.

Activity Session: Develop a business model canvas for the prototype; present and receive feedback from peers and mentors - Prepare and practice pitching the business ideas- Participate in a Pitching Competition and present to a panel of judges - receive & reflect feedback

MODULE – V: ENTREPRENEURIAL ECOSYSTEM **4L,8P**

Understanding the Entrepreneurial Ecosystem – Components: Angels, Venture Capitalists, Maker Spaces, Incubators, Accelerators, Investors. Financing models – equity, debt, crowdfunding, etc, Support from the government and corporates. Navigating Ecosystem Support: Searching & Identifying the Right Ecosystem Partner – Leveraging the Ecosystem - Building the right stakeholder network

Activity Session: Arrangement of Guest Speaker Sessions by successful entrepreneurs and entrepreneurial ecosystem leaders (incubation managers; angels; etc), Visit one or two entrepreneurial ecosystem players (Travel and visit a research park or incubator or makerspace or interact with startup founders).

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1: Develop an Entrepreneurial Mind-set and Understand the Entrepreneurial Ecosystem Components and Funding types

CO2: Comprehend the process of opportunity identification through design thinking, identify market potential and customers

CO3: Generate and develop creative ideas through ideation techniques

CO4: Create prototypes to materialize design concepts and conduct testing to gather feedback and refine prototypes to build a validated MVP

CO5: Analyse and refine business models to ensure sustainability and profitability Prepare and deliver an investible pitch deck of their practice venture to attract stakeholders

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2. Bill Aulet (2024). Disciplined Entrepreneurship: 24 Steps to a Successful Startup. John Wiley & Sons.
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4. Ries, E. (2011). The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. Crown Business
5. Blank, S. G., & Dorf, B. (2012). The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company. K&S Ranch
6. Osterwalder, A., & Pigneur, Y. (2010). Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. John Wiley & Sons
7. Marc Gruber & Sharon Tal (2019). Where to Play: 3 Steps for Discovering Your Most Valuable Market Opportunities. Pearson.