PG-Curriculum
(Structure and Course Contents)
Materials & Metallurgical Engineering
With effect from July 2018

EXPLORE INNOVATE EXCEL

Materials & Metallurgical Engineering
Punjab Engineering College
(Deemed to be University)
Chandigarh

PG Curriculum Structure

(Semester I)

Sr. No.	Course Stream	Code	Course Name		Segment {Fractal systems (each section of 0.5 credits and 7 contact hours)}						Credits
					1	**2**	**3**	**4**	**5**	**6**	
1.	Soft Computing		Internet of Things								1.5
			Machine Learning								1.5
2.	Soft skills & Management		Communication Skills								1.5
			Management Entrepreneurship and IPR								1
			Professional Ethics								0.5
3.	Bridge Course*		Bridge Course for M. Tech (IMM)								0
4.	Program Core-I		Physical Metallurgy								3
5.	Program Core-II		Steel Production Technology								3
6.	Program Elective I: PE I		**Industrial Metallurgy**	**Industrial Materials**							
			Casting Technology •Cast Iron Technology •Non Ferrous Casting Technology •Finishing Operations in Foundry •Casting design & simulations Lab	**Functional Materials** •Smart Materials & Sensors •Electronic Materials •Magnetic Materials							1.5
	Program Elective I: PE II		**Materials Joining Technology** •Welding Metallurgy •Weldament Characterization	**Surface Engineering** •Industrial Tribology •Corrosion & its control in Industry •Surface Engineering Lab							1.5
7.	Engineering Mathematics		Differential Equations								1
			Mathematical Modelling & Simulations								1
			Optimization Techniques- II								1
Total											**18**

(Semester II)

Sr. No.	Course Stream	Code	Course Name		Segment {Fractal systems (each section of 0.5 credits and 7 contact hours)}						Credits
					1	2	3	4	5	6	
1.	Design of Experiments and Research Methodology		Design of Experiments and Research Methodology (DE)								3
2.	Program Core-III		Characterization of Materials								3
3.	Program Core-IV		Materials Processing Technology								3
4.	Program Elective III: PE III		**Industrial Metallurgy**	**Industrial Materials**							
			Metal Forming & Heat Treatment •Industrial Heat Treatment •Metallurgy of Forming Processes •Modelling & Simulations in Process Metallurgy	**Biomaterials** •Engineered Materials in Medical App •Tissue -Biomaterial Interactions •Current Progress in Bio Medical Devices							1.5
	Program Elective IV: PE IV		**Powder Metallurgy Technology** • Powder manufacturing & conditioning •Powder Compaction & Sintering •Quality Control in Powder Metallurgy Components	**Nano Materials** •Nano materials for Electronic Applications •Nano materials for Energy Applications •Nano materials for Optical Applications							1.5
5.	Open Elective		Failure Analysis								1.5
			Characterization of Materials Functional Materials **(Any two courses will be offered in the semester)**								1.5
6.	Mini Project/ Pre Dissertation	MTP 5001	Mini Project/ Pre Dissertation								3
Total											**18**

PG Curriculum Structure

(Semester I)

Sr. No.	Course Stream	Course Code	Course Name		Credits
1.	Soft Computing	SCM 5011	Internet of Things		1.5
		SCM 5012	Machine Learning		1.5
2.	Soft skills & Management	SSM 5021	Communication Skills		1.5
		SSM 5022	Management Entrepreneurship and IPR		1
		SSM 5023	Professional Ethics		0.5
3.	Bridge Course*	MTM 5000	Bridge Course for M. Tech (IMM)		0
4.	Program Core-I	MTM 5011 MTM 5012 MTM 5013 MTM 5014	Physical Metallurgy		3
5.	Program Core-II	MTM 5021 MTM 5022 MTM 5023 MTM 5024	Steel Production Technology		3
6.	Program Elective I: PE I		**Industrial Metallurgy**	**Industrial Materials**	
			Casting Technology •Cast Iron Technology (MTM 5101) •Non Ferrous Casting Technology (MTM 5102) •Finishing Operations in Foundry (MTM 5103) •Casting design & simulations Lab (MTM 5104)	**Functional Materials** •Smart Materials & Sensors (MTM 5121) •Electronic Materials (MTM 5122) •Magnetic Materials (MTM 5123)	1.5
	Program Elective I: PE II		**Materials Joining Technology** •Welding Metallurgy (MTM 5201) •Weldament Characterization (MTM 5202)	**Surface Engineering** •Industrial Tribology (MTM 5221) •Corrosion & its control in Industry (MTM 5222) •Surface Engineering Lab (MTM 5223)	1.5
7.	Engineering Mathematics	EMM 5016	Differential Equations		1
		EMM 5017	Mathematical Modelling & Simulations		1
		EMM 5012	Optimization Techniques- II		1
Total					18

(Semester II)

Sr. No.	Course Stream	Course Code	Course Name		Credits
1.	Design of Experiments and Research Methodology	DRM 5011	Design of Experiments and Research Methodology (DE)		3
2.	Program Core-III	MTM 5031 MTM 5032 MTM 5033 MTM 5034 MTM 5035 MTM 5036	Characterization of Materials		3
3.	Program Core-IV	MTM 5041 MTM 5042 MTM 5043	Materials Processing Technology		3
4.	Program Elective III: PE III		**Industrial Metallurgy**	**Industrial Materials**	
			Metal Forming & Heat Treatment •Industrial Heat Treatment (MTM 5301) •Metallurgy of Forming Processes (MTM 5302) •Modelling & Simulations in Process Metallurgy (MTM 5303)	**Biomaterials** •Engineered Materials in Medical App (MTM 5321) •Tissue -Biomaterial Interactions (MTM 5322) •Current Progress in Bio Medical Devices (MTM 5323)	1.5
	Program Elective IV: PE IV		**Powder Metallurgy Technology** • Powder manufacturing & conditioning (MTM 5401) •Powder Compaction & Sintering (MTM 5402) •Quality Control in Powder Metallurgy Components (MTM 5403)	**Nano Materials** •Nano materials for Electronic Applications (MTM 5421) •Nano materials for Energy Applications (MTM 5422) •Nano materials for Optical Applications (MTM 5423)	1.5
5.	Open Elective		Failure Analysis (IMO 5001) Characterization of Materials (IMO5002) Functional Materials (IMO 5003) **(Any two courses will be offered in the semester)**		1.5 1.5
6.	Mini Project/ Pre Dissertation	MTP5001	Mini Project/ Pre Dissertation		3
			Total		18

Summer Term

After examination of 2nd semester, Industrial visit can be undertaken in the first week of summer vacation.

Sr. No.	Course Code	Course Name	Credits
1.		Industrial visit (3 days to one week of visit, submission and presentation of visit report)	Satisfactory/ Not-satisfactory

3rd Semester

Sr. No.	Course Code	Course Name	LTP	Credits
1.		Dissertation/Industrial Project-I	------	14
Total				14

4th Semester

Sr. No.	Course Code	Course Name	LTP	Credits
1.		Dissertation/Industrial Project-II	------	18
Total				18

Total Credits-68

- ***20% courses/ semester can be offered in blended mode MOOC's/Industry.***
- ***MOOC's/Industry offered course is having fractional credits.***
- ***Industry person will deliver and evaluate this subject. As per the duration of MOOC's/industry offered course, credits of this course can be decided (fractional credits).***

Semester-I

Soft Computing

Course Name	**:**	**Internet of Things**
Course Code	**:**	**SCM 5011**
Credits	**:**	**1.5**
L T P	**:**	**2-0-2**
Segment	**:**	**1-3**

Course Objectives:

The main objectives of this course are:	
1.	Understand core technology, applications, sensors used and IOT architecture along with the industry perspective.
2.	Principles and operations of different types of sensors commonly used on mobile platform will be taught in a manner that by the end of the course the students will be able to design and implement real time solutions using IOT.

Total No. of Lectures: 14
Total No of Lab Hours: 14

Course Contents:

Sr. No.	Course contents	No. of Hours
1.	**Introduction to IoT** What is IoT, how does it work? Difference between Embedded device and IoT device, Properties of IoT device, IoT Ecosystem, IoT Decision Framework, IoT Solution Architecture Models, Major IoT Boards in Market.	2
2.	**Setting Up Raspberry/Arduino to Create Solutions** Explore Raspberry Pi, Setting up Raspberry Pi, Showing working of Raspberry Pi using SSH Client and Team Viewer, Understand Sensing actions, Understand Actuators and MEMS.	3
3.	**Communication Protocols used in IoT** Types of wireless communication, Major wireless Short-range communication devices, properties, comparison of these devices (Bluetooth, WIFI, ZigBee, 6LoWPAN), Major wireless Long-range communication devices, properties, comparison of these devices (Cellular IoT,LPWAN).	3
4.	**IoT Applications** IoT in metallurgical processing industry, smart manufacturing. Smart home, smart city, smart grid, connected car, connected health (digital health, telehealth, telemedicine), smart retail.	3
5.	**Sensors:** Applications of various sensors: Google Maps, Waze, Whats App, Ola Positioning sensors: encoders and accelerometers, Image sensors: cameras, Global positioning sensors: GPS, GLONASS, IRNSS, Galileo and indoor localization systems, Motion & Orientation Sensors: Accelerometer, Magnetometer, Proximity Sensor, Gyroscope Calibration, noise modeling and characterization and-noise filtering and sensor data processing. Privacy & Security.	3

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Design and build systems that will use sensors, communication protocol and actuators.	14

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Understand concept of IOT and ability to implement in real time scenarios.
2.	Design solutions based on IOT architecture and applications in various fields.
3.	Critically analyse security and privacy issues in IOT.
4.	Apply knowledge to Design and develop various applications of sensors in Industrial, health care, commercial, and building automation.

Bibliography:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	Vijay Madisetti and Arshdeep Bahga, "Internet of Things (A Hands-on-Approach)", VPT, 1st Edition.	2014
2.	Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", Apress Publications, 1st Edition.	2013
3.	CunoPfister, "Getting Started with the Internet of Things", OReilly Media.	2011
4.	Kyung, C.-M., Yasuura, H., Liu, Y., Lin, Y.-L., Smart Sensors and Systems, Springer International Publishing.	2015

MOOCs on this course are available at:

1) Introduction to Internet of Things - https://www.edx.org/course/introduction-to-the-internet-of-things-iot.
2) IoT Programming and Big Data -https://www.edx.org/course/iot-programming-big-data-curtinx-iot4x.

Course Name	**:**	**Machine Learning**
Course Code	**:**	**SCM 5012**
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Total No. of Lectures: 14
Total No of Lab Hours: 14

Course Objectives:

The main objectives of this course are:	
1.	To formulate machine learning problems corresponding to different applications.
2.	To understand a range of machine learning algorithms along with their strengths and weaknesses.
3.	To develop reasoning behind model selection, model complexity, etc.

Course Contents:

Sr. No.	Course contents	No. of Hours
1.	**BASICS OF MACHINE LEARNING:** Applications of Machine Learning, processes involved in Machine Learning, Introduction to Machine Learning Techniques: Supervised Learning, Unsupervised Learning and Reinforcement Learning, Real life examples of Machine Learning.	3
2.	**SUPERVISED LEARNING:** Classification and Regression: K-Nearest Neighbour, Linear Regression, Logistic Regression, Support Vector Machine (SVM), Evaluation Measures: SSE, MME, R2,confusion matrix, precision, recall, F-Score, ROC-Curve.	6
3.	**UNSUPERVISED LEARNING:** Introduction to clustering, Types of Clustering: Hierarchical-Agglomerative Clustering and Divisive clustering; Partitional Clustering - K-means clustering, Principal Component Analysis, ICA.	5

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Python Introduction: Loops and Conditions and other preliminary stuff, Functions, Classes and Modules, Exceptions, Database access, Mathematical computing with Python packages like: numpy, Mat- plotLib, pandas Tensor Flow, Keras.	8
2.	Application Oriented Project Work.	6

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Design and implement machine learning solutions to classification, regression and clustering problems.
2.	Evaluate and interpret the results of the different ML techniques.
3.	Design and implement various machine learning algorithms in range of Real-world applications.
4.	Use Python for various applications.

Bibliography:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	Tom Mitchell, Machine Learning, McGraw Hill.	2017
2.	Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer.	2011.
3.	T. Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning, 2e.	2008
4.	Yuxi (Hayden) Liu, "Python Machine Learning By Example", Packet Publishing Limited.	2017

MOOCs on this course are available at:

1) Data Science: Machine Learning -https://www.edx.org/course/data-science-machine-learning.
2) Machine Learning - https://www.coursera.org/learn/machine-learning.

Soft Skills & Management

Course Name	**:**	**Communication Skills**
Course Code	**:**	**SSM5021**
Credits	**:**	**1.5**
L T P	**:**	**0 1 4**
Segment	**:**	**1-3**

Course Objectives:

The main objectives of this course are:	
1.	To enhance competence in communication skills: verbal and nonverbal.
2.	To provide orientation in technical communication skills: spoken and written.
3.	To sensitize students to attitude formation and behavioural skills.

Total No. of Tutorial: 07
Total No. of Lab Hours: 28

Course Contents:

Sr. No	Course Contents	No. of Hours
1.	**Introduction to Communication Skills**, Soft Skills and Interpersonal Communication	1
2.	**Speech:** Structure, Elements, Content, Organization and Delivery J-a-M	1
3.	**Writing Skills:** Letters, Minutes of Meeting	1
4.	**Technical Report Writing:** Concept & Structure	1
5.	**Research Writing:** Concept & Structural Framework	1
6.	**Power Point Presentation:** Project Presentation	1
7.	Interviews	1

Lab Work:

Sr. No	Lab. Contents	No. of Hours
1.	Self- Introduction	2
2.	Negotiation Skills & Role Play	2
3.	J-a-M Session	2
4.	Building Word Power through Reading	2
5.	Group Discussion and Case Study	4
6.	Writing Skills: Letters, Minutes of Meeting	2
7.	Technical Report Writing: Concept & Structure	4
8.	Research Writing: Concept & Structural Framework	4
9.	Power Point Presentation: Project Presentation	4
10.	Interviews	2

Course Outcomes:

At the completion of this course, students will be able to:	
1	Show enhanced competence in communication skills and technical communication.
2	Develop awareness of attitude formation and behavioural appropriateness.
3.	Gain self-confidence and perform better in their academic and professional life.

Bibliography:

Sr. No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	Technical Communication, Meenakshi Raman and Sangeeta Sharma,	2015

	Oxford University Press.	
2.	English for Research Paper Writing, Adrian Wallwork, Springer, London	2011
3.	English Vocabulary In Use: Advanced+ CD, McCarthy Michael, CUP, Cambridge.	2004
4.	Advanced English Grammar, Martin Hewings, CUP, Cambridge.	2003
5.	Study Listening, Lynch Tony, CUP, Cambridge.	2004
6.	Study Speaking , Anderson Kenneth, CUP, Cambridge.	2010
7.	Study Reading , Glendenning H. Eric, CUP, Cambridge.	2004
8.	Study Writing , Lyons Liz Hamp & Ben Heasley, CUP, Cambridge.	2004
9.	Study skills in English, Michael J. Wallace, CUP, Cambridge.	2004

Course Name	**:**	**Management Entrepreneurship and IPR**
Course Code	**:**	**SSM5022**
Credits	**:**	**1**
L T P	**:**	**0-2-0**
Segment	**:**	**4-5**

Total No. of Tutorials – 14

Course Objectives:

The main objectives of this course are:	
1.	To make students familiar with the concepts of Management, Entrepreneurship and Intellectual Property Rights (IPRs).
2.	To make students understand how to initiate a new Start-up and manage it effectively.
3.	To enable students to convert their innovative ideas into different forms of IPRs.

Course Contents:

Sr. No	Course contents	No. of Tutorials
1.	**Introduction to Management:** Concepts and Principles of Management	1
2.	**Functions of Management:** Planning Process - Hypothetical Planning of an Event/Activity, Form of Organization Structure - Case Study, Human Resource Planning and Process, Elements of Directing and Effective Control Mechanism, Activity: Role Playing/Management Game.	4
3.	**Introduction to Entrepreneurship:** Concepts of Entrepreneurship and Characteristics of Entrepreneurs	1
4.	**Development Phases of Entrepreneurship:** Innovation and Idea Generation, Project Formulation and Validation (Feasibility Analysis), Business plan.	2
5.	**Ecosystem for Entrepreneurship Development:** Government Schemes and Initiatives, Financial and Non-Financial Institutional Support, Legal Framework, Role of Incubator, Venture Capitalist, Angel Investor, Crowd Funding Accelerator etc.	2
6.	**Intellectual Property Rights (IPRs):** Concept and Relevance of IPRs, Process for filing IPR.	2
7.	**Different Forms of IPRs:** Patents, Copyright, Trademarks, Industrial Designs and Geographic Indicator.	2

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Develop and manage new project/Start-up.
2.	Apply managerial skills for success of entrepreneurial/business venture.
3.	Make effective use of IPR practices in their ventures.

Bibliography:

Sr. No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	"Management Principles and Practice", Srinivasan R. and Chunawalla S.A., Himalaya Publishing House.	2017
2.	"Introduction to Management", Schermerhorn John R. Jr. And Bachrach Daniel G., 13th Edition, Wiley Publications.	2016
3.	"Principles & Practice of Management", Prasad L.M., 8th Edition, Sultan Chand & Sons.	2015
4.	"The New Era of Management", Daft R.L., 11th Edition, Pubs: Cengage Learning.	2014

5.	"Case Studies in Management", Pandey Chandra Akhilesh, 2nd Edition, I.K. International Publishing House Pvt. Ltd.	2015
6.	"Harvard Business Review: Manager's Handbook", Harvard Business School Press.	2018
7.	"Entrepreneurship", Trehan Alpana, Dreamtech Press.	2016
8.	"Entrepreneurship and Small Business" Schaper Michael, Volery Thierry, Weber Paull and Lewis Kate, 3rd Asia-Pacific Edition, Wiley Publications.	2018
9.	"Harvard Business Review: Entrepreneur's Handbook", 1st Edition, Harvard Business Review Press.	2018
10.	"Take Me Home", Bansal Rashmi, 1st Edition, Westland.	2014
11.	"Intellectual Property Law", Narayanan P., 3rd Edition, Eastern Law House.	2017
12.	"Intellectual Property Rights", Pandey Neeraj and Dharni Khushdeep, PHI Learning.	2014
13.	"Intellectual Property Rights", Rosedar S.R.A., LexisNexis (Quick Reference Guide – Q&A Series).	2016
14.	MSME Annual Publications (www.msme.gov.in).	Annual
15.	WIPO Annual Publications (www.wipo.int).	Annual

MOOCs on this course are available at:

1) "Entrepreneurship: Do Your Venture", Available at edx (Offered by IIM Bangalore), Self-Paced (6 weeks).
   https://www.edx.org/course/entrepreneurship-do-your-venture
2) "Becoming an Entrepreneur", Available at edx (Offered by MIT), Self-Paced (6 weeks).
   https://www.edx.org/course/becoming-entrepreneur-mitx-launch-x-4
3) "How to Build a Start-up", Available at Udacity, Self-Paced (One Month).
   https://in.udacity.com/course/how-to-build-a-startup--ep245
4) "Intellectual Property Rights: A Management Perspective, Available at edx (Offered by IIM Bangalore), Starts on 1 August 2018 (6 weeks).
   https://www.edx.org/intellectual-property-rights-a-management-perspective

Course Name	**:**	**Professional Ethics**
Course Code	**:**	**SSM5023**
Credits	**:**	**0.5**
L T P	**:**	**0-1-0**
Segment	**:**	**6-6**

Total No. of Tutorials -7

Course Objectives:

The main objectives of this course are:	
1.	To imbibe ethical values and understanding.
2.	To develop moral thinking that will help students to recognize their potential.
3.	To engage and motivate the students to perform ethically in their professional life.

Course Contents:

Sr. No	Course contents	No. of Tutorials
1.	**Introduction to Ethics:** Concept of Ethics – Nature, Scope, Sources, Types, Functions and Factors influencing Ethics, Ethics in Engineering.	2
2.	**Ethics in Profession:** Concepts of Honesty, Integrity, Reliability, Risk, Safety and Liability, Responsibilities and Rights of Professionals, Professional accountability.	2
3.	**Ethics and Business:** Concept of Business Ethics – Nature and Objectives, Ethical dilemmas in business ethics.	1
4.	**Self-Development:** Concept of Self-Assessment – SWOT Analysis, Self-Concepts, Self-Confidence, Self-Esteem, Managing Time and Stress, Human values.	2

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Demonstrate knowledge and better understanding of self and to manage time and stress effectively.
2.	Have subjective well-being.
3.	Have ethical decision making ability in their personal and professional life.

Bibliography:

Sr. No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	"Professional Ethics", Subramaniam R., 2nd Edition, Oxford University Press.	2017
2.	"Introduction to Psychology", Kalat James W., 11th Edition, Cengage Learning.	2017
3.	"Business Ethics – Text and Cases", Murthy C.S.V., 1st Edition, Himalaya Publishing House.	2014
4.	**"A Foundation Course in Human Values and Professional Ethics", Gaur R.R., Sangal R. and Bagaria G.P., Excel Books.**	2010
5.	"Issues and Ethics in the Helping Professions", Corey G., Corey M.S. and Callanan P., 8th Edition, Brooks/Cole, Cengage Learning.	2010
6.	"The Curse of Self: Self-awareness, Egotism and the Quality of Human Life", Leary M.R., 1st Edition, Oxford University Press.	2007

7.	"Business Ethics", Hartman L.P. and Chatterjee A., 3rd Edition, Tata McGraw Hill.	2006
8.	"Business Ethics and Professional Values", Rao A.B., Excel Books.	2006
9.	"Business Ethics – Concepts and Cases", Velasquez M.G., 5th Edition, Prentice Hall.	2001
10.	"Theories of Personality", Hall C.S., Lindzey D. and Cambell J.B., 4th Edition, Hamilton Printing Company.	1997

MOOCs on this course are available at:

1) "Ethics in Engineering Practice". Available at SWAYAM(Offered by IIT Kharagpur), 8 weeks, Starts on August 27, 2018.
https://swayam.gov.in/courses/4799-july-2018-ethics-in-engineering-practice
2) "Ethics, Technology and Engineering". Available at Coursera (Offered by EindhovenUniversity of Technology), 8 weeks, Starts on July 16, 2018.
https://www.coursera.org/learn/ethics-technology-engineering

Bridge Course

Course Name	**:**	**Bridge Course**
Course Code	**:**	**MTM5000**
Credits	**:**	**0**
L T P	**:**	**3 0 0**
Segment	**:**	**1-6**

Course Objectives:

The main objectives of this course are:	
1.	To introduce students with fundamental concept of crystal structure, role of defects.
2.	To understand the importance of phase and phase diagram, the basics of plastic deformation in metals/alloys.
3.	Application of thermodynamics to understand the various metallurgical aspects.

Total No. of Lectures: 42

Course Contents:

Module-1 Crystal structure, defects and solidification	**No. of Hours**
Lattice, crystal structure and miller indices, Crystal structure determination, Imperfections in crystals, Solidification.	14

Module -2 Phase rule and phase diagrams	7
Gibbs' Phase rule, Lever rule, Binary phase diagrams for systems (like Fe-C, Cu-Ni, Al-Si, Al-Cu etc.) involving eutectic & eutectoid reactions.	

Module- 3 Micro plasticity	7
Plastic deformations in metals and alloys: Slip, Twin, Kink formation, Concepts of stress and strain, Strain hardening of BCC, FCC, HCP metals.	

Module - 4 Principles of metallurgical thermodynamics	14
Concept of entropy, equilibrium constant, free energy and Ellingham diagram, Solutions: real and ideal solution.	

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Familiar to the basics concepts of metallurgy and their importance in practical applications.

Bibliography:

Sr. No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	W. D. Callister, Materials Science and Engineering: An Introduction, John Wiley & Sons, Inc.	2007
2.	S. H. Avner, Introduction to Physical Metallurgy, 2nd edition, McGraw-Hill.	1997
3.	D. A. Brandt, J. C. Warner, Metallurgy Fundamentals, Ferrous and non-ferrous, 5th edition, Goodheart-Willcox Publisher.	2009
4.	D. R. Askeland, P. P. Phulay, W. J. Wright, Essentials of Materials Science and Engineering 2nd edition.	2009
Online sources:		
1.	Latest research articles	

Program Core

Course Name	**:**	**Physical Metallurgy**
Course Code	**:**	
Credits	**:**	**03**
L T P	**:**	**2 0 2**
Segment	**:**	**1-6**

Course Objectives:

The main objectives of this course are:	
1.	To introduce students the understanding of diffusion changes in the chemical distribution and microstructure of materials due to diffusional mechanism.
2.	To enable students to study the variety of phase transformations and the concept of common crystal defects and their role in materials behaviour.

Total No. of Lectures: 28
Total No of Lab Hours: 28

Course Contents:

Module-1 Defects in Solids **(Credit- 0.5), Code: MTM5011**	**No of Hours**
Defects and their role in materials development and processing: Role of Point defects in diffusion and deformation, Hall-Petch relation and inverse Hall-Petch effect (IHPE), Role of dislocations on creep-fatigue and fracture.	7

Module -2 Phase Transformations **(Credit- 1), Code: MTM5012**	
Phase transformations: Solidification, solid state transformation; Nucleation and growth, Diffusion equations.	14

Module- 3 Microstructural Evolution of Deformed Materials **(Credit- 0.5), Code: MTM5013**	
Physical mechanisms of microstructure evolution; structure, energy and mobility of grain boundaries, grain boundary segregation, precipitation, recovery, recrystallization, grain growth; Case study on microstructure evolution: 1 each for Ferrous and Non ferrous.	7

Lab Work:

Module-4 Structure-Property Lab **(Credit-1), Code: MTM5014**		
Sr. No.	**Lab Contents**	**No. of Hours**
The student will do physical and experimental validation of properties Phase diagrams, Phase transformations and properties of engineering steels using J Mat Pro Module.		
1.	Stable and meta stable phase equilibria.	04
2.	Solidification behaviour of materials.	06
3.	Thermal properties of materials.	04
4.	Modeling and simulation of physical properties of materials (eg. Thermal expansion, Thermal conductivity, Corrosion resistance).	06
5.	To study phase transformations of different alloys.	04
6.	To study chemical properties of materials.	04

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Identify common defects in materials and their effect on the mechanical properties of the materials.
2.	Describe the phase transformations in metals/alloys.

3.	Analyze the effect of temperature, driving force, and initial microstructure on the production of a wide range of final microstructures of the deformed materials.
4.	Correlate defects in materials with properties and suggest remedial alternatives.

Bibliography:

Sr. No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	R. Abbaschian, L. Abbaschian, R. E. Reed-Hill, Physical Metallurgy Principles, 4th edition, Wadsworth Publishing Co Inc.	2008
2.	R. E. Smallman A. H. W. Ngan Modern Physical Metallurgy, 8th edition, Oxford.	2014
3.	Donald R. Askeland, Pradeep P. Phulay, Wendelin J. Wright, The Science and Engineering of Materials, 6th edition, CENGAGE Learning.	2010
Online sources:		
1.	Latest research articles	
2.	http://nptel.ac.in/courses/113105023/	
3.	http://nptel.ac.in/courses/113105024/	

Classical Books:

Sr. No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	W.F. Smith, Principles of Materials Science & Engineering, 2nd edition, McGraw Hill Series.	1990
2.	D.A. Porter and K.E. Easterling, Phase Transformations in Metals and Alloys, 2nd edition, Taylor and Francis.	1992

Course Name	**:**	**Steel Production Technology**
Course Code	**:**	
Credits	**:**	**03**
L T P	**:**	**2 0 2**
Segment	**:**	**1-6**

Course Objectives:

The main objectives of this course are:	
1.	To introduce students the theoretical, practical and operational understanding of primary and secondary steelmaking.
2.	It includes visit to steel plants.

Total No. of Lectures: 28
Total No of Lab Hours: 28

Course Contents:
Module 1 and 4 are mandatory and any one from Module 2 or 3 is to be opted.

Module-1 Integrated & Secondary Steel Technology **(Credit- 1.5), Code: MTM5021**	**No. of Hours**
Steelmaking Fundamentals: Solution thermodynamics, Steelmaking Fundamentals: Role of slag in steelmaking, Physico-chemical properties of slag, Decarburization, Desulphurization, Dephosphorization reaction and Refractory in steelmaking, Continuous casting and finishing operations, Safety in steel plant and environment protection.	21

Module -2 Ladle Metallurgy Technology **(Credit- 0.5), Code: MTM5022**	
Ladle treatments and requirements, Synthetic slag practice, Principles of de-oxidation, Principles of degassing, Degassing technologies, Clean steel: Impact of inclusions on steel properties and Sources of inclusions in steel and their control.	7

Module -3 Special Steel Technology **(Credit- 0.5), Code: MTM5023**	
Alloy steel making processes – special reference to stainless steels, high speed steel, manganese steel and other special steels, Thermodynamics and kinetics of alloy steel making, Defects & remedies, Post solidification treatments, Secondary alloy steel making technologies.	7

Lab Work:

Module -4 Steel Making & Finishing Operations Lab **(Credit- 1.0), Code: MTM5024**		
Sr. No.	**Lab Contents**	**No. of Hours**
This lab includes practical study at industry dealing in primary/secondary/special steels:		
1.	To study various practices in steel making processes.	06
2.	To study different type of slags in steel making processes	06
3.	To study alloying additions in special steel making process.	06
4.	To study the continuous casting process.	04
5.	To study the inclusions and different type of defects in steels and assign reasons of their development during steel making processes.	06

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Describe and distinguish primary and secondary steel making processes.

2.	Design a steel making process for a given composition of steel and technology.

Bibliography:

Sr. No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	A. Ghosh and A. Chatterjee, Iron making and Steelmaking: Theory and Practice, Prentice Hall of India, New Delhi.	2008
2.	A.W. Cramb (Editor), Making Shaping and Treating of Steel, 11th Ed., Vol.1 and 2, AISE, Pittsburg.	2003
3.	M. Reutter, Making steel, University of Illinois Press.	2005
Online sources:		
1.	Latest research articles	
2.	http://nptel.ac.in/courses/113104059/	

Program Elective

Course Name	**:**	**Casting Technology**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**1-3**

Course Objectives:

The main objectives of this course are:	
1.	To introduce student a comprehensive understanding of all aspects of the casting process, particularly the requirements to cast defect-free products.
2.	To educate/expose casting design software and laboratory experiments for casting design and simulation.

Total No. of Lectures: 14
Total No of Lab Hours: 14

Course Contents:
The student may choose any two modules among module 1, 2, and 3. Module 4 is mandatory.

Module-1 Cast Irons Technology **(Credit- 0.5), Code: MTM5101**	**No. of Hours**
Metallurgical and casting characteristics of grey, chilled & ductile iron castings and their production.	7

Module -2 Non Ferrous Casting Technology **(Credit- 0.5), MTM5102**	
Metallurgical and casting characteristics of Aluminium and Copper base alloys and their production. Gravity and pressure die cast.	7

Module- 3 Finishing Operations in Foundry **(Credit- 0.5), MTM5103**	
Shot blasting, Fettling, Inspection and painting. Automation in fettling, Casting process control.	7

Lab Work:

Module- 4 Casting Design & Simulations Lab **(Credit- 0.5), MTM5104**		
Sr. No.	**Lab Contents**	**No. of Hours**
1.	To study principles, rules & factors affecting casting design and selection of casting process.	04
2.	To study problems related to Casting design parameters.	02
3.	To study problems related to Design of gating system.	02
4.	To study problems related to gating design.	02
5.	Modelling & simulation using software (such as Solid cast/ Flow cast).	04

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Explain and distinguish cast iron and nonferrous casting processes.
2.	Analyse and create the casting design and simulation the casting.

Bibliography:

S.No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	D.M. Stefanescu, Science and Engineering of Casting Solidification, Kluwar Publications.	2002

2.	R. W. Heine, C. R. Loper, P. C. Rosenthal, Principles of Metal Casting, 2nd edition McGraw-Hill.	2010
Online sources:		
1.	Latest research articles	

Classical Books:

Sr. No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	G.J. Davies, Solidification and Casting, John Wiley and Sons.	1973

MOOCs on this course are available at:

1) SAWAYM: Principles of casting technology

Course Name	**:**	**Materials Joining Technology**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Course Objectives:

The main objectives of this course are:	
1.	To introduce various methods of the joining of parts of components of the materials.
2.	To enhance knowledge on joining of the component with metallurgical incompatible materials through specific techniques.

Total No. of Lectures: 14
Total No of Lab Hours: 14

Course Contents:

Module-1 Welding Metallurgy **(Credit- 1), Code: MTM5201**	**No. of Hours**
Conventional and non-conventional welding processes in infrastructure development, AWS grades/standards, welding parameters, Limitations and challenges in welding, weldament characterization and future scope of welding in infrastructure , Welding automation and defect.	14

Lab Work:

Module -2 Weldament Characterization Lab. **(Credit- 0.5), Code: MTM5202**		
Sr. No.	**Lab Contents**	**No. of Hours**
1.	To study of microstructure & hardness profile of joints.	02
2.	HAZ analysis of post weld heat-treated mild steel through Arc Welding.	02
3.	Tungsten Inert Gas Welding (TIG).	02
4.	Gas Welding and Metal Inert Gas Welding (MIG).	02
5.	Plasma Arc Welding of mild steel.	02
6.	Diffusion bonding (Ag, Ti).	02
7.	Friction Stir Welding of light metals (Al, Mg).	02

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Explain and distinguish various joining techniques, acquire skill of differentiating joint characteristics and design joining technique for a specific job in hand.
2.	Analyse the basics of materials joining.
3.	Identify welding defects and suggest remedies.

Bibliography:

Sr. No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	K. Sindo, Welding Metallurgy, 2nd edition, John Wiley & Sons, Inc.	2003
2.	J.F. Lancaster, Metallurgy of welding, 6th edition, Abington Publishing, Cambridge England.	1999
3.	W. Robert, Jr. Messler, Principles of welding, Processes, Physics, Chemistry and Metallurgy, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim.	2004

Online sources:		
1.	Latest research articles	

Classical Books:

Sr. No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	Welding handbook, 8th ed., vol 2, welding processes, AWS.	1991

Course Name	**:**	**Functional Materials**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**3 0 0**
Segment	**:**	**1-3**

Course Objectives:

The main objectives of this course are:	
1.	To introduce various functional materials, their physics, applications, and examples.
2.	To expose the properties and applications of functional materials in modern technology.

Total No. of Lectures: 21

Course Contents:

Module-1 Smart Materials & Sensors **(Credit- 0.5), Code: MTM5121**	**No. of Hours**
Material aspects and design rules of functional devices, Piezoelectric sensors, Actuators and transducers thermoelectric & optical sensors, Transparent ceramics, multiferroic and magnetoelectrics: Issues & possible applications, GMR Materials.	7

Module -2 Electronic Materials **(Credit- 0.5), Code: MTM5122**	
Ferroelectric crystals and applications, Relaxor Materials, Spintronic: Spin polarization and application, Piezoelectrics for energy harvesting applications, Materials for optoelectronic devices: solar cells & OLED's.	7

Module -3 Magnetic Materials**(Credit- 0.5), Code: MTM5123**	
Soft & Hard magnetic materials and their applications, DC, low frequency, RF, microwave and recording applications of magnetic oxides and alloys; CMR Materials, Magneto caloric materials and spin glasses, Super paramagnetism, Ferrofluid Magneto electronics, Recent developments in the applications of Magnetic Materials.	7

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Describe a broad range of present and future functional materials.
2.	Correlate the structural-property of functional materials.
3.	Design the thin films and their characterizations.

Bibliography:

Sr. No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	S. O. Kasap, Principles of Electronic Materials & Devices, 3rd edition, McGraw Hill.	2007
2.	B.D. Cullity, C.D. Graham, Introduction to Magnetic Materials, Wiley, 2nd edition.	2008
3.	Eugene A. Irene, Electronic Materials Science, Wiley.	2005
4.	The Science and Engineering of Microelectronics Fabrication, Oxford University Press by Stephen A. Campbell.	1996
5.	Electronic Materials and Devices, Wiley by David K. Ferry, Jonathan P Bird.	2001
6.	Tseung-Yuen Tseng and Hari Singh Nalwa, Handbook of Nanoceramics	2009

	and their Based Nanodevices, American Scientific Publishers.	
7.	A. J. Moulson & J. M. Herbert, Electroceramics: Materials, Properties, Applications, Wiley.	2003
8.	M. Lines & A. Glass, Principles and applications of ferroelectrics and related materials, Oxford University Press, New York.	2001
Online sources:		
1.	Latest research articles	

Course Name	**:**	**Surface Engineering**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Course Objectives:

The main objectives of this course are:	
1.	To introduce student the analysis of the various concepts of surface engineering and comprehend the design difficulties, friction and wear behaviour of materials, industrial applications of tribology.
2.	Identify and distinguish the corrosion problems and their control in engineering.

Total No. of Lectures: 14
Total No. of Lab Hours: 14

Course Contents:

Module-1 Industrial Tribology **(Credit- 0.5), Code: MTM5221**	**No. of Hours**
Industrial significance of tribology (Micro/Nano), Study of friction & wear behaviour of materials, Tribological components & applications such as common tribological components (bearings, seals, gears, cams, piston rings, electrical brushes, MEMS/NEMS, Material processing (cutting tools, cutting fluids, grinding, lapping, Industrial applications (automotive engines, railroads, magnetic storage devices), Green Tribology & Biomimetic, Conventional & Non-conventional surface treatments to improve Tribological performances (such as shot blasting, coatings, Hybridization of materials, Composite materials etc.).	7

Module -2 Corrosion & its Control in Industry **(Credit- 0.5), Code: MTM5222**	
Corrosion & its control in industries such as Electronics, Infrastructure, Power, Process, Petrochemical, Shipbuilding, Marine and Fertilizer industries with case studies, Conventional & Non-conventional methods of corrosion protection, Corrosion auditing in industries, Corrosion map of India.	7

Lab Work:

Module -3 Surface Engineering Lab **(Credit- 0.5), Code: MTM5223**		
Sr. No.	**Lab Contents**	**No. of Hours**
1.	To study tribological properties - abrasion, erosion, surface characteristics of materials.	02
2.	To study and optimize the coating parameters using spin/dip coating.	02
3.	To study Adhesion characteristics using scratch/peel test.	02
4.	To study sliding and reciprocating wear/friction behaviour.	02
5.	To conduct linear polarization experiment.	02
6.	To perform EIS studies.	02
7.	To perform cyclic voltammetry on given electrochemical system.	02

Course Outcomes:

At the completion of this course, students will be able to:	
1	Explain the fundamental of tribology and related contact mechanics.
2	Analyse the principles of coating deposition methods.

3	Identify reasons for corrosion and suggest solutions for protection or prevention.

Bibliography:

Sr. No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	M.G. Fontana, Corrosion Engineering 7th edition, Tata McGraw Hill.	2005
2.	R.G. Kelly, J.R. Scully, D.W. Shoesmith, R.G. Buchheit, Electrochemical Techniques in Corrosion Science and Engineering, Marcel Dekker, Inc., New York.	2003
3.	L. Yang, Techniques for corrosion monitoring, Woodhead Publishing Limited.	2008
4.	V S Raja and T Shoji, Stress corrosion cracking 302226 Theory and Practice, Woodhaed Publishing Limited, Oxford.	2011
Online sources:		
1.	Latest research articles	

Classical Books:

Sr. No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	H.H. Uhlig and R.W. Revie, Corrosion and its Control, 3rd edition, , John Wiley, Singapore	1991

Engineering Mathematics

Course Name	**:**	**Differential Equations**
Course Code	**:**	**EMM5016**
Credits	**:**	**01**
L T P	**:**	**2 1 0**
Segment	**:**	**1-2**

Course Objectives:

The main objectives of this course are:	
1.	To make the students understand the methods to formulate and solve linear differential equations.
2.	To make the students able to apply the theory of differential equations to solve engineering problems.

Total No. of Lectures: 10
Total No. of Tutorials: 05

Course Contents:

Sr. No	**Course Contents**	**No. of Hours**
1.	Order and degree of differential equations, Solutions of differential equation First order equations, second order linear homogeneous differential equation with constant coefficients. Applications to Engineering problems.	4
2.	Wronskian, Non-homogeneous equations of order two, Homogeneous equations of n^{th} order, Initial value problem, Applications to Engineering problems.	4
3.	Use of Mathematica / MATLAB to solve differential equations numerically.	2

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Learn the methods to formulate and solve linear differential equations.
2.	Apply differential equations to solve engineering problems.
3.	Use Mathematica / MATLAB to solve differential equations numerically.

Bibliography:

Sr. No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	"Advanced Engineering Mathematics", E. Kreyszig. 9th Edition, Wiley.	2006
2.	"Elementary Differential Equations and Boundary Value Problems", Boyce, W.E. and Diprima, , John Wiley and Sons, USA.	2001

Classical Books:

Sr. No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	"An introduction to ordinary differential equations", E A Coddington.	1972

Course Name	**:**	**Mathematical Modelling and Simulations**
Course Code	**:**	**EMM5017**
Credits	**:**	**01**
L T P	**:**	**2 1 0**
Segment	**:**	**3-4**

Course Objectives:

The main objectives of this course are:	
1.	To introduce the students the role of mathematics in problem solving, classification of mathematical models.
2.	To make the student understand the software aspects of Mathematical modelling.

Total No. of Lectures: 10
Total No. of Tutorials: 05

Course Contents:

Module-1 (Credit-0.5)	**No. of Hours**
Role of Computers in engineering Design. Introduction to 3D CAD, Role of mathematics in problem solving; Concepts of mathematical modeling, Classification of models, Need, Techniques and simple illustrations, Mathematical Modeling through Differential Equations, Mathematical Modeling through graphs. Numerical Analysis technique.	5

Module-2 (Credit-0.5)	
Basics of Advance modelling techniques like Artificial Neural Network, FEA etc. Pitfalls in modelling. Software aspects in Mathematical modelling/optimization. Illustrations of applications/ case studies in Furnace design, Solidification of metals. Die Casting etc. or other engineering problems.	5

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Identify the mathematical models.
2.	Analyses the role of mathematics in problem solving.
3.	Design the software aspects of Mathematical modelling.

Bibliography:

Sr. No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	E.A. Bender, An Introduction to Mathematical Modelling, John Wiley and sons.	2000
2.	Rutherford Aris, Mathematical Modelling Techniques, New York : Dover.	1994
3.	N. Gershenfeld, The Nature of Mathematical Modelling, Cambridge University Press.	2003
Online sources:		
1.	Latest research articles	

Classical Books:

Sr. No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**

1.	J.N. Kapur, Mathematical Modeling, New Ace International (P) Ltd. Publishers.	1988
2.	J. Szekely, J.E. Evansand, J.K. Brimacambe, The Mathematical and Physical Modeling of Primary Metal Processing Operations, Wiley.	1988

Course Name	**:**	**Optimization Techniques and Genetic Algorithms**
Course Code	**:**	**EMM5012**
Credits	**:**	**01**
L T P	**:**	**2 0 2**
Segment	**:**	**5-6**

Course Objectives:

The main objectives of this course are:	
1.	To make the students understand the need of Optimization Techniques and develop the ability to form mathematical model of optimization problems.
2.	To make the students able to identify and solve linear and non-linear models of optimization problems using Genetic Algorirhms.

Total No. of Lectures: 10
Total No of Lab Hours: 10

Course Contents:

Sr. No	Course Contents	No. of Hours
1.	Introduction to optimization problem, local and global optimum, conversion of a constrained problem to unconstrained problem.	4
2.	Genetic Algorithms, Binary and Real coded Genetic Algorithms, Coding and decoding of variables, Key steps in a GA, starting population, fitness evaluation, reproduction, crossover, mutation, evaluation.	6

Lab Work:

Sr. No	Lab Contents	No. of Hours
1.	Using Genetic Algorithms in various optimization problems.	10

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Form mathematical model of optimization problems.
2.	Distinguish between linear and nonlinear models.
3.	Solve simple problems using Mathematica/MATLAB.

Bibliography:

Sr. No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
3.	"Engineering Optimization", Ranjan, Ganguli, University Press.	2011

Classical Books:

Sr. No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	"Practical Genetic Algorithms", Haupt, R. L. and Haupt, S.E., John Wiley & Sons.	1998
2.	"Genetic Algorithm in Search, Optimization and Machine Learning", Goldberg, D.E., Addison Wesley.	1989

Semester-II

Design of Experiments & Research Methodology

Course Name	**:**	**Design of Experiments & Research Methodology**
Course Code	**:**	**DRM5011**
Credits	**:**	**3**
L T P	**:**	**2-0-2**
Segment	**:**	**1-6**

Total No. of Lectures: 28
Total No. of Lab Hours: 28

Course Objectives:

The main objectives of this course are:	
1.	To introduce objective of research for various types of research.
2.	To enhance competence analysing experimental results.
3.	To enhance competence in understanding mathematical relation between process variables and results.
4.	To introduce contribution of Taguchi in designing, analysing and interpreting experiments.

Course Contents:

Sr. No.	Course contents	No. of Hours
1.	Overview of scientific research& Engineering Research: Nature and objective of research, Research topic, Literature review, steps in conducting literature review Formulation of problem, research questions and hypothesis, types of hypothesis, evaluation of hypothesis Research design, Sampling design, Measurement and scaling technique, Methods of Data collection, Statistical and sensitive analysis of data, Interpretation of result.	4
2.	Analyzing results of from experiment: Various Tests of significance based on type of input and output data, Steps involved in testing for significance, concept of p value, testing for means, Testing for variance, chi-square test-Goodness of fit, test of independence.	3
3.	Regression & correlation, linear and non linear regression, multi variable liner regression.	3
4.	Classification of experimental designs, Analysis of variance (ANOVA), ANOVA for detecting sources of variation – Statistical procedure for one-way ANOVA, Procedure for two-way ANOVA.	3
5.	Engineering research: Planning & management of experiments; Conventional method for experiment: One factor at a time (OFAT) experiment, Concept of design of experiments: Common terms, Designed experiment, Full factorial experiments: Orthogonality of experiments, Y = F (x) for DoE, main effect analysis, interaction analysis and results.	4
6.	Fractional factorial experiments, Resolution of design, screening DoE, practicing with excel and statistical software, Optimizing using Response Surface Methodology (RSM).	4
7.	Taguchi methods: Difference between conventional DoE and Taguchi methods, Orthogonal arrays, Taguchi's Robust parameter design, Noise factors, S/N ratio, Selection of right orthogonal array.	5
8.	Procedure for writing a research report and manuscript: steps of writing a report, layout of report, layout of research paper, ethical issues related to publishing, Plagiarism and Self-Plagiarism.	2

Lab Work

Sr. No.	Lab Contents	No. of Hours
	Performing following analysis using statistical software.	
1.	Hypothesis tests (Z-test, t-test, 2t test, paired t-test, Chi s square and test of equal variance etc).	4
	Correlation analysis between independent events, Regression analysis for dependent variables (having cause & effect) and developing Y = F (x).	6
2.	One-way ANOVA, Two-way ANOVA, General Linear Model.	6
3.	Creating and analysing 2^kExperiments (Full & Fractional Factorial) and General Full Factorial Design.	4
4.	Development of model using Response Surface Methodology.	4
5.	Creating and analysing Taguchi design.	4

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Plan a research activity including sample design, scaling, data collection and analysis.
2.	Perform a required statistical analysis for a research/ experiment.
3.	Describe the relationship between process variables and output as Y = F(x) + □.
4.	Select the appropriate orthogonal array for a Taguchi design.

Bibliography:

Sr. No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	Design and Analysis of Experiment, Douglas C Montgomery, John Wiley & Sons.	2016
2.	Taguchi Techniques for Quality Engineering Phillip, J. Ross; The Tata McGraw-Hill.	2017
3.	Research Methodology - Methods and Techniques, C. K. Kothari, New Age International, 2nd Edition.	2004

Program Core

Course Name	**:**	**Characterization of Materials**
Course Code	**:**	
Credits	**:**	**03**
L T P	**:**	**2 0 2**
Segment	**:**	**1-6**

Course Objectives:

The main objectives of this course are:	
1.	To introduce student the materials characterization using optical and electron microscopy.
2.	To expose students with different NDT, spectroscopy and thermal analysis techniques.

Total No. of Lectures: 28
Total No of Lab Hours: 28

Course Contents:

The student may choose any four modules among module 1-5. Module 6 is mandatory.

Module-1 Non Destructive Testing **(Credit- 0.5), Code: MTM5031**	**No. of Hours**
Non Destructive Testing (such as: X-ray radiography, Ultrasonic testing, Magnetic particle test, Die penetration test, Eddy current test, X-ray diffraction); Recording observations, Analysis, Preparation of reports on results, Correlating results with materials processing through case studies.	7

Module -2 Optical Microscopy **(Credit- 0.5), Code: MTM5032**	
Optical microscopy and their applications (such as phase contrast, Polarised light, differential interface contrast, Fluorescence Microscopy); Recording observations, Analysis, Preparation of reports on results, Correlating results with materials processing through case studies.	7

Module- 3 Electron Microscopy **(Credit- 0.5), Code: MTM5033**	
Instrumental detail, sample preparation and applications of following Electron microscopy: Scanning Electron Microscopy, Transmission Electron Microscopy; Recording observations, Analysis, Preparation of reports on results, Correlating results with materials processing through case studies.	7

Module -4 Spectroscopy **(Credit- 0.5), Code: MTM5034**	
Instrumental detail, sample preparation and applications of following spectroscopy: X-Ray Photon Spectroscopy (XPS), Ultra Violet Photon Spectroscopy (UPS), FTIR, IR; Recording observations, Analysis, Preparation of reports on results, Correlating results with materials processing through case studies.	7

Module- 5 Thermal Analysis **(Credit 0.5), Code: MTM5035**	
Technique, Instrumentation and applications of: DSC, DTA, TGA; Recording observations, Analysis, Preparation of reports on results, Correlating results with materials processing.	7

Lab Work:

Module -6 Materials Characterization Project/Lab **(Credit- 1), Code: MTM5036**		
Sr. No.	**Lab Contents**	**No. of Hours**
1.	To characterize a given material using Ultrasonic Flaw Detector.	04
2.	To perform Infrared Spectroscopy for ceramic and polymeric materials.	04

3.	To perform thermal analysis using DSC for glass transition temperature, crystallization and melting temperature.	06
4.	To perform optical microscopy for ferrous and non-ferrous.	04
5.	To study ferrous and non-ferrous samples using SEM.	06
6.	To perform structural analysis using X-ray diffraction technique.	04

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Describe the mechanisms, capabilities and limitations of the different characterization techniques.
2.	Perform the characterization of materials based on microscopy, chemical, physical, structural, and thermal analysis techniques.

Bibliography:

Sr. No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	R.J.D. Tilley, Crystals and crystal structures, John Wiley and Sons.	2006
2.	W.D. Callister, Materials science and engineering, Jr. Wiley India(P) Ltd.	2007
3.	G.S. Upadhyaya and Anish Upadhyaya, Materials science and engineering, , Viva books.	2010
4.	E.J. Mittemeijer, Fundamentals of materials science-the microstructure-property relationship using metals as model systems, Springer.	2010
5.	D. Brandon and W.D. Kaplan, Microstructural characterization of materials, John Wiley and Sons.	2008
6.	P.W. Hawkes and J.C.H. Spence, Science of microscopy, Springer.	2007
7.	J. Goldstein, Scanning electron microscopy & X-ray microanalysis, Springer.	2003
8.	B.D. Williams & C.B. Carter, Transmission electron microscopy, Springer.	2009
9.	D.J.O. Connor, B.A. Sextton, R.St.C. Smart, Surface analysis methods in materials science, Springer.	2003
10.	S. Zhang, Lin Li and Ashok Kumar, Materials characterization techniques, CRC Press.	2009
Online sources:		
1.	Latest research articles	
2.	http://nptel.ac.in/courses/113106034/	

MOOCs on this course are available at:

1) SAWAYM: Material Characterization

Course Name	**:**	**Materials Processing Technology**
Course Code	**:**	
Credits	**:**	**03**
L T P	**:**	**3 0 0**
Segment	**:**	**1-6**

Course Objectives:

The main objectives of this course are:	
1.	To introduce students with different processing technologies for ceramic, polymer and composite materials.
2.	To expose students with different applications of ceramic, polymer and composite materials.

Total No. of Lectures: 42

Course Contents:

Module-1 Ceramic Processing Technology**(Credit- 1.0), Code: MTM5041**	**No. of Hours**
Technology for ceramic powder preparations: mechanical methods, chemical methods and colloidal processing, Powder Characteristics, shaping techniques such as powder compaction, Extrusion, Injection molding, Slip casting, Solid state and liquid phase sintering, Sintering furnaces and atmospheres, Case studies highlighting selection of materials for specific applications.	14

Module -2 Polymer Processing Technology **(Credit- 1.0), Code: MTM5042**	
Structure and its relation to thermal, chemical, electrical and optical properties. Polymer Processing technology: Addition and condensation polymerization, compounding and vulcanization techniques, polymer blending injection moulding, Extrusion, thermoforming, compression and transfer moulding, blow moulding, spinning, calendaring, roller and blade coating, film blowing, textile/fiber spinning technology. Engineering applications of polymers.	14

Module -3 Composites & Hybrid Materials Processing Technology **(Credit- 1.0), Code: MTM5043**	
Mechanics of composite materials, Reinforcements- particles, whiskers, fibers, Technology and applications of Dispersion hardened composites, Fiber reinforcement composites, metal matrix composite, ceramic matrix composites, polymer matrix composites. Production of diamond tools and cermets, composite coatings, electrodeposition techniques, spray forming, characterization of composites.	14

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Describe the various synthesis and consolidation processes of ceramic powders.
2.	Analyse the microstructure and defects developed during consolidation process.
3.	Design and optimize fabrication process parameters for ceramics, polymers and composite materials.

Bibliography:

Sr. No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	Tadmor, Principles of polymer processing, 2nd Edition, Wiley.	2006

2.	C.B Carter and M.G. Norton Ceramic materials: Science and engineering, Springer.	2013
3.	Md. N. Rahaman, Ceramic processing and sintering, Marcel Dekker Inc.	2003
4.	K.K. Chawla, Composite materials, Springer-Verlag, New York.	2012
5.	E.J. Barbero, Introduction to composite materials design, CRC Press.	2011
Online sources:		
1.	Latest research articles	

Classical Books:

Sr. No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	D. Hull, T. W. Clyne, An introduction to composite materials 2nd edition, Cambridge University press.	1996
2.	Tim A. Osswald, Polymer processing fundamentals, Hanser.	1998
3.	L.A. Pilato and M.J. Michno, Advanced composite materials, Springer.	1994

Program Elective

Course Name	**:**	**Metal Forming & Heat treatment**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2 1 0**
Segment	**:**	**1-3**

Course Objectives:

The main objectives of this course are:	
1.	To introduce students with understanding of phase changes that occurs during thermal, thermo mechanical treatments.
2.	To expose students with modelling and simulation for metallurgical processes.

Total No. of Lectures: 21

Course Contents:

Module 1 is mandatory. The student may choose any one module among module 2 and 3.

Module-1 Industrial Heat Treatment **(Credit- 1), Code: MTM5301**	**No. of Hours**
Heat treatment of steels: TTT and CCT diagrams, Industrial heat treatment practices such as surface hardening of steels- carburizing, nitriding, carbonitriding and others. Important HT parameters, Process Design, Limitation and Challenges in HT. Advance HT Techniques, HT of Micro components. Various thermo-mechanical processing treatments especially in micro alloyed, ultra high strength steels, super alloys. Toughening operation through HT.	14

Module- 2 Metallurgy of Forming Process**(Credit- 0.5), Code: MTM5302**	
Metallurgical aspects in conventional Metal forming processes. Advance forming processes: Explosive forming, electro-hydraulic and magnetic forming processes, Die Design.	7

Module -3 Modelling & Simulation in Process Metallurgy**(Credit- 0.5), Code: MTM5303**	
Basic concepts on CAD& FEA, their applications for metal working simulations. Basic concepts on ANN and applications in alloy developments & HT.	7

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Describe the heat treatment of steels using TTT and CCT.
2.	Design the heat treatment required to obtain a required microstructure.
3.	Correlate the solid state atomic mobility to transport phenomena in heat treatment of materials.
4.	Design the modelling and simulation for metallurgical processes.

Bibliography:

Sr. No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	W.F. Hosford, and R.M. Cadell, Metal Forming: Mechanics and Metallurgy, Cambride University Press, Cambridge.	2007
2.	T.V. Rajan, V.P. Sharma, A. Sharma, Heat treatment: principle and practice. Prentice-Hall of India.	2004
3.	D. C. Rapaport, The art of molecular dynamics simulation, Cambridge University Press.	2004
4.	June Gunn Lee, Computational materials science: an introduction, CRC	2012

	Press.	
Online sources:		
1.	Latest research articles	

Classical Books:

Sr. No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	G. Dieter, Mechanical Metallurgy, Mc-Graw Hill.	1961
2.	Y. Lakhtein, Engineering physical metallurgy and heat treatment, Mir Publisher.	1979
3.	D.A. Porter and K.E. Easterling, Phase transformations in metals and alloys, Taylor and Francis.	1992
4.	J. M. Haile, Molecular dynamics simulation: Elementary methods, Wiley Professional.	1997
5.	Allen and Tildesley, Computer simulation of liquids, Oxford.	1987

Course Name	**:**	**Biomaterials**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**3 0 0**
Segment	**:**	**1-3**

Course Objectives:

The main objectives of this course are:	
1.	To introduce student the fundamentals of biomaterials.
2.	To emphasis on understanding of biomaterials, their synthesis techniques, their behavior under loadings and application in design for broken or failed parts of the human body.

Total No. of Lectures: 21

Course Contents:

Module-1 Engineered Materials in Medical Applications **(Credit- 0.5), Code: MTM5321**	**No. of Hours**
Basic understanding on the engineering and processing aspects of biomaterials used in medical applications, Biocompatible, Bioactive, and Biodegradable materials, Metallic implants, Bioceramic, Polymeric hydrogel, Composites in biomedical applications.	7

Module -2 Tissue -Biomaterial Interactions **(Credit- 0.5), Code: MTM5322**	
Biocompatibility of Biomaterials: Protein structure, interaction of proteins with synthetic materials; Characterization of cell material interactions; inflammatory responses; acute inflammation, chronic inflammation, foreign body response, assessment of material performance.	7

Module -3 Current Progress in Bio Medical Devices **(Credit- 0.5), Code: MTM5323**	
Application of biomaterials in medicine, biology, and artificial organs (such as medical devices, to drug delivery, regenerative medicine).	7

Course Outcomes:

At the completion of this course, students will be able to:	
1	Identify the biomaterials and their production.
2	Describe the application areas of biomaterials.
3	Create a skill to prepare and explain a presentation topic about biomaterials.
4	Analyse the importance of relationships between living tissues and biomaterials.

Bibliography:

Sr. No	**Name of Book/ Authors/ Publisher**	**Year of Publication**
1.	J. Park, R. S. Lakes, Biomaterials: An Introduction, Springer.	2007
2.	R. Pignatello, Biomaterials Science and Engineering, Janeza Trdine 9.	2011
Online sources:		
1.	Latest research articles	
2.	http://nptel.ac.in/courses/113104009/	
3.	http://nptel.ac.in/courses/113108071/	

MOOCs on this course are available at:

1) SAWAYM: Biomaterials for bone tissue engineering applications.

Course Name	**:**	**Powder Metallurgy Technology**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**3 0 0**
Segment	**:**	**4-6**

Course Objectives:

The main objectives of this course are:	
1.	To introduce student with various powder metallurgical processes.
2.	To understand various ways of designing components using powder metallurgy.
3.	To introduce students with advance manufacturing processing of intricate machine component with metallurgical compatible and incompatible materials through powder metallurgy route.

Total No. of Lectures: 21

Course Contents:

Module-1 Powder Manufacturing & Conditioning **(Credit- 0.5),** **Code: MTM5401**	**No. of Hours**
Chemical Methods: Chemical reduction, chemical decomposition of compound. Physical methods: Electrolytic method, Atomization, Mechanical methods (Milling), selection of metal powder production method, powder characterization, chemical composition and structure of metal powder, particle size and shape, particle surface topography, surface area, apparent and tap density, flow rate, compressibility and green strength, particle size reduction, granulation, coating of metal powders with organic of inorganic materials.	7

Module -2 Powder Compaction & Sintering. **(Credit- 0.5),** **Code: MTM5402**	
Die compaction, Cold isostatic compaction, Powder roll compaction, Hot pressing, Hot-isostatic pressing, Compaction process variables and limitations, Sintering process, sintering furnaces, process parameter and challenges and industrial practice in sintering.	7

Module -3 Quality Control in Powder Metallurgy Components **(Credit- 0.5),** **Code: MTM5403**	
Case studies of novel upcoming powder metallurgy components and devices.	7

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Manufacture powders metallurgy components.
2.	Design various components though powder metallurgy route.

Bibliography:

Sr. No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	A. Upadhyaya, G.S. Upadhyaya, Powder Metallurgy: Science, Technology and Materials.	2011
Online sources:		
1.	Latest research articles	

Classical Books:

Sr. No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	R.M. German, Powder Metallurgy Science, 2nd edition, Metal Powder Industries Federation.	1994
2.	ASM Handbook, Volume 7: Powder Metal. Technologies & Applications.	1998

Course Name	**:**	**Nano Materials**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**3 0 0**
Segment	**:**	**4-6**

Course Objectives:

The main objectives of this course are:	
1.	To introduce students with fundamentals and recent advancements of nanomaterials in electronic, energy and optical industries.
2.	To introduce student with different application of nano materials in energy, electronics and optical industries.

Total No. of Lectures: 21

Course Contents:

Module-1 Nanomaterials for Electronic Applications **(Credit- 0.5),** **Code: MTM5421**	**No. of Hours**
Quantum dots, quantum wires, Photonic band gap materials, nanoscale photonic devices, special phenomena in 2D and 3D nano structures. Carbon nanomaterials: Carbon nanotubes and grapheme. Single-Electron Transistor, Carbon Nanotube Transistors (FETs and SETs), Semiconductor Nanowire for FETs and SETs, High Electron Mobility Transistors; Quantum Interference Transistors; Quantum Corrals in Electronics, Spintronic. Recent development in nanoelectronics.	7

Module -2 Nanomaterials for Energy Applications **(Credit- 0.5),** **Code: MTM5422**	
Nanotechnology enabled renewable energy technologies -Energy transport, conversion and storage- quantum dots, nano, micro, and poly crystalline. Solar cells. Capacitance measurement and analysis. Nanomaterials for fuel cells, Carbon Nanotubes for energy storage, Hydrogen storage in carbon nanotubes, Use of nanoscale catalysts to save energy and increase the industrial productivity. Current status and future prospects.	7

Module -3 Nanomaterials for Optical Applications **(Credit- 0.5),** **Code: MTM5423**	
Optical luminescence and fluorescence, LED and solar cells, electroluminescence, barriers to nanoparticle lasers, doping nanoparticles, Si nano dots. Nanophotonic and Plasmonic, Nano lasers, nano antennas, photonic crystals; optical communication, sensing; negative refraction, nanostructures for large-area opto-electronics. Current development in nanomaterials for optical applications.	7

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Describe the basic concepts of nanoscale materials.
2.	Select nanomaterials for specific applications.
3.	Analyse the application of nanomaterials in the field of electronics, optical, and energy.

Bibliography:

Sr. No	**Name of Book/ Authors/ Publisher**	**Year of Publication**
1.	D.M. Ashby, P. Ferreira, D.L. Schodek, Nanomaterials,	2009

	Nanotechnologies and Design: an Introduction to Engineers and Architects, Butterworth-Heinemann.	
2.	Z.L. Wang, Y. Liu, Z. Zhang, Handbook of Nanophase and Nanostructured Materials (in four volumes), Kluwer Academic/Plenum Publishers.	2003
3.	G.L. Hornyak, J. Dutta, H.F. Tibbals, A.K. Rao, Introduction to nanoscience, CRC Press.	2008
4.	A. Luque and S. Hegedus, Handbook of Photovoltaics Science and Technology.	2003
5.	A. Kitai, Principles of Solar Cells, LEDs and Diodes: The Role of the PN Junction, Wiley.	2011
6.	A.J. Moulson and J.M. Herbert, Electroceramics: materials, properties, applications.	2003
Online sources:		
1.	Latest research articles	

Open Elective

Course Name	**:**	**Failure Analysis**
Course Code	**:**	**IMO5001**
Credits	**:**	**1.5**
L T P	**:**	**3 0 0**
Segment	**:**	

Course Objectives:

The main objectives of this course are:	
1.	To introduce students with fundamental understanding of the fracture of materials.
2.	To introduce students with various fracture phenomenons and their analysis using different techniques.

Total No. of Lectures: 21

Course Contents:

Student may choose any three modules.

Module-1 Failure in Metals **(Credit- 0.5)**	**No. of Hours**
Reason of failure, types of failure; Basic models of deformation, Resolved shear stress, Critical resolved shear stress, Types of fracture, Griffith theory, Nucleation of crack – different models, Propagation of crack, effect of grain size on brittle fracture.	7

Module-2 Failure Modes **(Credit- 0.5)**	
Failure in tension, compression, torsion, impact, wear, fatigue, creep, oxidation, corrosion, erosion. Metallurgical factors (such as structure, composition, processing) influencing failure mechanism.	7

Module-3 Techniques of Failure Analysis **(Credit- 0.5)**	
Destructive and Non-destructive Testing, Macro- examination, Microscopic examination, TEM, SEM, X-Ray diffraction techniques.	7

Module-4 Quality Assurance and Case studies **(Credit- 0.5)**	
A strong link to failure analysis, Quality control concept, quality assurance, at least one case study representing each failure mode given in module 4. For example- Failure of a low-pressure turbine rotor (LPTR) blade (Fatigue), Failure of an aircraft engine fuel pump (wear), Failure of a stabilizer link rod in an aircraft (over load, tension and bending) etc.	7

Course Outcomes:

At the completion of this course, students will be able to:	
1	Identify the fracture in materials.
2	Analyse the fracture of materials due to defects.
3	Design the prevention plan to solve engineering fracture problems.

Bibliography:

Sr. No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
2.	C. R. Brooks and A. Choudhury, Failure analysis of engineering materials, McGraw-Hill.	2002
3.	V. Ramachandran, A.C. Raghuram, R.V. Krishnan, and S.K. Bhaumik, Failure analysis of engineering structures: Methodology and case histories, ASM International.	2005
4.	Damage and fracture mechanics: Failure analysis of engineering	2009

	materials and structures, Springer Science and Business media B V.	
Online sources:		
1.	Latest research articles.	

Classical Books:

Sr. No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	R. W. Hertzberg, Deformation and fracture mechanics of engineering materials, John Wiley & Sons.	1996

MOOCs on this course are available at:

1) SAWAYM: Failure analysis and Prevention

Course Name	**:**	**Characterization of Materials**
Course Code	**:**	**IMO5002**
Credits	**:**	**1.5**
L T P	**:**	**3 0 0**
Segment	**:**	

Course Objectives:

The main objectives of this course are:	
1.	To introduce student the materials characterization using optical and electron microscopy.
2.	To expose students with different NDT, spectroscopy and thermal analysis techniques.

Total No. of Lectures: 21

Course Contents:

Student may choose any three modules.

Module -1 Optical Microscopy **(Credit- 0.5)**	**No. of Hours**
Optical microscopy and their applications (such as phase contrast, Polarised light, differential interface contrast, Fluorescence Microscopy); Recording observations, Analysis, correlating results with materials processing through case studies.	7

Module- 2 Electron Microscopy **(Credit- 0.5)**	
Instrumental detail, sample preparation and applications of following Electron microscopy: Scanning Electron Microscopy, Transmission Electron Microscopy; Recording observations, Analysis, correlating results with materials processing through case studies.	7

Module -3 Spectroscopy **(Credit- 0.5)**	
Instrumental detail, sample preparation and applications of following spectroscopy: X-Ray Photon Spectroscopy (XPS), Ultra Violet Photon Spectroscopy (UPS), FTIR, IR; Recording observations, Analysis, correlating results with materials processing through case studies.	7

Module- 4 Thermal Analysis **(Credit 0.5)**	
Technique, Instrumentation and applications of: DSC, DTA, TGA; Recording observations, Analysis, correlating results with materials processing.	7

Course Outcomes:

At the completion of this course, students will be able to:	
1	Describe the mechanisms, capabilities and limitations of the different characterization techniques.
2	Perform the characterization of materials based on microscopy, chemical, physical, structural, and thermal analysis techniques.

Bibliography:

Sr. No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	R.J.D. Tilley, Crystals and crystal structures, John Wiley and Sons.	2006
2.	W.D. Callister, Materials science and engineering, Jr. Wiley India(P) Ltd.	2007
3.	G.S. Upadhyaya and Anish Upadhyaya, Materials science and engineering, , Viva books.	2010

4.	E.J. Mittemeijer, Fundamentals of materials science-the microstructure-property relationship using metals as model systems, Springer.	2010
5.	D. Brandon and W.D. Kaplan, Microstructural characterization of materials, John Wiley and Sons.	2008
6.	P.W. Hawkes and J.C.H. Spence, Science of microscopy, Springer.	2007
7.	J. Goldstein, Scanning electron microscopy & X-ray microanalysis, Springer.	2003
8.	B.D. Williams & C.B. Carter, Transmission electron microscopy, Springer.	2009
9.	D.J.O. Connor, B.A. Sextton, R.St.C. Smart, Surface analysis methods in materials science, Springer.	2003
10.	S. Zhang, Lin Li and Ashok Kumar, Materials characterization techniques, CRC Press.	2009
Online sources:		
1.	Latest research articles	
2.	http://nptel.ac.in/courses/113106034/.	

MOOCs on this course are available at:

1) SAWAYM: Material Characterization.

Course Name	**:**	**Functional Materials**
Course Code	**:**	**IMO5003**
Credits	**:**	**1.5**
L T P	**:**	**3 0 0**
Segment	**:**	

Course Objectives:

The main objectives of this course are:	
1.	To introduce various functional materials, their physics, applications, and examples.
2.	To expose the properties and applications of functional materials in modern technology.

Total No. of Lectures: 21

Course Contents:

Module-1 Smart Materials & Sensors **(Credit- 0.5)**	**No. of Hours**
Material aspects and design rules of functional devices, Piezoelectric sensors, Actuators and transducers thermoelectric & optical sensors, Transparent ceramics, multiferroic and magnetoelectrics: Issues & possible applications, GMR Materials.	7

Module -2 Electronic Materials **(Credit- 0.5)**	
Ferroelectric crystals and applications, Relaxor Materials, Spintronic: Spin polarization and application, Piezoelectrics for energy harvesting applications, Materials for optoelectronic devices: solar cells & OLED's.	7

Module -3 Magnetic Materials **(Credit- 0.5)**	
Soft & Hard magnetic materials and their applications, DC, low frequency, RF, microwave and recording applications of magnetic oxides and alloys; CMR Materials, Magneto caloric materials and spin glasses, Super paramagnetism, Ferrofluid Magneto electronics, Recent developments in the applications of Magnetic Materials.	7

Course Outcomes:

At the completion of this course, students will be able to:	
1	Describe a broad range of present and future functional materials.
2	Correlate the structural-property of functional materials.
3	Design the thin films and their characterizations.

Bibliography:

Sr. No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	S. O. Kasap, Principles of Electronic Materials & Devices, 3rd edition, McGraw Hill.	2007
2.	B.D. Cullity, C.D. Graham, Introduction to Magnetic Materials, Wiley, 2nd edition.	2008
3.	Eugene A. Irene, Electronic Materials Science, Wiley.	2005
4.	The Science and Engineering of Microelectronics Fabrication, Oxford University Press by Stephen A. Campbell.	1996
5.	Electronic Materials and Devices, Wiley by David K. Ferry, Jonathan P Bird.	2001

6.	Tseung-Yuen Tseng and Hari Singh Nalwa, Handbook of Nanoceramics and their Based Nanodevices, American Scientific Publishers.	2009
7.	A. J. Moulson & J. M. Herbert, Electroceramics: Materials, Properties, Applications, Wiley.	2003
8.	M. Lines & A. Glass, Principles and applications of ferroelectrics and related materials, Oxford University Press, New York.	2001
Online sources:		
1.	Latest research articles.	