Malaviya National Institute of Technology Jaipur

Revised Curriculum of M. Tech. (Steel Technology)

M. Tech I Semester

With effect from 2021-22 session

S. No.	Course Code	Course Title	Category	Type	Credit	L	T	P
1.	21MTT-521	Advanced Manufacturing Processes of Steels	PC	Theory	3	3	0	0
2.	21MTT-522	Advanced Metallurgical Thermodynamics	PC	Theory	3	3	0	0
3.	21MTT-523	Materials Characterization	PC	Theory	3	3	0	0
4.		Program Elective-I	PE	Theory	3	3	0	0
5.		Program Elective-II	PE	Theory	3	3	0	0
6.	21MTP-524	Microstructure Property Correlation Lab	PC	Lab	2	0	0	4
					17			
List of Electives								
1.	21MTT-817	Advanced Foundry Technology	E-2	Theory	3	3	0	0
2.	21MTT-818	Advances in Heat Treatment	E-1	Theory	3	3	0	0
3.	21MTT-819	Corrosion and its Prevention	E-1	Theory	3	3	0	0
4.	21MTT-820	Mathematical Modeling and Simulation in Materials Processing	E-2	Theory	3	3	0	0
5.	21MTT-821	Physical Metallurgy of Alloy Steels	E-2	Theory	3	3	0	0
6.	21MTT-822	Steels for Structural Applications	E-1	Theory	3	3	0	0

L=Lecture hours/week; **P**=Practical hours/week; **T**=Tutorial hours/week

M. Tech II Semester

S. No.	Course Code	Course Title	Category	Type	Credit	L	T	P
1.	21MTT-525	Advanced Physical Metallurgy	PC	Theory	3	3	0	0
2.	21MTT-526	Advanced Solidification Processing of Steels	PC	Theory	3	3	0	0
3	21MTT-527	Advances in Iron making and Steel making	PC	Theory	3	3	0	0
4.		Program Elective-I	PE	Theory	3	3	0	0
5.		Program Elective-II	PE	Theory	3	3	0	0
6.		Program Elective-III	PE	Theory	3	3	0	0
					18			
List of Electives								
1.	21MTT-823	Advanced Ceramics and Glasses	E-3	Theory	3	3	0	0
2.	21MTT-824	Advanced Welding Technology of Steel	E-3	Theory	3	3	0	0
3.	21MTT-825	Fracture and Failures Analysis	E-1	Theory	3	3	0	0
4.	21MTT-826	Functional Materials	E-3	Theory	3	3	0	0
5.	21MTT-827	Mechanical Behavior of Steels	E-1	Theory	3	3	0	0
6.	21MTT-828	Non-Destructive Testing and Evaluation	E-2	Theory	3	3	0	0
7.	21MTT-829	Powder Metallurgy and Particulate Materials Processing	E-2	Theory	3	3	0	0
8.	21MTT-830	Surface Engineering	E-1	Theory	3	3	0	0
9.	21MTT-831	Transport Phenomena in Materials Processes	E-2	Theory	3	3	0	0

M. Tech III Semester

S. No.	Course Code	Course Title	Category	Type	Credit	L	T	P
1.	21MTD-621	Dissertation-I	PC	-	10	0	0	20
2.	21MTS-622	Seminar *	PC	-	2	0	0	4

**** In lieu of seminar, interested students may be encouraged to do an internship in an industry/research organization for 4-8 weeks during summer vacation after Semester-II and will present a seminar in semester-III.***

M. Tech IV Semester

S. No.	Course Code	Course Title	Category	Type	Credit	L	T	P
1.	21MTD-623	Dissertation-II	PC	-	12	0	0	24

L=Lecture hours/week; **P**=Practical hours/week; **T**=Tutorial hours/week

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**:**	Department of Metallurgical and Materials Engineering
Course Code	**:**	21MTT-521
Course Name	**:**	Advanced Manufacturing Processes of Steels
Credits	**:**	3 **(L -** 3 **T -** 0 **P -** 0**)**
Course Type	**:**	Core
Prerequisites	**:**	none

Course Contents

Unit-1

Manufacturing Processes - Basic Introduction, the importance of manufacturing, economics and technological definition, classification, and selection of manufacturing processes. (**No. of Lectures: 06)**

Unit-2

Metal Casting Processes - Metal mold casting, continuous casting, vacuum mold casting, evaporative pattern casting, ceramic shell casting. (**No. of Lectures: 12)**

Unit-3

Advanced Welding Processes - Details of electron beam welding (EBW), laser beam welding (LBW), ultrasonic welding (USW), and friction-stir welding. (**No. of Lectures: 06)**

Unit-4

Metal Forming Processes - Rolling and forging of steel, Details of high energy rate forming (HERF) process, Electro-magnetic forming, explosive forming, Electro-hydraulic forming, Stretch forming, and Contour rolls forming, Additive manufacturing. (**No. of Lectures: 12)**

Recommended Readings

Text Books

1. P. N. Rao, Manufacturing technology (foundry, forming & welding), Tata McGraw Hill, 2018.
2. J. A. Schey, Introduction to manufacturing processes, McGraw Hill Education, 2012.

Reference book-

1. S. Mukherjee, Metal fabrication technology, PHI Learning (P) Ltd., 2010.
2. J .P. Kaushish, Manufacturing processes, PHI Learning (P) Ltd., 2013.
3. S. Kalpkjian and S. R. Schmid, Manufacturing Processes for engineering materials, Pearson Education Asia, 2017.
4. R. G. Bruce, W. K. Dalton, J. E. Neely, and R. R. Kibbe, Modern materials and manufacturing processes, Pearson, 2003.
5. J. S. Campbell, Principles of manufacturing materials and processes, Tata McGraw Hill, 1984.

Online resources- https://nptel.ac.in

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**:**	Department of Metallurgical and Materials Engineering
Course Code	**:**	21MTT-522
Course Name	**:**	Advanced Metallurgical Thermodynamics
Credits	**:**	3 **(L -** 3 **T -** 0 **P -** 0**)**
Course Type	**:**	Core
Prerequisites	**:**	none

Course Contents

Unit-1

Review of Thermodynamics - First, second and third laws of thermodynamics, concepts of entropy, Maxwell's relations, Clausius-Clayperon equation.

(**No. of Lectures: 08)**

Unit-2

Solutions - Solution models, regular, sub-regular, cluster variation models, multi-parameter models, quasi-chemical theory, statistical thermodynamics, multi-component systems.

(**No. of Lectures: 07)**

Unit-3

Equilibrium Concepts - Unary, binary, and multi-component systems, phase equilibria, the evolution of phase diagrams, metastable phase diagrams, calculation of phase diagrams, thermodynamics of defects.

(**No. of Lectures: 08)**

Unit-4

Thermodynamics of Phase Transformations - Melting and solidification, precipitation, eutectoid, massive, spinodal, martensitic, order-disorder transformations and glass transition, first and second-order transitions.

(No. of Lectures: 08)

Unit-5

Heterogeneous Systems - Equilibrium constant, Ellingham diagrams and their application to commercially important reactions, Porbaix Diagram, introduction to computational tools for thermodynamic equilibrium.

(No. of Lectures: 05)

Recommended Readings

Text books

1. D. R. Gaskell and D. E. Laughlin, Introduction to Thermodynamics of Materials, 6th Ed., CRC Press Taylor and Francis Group, 2018.
2. D. A. Porter and K. E. Easterling, and M. Y. Sherif, Phase Transformations in Metals and Alloys, CRC Press, 3rd edition (Indian reprint), 2009.
3. A. Ghosh. Textbook of Materials & Metallurgical Thermodynamics, Prentice Hall India, 2002.

Reference books

1. A. Ghosh, H. S. Ray, Principles of Extractive Metallurgy, New Age Int. (P) Ltd., New Delhi, 1991.
2. R. A. Swalin, Thermodynamics of Solids, 2nd Ed., Wiley, New York, 1972.
3. S. K. Bose and S. K. Roy. Principles of Metallurgical Thermodynamics, Universities Press 2015.

Online resources- https://nptel.ac.in

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**:**	Department of Metallurgical and Materials Engineering
Course Code	**:**	21MTT-523
Course Name	**:**	Materials Characterization
Credits	**:**	3 **(L -** 3 **T -** 0 **P -** 0**)**
Course Type	**:**	Core
Prerequisites	**:**	none

Course Contents

Unit-1

Optical Microscopy - Principle of the optical microscope, components of the microscope, the concept of resolution and magnification, specimen preparation for microscopic examination: sectioning and mounting, grinding, polishing, etching, determination of grain size and volume fractions of the phases present in the microstructure. (**No. of Lectures: 06)**

Unit-2

X-ray Diffraction (XRD)- X-ray diffraction, structure factor, indexing of XRD, determination of phases, lattice parameters, crystallite size, and residual stresses. (**No. of Lectures: 06)**

Unit-3

Electron Microscope (EM) - Principle and optics of scanning electron microscope (SEM) and Transmission electron microscope (TEM), types of electron sources, image formation, resolving power, specimen preparation techniques, applications of EMs. Electron beam-specimen interaction: contrast mechanism, bright-field image, and dark-field image, selected area diffraction (SAD), indexing of SAD pattern, texture analysis. (**No. of Lectures: 10)**

Unit-4

Micro and Surface Analysis - Basic principle and applications of X-ray photoelectron spectroscopy (XPS), auger electron spectroscopy (AES), energy dispersive spectroscopy (EDS), wavelength dispersive spectroscopy (WDS), scanning probe microscope, electron backscattered diffraction (EBSD). (**No. of Lectures: 06)**

Unit-5

Spectroscopy – UV Visible spectroscopy, X-ray fluorescence, infrared spectroscopy, and Raman spectroscopy. (**No. of Lectures: 03)**

Unit-6

Thermal Analysis - Basic principles of thermogravimetry analyzer (TGA), differential thermal analyzer (DTA), differential scanning calorimeter (DSC), dilatometer, etc. Interpretation of curves obtained from TGA/ DSC/ dilatometer for various materials etc. (**No. of Lectures: 05)**

Recommended Readings

Text book

1. B. D. Cullity and S. R. Stock, Elements of Diffraction, 3rdEdn (Indian), Pearson, Noida, India, 2016.
2. J. Goldstein, Scanning Electron Microscopy and X-ray microanalysis, 3rd edition, Springer, 2007.

Reference book-

1. S. Zhang, L. Li, and A. Kumar, Materials Characterization Techniques, CRC Press, New York, 2009.
2. D. Brandon and W. D. Kaplan, Microstructural Characterization of Materials, 2nd edition, Wiley, 2008.
3. D. B. Williams and C. Barry Carter, Transmission Electron Microscopy, 2nd edition, Springer, 2009.

Online resources- https://nptel.ac.in

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**:**	Department of Metallurgical and Materials Engineering
Course Code	**:**	21MTT-817
Course Name	**:**	Advanced Foundry Technology
Credits	**:**	3 **(L -** 3 **T -** 0 **P -** 0**)**
Course Type	**:**	Elective (E-2)
Prerequisites	**:**	None

Course Contents

Unit-1

Introduction to the foundry, pattern, core, mold, molding materials, special additives, pattern allowances, gating, and risering system.

(**No. of Lectures: 09)**

Unit-2

Solidification, nucleation, and growth, pure metal and alloy solidification, directional and progressive solidification.

(**No. of Lectures: 09)**

Unit-3

Die casting, hot box process, cold box process, high-pressure casting, continuous casting, investment casting, centrifugal casting, sodium silicate process, shell casting, casting of functionally graded material, evaporative pattern casting, vortex stir casting of metal matrix composite, direct chill casting.

(**No. of Lectures: 09)**

Unit-4

Casting defects and their remedies.

(**No. of Lectures: 09)**

Recommended Readings

Text Books

1. P. R. Beeley, Foundry Technology, Butterworth & Co., 2001.
2. P. N. Rao, Manufacturing technology (foundry, forming & welding), Tata McGraw Hill, 2018.
3. P. L. Jain, Principles of Foundry Technology, Tata McGraw-Hill Education, 2003.

Reference book

1. T. Vijayaram, Advanced casting technologies, IntecOpen, 2018.
2. P. C. Mukherjee, Fundamentals of Metal Casting Technology, Oxford & IBH Publishing Company, 1988.

Online resources- https://nptel.ac.in

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**:**	Department of Metallurgical and Materials Engineering
Course Code	**:**	21MTT-818
Course Name	**:**	Advances in Heat Treatment
Credits	**:**	3 **(L -** 3 **T -** 0 **P -** 0**)**
Course Type	**:**	Elective (E-1)
Prerequisites	**:**	none

Course Contents

Unit-1

Furnaces,basics of heat treatment, review on different types of heat treatment techniques, heat treatment process variables, the effect of heating and cooling on properties of steel, quenching technology, high-pressure gas quenching, applications of vacuum oil quenching.

(**No. of Lectures: 09)**

Unit-2

Recovery, recrystallization, and grain growth, TTT curves, and CCT diagram and its significance to heat treatment.

(**No. of Lectures: 08)**

Unit-3

Hardness and hardenability of steels and methods of determination, case hardening processes for steels (induction hardening, carburizing, nitriding, boronizing, carbonitriding), thermo-mechanical treatments, precipitation hardening (Maraging steel, PH stainless steel, Al-Cu based alloys), vacuum treatments, vacuum carburizing**.**

(**No. of Lectures: 07)**

Unit-4

Heat treatment of special steels like high speed steels, maraging steels, spring steels, ball bearing steels, stainless steels heat treatment defects and remedial measures.

(**No. of Lectures: 06)**

Unit-5

Heat treatment of some important non-ferrous metals such as aluminium, titanium, nickel, etc.

(**No. of Lectures: 06)**

Recommended Readings

Text Books

1. T. V. Rajan, C. P. Sharma, A. Sharma, Heat Treatment: Principles, Prentice Hall of India Pvt. Ltd., New Delhi,1994.
2. V. Raghvan, Physical Metallurgy: Principles and Practice, Third Edition, Prentice-Hall of India Publishing, 2015.

Reference book

1. S. K. Mandal, Heat Treatment of Steels, McGraw Hill Education (Noida, India), 2017.
2. V. Singh, Heat treatment of Metals, Standard Publisher Distributors, 1998.
3. ASM Metals Handbook, 9th edition, Vol.4.

Online resources- https://nptel.ac.in

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**:**	Department of Metallurgical and Materials Engineering
Course Code	**:**	21MTT-819
Course Name	**:**	Corrosion and its Prevention
Credits	**:**	3 **(L -** 3 **T -** 0 **P -** 0**)**
Course Type	**:**	Elective (E-1)
Prerequisites	**:**	none

Course Contents

Unit-1

Relevance & importance of corrosion studies, costs of corrosion, expressions for corrosion rate. (**No. of Lectures: 02)**

Unit-2

Electrochemical & thermodynamic principles of corrosion, electrode kinetics, its application to experimental observations, activation, and concentration polarization, graphical representation of kinetic data, determination of E_{corr} and I_{corr} from potentiodynamic polarization curve, passivity & electrochemical behaviour of active-passive metals & alloys.

(**No. of Lectures: 14)**

Unit-3

Different forms of corrosion: Uniform, galvanic, intergranular, pitting, crevice, dealloying, stress corrosion cracking, corrosion fatigue, hydrogen embrittlement, high temperature corrosion. (**No. of Lectures: 10)**

Unit-4

Corrosion prevention: Selection of proper materials, development of suitable alloys, design improvement, modification of environment, cathodic & anodic protection, corrosion & its prevention, coating. (**No. of Lectures: 06)**

Unit-5

Case studies related to combatting corrosion in industries. (**No. of Lectures: 04)**

Recommended Readings

Text book

1. L. L. Shrier, R. A. Jarmon & G.T. Bursteir, Corrosion: Vol. I & II, Butterworth & Heinemann publications, Great Britain, 1994.
2. D. Talbot and J. Talbot, Corrosion Science & Technology, CRC Press, London, 2019.

Reference book

1. M. G. Fontana, Corrosion Engineering, Tata McGraw-Hill, 3rd Ed. (seventh reprint), 2008.
2. D. A. Jones, Principles and Prevention of Corrosion, Prentice-Hall, 1996.
3. P. R. Roberge, Corrosion engineering: principles and practice, McGraw-Hill, 2008.
4. V. S. Sastri, E. Ghali, and M. Elboujdaini, Corrosion prevention and protection: Practical solutions, John Wiley and Sons, 2007.

Online resources- https://nptel.ac.in

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**:**	Department of Metallurgical and Materials Engineering
Course Code	**:**	21MTT-820
Course Name	**:**	Mathematical Modelling and Simulation in Materials processing
Credits	**:**	3 **(L -** 3 **T -** 0 **P -** 0**)**
Course Type	**:**	Elective (E-2)
Prerequisites	**:**	None

Course Contents

Unit 1

Basics of mathematical modelling-deterministic and stochastic/probabilistic models, steps in building mathematical models, source of errors, dimensional analysis, model classification, and illustration.

(**No. of Lectures: 12)**

Unit-2

Mathematical formulation of liquid state metallurgical processes of iron making, primary steel making & secondary steel making using momentum, mass & energy balance; mathematical formulation of solid-state processes of heat treatment & microstructure evolution, diffusion & kinetics.

(**No. of Lectures: 12)**

Unit-3

Formulation of rolling and forging operations, statistical methods for validating models, introduction to FEM, FDM, FVM, and computer packages: Mat Lab, Sci Lab, ANN.

(**No. of Lectures: 12)**

Recommended Readings

Text book

1. D. Mazumdar and J. W. Evans, Modelling of steel making processes, 1st edition, CRC Publication, 2010.

Reference book

1. H. K. Versteeg and W. Malalsekera, An introduction to computational fluid dynamics, 1st edition, Longman Scientific & Technical, 1995.
2. S. C. Chapra, R. P. Canale- Numerical Methods for Engineers, 5th edition, McGraw Hill India Pvt. Ltd., 2007.

Online resources- https://nptel.ac.in

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**:**	Department of Metallurgical and Materials Engineering
Course Code	**:**	21MTT-821
Course Name	**:**	Physical Metallurgy of Alloy Steels
Credits	**:**	3 **(L -** 3 **T -** 0 **P -** 0**)**
Course Type	**:**	Elective (E-2)
Prerequisites	**:**	Physical Metallurgy/ Materials Science

Course Contents

Unit-1

Advantages of alloy steels over plain carbon steels, classification of alloy steels, physical metallurgy of alloy tool steels of different varieties, microstructural variation with heat treatment and its impact on properties and application of steels such as cold work tool steel, hot work tool steels, water hardening tool steels, shock-resisting tool steels, and high-speed steels.

(**No. of Lectures: 12)**

Unit 2

Physical metallurgy of advanced steel e.g. dual-phase steel, IF steel, high manganese steel, TRIP steel, TWIP steel, high boron steels.

(**No. of Lectures: 08)**

Unit 3

Physical metallurgy of stainless steel and their classification, embrittlement in ferritic stainless steel, sensitization, and stabilization in austenitic stainless steel; stabilized austenitic alloys, physical metallurgy of discaloy, and A286 with their specific applications.

(**No. of Lectures: 13)**

Unit 4

Strengthening mechanisms and influence of reverted austenite on the properties of maraging steels. (**No. of Lectures: 03)**

Recommended Readings

Text Books

1. T. V. Rajan, C. P. Sharma, and A. Sharma, Heat treatment: principles, Prentice Hall of India Pvt. Ltd., New Delhi,1994
1. V. Singh, Heat treatment of metals, Standard Publisher Distributors,1998
2. G. Krauss, Steels processing, structure, and performance, 2nd edition, ASM International, 2015

Online resources- https://nptel.ac.in

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**:**	Department of Metallurgical and Materials Engineering
Course Code	**:**	21MTT-822
Course Name	**:**	Steels for Structural Applications
Credits	**:**	3 **(L -** 3 **T -** 0 **P -** 0**)**
Course Type	**:**	Elective (E-1)
Prerequisites	**:**	none

Course Contents

Unit-1

Selection criteria of steels for structural and constructional applications, classification of steels on the basis of composition, equilibrium structure and method of the manufacturing process, the effect of carbon and inherent impurities on properties of steels, the purpose of alloying additions in steel, various effects of alloying additions on steel. (**No. of Lectures: 10)**

Unit-2

Property requirements for structural steels, methods of improving the strength of structural steels, characteristics and applications of mild steels, medium carbon and low-alloy steels, HSLA steels, quenched and self-tempered (QST) steels, ball bearing steels, case-carburizing steels, discussion on the basis of AISI specifications. (**No. of Lectures: 08)**

Unit-3

Steels for making fasteners, steels used in fabrication industries, steels for seismic resistant constructions, steels for oil and gas industries, steels for marine applications, steels for the nuclear sector, steels for the aerospace sector.

(**No. of Lectures: 09)**

Unit-4

Steels for making springs, bearings, gears, crankshafts, and rolls; steels for structural application in railways- tracks, bogie structures and bodies, structural steels for automotive bodies, stainless steels as structural materials.

(**No. of Lectures: 09)**

Recommended Readings

Text Books

1. T. V. Rajan, C. P. Sharma, and A. Sharma, Heat treatment: principles and techniques, 2nd edition, PHI Learning (P) Ltd., 2011.
2. V. Singh, Heat treatment of metals, Standard Publisher Distributors, 2006.

Reference book-

1. R. M. Brick, R. B. Gordon, and A. Philips, Structure and properties of alloys, Eurasia Publishing House Ltd., New Delhi, 2002.
2. Metals Hand Book, Vol.1: Properties and Selection-Irons and Steels, 9th Edition, 1978
3. F. B. Pickering, Physical metallurgy and the design of steels, Applied Science Publishers, 1978

Online resources- https://nptel.ac.in

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**:**	Department of Metallurgical and Materials Engineering
Course Code	**:**	21MTP-524
Course Name	**:**	Microstructure Property and Correlation lab
Credits	**:**	2 **(L -** 0 **T -** 0 **P -** 4**)**
Course Type	**:**	Core
Prerequisites	**:**	none

Course Contents

Students should perform at least eight experiments.

1. Study of optical microscopy and its application in microstructural characterization of materials.
2. Metallographic sample preparation techniques for microstructural characterization.
3. Microstructural examination of ferrous systems (grain size measurements, phase analysis, inclusions rating, etc.).
4. Quenching and tempering of steels.
5. Jominy end quench test.
6. Heat treatment of ferrous alloys.
7. Microstructural characterization using electron microscope.
8. X-ray diffraction and its applications in materials characterization (Miller indexing of XRD pattern).
9. Thermal analysis and its application in materials characterization.
10. Study and measurement of mechanical behaviour of materials.
11. Study and measurement of corrosion behaviour of materials.

Recommended Readings

Text Books

1. G. F. Vander Voort, Metallographic Principles and Practice, ASM International, USA, 1999.

Reference Books

1. ASM Handbook, Volume 9: Metallography and Microstructures, 2020.
2. ASM Handbook, Volume 10: Materials Characterization, 2020.
3. ASM Handbook, Volume 8: Mechanical Testing and Evaluation, 2020.
4. ASM Handbook, Volume 13A: Corrosion: Fundamentals, Testing, and Protection, 2020.

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**:**	Department of Metallurgical and Materials Engineering
Course Code	**:**	21MTT-525
Course Name	**:**	Advanced Physical Metallurgy
Credits	**:**	3 **(L -** 3 **T -** 0 **P -** 0**)**
Course Type	**:**	Core
Prerequisites	**:**	None

Course Contents

Unit-1

Structure of solids, experimental tools, and techniques, solidification of pure metals- the concept of free energy, stability, equilibrium concept in the unary system, the effect of pressure on equilibrium transformations.

(No. of Lectures: 07)

Unit-2

Plastic deformation of pure metals – Mechanisms (slip & twin), critical resolved shear stress, single-crystal tensile test (FCC), theoretical strength of ideal crystal. Imperfections in solids including fundamentals of dislocations, diffusion in solids. **(No. of Lectures: 07)**

Unit-3

Solidification of binary alloys –free energy of solutions, free energy vs composition diagrams, chemical potential.

(No. of Lectures: 07)

Unit-4

Phase rules, phase diagrams, the evolution of phase diagrams, solid-state transformations - precipitation hardening, pearlitic, bainitic& martensitic transformation. Thermodynamics of heterogeneous systems, stress, and strain-induced transformations. **(No. of Lectures: 08)**

Unit-5

Heat treatment of steel, TTT diagram, the effect of alloying elements, hardenability, application of physical metallurgy - strengthening mechanism, strength vs. toughness (ductility), thermomechanical processing, micro-alloyed steel, ultra-high strength steel, superalloy, control of texture. **(No. of Lectures: 07)**

Recommended Readings

Text books

1. V. Raghavan, Solid-state phase transformations, PHI of India Pvt. Ltd., New Delhi, 1987.
2. D. A. Porter and K. E. Esterling, Phase transformation in metal and alloys, Chapman Hall, 1992.
3. R. E. Smallman and A. H. W. Ngan, Physical Metallurgy and Advanced Materials Engineering, 7th Ed., Butterworth-Heinemann, 2011.

Reference books

1. R. Abbaschian, L. Abbaschian, R. E. Reed-Hill, Physical Metallurgy Principles, 4th Ed., Cengage Learning, 2009.
2. G. Gottstein, Physical Foundations of Materials Science, Springer, 2004.

Online resources- https://nptel.ac.in

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**:**	Department of Metallurgical and Materials Engineering
Course Code	**:**	21MTT-526
Course Name	**:**	Advanced Solidification Processing of Steels
Credits	**:**	3 **(L -** 3 **T -** 0 **P -** 0**)**
Course Type	**:**	Core
Prerequisites	**:**	None

Course Contents

Unit-1

Introduction to solidification, thermodynamics, and kinetics of solidification, heat flow in solidification.

(No. of Lectures: 06)

Unit-2

Plane front solidification of single-phase alloys, interface stability, cellular solidification, formation of dendrites, cellular-dendritic transition, solidification of alloys – constitutional super-cooling, solid-state diffusion.

(No. of Lectures: 10)

Unit-3

Plane front solidification of polyphase alloys, macro-and micro-morphology of eutectic growth, growth of graphite in cast irons, some problems in solidification of polyphase alloys, inclusions - their formation and distribution.

(No. of Lectures: 08)

Unit-4

Peritectic and eutectic solidification in steels and cast iron, solidification of low, medium carbon, and high carbon steel ingots and castings, the structure of ingots, formation of the columnar zone, segregation in steel ingots and steel castings.

(No. of Lectures: 08)

Unit-5

Various solidification techniques, compact strip casting (CSP), thin strip casting (TSP), rapid solidification.

(No. of Lectures: 04)

Recommended Readings

Text Books

1. W. Kurtz and D.J. Fischer, Principles of solidification, Trans Tech Publications, 1992.
2. M. C. Flemings, Solidification Processing, McGraw-Hill Education, 1974.
2. R. W. Heine, C.R. Loper, and P.C. Rosenthal, Principles of Metal Casting, McGraw-Hill India, 1976.
3. J. Campbell, Castings, Elsevier (Butterworth-Heinemann), 2003.

Reference books

1. Casting, ASM handbook, vol-15, 1997.

Online resources- https://nptel.ac.in

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**:**	Department of Metallurgical and Materials Engineering
Course Code	**:**	21MTT-527
Course Name	**:**	Advances in Iron Making and Steel Making
Credits	**:**	3 **(L -** 3 **T -** 0 **P -** 0**)**
Course Type	**:**	Core
Prerequisites	**:**	none

Course Contents

Unit-1

Raw materials required for iron making, agglomeration techniques, physical chemistry of iron making process, theory and practice of iron making in blast furnace including gas cleaning and hot blast stoves, modern trends in the blast furnace.

(No. of Lectures: 08)

Unit-2

Principles of sponge iron making, degree of metallization, a percentage reduction, smelt reduction processes, sponge iron making in India.

(No. of Lectures: 06)

Unit-3

Raw materials for steel making, Physico-chemical principles of steel making, thermodynamics and kinetics of steel making reactions involving removal of impurities like Si, C, Mn, P, and S, etc.

(No. of Lectures: 06)

Unit-4

Genesis of the modern hybrid steel making process, ultra-high power electric arc furnace, induction furnace, EOF, and CONARC processes with respect to raw materials, energy consumption, productivity, and product quality.

(No. of Lectures: 10)

Unit-5

Secondary steel making - Development of secondary steel making and their importance under Indian conditions, sources of inclusions, sulphur, phosphorus, and gasses in steel. Principles of deoxidation, desulphurization and inclusion control, vacuum degassing techniques – RH/DH, VD, VAD, and stream degassing.

(No. of Lectures: 06)

Recommended Readings

Text Book

1. A.Ghosh, and A. Chatterjee, Iron making and steelmaking: theory and practice, PHI Learning (P) Ltd., 2008.
2. D. Mazumdar, A first course in iron and steel making, Universities Press (P) Ltd., 2015.
3. A. K. Chakrabarti, Steel making, PHI Learning (P) Ltd., 2007.
4. A. Ghosh, Secondary steelmaking: principles & applications, CRC Press, 2001.

Reference books

1. W. R. George, Introduction to physical chemistry of iron and steel making, Hodder & Stoughton Educational, 1972.
2. J. M. Camp, The making, shaping and treating of steel, Hardpress Publishing, 2012.

Online resources- https://nptel.ac.in

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**:**	Department of Metallurgical and Materials Engineering
Course Code	**:**	21MTT-823
Course Name	**:**	Advanced Ceramics and Glasses
Credits	**:**	3 **(L -** 3 **T -** 0 **P -** 0**)**
Course Type	**:**	Elective (E-3)
Prerequisites	**:**	Introduction to Engineering Materials

Course Contents

Unit-1

Introduction to ceramic structures, point defect equilibria in ceramics, novel processing techniques for ceramic powders, deformation behaviour, and toughening of ceramics. (**No. of Lectures: 08)**

Unit-2

Refractories, structural ceramics, ceramic cutting tools, ceramic coatings, wear components, high strength, and high-temperature components, ceramics for sensors, advanced functional ceramics, advanced ceramics for strategic applications. (**No. of Lectures: 10)**

Unit-3

Glassy State; kinetic and thermodynamic criteria for glass formation, nucleation and crystal growth in glasses, nucleation through micro miscibility, nucleating agents, properties and applications of glass-ceramics, use of Na_2O-SiO_2 and Na_2O-CaO- SiO_2 phase diagrams in glass manufacture, types and properties of glasses. (**No. of Lectures: 10)**

Unit-4

Thermal endurance of glass, toughening of glasses, strength and fracture behavior of glass, surface tension, effect of temperature and composition on the physical properties of glasses, defects in glass. (**No. of Lectures: 08)**

Recommended Readings

Text Books

1. B. Carter and G. Norton, Ceramic Materials: Science and Engineering, Springer, 2007.
2. W. Höland and G. H. Beall, Glass Ceramic Technology. John Wiley & Sons, 2012.
3. W. D. Kingery, H. K. Bowen and D. R. Uhlman, Ceramic Science and Technology, John Wiley and Sons, 1976.
4. C. J. Brinker, D. E. Clark, and D. R. Ulrich, Better Ceramics through Chemistry, North Holland, 1984.
5. R. C. Buchanan and M. Dekker, Ceramic Materials for Electronics, Inc. 1986.

Reference Books:-

1. B. Karmakar, Functional Glasses and Glass-Ceramics: Processing, Properties and Applications. Butterworth-Heinemann, 2017.
2. F. F. Y. Wang, Ceramic Fabrication Processes, Academic Press, 1976.

Online resources- https://nptel.ac.in

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**:**	Department of Metallurgical and Materials Engineering
Course Code	**:**	21MTT-824
Course Name	**:**	Advanced Welding Technology of Steel
Credits	**:**	3 **(L -** 3 **T -** 0 **P -** 0**)**
Course Type	**:**	Elective (E-3)
Prerequisites	**:**	None

Course Contents

Unit-1

Introduction - Overview of welding processes, importance, and application of welding, classification of welding processes, some common concerns, types of joints, edge preparation, design considerations, heat effects, weldability, and join-ability.

(**No. of Lectures: 04)**

Unit-2

Advanced Welding Processes - Working principle and application of advanced welding techniques such as plasma arc welding, electro-slag welding, laser beam welding, electron beam welding, ultrasonic welding, friction stir welding

(**No. of Lectures: 08)**

Unit-3

Advanced Welding Processes - Working principle and application of advanced welding techniques such as explosive welding/ cladding, underwater welding, spray-welding / metallizing, hard facing. (**No. of Lectures: 08)**

Unit-4

Metallurgical Aspects of Welding - Responses of materials to welding (heat flow in welding, solidification fusion welds - influence of welding speed on the microstructure of steels, the structure of the welded joint, welding stresses and distortion, fundamentals of welding of steels, heat-affected zone. influence of welding on the steel, weldment soundness; weld-decay in the austenitic steel, and its remedial measures. structural degradation due to welding of steel and its remedies.

(**No. of Lectures: 10)**

Unit-5

Case Studies - Welding metallurgy of carbon and alloy steels, cast irons, stainless steels, welding of dissimilar steels, welding of steel with other non-ferrous metals/alloys. (**No. of Lectures: 06)**

Recommended Readings

Text Books

1. R.S. Parmar, Welding Engineering and Technology, Khanna Publishers, 2004.
2. S. Kou, Welding Metallurgy, Wiley and Sons, 2005.
3. H. Cary, and S. Helzar, Modern Welding Technology, Pearson Prentice Hall, 2004.

Reference books

1. L. Jeffus. Welding: Principles and Application, Delmar Cengage Learning, 2007.

Online resources- https://nptel.ac.in

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**:**	Department of Metallurgical and Materials Engineering
Course Code	**:**	21MTT-825
Course Name	**:**	Fracture and Failure Analysis
Credits	**:**	3 **(L -** 3 **T -** 0 **P -** 0**)**
Course Type	**:**	Elective (E-1)
Prerequisites	**:**	Students should have a fundamental understanding of mechanical behavior especially elastic and plastic deformation.

Course Contents

Unit-1

Basic Concepts in Fracture Mechanics - The geometry of stress and strain, elastic deformation, plastic, and elastoplastic deformation, the concept of catastrophic failure, Brittle fracture: Griffiths theory, ductile fracture, probabilistic aspects of fracture mechanics. (**No. of Lectures: 08)**

Unit-2

Mechanics of Fracture- Static Loading - Elastic fields – Analytical solutions yielding near a crack front – Irwin's approximation-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.

(**No. of Lectures: 08)**

Unit-3

Failure Analysis of Fatigue Fracture - Fundamental sources of failures- deficiency in design, empirical relation describing crack growth by fatigue – life calculations for a given load amplitude-effects of changing the load spectrum-effects of environment, microstructural analysis of fatigue failures, some case studies in the analysis of fatigue failures.

(**No. of Lectures: 08)**

Unit-4

Failure Analysis of Creep Rupture - 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 the analysis of creep failures. (**No. of Lectures: 08)**

Unit-5

Failure Analysis of Corrosion and Wear: Failure due to erosion and corrosion. (**No. of Lectures: 04)**

Recommended Readings

Text Books

1. P. Kumar, Elements of Fracture Mechanics, 2nd Ed., Wheelers Publishing Co. Ltd India, 2010.
2. R. J. Sanford, Principles of Fracture Mechanics, Printice Hall, USA, 2003.
3. G. E. Dieter, Mechanical Metallurgy, 3rd edition, McGraw Hill Book Co., N. Delhi (Indian Edition), 2017.

Online resources- https://nptel.ac.in

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**:**	Department of Metallurgical and Materials Engineering
Course Code	**:**	21MTT-826
Course Name	**:**	Functional Materials
Credits	**:**	3 **(L -** 3 **T -** 0 **P -** 0**)**
Course Type	**:**	Elective (E-3)
Prerequisites	**:**	Introduction to Engineering Materials

Course Contents

Unit-1

Introduction, phase transformations and relations between crystal structure and functional properties; piezoelectricity, ferroelectricity, magnetism, and energy storage etc. (**No. of Lectures: 06)**

Unit-2

Applications in dielectric, piezoelectric, ferroelectric, magnetic, semiconducting, electronic, electromagnetic interference/radio frequency, optical devices (light-emitting diodes, organic solar cells, smart windows), transistors, sensors, energy storage or solar harvesting functions, etc. (**No. of Lectures: 12)**

Unit-3

Ionic conductors in batteries, sensors, and fuel cells. (**No. of Lectures: 06)**

Unit-4

Materials in medical applications: stainless steel alloys, cobalt alloys, titanium-based alloys, polymer and its composites, bio-resorbable materials, bio-ceramics, bioactive glasses, calcium phosphate, naturally derived biomaterials, bio-functional coatings**.** (**No. of Lectures: 12)**

Recommended Readings

Text Books

1. D. D. L. Chung. Functional Materials: Electrical, Dielectric, Electromagnetic, Optical and Applications, Vol. 2, World Scientific Pub., 2010.
2. S. Ramakrishna, M. Ramalingam, T. S. Sampath Kumar. Biomaterials: A Nano Approach, CRC Press, 2013.
3. S. Banerjee and A. K. Tyagi. Functional Materials: Preparation, Processing and Applications by, 1st edition, Elsevier, USA, 2012.

Reference books

1. J. Kilner, S. Skinner, S. Irvine, P. Edwards, Functional Materials for Sustainable Energy Applications, Woodhead Publishing, 2012.

Online resources- https://nptel.ac.in

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**:**	Department of Metallurgical and Materials Engineering
Course Code	**:**	21MTT-827
Course Name	**:**	Mechanical Behaviour of Steels
Credits	**:**	3 **(L -** 3 **T -** 0 **P -** 0**)**
Course Type	**:**	Elective (E-1)
Prerequisites	**:**	None

Course Contents

Unit-1

Continuum Plasticity in Steels - Stress-Strain behavior, Necking Criterion. Plastic stress-strain relations. Phenomena of severe plastic deformation, super-plasticity. **(No. of Lectures: 06)**

Unit-2

Microstructural Aspects of Plasticity - Theoretical shear strength; Elements of dislocation theory as applied to mechanical behavior of steels. Crystallography of slip and Independent Slip Systems, Slip Plane relation, Twinning in steels. **(No. of Lectures: 06)**

Unit-3

Strengthening Mechanisms in steels -Work Hardening, Grain boundary strengthening, Solid Solution Strengthening, point defect dislocation interactions, Yield point phenomenon, Precipitation hardening, dislocation precipitate interactions, and ordered hardening. **(No. of Lectures: 10)**

Unit-4

Fracture behavior in Steels - Fundamentals of stress Intensity factor and determination of KIC. **(No. of Lectures: 08)**

Unit-5

Fatigue in steels - Fatigue, Fatigue crack initiation, Fatigue crack growth, Different stages of fatigue crack growth, Paris law and models, Threshold, Damage tolerant approach, Striations, ultra-high cycle fatigue in steels. **(No. of Lectures: 03)**

Unit-6

Creep Behavior of steels - Time-dependent deformation-creep, different stages of creep, creep and stress rupture, use of creep data, Larsen-Miller parameter, creep mechanisms and creep mechanism maps, creep under multi-axial loading, microstructural aspects of creep, creep-fatigue interaction. **(No. of Lectures: 03)**

Recommended Readings

Text Books

1. A. K. Bhargava, and C.P. Sharma, Mechanical Behavior and Testing of Materials, PHI Learning (P) Ltd., 2011.
2. G. E. Dieter, Mechanical Metallurgy, McGraw Hill Education, Indian Edition, 2017.
3. R. W. K Honeycombe, Plastic deformation in metals, Hodder Arnold, 1984.
4. R. W. Hertzberg, R. P. Vinci, and J. L. Hertzberg, Deformation and Fracture Mechanics of Engineering Materials, John Wiley & Sons, 2012.

Reference books-

1. M. N. Shetty, Dislocations and Mechanical Behavior of Materials, PHI Learning (P) Ltd., 2013.
2. F. R. N. Nabarro, Dislocations in solids. Vol. 4: Dislocations in metallurgy, North Holland Publishing, 1979.

Online resources- https://nptel.ac.in

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**:**	Department of Metallurgical and Materials Engineering
Course Code	**:**	21MTT-828
Course Name	**:**	Non-Destructive Testing and Evaluation
Credits	**:**	3 **(L -** 3 **T -** 0 **P -** 0**)**
Course Type	**:**	Elective (E-2)
Prerequisites	**:**	None

Course Contents

Unit-1

Introduction - Need for inspection, types of the inspection system, quality of inspection, reliability of defect detection, and benefits of NDT examination. (**No. of Lectures: 05)**

Unit-2

Visual Inspection - Basic principles, physical aids used for visual inspection and applications, liquid penetrant inspection: Physical principles, procedures of testing, penetrant testing materials, penetrant testing methods, applications and limitations. (**No. of Lectures: 06)**

Unit-3

Magnetic Particle Testing - Principle of MPT, magnetization techniques, procedure used for testing a component, equipment used for MPT, Eddy current testing: Basic principles, techniques used for ECT, applications and limitations. (**No. of Lectures: 06)**

Unit-4

Radiography - Basic principles, electromagnetic radiation sources, effect of radiation in film, radiographic imaging, inspection techniques, micro-computed tomography, applications and limitations. (**No. of Lectures: 05)**

Unit-5

Ultrasonic Testing - Basic principles of sound beam, ultrasonic transducers, type of display, inspection methods A, B and C scanning modes, identification of defects, immersion testing, applications and limitations. (**No. of Lectures: 06)**

Unit-6

Acoustic Emission Testing (AET) - Principles, technique, instrumentation and applications, miscellaneous tests, reliability in NDT, statistical methods for quality control. (**No. of Lectures: 05)**

Unit-7

Leak Testing - Basic principles and application. (**No. of Lectures: 03)**

Recommended Readings

Text Books

1. B. Raj, T. J. Kumar and M Thavasimuthu, Practical Non-Destructive Testing, ASM Intl, 2nd edition, 2002.
2. B. Hull and V. John, Non Destructive Testing, Springer;New York, 1st edition, 1988.
3. S. H. Avner, Introduction to Physical Metallurgy, McGraw-Hill Inc., US, 2nd edition, 1974.

Reference books

1. A.V. K. Suryanarayana, Testing of Metallic Materials, PHI, New Delhi, 2007.

Online resources- https://nptel.ac.in

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**:**	Department of Metallurgical and Materials Engineering
Course Code	**:**	21MTT-829
Course Name	**:**	Powder Metallurgy and Particulate Materials Processing
Credits	**:**	3 **(L -** 3 **T -** 0 **P -** 0**)**
Course Type	**:**	Elective (E-2)
Prerequisites	**:**	None

Course Contents

Unit-1

Introduction - Historical background of particulate materials involving metal powders and ceramics. Powder Production: General principles of mechanical, atomization, chemical, and electrolytic method of metal and alloy powders production, production of nano-powders, Mechanical alloying. (**No. of Lectures: 06)**

Unit-2

Powder characterization - Chemical composition, microstructure, size and size distribution, shape, surface area, flow rate, apparent and tap density, compressibility, pyrophoricity and toxicity of metallic powders. (**No. of Lectures: 06)**

Unit-3

Powder conditioning - Annealing, mixing, and blending and their mechanics, powder mixers. (**No. of Lectures: 03)**

Unit-4

Cold compaction and sintering - Cold compaction: compaction in rigid dies, uniaxial and biaxial compaction, cold isostatic pressing, mechanical and hydraulic presses, basic stages of sintering and mechanisms involved, solid-state and liquid state sintering, reaction sintering, sintering of ferrites, spark plasma sintering, microwave sintering, sintering furnaces, various sintering atmospheres, additive manufacturing. **No. of Lectures: 09)**

Unit-5

Hot compaction - Hot pressing, powder compact extrusion, and powder compact forging, hot isostatic pressing, ECAP, powder rolling. (**No. of Lectures: 06)**

Unit-6

Applications - Porous PM parts viz. bushes, filters, and bioimplants, dispersion strengthened materials, cemented carbides. (**No. of Lectures: 06)**

Recommended Readings

Text Books

1. P. C. Angelo and R. Subramanian, Powder metallurgy: science, technology and applications, PHI Learning (P) Ltd., 2008.
2. B. K. Datta, Powder metallurgy: an advanced technique of processing, engineering materials, second edition, PHI Learning (P) Ltd., 2014.
3. A. Upadhyaya and G. S. Upadhyaya, Powder metallurgy: science, technology and materials, Universal Press, 2011.
4. A. K. Sinha, Powder metallurgy, DhanpatRai publication, 2021.

Reference Books

1. R. M. German, Powder Metallurgy Science Princeton, N.J.: Metal Powder Industries Federation, 1994.
2. R. H. T. Dixon and A. Clayton, Powder Metallurgy for Engg. Machinery Publishing, Brighton, UK, 1996.
3. F.V. Lenel, Powder Metallurgy: Principles & Applications, Princeton, N.J.: Metal Powder Industries Federation, 1980.

Online resources- https://nptel.ac.in

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**:**	Department of Metallurgical and Materials Engineering
Course Code	**:**	21MTT-830
Course Name	**:**	Surface Engineering
Credits	**:**	3 **(L -** 3 **T -** 0 **P -** 0**)**
Course Type	**:**	Elective (E-1)
Prerequisites	**:**	None

Course Contents

Unit-1

Surface degradation, introduction to tribology and corrosion of surfaces, wear: types of wear, roles of friction and lubrication, and corrosion: an overview of different forms of corrosion, Introduction to surface engineering, the importance of substrate. (**No. of Lectures: 08)**

Unit-2

Chemical and electrochemical polishing, significance, specific examples, chemical conversion coatings, phosphating, chromating, chemical colouring, anodizing of aluminium alloys, thermochemical processes -industrial practices. (**No. of Lectures: 08)**

Unit-3

Surface pre-treatment, deposition of copper, zinc, nickel and chromium - principles and practices, alloy plating, electrocomposite plating, electroless plating of copper, nickel phosphorous, nickel-boron; electroless composite plating; application areas, properties, test standards (ASTM) for assessment of quality of deposits. (**No. of Lectures: 07)**

Unit-4

Definitions and concepts related to physical vapour deposition (PVD), evaporation, sputtering, ion plating, plasma nitriding, process capabilities, chemical vapour deposition (CVD), metal organic CVD, plasma assisted CVD, thermal spraying, conventional shot peening, LASER shock pinning, severe surface deformation, surface mechanical alloying, LASER nitriding, specific industrial applications. (**No. of Lectures: 07)**

Unit-5

Surface characterization techniques: Film thickness measurements using optical techniques, corrosion testing of coatings, evaluation of mechanical properties of thin films, microstructural characterization of coatings and thin films, wear and erosion testing of coatings. (**No. of Lectures: 06)**

Recommended Readings

Text Books

1. T. S. Sudarshan. Surface Modification Technologies - An Engineer's guide, Marcel Dekker, New York, 1989.
2. I. M. Hutchings. Tribology: Friction and Wear of Engineering Materials, Butterworth-Heinemann, 1992.
3. C. D. Varghese. Electroplating and Other Surface Treatments - A Practical Guide, TMH, 1993.
4. T. Burakowski and T. Wierzchon. Surface Engineering of Metals, CRC Press, 1998.

Reference Books

1. W. Batchelor, L. N. Lam and M. Chandrasekaran. Materials Degradation and its Control by Surface Engineering, Imperial college press, 1999.
2. S. S. Hosmani, P. Kuppusami, and R. K. Goyal. An Introduction to Surface Alloying of Metals, Springer, 2014.

Online resources- https://nptel.ac.in

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**:**	Department of Metallurgical and Materials Engineering
Course Code	**:**	21MTT-831
Course Name	**:**	Transport Phenomena in Materials Processes
Credits	**:**	3 **(L -** 3 **T -** 0 **P -** 0**)**
Course Type	**:**	Elective (E-2)
Prerequisites	**:**	None

Course Contents

Unit-1

Fluid Dynamics - Continuum fluids, laminar and turbulent flow, Newton's law of viscosity, introduction to non-newtonian fluids, pressure and temperature dependency of viscosity, viscosity of gases at low density, fundamental concepts in momentum transfer, shell balance, governing equations and relevant boundary conditions, equations of change for isothermal systems – Navier-Stokes equation, use of equations of change to set up steady state flow problems with newtonian fluids, friction factor, microscopic mass, momentum and energy balance for isothermal systems, Bernoulli's equation, Euler's equations and its integration to obtain Bernoulli's equation.

(**No. of Lectures: 12)**

Unit-2

Heat Transfer - Physical origins and rate equations, introduction to conduction, conduction rate equation, thermal properties of matter, heat diffusion equation, boundary and initial conditions, one-dimensional, steady-state conduction, the plane wall, radial systems, conduction with thermal energy generation, concept of heat transfer coefficient, forced and free convection, aspects of radiative heat transfer.

(**No. of Lectures: 12)**

Unit-3

Mass Transfer - Fick's Law of diffusion, analogy with heat transfer, shell mass balances, boundary conditions, applications, conductive mass transfer, mass transfer coefficients, applications, correlations.

(**No. of Lectures: 09)**

Unit-4

Similarity of three transport processes and its applications, momentum transfer.

(**No. of Lectures: 03)**

Recommended Readings

Text Books

1. R. B. Bird, W. E. Stewart, and E. W. Lightfoot, Transport Phenomena, 2nd Revised Edition, John Wiley, 2007.
2. T. L. Bergman, A. S. Lavine, F. P. Incropera, and D. P. DeWitt, Fundamentals of Heat and Mass Transfer, 8th Edition, John Wiley, 2006.
3. A. K. Mahanty, Rate Processes in Metallurgy, PHI, 2009.

Reference books

1. Y. V. C. Rao, Heat Transfer, University Press, 2001.

Online resources- https://nptel.ac.in