MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF METALLURGICAL AND MATERAILS ENGINEERING

Curriculum Structure for B.Tech with Minor Specialization in "Materials Processing"

Semester V

S. N.	Course Code	Course Title	Category	L	T	P	Credits	Contact Hrs	Total Credits
1	22MTT101	Introduction to Engineering Materials	PC	3	0	0	3	3	
2	22MTT202	Foundry Technology	PC	3	1	0	4	4	

Semester VI

1	22MTT303	Powder Metallurgy	PC	3	0	0	3	3	
2	22MTT311	Joining of Materials	PC	3	1	0	4	4	

Semester VII

1	22MTT801	Additive Manufacturing Process	PE	3	0	0	3	3	

Semester VIII

1	22MTP312	*Joining of Materials Lab*	PC	0	0	2	1	2	

Prof. Upender Pandel
(Head of the Department)

for **Dr. Krishna Kumar**
(DUGC Convener)

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DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT101	Introduction to Engineering Materials	3	3	0	0	0

PREREQUISITES: Basic Knowledge of Physics, Chemistry & Mathematics

COURSE OBJECTIVE:

To acquire the knowledge of engineering materials from metals to polymers and ceramics and about their engineering applications in detail.

COURSE OUTCOMES:

CO1	Impart an understanding about different classes of materials.
CO2	Develop the knowledge of fundamental principles related to materials structure, properties and applications.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Weekly Submissions/assignments/Quizzes	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Basic Introduction: History of materials, Atomic structure. Atomic bonding in solids: bonding forces and energies, primary interatomic bonds, secondary bonding with examples of metals, ceramics and polymers.

(No. of lectures - 4)

Unit II Structures of Materials: Crystal structure and Bravias lattice, Unit cell and Miller indices, Crystal system, coordination number and packing fraction. Polymorphism and allotropy. Crystallographic directions and planes. Crystalline materials: single crystals, polycrystalline materials. Non- crystalline materials, Imperfection in solid (point defects, line defects, surface defects and volume defects).Level of Structures: macrostructure, microstructure, substructure, crystal structure, electronic structure, nuclear structure.

(No. of lectures - 10)

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Unit III Engineering Materials: Classification of engineering materials: ferrous alloys and nonferrous alloys, ceramics (glasses, glass- ceramics, refractories, abrasives, traditional ceramics, advanced ceramics), polymers, composites. Salient features of metals, ceramics, glass, polymers, composites.

(No. of lectures - 8)

Unit IV Properties of Materials: Physical, chemical and mechanical properties. Physics of thermal, electrical, optical and mechanical properties. Factors controlling these properties.

(No. of lectures - 8)

Unit V Materials with Specific Properties: Electrical conductors, Electrical resisters, Magnetic materials, Structural materials, Nanomaterials. Refractory materials. Applications of metals, alloys, polymers, ceramics and composites.

(No. of lectures - 10)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Introduction to Materials Science, William D. Callister Jr., David G. Rethwisch, John Wiley & Sons; 8th Edition, 2010
2. Introduction to Materials Science, V. Raghvan, Prentice Hall India Learning Private Limited, New Delhi, Sixth Edition, 2015
3. Introduction to Physical Metallurgy, Sidney H. Avner, McGraw Hill Education, New York; 2nd edition, 2017
4. Engineering Materials, A. K. Bhargava, Prentice Hall India Learning Private Limited, New Delhi, 2011
5. Engineering Materials – Properties and applications of Metal and Alloys, C. P. Sharma, Prentice- Hall of India Pvt. Ltd; 1st edition, New Delhi, 2004

ONLINE/E RESOURCES:

1. https://nptel.ac.in

DETAILS OF THE COURSE:

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT202	Foundry Technology	4	3	1	0	0

PREREQUISITE: Introduction to Physical Metallurgy

COURSE OBJECTIVE:

To provide the students with the knowledge of foundry material, equipment and processes.

COURSE OUTCOMES:

CO1	Familiarize different pattern and mold materials used in foundry industries.
CO2	Understand different molding and allied processes.
CO3	Analyze the solidification of metals.
CO4	Understand different furnaces used in foundry industries.
CO5	Understand casting defects, their causes, remedies and quality control in foundry.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following four components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Introduction to foundry practice as a process of manufacturing, Patterns: Functions, classification, materials, allowances and design considerations. Molding materials: Types of molding sand and their characteristics, Ingredients of molding sand, Special additives, Binders: their effect on the properties of molding sand, Parting and facing materials, Core sand, Cores and their types.

(No. of lectures - 10)

Unit II: Molding/Casting processes: Sand mold casting (Green, dry, floor, pit, cement bonded core sand), Shell molding, CO_2 mold casting, Investment casting, Shell casting, Ceramic mold casting, Plaster mold casting, Permanent mold casting: centrifugal casting, gravity die- casting and pressure die casting, Gating and risering: basic requirements of gating and feeding system, design of gating system, types of gates, design of feeders, Use of exothermic compounds, exothermic sleeves, chills and padding.

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(No. of lectures - 15)

Unit III: Solidification of castings: nucleation and growth phenomena, Metal mold vs. sand mold, pure metal vs. alloy, Effect of grain refiner, Melting furnaces: selection of remelting furnace, Cast iron foundry practice, Cupola melting practice, Production of SG and cast iron, Remelting practice for ferrous and nonferrous alloys.

(No. of lectures - 10)

Unit IV: Casting defects: causes and remedies, Quality control in foundry, Sand reclamation, Recent practices in foundry industries.

(No. of lectures - 5)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. R.W. Heine, C.R. Loper, P.C. Rosenthal, Principles of Metal Casting, Tata McGraw Hill Pub. Co. Ltd., New Delhi, 2nd edition, 2017.
2. P.L. Jain, Principles of foundry Technology, Tata McGraw Hill Co. Ltd., New Delhi, 2003.
3. P.L. Jain, Tool Engineering for Metal Casting Processes, Tata McGraw Hill Co. Ltd., New Delhi, 2015.
4. H.F. Taylor, M.C. Flemings, J. Wulf, Foundry Engineering, Wiley Eastern Ltd., New Delhi,1962
5. D. Kumar & S.K.Jain, Foundry Technology, CBS, Publishers, New Delhi, 2007.
6. P.C. Mukherjee, Fundamentals of Metal Casting Technology, Oxford& 1BH Pub. Co. Pvt. Ltd., New Delhi, 2nd Edition, 1988.
7. ASM metal handbook, Vol. 15, 2008.

ONLINE RESOURCES:

1. https://nptel.ac.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT303	Powder Metallurgy	3	3	0	0	0

PREREQUISITES: Manufacturing, Physical Metallurgy

COURSE OBJECTIVES:

- To learn and get an in depth understanding of powder metallurgical processes and characterization in a scientific and systematic manner

COURSE OUTCOMES:

CO1	Understand the key concepts and terminology in the field of powder metallurgy
CO2	Describe and explain different powder production techniques
CO3	Correlate the microstructure and mechanical properties of powder metallurgy components in relation to their applications

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction: Introduction and historical background of powder metallurgy, significance and advantages of powder metallurgy technique over other manufacturing processes. Methods of powder production and general principles involved in mechanical, chemical, atomization and electrolytic methods of metal and alloy powder production.

(No. of Lectures - 8)

Unit II 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 - 8)

Unit III Powder Processing: Mechanical alloying of powders involving high energy mechanical milling and its mechanism, heat treatment of powders, cold compaction involving

uniaxial and biaxial compaction with mechanical and hydraulic presses using rigid dies, cold isostatic pressing of green compacts, warm compaction.

(No. of Lectures - 8)

Unit IV Hot Consolidation techniques: Sintering: Stages of sintering and bonding mechanisms involved, liquid phase sintering, solid state sintering, spark plasma sintering, reactive sintering, sintering furnaces, sintering atmospheres, pressurized sintering, hot pressing, powder compact extrusion, powder compact forging, hot isostatic pressing (HIP), Sinter- HIP process, powder compact rolling, powder injection molding, additive manufacturing.

(No. of Lectures - 8)

Unit V Powder Metallurgy parts and applications: Design considerations of powder metallurgy parts, near net shape technology, applications in aerospace and automobiles, Porous parts viz. bushes, filters, bioimplants, dispersion strengthened materials, cemented carbides, bearing materials, sintered friction materials- clutches, brake linings.

(No. of Lectures - 8)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Introduction to Powder Metallurgy, J.S. Hirschoron-American Powder Metallurgy Institute, 1st Edition 1969.
2. Powder Metallurgy Science, R.M. German –Metal Powder Industry; Subsequent edition, 1994.
3. Powder Metallurgy: Principles & Applications, F.V. Lenel - Metal Powder Industry; First edition, 1980.
4. Powder Metallurgy, P.C. Angelo & R. Subramanian, PHI Learning Pvt. Ltd., Eastern economy edition, 2008.
5. Powder Metallurgy for Engg. (Brighton), R.H.T. Dixon & A. Clayton –Machinery Publishing, 2011.
6. Powder Metallurgy, K. Sinha, Dhanpat Rai Publications, New Delhi, 2nd edition, 2016.
7. ASM Hand Book, Volume 7, Powder Metallurgy, 2015.

ONLINE/E RESOURCES:

1. https://nptel.ac.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT311	Joining of Materials	4	3	1	0	0

PREREQUISITE: Foundry Technology

COURSE OBJECTIVE:

- To impart knowledge about various metal joining techniques, their principles and applicability for various ferrous and non- ferrous metals.

COURSE OUTCOMES:

CO1	Understand the principle of metal joining.
CO2	Familiarize with different welding techniques
CO3	Compare and contrast welding, brazing, and soldering processes.
CO4	Correlate weldability, welding stresses, and welding defects.
CO5	Select and design welding materials, processes and inspection techniques based on application, fabrication and service conditions

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction of joining processes: Mechanical joining (mechanical fasteners, integral attachments, and other mechanical joining methods), adhesive joining (types of adhesives, wettability, surface preparation, and joint design), and welding (fusion and solid state). Surface requirements for joining.

(No. of lectures - 6)

Unit II Fusion welding processes: Gas welding, thermit welding, arc welding (SMAW, GTAW, GMAW, SAW). Plasma arc welding, laser beam welding, and electron beam welding. Shielding gases. Electrodes. Welding design.

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(No. of lectures - 10)

Unit III Solid state welding processes: friction welding, friction- stir welding, diffusion bonding, explosive welding, forge welding, etc. resistance welding processes. surface cladding. Brazing and soldering (filler materials and fluxes, heating methods, wettability, and joint design).

(No. of lectures - 10)

Unit IV Responses of materials to welding: Structure of the welded joint, solidification modes, welding stresses and distortion, heat treatment of parent metals and welds, solidification cracking, reheat cracking, welding defects and detection techniques.

(No. of lectures - 8)

Unit V Joining of specific materials and structures: (Metals & alloys, ceramics & glasses, polymers, composite materials and dissimilar material combinations).

(No. of lectures - 6)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Welding Engineering and Technology, R.S. Parmar, 3rd Edition, Khanna Publishers, 2013.
2. Welding: Principles and Application, L. Jeffus, 8th Edition, Delmar Cengage Learning, 2016.
3. Welding Metallurgy, S. Kou, 2nd Edition, Wiley and Sons, 2005.
4. Modern Welding Technology, H. Cary and S. Helzar, 6th Ed., Pearson Prentice Hall, 2004.
5. Joining of Materials and Structures, R.W. Messler, Elsevier, 2004.
6. Metallurgy of Welding, J. F. Lancaster, Springer, 1980.

ONLINE/E RESOURCES:

1. https://nptel.ac.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT818	Additive Manufacturing Process	3	3	0	0	0

PREREQUISITES: Basics of engineering materials, manufacturing process

COURSE OBJECTIVES:

- To educate students with fundamental and advanced knowledge in the field of Additive manufacturing technology

COURSE OUTCOMES:

CO1	Understand the working principles and process parameters of additive manufacturing processes
CO2	Distinguish different additive manufacturing processes and suggest suitable methods for building a particular component
CO3	Design and develop a working model using additive manufacturing processes

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Weekly submissions/ assignments/ quizzes	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction to Additive Manufacturing: Introduction to AM, AM evolution, Distinction between AM & CNC machining, Steps in AM, Classification of AM processes, Advantages of AM and types of materials for AM.

(No. of lectures - 4)

Unit II Additive Manufacturing Methods: Vat Photo- polymerization: Material Jetting: Material extrusion: Binder Jetting: Sheet Lamination: Powder Bed fusion: Direct Energy Deposition: discuss on process mechanism, process parameters, advantages, limitations, applications, recent advances; other similar Processes: thermal spray direct writing, beam deposition, liquid phase deposition, hybrid techniques

(No. of lectures - 16)

Unit III Additive Manufacturing Equipment and Sub- systems: Laser: Laser fundamentals, construction of laser systems, laser properties, laser material interaction, types of laser; Electron Beam: Fundamentals, electron beam –metal interaction, electron beam based additive manufacturing systems Arc- based AM: process mechanism, process parameters, advantages, limitations, applications, recent advances Beam, Material Feeding and Job Manipulation System: laser beam scanning, laser optics, fibre delivery system, job manipulation, electron beam manipulation, process chambers, sensors, material feeding systems, co- axial and lateral nozzles, powder spreading, multi- material spreading.

(No. of lectures - 7)

Unit IV Additive Manufacturing Materials: Types of materials, Polymer, Metals, Ceramics, recent advances in materials, forms of raw materials, support materials, powder production techniques, and powder characterization.

(No. of lectures - 3)

Unit V Post-Processing: Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non- thermal and thermal techniques.

(No. of lectures - 6)

Unit VI Guidelines for Process Selection: Selection methods for a part, challenges of selection, example system for preliminary selection, process planning and control.

(No. of lectures - 4)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Additive Manufacturing: Principles, Technologies and Applications, C.P Paul, A.N Junoop, McGraw-Hill, 2021
2. Additive Manufacturing, Second Edition, Amit Bandyopadhyay Susmita Bose, CRC Press Taylor & Francis Group, 2020.
3. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Ian Gibson, David W Rosen, Brent Stucker, Springer, 2015, 2nd Edition.
4. 3D Printing and Additive Manufacturing: Principles & Applications, Chua Chee Kai, Leong Kah Fai, World Scientific, 2015, 4th Edition.
5. Rapid Prototyping: Laser- based and Other Technologies, Patri K. Venu Vinod and Weiyin Ma, Springer, 2004.

ONLINE/E RESOURCES

1. https://www.nist.gov/additive- manufacturing
2. http://additivemanufacturing.com/basics/
3. https://nptel.co.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTP312	Joining of Materials Lab	1	0	0	2	0

PREREQUISITE: Basic Sciences (10+2 level), Physical Metallurgy

COURSE OBJECTIVE:

- To impart knowledge about various metal joining techniques, their principles and applicability for various ferrous and non- ferrous metals.

COURSE OUTCOMES:

CO1	Design and fabricate weldments using various fusion welding processes.
CO2	Design and fabricate weldments using various solid- state welding processes.
CO3	Fabricate joints using the brazing and soldering process.
CO4	Evaluate the quality of welded joints using non- destructive testing methods
CO5	Analyze the metallurgical changes in welded joints.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following four components.

S. No.	Component	Weightage
a)	PRS (Practical Sessionals)	60%
b)	PRM (Practical Mid Term Exam)	20%
c)	PRE (Practical End Term Exam)	20%

COURSE CONTENTS:

1. To study about welding processes, weld joint designs and welding symbols.
2. To fabricate a butt joint using the Oxy- Acetylene gas Welding (OAW) process from the given samples.
3. To fabricate a lap joint using the Shielded Metal Arc Welding (SMAW) process from the given samples.
4. To fabricate a corner joint using the Gas Metal Arc Welding (GMAW) process from the given samples.
5. To fabricate an autogenously butt joint using the Gas Tungsten Arc Welding (GTAW) process from the given samples.
6. To fabricate a joint using the brazing process (Torch brazing) from the given samples
7. To fabricate a job by soldering two copper wires using Pb-Sn solder.

8. To fabricate a joint using the friction welding process from the given samples.
9. To fabricate a joint using the resistance spot welding process from the given samples.
10. To fabricate a joint using the friction- stir welding (FSW) process from the given samples.
11. To study about the weld section.

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Manufacturing Technology: Foundry, Forming and Welding, P.N. Rao, 2nd Edition, Tata McGraw- Hill Education, 2017.
2. Manufacturing Science, A. Ghosh and A.K. Mallick, 2nd Edition, East- West Press Pvt. Ltd. 2010.

ONLINE/E RESOURCES:

1. https://nptel.ac.in