



SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. (Materials Science) Semester-II

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSC	P2S02NCMAT01	Microstructure Control and Metallic Processing	4-0-1	120	04

• Course Learning Outcomes (CLOs)

On completion of this course, students will be able to:

- CLO1. Explain the fundamental concepts of Khani shastra, deformation, strain hardening, annealing, and microstructure property relationships in metals.
- CLO2. Analyze solidification processes, nucleation mechanisms, casting defects, and methods for their control.
- CLO3. Interpret unary, binary, and ternary phase diagrams and apply thermodynamic concepts such as free energy and Ellingham diagrams.
- CLO4. Evaluate strengthening mechanisms, including solid solution strengthening, dispersion strengthening and precipitation hardening.
- CLO5. Assess phase transformations and heat treatment processes in steels, ancient Indian ferrous alloys and non-ferrous alloys for engineering applications.

Unit	Course Content	Learning Pedagogies*	CLO(s)
I	Metals and Extractive Metallurgy Khani shastra: Mining and Metallurgy of ancient India, Extractive metallurgy, Deformation, Strain hardening, Annealing, Cold and hot working, Residual stresses, Dislocation multiplication, Deformation & bonding process, Superplastic forming, Solidification and grain size strengthening, Microstructure and its relation to the properties. Homogeneous and heterogeneous nucleation, Growth, Types of growth, Solidification time, Casting, Solidification defects, Control of casting structure, Solidification and metal joining, Heat treatment related problem solutions.	CL, CBL, PBL, MP, ROL, Collaborative Learning, Seminars, ICT, IBL, SDL, Mini research proejct	CLO1 CLO2
II	Phase Diagram Phase and the unary phase diagram, Solubility and solutions, Hume- Rothery's rules of solid solubility, Solid solution strengthening, Isomorphous phase diagram, Strength and phase diagram, Solidification of solid solution alloys, Equilibrium and non-equilibrium solidification, Segregation, Castability, Free-energy vs. composition diagrams, Ellingham diagram, Dhar Iron Pillar.	CL, PBL, CBL, ICT, ROL, IBL, SDL	CLO3 CLO4
III	Dispersion Strengthening and Heat Treatments Dispersion Strengthening, Intermetallic compounds, Three phase reactions, Eutectic phase diagram, Eutectic system, Peritectic reactions, Monotectic reaction, Ternary phase diagram, Nucleation and growth in solid state reactions, Alloys strengthening by exceeding solubility limit. Age hardening or precipitation hardening.	CL, PBL, MP, ROL, Collaborative Learning, ICT, IBL, SDL	CLO4



SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. (Materials Science) Semester-II

	Nucleation & growth in solid state reaction, Eutectoid reaction, Control of eutectoid reactions, Age hardening, G.P. Zones, Controlling the transformation, Heat treatments, Phase diagram related problem solutions.		
IV	Fe-Fe₃C Phase Diagram and Alloys Metal technology of the HARAPPA culture, Fe-Fe ₃ C Phase Diagram, Bainite, Martensite, Cementite, Heat treatments processes, Jominy test, Surface treatments. Classification of steels and their applications, Iron Pillar of Delhi, Ancient Indian alloys, Wootz Steel, Aluminium alloys, Magnesium alloys, Copper alloys, Nickel, Cobalt, Zinc alloys, Titanium alloys, Refractory metals	CL, CBL, PBL, MP, EL, IV, ICT, SDL	CLO5

- (*) **Learning Pedagogies/Methods**

- (a) Classroom Lecture (CL)
- (b) Seminars (Student-led and Faculty-moderated)
- (c) Case-Based Learning (CBL)
- (d) Micro-Projects (MP)/Mini Research Tasks
- (e) Industrial Visit/Field Visit/Institutional Visit
- (f) Problem-Based Learning (PBL)
- (g) Research-Oriented Learning(ROL) (Literature Review, Tool Construction, Data Analysis Exercises)
- (h) Collaborative Learning (Group Tasks, Peer Discussion, Joint Presentations)
- (i) Experiential Learning(EL) (Community Engagement, Internship-linked Activities, Practice-based Tasks)
- (j) Simulation and Role-Play (Academic, Professional, or Policy-based Scenarios)
- (k) ICT-Enabled Learning (LMS-based Tasks, Digital Resources, Virtual Labs/Webinars)
- (l) Reflective Practices (Learning Journals, Reflective Notes, Concept Mapping)
- (m) Inquiry-Based Learning(IBL)
- (n) Self-Directed Learning(SDL) (Guided Readings, Concept Exploration Tasks)

- **Assessment Methodologies**

- (A) **Internal Assessment (50 Marks)**

- a. **Internal Formative assessment (25 Marks)**

- (a) Assignment
- (b) Seminar/Presentation
- (c) Quiz
- (d) Class regularity

- b. **Internal Summative Assessment (25 Marks)**

- (a) Mid-term test



SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. (Materials Science) Semester-II

(B) Weightage of Learning Efforts for External Assessment (50 Marks)

(a) Term End Test

Unit	Aligned CLOs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Analyse & above (A)	
I	CLO1 CLO2	30	1	1	10	12
II	CLO3 CLO4	32	1	1	11	13
III	CLO4	30	1	1	11	13
IV	CLO5	28	1	1	10	12
		120	04	04	42	50

• Assessment and Evaluation

Sr.No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Seminars/Assignments, Self-learning, Quizzes, Class Regularity, Mid-term test	50%
2	End-Semester Examination	Written Exam	50%

• CLOs – PLOs Matrix

CLO	PLO											
	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12
CLO1	3	3	3	-	1	3	-	3	3	3	3	3
CLO2	3	3	3	-	3	3	-	2	2	3	3	3
CLO3	3	3	3	-	-	3	-	3	1	3	3	3
CLO4	3	3	3	3	1	3	-	3	2	3	3	3
CLO5	3	3	3	-	-	3	-	3	3	3	3	3

Values to CLO-PLO matrix are assigned by judging the importance of the particular CLO in relation to the PLOs.

CLO – PLO correlation	Value
Strong	3
Moderate	2
Low	1
No correlation	-

• Suggested Learning Materials Books:

Sr. No.	Title	Author(s)	Edition/ Year	Publisher
1	The Science and Engineering of Materials	D. R. Askeland, P. R. Fulay & W. J. Wright	2010	Cengage Learning, Stamford, CT, USA.
2	Materials Science & Metallurgy	V. D. Kodgire	2011	Everest Publishing House



SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. (Materials Science) Semester-II

3	Physical metallurgy: principles and practice	V. Raghavan	2015	PHI Learning Pvt. Ltd
4	Science of Engineering Materials: (Vol. 2) Materials	Manas Chanda	1981	Macmillan International Higher Education.
5	Materials science and engineering: an introduction (Vol. 9)	W. D. Callister & D. G. Rethwisch	2018	New York: Wiley.
6	History of science and technology in Ancient India ED. 1ST	Neemdharm, Joseph	1986	West Bengal Public Library
7	Indian Knowledge System of Materials in Science and Technology	Dr. Ravindra Singh Rana, Dr. Rajesh Purohit, Dr. Manish Vishwakarma, Dr. Vimlesh Kumar Soni, Dr. Satish Pal Singh Rajput.	19 June 2023	Walnut Publication

• Online Resources (Open Source)

Sr. No.	Description of Resource(s)	Weblink
1	Video Source: Powder Metallurgy	https://onlinecourses.nptel.ac.in/noc22_mm31/preview
2	Video Source: Time-Temperature-Transformation (TTT) Diagram	https://www.youtube.com/watch?v=wVZkdWEZv80
3	Video Source: Advanced Metallurgical Thermodynamics	https://www.youtube.com/watch?v=nfMO7_hwYuE&list=PLbMVogVj5nJS_jlBSbduzYmy6YX_K4KyM
4	Video Source: Introduction to Solidification Processing	https://www.youtube.com/watch?v=nb6rkuaw9yA
5	Video Source: Indian Knowledge System: Concepts and Applications in Engineering	https://onlinecourses.swayam2.ac.in/e-learning/preview/imb26_mg12



SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. (Materials Science) Semester-II

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSC	P2S02NCMAT02	Glass, Ceramic and Carbon Materials	4-0-0	120	04

• Course Learning Outcomes (CLOs)

On completion of this course, students will be able to:

- CLO1. Explain the structure, classification and formation mechanisms of glass and ceramic, including silicate and non-silicate systems.
- CLO2. Describe the importance of raw materials selection, processing parameters and preparation methods for glass materials.
- CLO3. Examine the type of minerals, structure-properties relationship and performance of ceramics.
- CLO4. Demonstrate the knowledge on allotropes of carbon, graphitized carbon and porous carbon.
- CLO5. Investigate the properties and behaviour of glass, ceramic and carbon materials for technological applications, including IKS perspective.

Unit	Course Content	Learning Pedagogies*	CLO(s)
I	Glass: Basic structure, Properties and Applications Glass, Glass in ancient India, Nature of glass, Supercooled liquid, Structure, Glass forming systems, Silicate systems, Non-silicate systems, Types of Glasses, Glass-ceramic, Photochromic glass. Processing of glass - annealing point, strain point and glass formation parameters, Properties of glass, Glass like coatings, Ceramic coatings, Glass in Industry and Engineering, Applications of glass.	CL, CBL, PBL, Industrial Visit, ICT-Enabled learning	CLO1 CLO2 CLO5
II	Ceramic Materials Ceramic materials, Traditional Indian ceramics, Various types of ceramics, Basic properties of ceramics, Structure of silicates - Discrete anion, extended anion and three-dimensional networks, Earth's crust and elements. Layered ceramics: Mica and Clays minerals, Whiteware ceramics, Rocks and minerals, Zeolite, Bioceramics- Bioinert, Bioactive and Bioresorbable ceramics.	CL, CBL, Experiential Learning, Industrial Visit, ICT-Enabled learning	CLO1 CLO3 CLO5
III	Properties and Applications of Ceramics Processing of ceramics, Properties of ceramics-density, porosity, permeability, mechanical properties, thermal properties and optical properties, Traditional heat-resistant ceramics, Applications of ceramics. Cement and concrete, Ceramic materials in ancient architecture, Refractories-fireclay, mullite-phase diagram, silica refractories, magnesite refractories, carbide and nitride refractories, pure oxide refractories, chrome and magnesite refractories.	CL, CBL, PBL, Collaborative Learning, ICT-Enabled learning, Inquiry-Based Learning, Research-Oriented Learning	CLO1 CLO3 CLO5



SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. (Materials Science) Semester-II

IV	<p>Carbon: Structure, Properties and Applications Introduction to carbon, Allotropes of carbon, Different crystalline and amorphous carbon, Processing of carbon and graphite materials, Disordered to ordered carbon, Types of carbon, Properties and applications of carbon materials, Applications of carbon in ancient era. Activated carbon, Raw materials, Processing of raw materials, Pyrolysis, Physical activation, Chemical activation, Activated carbon in traditional practices, Adsorption properties and applications of porous carbon, Carbon molecular sieves and pore-size distribution.</p>	CL, Seminar, CBL, PBL, ICT-Enabled Learning, Self-directed learning	CLO1 CLO4 CLO5
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- **(* Learning Pedagogies/Methods)**
 - (a) Classroom Lecture (CL)
 - (b) Seminars (Student-led and Faculty-moderated)
 - (c) Case-Based Learning (CBL)
 - (d) Industrial Visit/Field Visit/Institutional Visit
 - (e) Problem-Based Learning (PBL)
 - (f) Research-Oriented Learning (Literature Review, Tool Construction, Data Analysis Exercises)
 - (g) Collaborative Learning (Group Tasks, Peer Discussion, Joint Presentations)
 - (h) Experiential Learning (Community Engagement, Internship-linked Activities, Practice-based Tasks)
 - (i) ICT-Enabled Learning (LMS-based Tasks, Digital Resources, Virtual Labs/Webinars)
 - (j) Inquiry-Based Learning
 - (k) Self-Directed Learning (Guided Readings, Concept Exploration Tasks)
- **Assessment Methodologies**
 - (A) Internal Assessment (50 marks)**
 - a. Internal Formative assessment (25 marks)**
 - (a) Assignment
 - (b) Seminar/Presentation
 - (c) Quiz
 - (d) Class regularity
 - b. Internal Summative Assessment (25 marks)**
 - (a) Mid-term Test
 - (B) Weightage of Learning Efforts for External Assessment (50 marks)**
 - (a) Term End Test

Unit	Aligned COs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Application/Analyse & above (A)	
I	CLO1 CLO2 CLO5	30	1	1	11	13



SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. (Materials Science) Semester-II

II	CLO1 CLO3 CLO5	30	1	1	10	12
III	CLO1 CLO3 CLO5	30	1	1	11	13
IV	CLO1 CLO4 CLO5	30	1	1	10	12
		120	04	04	42	50

• Assessment and Evaluation

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Seminars/Assignments, Quizzes, Class Regularity, Mid-term test	50
2	End-Semester Examination	Written Exam	50

(C) CLOs – PLOs Matrix

CLO	PLO											
	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12
CLO1	2	3	2	-	-	3	2	1	2	3	3	3
CLO2	3	3	1	-	-	2	1	1	2	3	3	3
CLO3	3	3	2	-	-	3	3	2	3	3	3	3
CLO4	3	3	1	-	-	2	2	2	3	3	3	3
CLO5	3	3	2	-	-	3	3	3	3	3	3	3

Values to CLO-PLO matrix are assigned by judging the importance of the particular CLO in relation to the PLOs.

CLO – PLO correlation	Value
Strong	3
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NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. (Materials Science) Semester-II

• Suggested Learning Materials Books:

Sr. No.	Title	Author(s)	Edition/Year	Publisher
1	Glass Physics	Douglas Suarez	2017	Larsen and Keller Education
2	Ceramic Science for Materials Technologists	I. J. McColm	1983	Chapman & Hall
3	Engineering Materials: An Introduction to Microstructures, Processing and Design (Vol.2)	David R.H. Jones, Michael F. Ashby	2006	Butterworth-Heinemann
4	Industrial Ceramics	F. Singer and S. Singer	1963	Chapman & Hall
5	Science of Engineering Materials (Vol. 2) Materials	Manas Chanda	1979	Macmillan India Ltd.
6	Introduction to Carbon Science	Harry Marsh	1989	Butterworths
7	Ancient Ceramics: Historical Enquiries and Scientific Approaches	P. C. Pant, Vidula Jayaswal	1997	Agam Kala Prakashan

• Online Resources (Open Source)

Sr. No.	Description of Resource(s)	Weblink
1	Glass and Ceramics	https://egyankosh.ac.in/bitstream/123456789/29633/1/Unit-8.pdf
2	Ceramics and Glasses	https://www.scribd.com/document/281665530/Ceramics-and-Glasses-3rd-Year-Lecture-Notes
3	Video Source: Carbon Materials	https://nptel.ac.in/courses/113106099
4	Book: Classic and Advanced Ceramics	https://theswissbay.ch/pdf/Books/STEM/Classic_and_Advanced_Ceramics_From_Fundamentals_to_Applications.pdf
5	Book: Ancient Glass and India	https://ia802908.us.archive.org/3/items/in.ernet.dli.2015.211575/2015.211575.Ancient-Glass_text.pdf

SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. (Materials Science) Semester-II

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSC	P2S02NCMAT03	Fundamentals of Material Properties: Optical, Thermal, Electrical and Magnetic	4-0-0	120	04

• Course Learning Outcomes (CLOs)

On completion of this course, students will be able to:

CLO1. Analyse electromagnetic radiation–material interactions and relate optical properties to the behaviour of metals, non-metals, and advanced photonic and plasmonic materials.

CLO2. Evaluate electrical and dielectric behaviour of materials by relating conductivity, polarization, and symmetry concepts to functional materials and their applications.

CLO3. Integrate and apply concepts of magnetism and thermodynamics to analyze magnetic properties, heat transfer, and energy systems.

CLO4. Examine electromagnetic, dielectric, optical, and magnetic behaviour of materials and relate fundamental mechanisms to their performance in advanced technological applications.

CLO5. Investigate magnetic materials by understanding classification, domain structure, hysteresis, and temperature effects, and relate them to modern applications including nanomaterials and spintronics.

Unit	Course Content	Learning Pedagogies*	CLO(s)
I	Light–Matter Interactions in Materials Electromagnetic radiation, Interaction of light with matter, Atomic and electronic interactions, Optical properties of metals and non- metals, Reflection, Refraction, Transmission and Absorption, Dark and photo conductivity, Photonic materials and photonic crystals, Plasmonic and surface plasmon resonance.	CL, CBL, PBL, Self-Directed Learning	CLO1 CLO4
II	Electrical and Dielectric Properties of Materials Introduction, Classification of materials based on electrical conductivity, Dielectric properties of materials, Dielectric constant, Strength and loss factor, Capacitance and capacitors, Field vector and polarization, Types of polarization. Concept of symmetry, Classification of materials based on symmetry, Piezoelectric and converse effect, Piezoelectric materials, Pyroelectricity and pyroelectric materials, Ferroelectricity, Ferroelectric materials and antiferroelectric materials.	CL, Seminar, CBL, Experiential Learning, Research-Oriented Learning, Industrial Visit	CLO2 CLO4
III	Magnetic and Thermal Properties of Materials Introduction and basic concepts, Magnetic dipoles and field vectors, Magnetic induction, Magnetization and magnetic susceptibility. Origin of magnetic moments, Magnetic moments of body, Magnetic moments of atoms, Calculation of atomic magnetic moments, Bohr magneton, Magnetic resonance (NMR, ESR) principles.	CL, CBL, PBL, Collaborative Learning, Inquiry-Based Learning, ICT-Enabled Learning	CLO3 CLO4



SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

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M.Sc. (Materials Science) Semester-II

	Law of Thermodynamics, Specific heat capacity, Latent Heat, Carnot engine, Otto cycle, Heat flow in materials and Clausius-Clapeyron equation.		
IV	Magnetic Behaviour of Materials and Applications Classification of magnetic materials, Magnetic domains and walls, Hysteresis, Classification into soft and hard magnetic materials. Applications, Influence of temperature on magnetic behaviour, Magnetic nanomaterials and spintronics, Magnetic materials for data storage and biomedical applications.	CL, Seminar, CBL, PBL, ICT-Enabled Learning, Simulation and Role-Play	CLO5 CLO4

- (* Learning Pedagogies/Methods**

- Classroom Lecture (CL)
- Case-Based Learning (CBL)
- Industrial Visit/Field Visit/Institutional Visit
- Problem-Based Learning (PBL)
- Research-Oriented Learning (Literature Review, Tool Construction, Data Analysis Exercises)
- Collaborative Learning (Group Tasks, Peer Discussion, Joint Presentations)
- Experiential Learning (Community Engagement, Internship-linked Activities, Practice-based Tasks)
- Simulation and Role-Play (Academic, Professional, or Policy-based Scenarios)
- ICT-Enabled Learning (LMS-based Tasks, Digital Resources, Virtual Labs/Webinars)
- Inquiry-Based Learning
- Self-Directed Learning (Guided Readings, Concept Exploration Tasks)

- Assessment Methodologies**

- Internal Assessment (50 marks)**

- Internal Formative assessment (25 marks)**

- Assignment
- Seminar/Presentation
- Quiz
- Class regularity

- Internal Summative Assessment (25 marks)**

- Mid-term Test

- Weightage of Learning Efforts for External Assessment (50 marks)**

- Term End Test

Unit	Aligned COs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Application/Analyse & above (A)	
I	CLO1 CLO4	30	1	1	11	13
II	CLO2 CLO4	32	1	1	10	12



SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. (Materials Science) Semester-II

III	CLO3 CLO4	28	1	1	10	12
IV	CLO4 CLO5	30	1	1	11	13
		120	04	04	42	50

• Assessment and Evaluation

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Seminars/Assignments, Self-learning, Quizzes, Class Regularity, Mid-term test	50
2	End-Semester Examination	Written Exam	50

(C) CLOs – PLOs Matrix

CLO	PLO											
	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12
CLO1	3	3	-	-	-	3	-	3	-	2	-	-
CLO2	3	3	-	3	-	3	-	3	1	2	-	-
CLO3	3	2	-	-	-	3	-	3	-	2	2	-
CLO4	3	3	-	2	-	3	-	3	1	3	2	-
CLO5	3	3	2	-	-	3	2	3	1	3	2	-

Values to CLO-PLO matrix are assigned by **judging the importance of the particular CLO** in relation to the PLOs.

CLO – PLO correlation	Value
Strong	3
Moderate	2
Low	1
No correlation	-

• Suggested Learning Materials Books:

Sr. No.	Title	Author(s)	Edition/Year	Publisher
1	Materials Science and Engineering: An Introduction	William D. Callister, David G. Rethwisch	10 th Edition / 2018	Wiley
2	Materials Science for Engineers	J. C. Anderson, K. D. Leaver, P. Leavers, R. D. Rawlings	5 th Edition / 2009	Taylor & Francis
3	Science of Engineering Materials	Manas Chandra	1 st Edition / 1980	Macmillan Publishers Limited



SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

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NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. (Materials Science) Semester-II

- **Online Resources (Open Source)**

Sr. No.	Description of Resource(s)	Weblink
1	Video presentation - Electromagnetism	https://nptel.ac.in/courses/115/106/115106122
2	Video presentation - Introduction to Materials Science and Engineering	https://nptel.ac.in/courses/113102080
3	Video presentation - Properties of Materials	https://nptel.ac.in/courses/113104096



SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

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M.Sc. (Materials Science) Semester-II

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSC	P2S02NCMAT04	Practical-I	0-8-0	120	04

• Course Learning Outcomes (CLOs)

On completion of this course, students will be able to:

- CLO1. Perform metallographic sample preparation and analyse microstructures of metals and alloys, including cast irons and heat-treated steels.
- CLO2. Evaluate mechanical properties of materials using hardness testing, Jominy end quench test, and cold work analysis.
- CLO3. Investigate the effects of heat treatment processes (annealing, tempering, quenching, carburizing) on the microstructure and properties of materials.
- CLO4. Analyse material degradation and processing phenomena, including corrosion, casting defects, shrinkage, and porosity.
- CLO5. Determine thermal and physical properties of materials such as thermal conductivity, specific heat, and Curie transition temperature.

Unit	Course Content	Learning Pedagogies*	CLO(s)
1	<ol style="list-style-type: none"> 1. Electrochemical purification of copper from impure copper rod. 2. Metallographic sample preparation using a disc polishing machine. 3. To study the microstructure of cast irons by etching method. (grey cast iron and white cast iron). 4. Jominy end quench test for evaluating hardenability of metallic materials. 5. Effect of heat treatments on hardness of various steels. 6. To study the carburising process of metallic materials and analyse its effect on surface hardness and microstructure. 7. Study of corrosion rate using weight loss method. 8. Mould preparation for sand casting process. 9. Study of shrinkage and porosity in casted low melting temperature materials. 10. Preparation of Al-Cu Alloy using heat treatment. 11. Determination of thermal conductivity of aluminium rod. 12. Calculation of the Curie transition temperature (T_c) of BaTiO₃ ceramic material. 13. Determination of specific heat of graphite rod at different temperature. 13. Calculate the reflective index of different solution using Abbe Refractometer. 	CL, PBL, Seminars, MP, Experiential Learning, Collaborative Learning, Industrial Visit, CBL, ROL, ICT, IBL, SDL	CLO1 CLO2 CLO3 CLO4 CLO5



SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

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M.Sc. (Materials Science) Semester-II

(* Learning Pedagogies/Methods

- Classroom Lecture (CL)
- Seminars (Student-led and Faculty-moderated)
- Case-Based Learning (CBL)
- Micro-Projects (MP)/Mini Research Tasks
- Industrial Visit/Field Visit/Institutional Visit
- Problem-Based Learning (PBL)
- Research-Oriented Learning(ROL) (Literature Review, Tool Construction, Data Analysis Exercises)
- Collaborative Learning (Group Tasks, Peer Discussion, Joint Presentations)
- Experiential Learning (Community Engagement, Internship-linked Activities, Practice-based Tasks)
- ICT-Enabled Learning (LMS-based Tasks, Digital Resources, Virtual Labs/Webinars)
- Inquiry-Based Learning (IBL)
- Self-Directed Learning (SDL) (Guided Readings, Concept Exploration Tasks)

• Assessment Methodologies

(A) Internal Assessment (50 Marks)

a. Internal Formative assessment (25 marks)

- Working methodology: Handling of instruments and Observation skills
- Record book and Updating of practical journal
- Troubleshooting ability

b. Internal Summative Assessment (25 marks)

- Mid-term practical examination
(Working methodology: Handling of instruments and Observation skills, Result Interpretation and Viva-voce)

(B) Weightage of Learning Efforts for External Assessment (50 Marks)

- Term End Test

Unit	Aligned CLOs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Analyse & above (A)	
I	CLO1 CLO2 CLO3 CLO4 CLO5	120	10	10	30	50
		120	10	10	30	50

• Assessment and Evaluation

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Working methodology: Handling of instruments and Observation skills, Record book and Updating of practical journal, Self-learning and Terms work, Troubleshooting ability, Mid-term practical examination	50%



SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. (Materials Science) Semester-II

2	End-Semester Examination	Practical examination (Working methodology: Handling of instruments and Observation skills, Result Interpretation and Viva-voce)	50%
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• CLOs – PLOs Matrix

CLO	PLO											
	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12
CLO1	3	3	3	-	1	3	2	-	-	2	3	3
CLO2	3	3	3	-	-	2	2	-	-	3	3	3
CLO3	3	3	3	-	-	2	2	1	-	3	3	3
CLO4	3	3	3	-	-	2	2	1	3	3	3	3
CLO5	3	2	3	-	-	3	2	-	2	2	3	3

Values to CLO-PLO matrix are assigned by judging the importance of the particular CLO in relation to the PLOs.

CLO – PLO correlation	Value
Strong	3
Moderate	2
Low	1
No correlation	-

• Suggested Learning Materials Books:

Sr.No.	Title	Author(s)	Edition/Year	Publisher
1	The Science and Engineering of Materials.	D. R. Askeland, P. R. Fulay & W. J. Wright	2010	Cengage Learning, Stamford, CT, USA.
2	Materials Science & Metallurgy	V. D. Kodgire	2011	Everest Publishing House
3	Physical metallurgy: principles and practice	V. Raghavan	2015	PHI Learning Pvt. Ltd
4	Science of Engineering Materials (Vol. 2) Materials.	Manas. Chanda	1981	Macmillan International Higher Education.
5	Materials science and engineering: an introduction (Vol. 9)	W. D. Callister, & D. G. Rethwisch	2018	New York: Wiley.

SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. (Materials Science) Semester-II

• Online Resources (Open Source)

Sr. No.	Description of Resource(s)	Weblink
1	Video Source: Powder Metallurgy	https://onlinecourses.nptel.ac.in/noc22_mm31/preview
2	Video Source: Time-Temperature-Transformation (TTT) Diagram	https://www.youtube.com/watch?v=wVZkdWEZv80
3	Video Source: Advanced Metallurgical Thermodynamics	https://www.youtube.com/watch?v=nfMO7_hwYuE&list=PLbMVogVj5nJS_jlBSbduzYmy6YX_K4KyM
4	Video Source: Introduction to Solidification Processing	https://www.youtube.com/watch?v=nb6rkuaw9yA



SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. (Materials Science) Semester-II

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSC	P2S02NCMAT05	Practical-II	0-8-0	120	04

• Course Learning Outcomes (CLOs)

On completion of this course, students will be able to:

- CLO1. Explain the principles and procedures of various analytical techniques such as titration, gravimetric and distillation used for quantitative estimation
- CLO2. Determine the composition of chemical species using appropriate analytical methods.
- CLO3. Perform preparation and standardization of solutions and carry out experiments such as Kjeldahl analysis, steam distillation and resin characterization with accuracy and safety.
- CLO4. Analyze experimental data, perform relevant calculations and interpret the results for chemical analysis.
- CLO5. Select and implement suitable analytical techniques to produce practically applicable results.

Unit	Course Content	Learning Pedagogies*	CLO(s)
I	<ol style="list-style-type: none"> 1. Determination of percentage of nitrogen by Kjeldhal's method in the given sample. 2. Determination of Percentage of acetyl groups in the given sample. 3. Determination of Molecular weight by steam distillation method of the given sample. 4. Determination of Hydrolyzable chlorine content of resin. 5. Determination of gel time, peak exotherm temp. using dynamic & isothermal curing processes for thermosets. Determination of Oxirane oxygen content & molecular weight of epoxy resin. 6. Determination of Aluminium in the given solution. 7. Determination of Nickel in the given solution. 8. Determination of iron in FeCl₃ solution. 9. Determination of strength of silver in silver nitrates solution. 10. Determination of Calcium in the unknown solution. 11. Determination of chloride content in water. 12. Determination of Hardness of water. Analysis of different constituents present in the given solution. 	Classroom Lecture (CL), Case-Based Learning (CBL), Experiential Learning, Self-Directed Learning, Industrial Visit/Field Visit/Institutional Visit, Collaborative Learning (Group Tasks, Peer Discussion, Joint Presentations), ICT-Enabled Learning	CLO1 CLO2 CLO3 CLO4 CLO5



SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. (Materials Science) Semester-II

(*) Learning Pedagogies/Methods

- (a) Classroom Lecture (CL)
- (b) Case-Based Learning (CBL)
- (c) Industrial Visit/Field Visit/Institutional Visit
- (d) Problem-Based Learning (PBL)
- (e) Collaborative Learning (Group Tasks, Peer Discussion, Joint Presentations)
- (f) Experiential Learning (EL) (Community Engagement, Internship-linked Activities, Practice-based Tasks)
- (g) ICT-Enabled Learning (LMS-based Tasks, Digital Resources, Virtual Labs/Webinars)
- (h) Self-Directed Learning (SDL) (Guided Readings, Concept Exploration Tasks)

• **Assessment Methodologies/Tools**

(A) Internal Assessment (50 Marks)

a. Internal Formative assessment (25 marks)

- (a) Working methodology: Handling of instruments and Observation skills
- (b) Record book and Updating of practical journal
- (c) Self-learning and Terms work
- (d) Troubleshooting ability

b. Internal Summative Assessment (25 marks)

- (a) Mid-term practical examination
(Working methodology: Handling of instruments and Observation skills, Result Interpretation and Viva-voce)

(B) Weightage of Learning Efforts for External Assessment (50 Marks)

- (a) Term end Test

Unit	Aligned COs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Application/ Analyse & above (A)	
I	CLO1 CLO2 CLO3 CLO4 CLO5	120	10	10	30	50
		120	10	10	30	50

• **Assessment and Evaluation**

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Working methodology: Handling of instruments and Observation skills, Record book and Updating of practical journal, Self-learning and Terms work, Troubleshooting ability, Mid-term practical examination	50



SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. (Materials Science) Semester-II

2	End-Semester Examination	Practical examination (Working methodology: Handling of instruments and Observation skills, Result Interpretation and Viva-voce)	50
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• CLOs – PLOs Matrix

CLO	PLO											
	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12
CLO1	2	2	–	–	–	2	–	–	1	2	1	1
CLO2	2	1	–	1	–	2	–	–	–	2	2	3
CLO3	2	2	–	1	–	3	–	–	–	2	2	3
CLO4	2	2	1	2	1	2	1	1	2	3	2	2
CLO5	1	1	–	1	–	2	–	–	2	2	2	3

Values to CLO-PLO matrix are assigned by **judging the importance of the particular CLO** in relation to the PLOs.

CLO – PLO correlation	Value
Strong	3
Moderate	2
Low	1
No correlation	-

• Suggested Learning Materials Books:

Sr. No.	Title	Author(s)	Edition/Year	Publisher
1	Vogel's textbook of quantitative chemical analysis	R. C. Denney, A. I. Vogel & J. Mendham,	2006	Pearson Education India
2	Vogel's textbook of practical organic chemistry.	B. S. Furniss	2004	Pearson Education India

• Online Resources (Open Source)

Sr. No.	Description of Resource(s)	Weblink
1	Video Source: Quantitative Methods in Chemistry	https://onlinecourses.nptel.ac.in/noc20_cy02/preview
2	Volumetric Analysis	https://ebooks.inflibnet.ac.in/esp02/chapter/volumetric-analysis



SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. (Materials Science) Semester-II

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSC	P2S02NCMAT06	Materials Testing and Analysis-II	2-0-1	60	02

• Course Learning Outcomes (CLOs)

On completion of this course, students will be able to:

- CLO1. Explain the fundamental principles of atomic absorption, flame emission, UV–visible and photoelectron spectroscopy, along with their theoretical background and applications.
- CLO2. Interpret microwave and infrared spectra of molecules, including rigid rotor models, vibrational modes, and group frequency concepts.
- CLO3. Analyse Raman and IR spectroscopic behaviour using selection rules, harmonic and anharmonic oscillations, and their limitations.
- CLO4. Evaluate NMR spectral features such as chemical shift, spin–spin coupling, and decoupling techniques for molecular structure determination.
- CLO5. Apply LC-MS techniques for qualitative and quantitative analysis through interpretation of mass spectra, fragmentation patterns and molecular characterizations.

Unit	Course Content	Learning Pedagogies*	CLO(s)
I	<p>Atomic and Molecular Spectroscopy: Principles and Applications</p> <p>Bhardwaj spectral rings.</p> <p>Atomic absorption and flame emission spectroscopy, UV, Visible and photoelectron spectroscopy Introduction, Theoretical consideration, and application.</p> <p>Introduction of microwave spectroscopy, Rigid rotors. Microwave spectra of diatomic and linear triatomic molecules, Numerical problems.</p> <p>Harmonic and anharmonic oscillation in presence of IR, Group frequency concept and its limitation, Classical theory of Raman effect, Selection rule for IR/Raman active vibrations.</p>	CL, CBL, PBL, ICT, Reflective Practices, Seminars, MP	CLO1 CLO3
II	<p>Advanced Spectroscopic Methods and Data Interpretation</p> <p>Principle of NMR spectroscopy, Chemical shift, Neighbour, Ring current effect, Spin-spin splitting and effect of spin-spin splitting on the spectrum, Spin decoupling techniques, Molecular structure studies by NMR.</p> <p>Principle of LC-MS spectroscopy, Instrumentation and components (liquid chromatography system, ionization sources, mass analyzer, detector), Ionization techniques (ESI, APCI), Mass analysis, Fragmentation patterns, interpretation of mass spectra, qualitative and quantitative analysis, applications of LC–MS in molecular characterization and structure elucidation.</p>	CL, CBL, PBL, ICT, Reflective Practices, Seminars, Institutional Visit, EL, SDL	CLO2 CLO4 CLO5



SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. (Materials Science) Semester-II

- (*) **Learning Pedagogies/Methods**
 - (a) Classroom Lecture (CL)
 - (b) Seminars (Student-led and Faculty-moderated)
 - (c) Case-Based Learning (CBL)
 - (d) Micro-Projects (MP)/Mini Research Tasks
 - (e) Industrial Visit/Field Visit/Institutional Visit
 - (f) Problem-Based Learning (PBL)
 - (g) Collaborative Learning (Group Tasks, Peer Discussion, Joint Presentations)
 - (h) Experiential Learning (EL) (Community Engagement, Internship-linked Activities, Practice-based Tasks)
 - (i) ICT-Enabled Learning (LMS-based Tasks, Digital Resources, Virtual Labs/Webinars)
 - (j) Reflective Practices (Learning Journals, Reflective Notes, Concept Mapping)
 - (k) Self-Directed Learning (SDL) (Guided Readings, Concept Exploration Tasks)
- **Assessment Methodologies/Tools**
 - (A) **Internal Assessment (25 Marks)**
 - a. **Internal Formative assessment (10 marks)**
 - (a) Assignment
 - (b) Seminar/Presentation
 - (c) Quiz
 - (d) Class regularity
 - b. **Internal Summative Assessment (15 marks)**
 - (a) Mid-term tests
 - (B) **Weightage of Learning Efforts for External Assessment (25 Marks)**
 - (a) End Term test

Unit	Aligned CLOs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Application/ Analyse & above (A)	
I	CLO1 CLO3	30	1	1	11	13
II	CLO2 CLO4 CLO5	30	1	1	10	12
		60	02	02	21	25

Assessment and Evaluation

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Seminars, Assignments, Quizzes, Class Regularity, Mid-term test	50
2	End-Semester Examination	Written Exam	50



SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. (Materials Science) Semester-II

- CLOs -PLOs Matrix**

CLO	PLO											
	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12
CLO1	2	2	–	1	–	3	1	1	1	2	–	2
CLO2	2	2	–	–	–	3	1	1	–	2	–	–
CLO3	2	2	1	–	–	3	–	1	1	2	1	2
CLO4	3	2	–	1	–	3	–	2	–	3	2	1
CLO5	3	2	–	2	1	3	–	2	1	3	2	1

Values to **CLO-PLO** matrix are assigned by **judging the importance of the particular CLO** in relation to the **PLOs**.

CLO – PLO correlation	Value
Strong	3
Moderate	2
Low	1
No correlation	-

- Suggested Learning Materials Books:**

Sr. No.	Title	Author(s)	Edition/Year	Publisher
1	Fundamentals of molecular spectroscopy	C. N. Banwell	2013	McGraw-Hill Education
2	Spectroscopy of organic compounds	P. S. Kalsi	2007	New Age International
3	Molecular Spectroscopy	T. Gates	2023	Brilliance Publications LLP
4	Analysis of Bharadwaj Spectral Ring	Rakesh Kumar Pandey	2025	Oriental Journal of Physical Sciences

- Online Resources (Open Source)**

Sr. No.	Description of Resource(s)	Weblink
1	Video source: Fundamentals of Spectroscopy	https://nptel.ac.in/courses/104/106/104106122
2	Video source: Spectroscopic Techniques for Pharmaceutical and Biopharmaceutical Industries	https://onlinecourses.nptel.ac.in/noc25_cy43/preview

SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. (Materials Science) Semester-II