

LESSON PLAN

METALLOGRAPHY AND CHARACTERIZATION LABORATORY

MTPC305 | PR:1 | 60 Syllabus Hours | 4P/Week | Teaching Plan: 06 August 2026 – 05 November 2026

L	T	P	Course Code	MTPC305	
0	0	4	Total Marks	50	
Total Contact Hours	Practical : 60 Hrs	End Exam	15	Progressive Assessment	35
Branch	Metallurgical Engineering		Name of the Teaching faculty	Tushar K. Pattanayak	

Course Outcomes (COs)

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

CO	Course Outcome
CO1	Prepare metallographic samples of metals and alloys using standard procedures.
CO2	Identify different microstructural features using optical microscopy.
CO3	Analyze microstructures for phase composition, grain size, and defects.
CO4	Apply advanced characterization techniques (SEM/EDX, image analysis, etc.) to support industrial materials testing and research.

CO Mapping: CO1 – Sample Preparation | CO2 – Optical Microstructure Identification | CO3 – Microstructure Analysis | CO4 – Advanced Characterization.

Period-wise Lesson Plan with CO Mapping

Period	Date	Day	Unit	Experiment / Integrated Coverage	Key Content / Learning Focus	Suggested Method	CO Mapping	Assessment / Record
1	07-08-2026	Friday	UNIT-I	Lab Orientation, Safety & Metallographic Workflow	Introduction to Metallography and Characterization Laboratory; objectives; specimen identification; standard workflow; PPE; equipment authorization; emergency shut-off, fire extinguisher and eyewash awareness; record format.	Safety briefing + laboratory orientation	CO1, CO4	Observation + data / image record
2	07-08-2026	Friday	UNIT-I	Sample Preparation: Cutting, Mounting & Lab Safety	Sample cutting; selection of representative area; hot/cold mounting concepts; use of guards and clamps; safe handling of hot-mounted samples.	Demonstration + specimen preparation	CO1	Observation + data / image record
3	07-08-2026	Friday	UNIT-I	Grinding & Polishing	Sequential grinding, polishing, water management and surface preparation; avoid scratches and deformation; machine clean-up.	Hands-on preparation	CO1	Observation + data / image record
4	07-08-2026	Friday	UNIT-I	Etching & Final Metallographic Preparation	Etching principles; fume hood/ventilation; specified etchant	Demonstration + supervised etching	CO1	Observation + data / image record

					quantity; safe storage/handling; rinse and dry etched specimens.			
	14-08-2026	Friday	UNIT-I	Metallurgical Microscope: Setup & Illumination	Optical microscope components; illumination, magnification, focusing and specimen positioning; safe microscope operation.	Instrument demonstration	CO2	Observation + data / image record
6	14-08-2026	Friday	UNIT-I	Experiment 1: Mild Steel Microstructure	Observe grain size and phase boundaries of mild steel using metallurgical microscope.	Hands-on microscopy + record	CO1, CO2, CO3	Observation + data / image record
7	14-08-2026	Friday	UNIT-I	Experiment 1: Stainless Steel Microstructure	Observe microstructure, grain size and phase boundaries of stainless steel using metallurgical microscope.	Hands-on microscopy + record	CO1, CO2, CO3	Observation + data / image record
8	14-08-2026	Friday	UNIT-I	Experiment 1: High Speed Steel Microstructure	Observe grain structure and phases of High Speed Steel; compare with mild and stainless steels.	Comparative microscopy	CO1, CO2, CO3	Observation + data / image record
9	21-08-2026	Friday	UNIT-I	Experiment 1: Microstructure Analysis & Report	Compare grain size, phase boundaries and microstructural features of mild steel, stainless steel and HSS; report and viva.	Image interpretation + viva	CO2, CO3	Observation + data / image record
10	21-08-2026	Friday	UNIT-I	Experiment 2: Cast Iron – Graphite Morphology	Identify graphite morphology of different cast irons using metallurgical microscope.	Hands-on microscopy	CO1, CO2, CO3	Observation + data / image record
11	21-08-2026	Friday	UNIT-I	Experiment 2: Cast Iron – Comparative Morphology	Compare graphite morphology and matrix features in different cast irons; relate morphology to properties.	Comparative analysis	CO2, CO3	Observation + data / image record
12	21-08-2026	Friday	UNIT-I	Experiment 2: Record & Interpretation	Document graphite morphology, matrix observations and conclusions; identify microstructural differences.	Record + viva	CO2, CO3	Record submission / verification
13	28-08-2026	Friday	UNIT-I	Experiment 3: Non-Ferrous Alloys – Alpha/Beta Phases	Study alpha/beta phases in Cu-, Al- and Zn-based non-ferrous alloys using metallurgical microscope.	Hands-on microscopy	CO2, CO3	Observation + data / image record
14	28-08-2026	Friday	UNIT-I	Experiment 3: Solid Solution Structures	Identify solid solution structures in non-ferrous alloys and relate phase constitution to microstructure.	Microstructure interpretation	CO2, CO3	Observation + data / image record
15	28-08-2026	Friday	UNIT-I	Experiment 3: Eutectic Structures	Identify eutectic structures in Cu-, Al- and Zn-based alloys; compare phase morphology.	Microscopy + comparison	CO2, CO3	Observation + data / image record

	28-08-2026	Friday	UNIT-I	Experiment 3: Non-Ferrous Alloy Report	Consolidated phase identification, comparison of alpha/beta, solid solution and eutectic structures; report/viva.	Report + viva	CO2, CO3	Observation + data / image record
17	11-09-2026	Friday	UNIT-I	Experiment 4: Grain Size – ASTM Chart Method	Quantitative grain-size measurement using ASTM chart method; specimen selection and comparison.	Image-based measurement	CO3	Observation + data / image record
18	11-09-2026	Friday	UNIT-I	Experiment 4: Grain Size – Intercept Method	Quantitative grain-size measurement using intercept method; count intercepts and calculate grain size.	Worked measurement + calculation	CO3	Observation + data / image record
19	11-09-2026	Friday	UNIT-I	Experiment 4: Image Analyzer for Grain Size	Use image analyzer for quantitative grain-size measurement; compare ASTM, intercept and software methods.	Image analysis practical	CO3, CO4	Observation + data / image record
20	11-09-2026	Friday	UNIT-I	Experiment 4: Grain Size Report & Assessment	Interpret grain-size results; discuss accuracy, repeatability and industrial relevance; practical assessment.	Data analysis + viva	CO3, CO4	Practical assessment / viva
21	18-09-2026	Friday	UNIT-I	Experiment 5: Digital Imaging & Image Acquisition	Digital imaging of microstructures; image capture, scale and documentation.	Image Analyzer demonstration	CO2, CO4	Observation + data / image record
22	18-09-2026	Friday	UNIT-I	Experiment 5: Contrast Adjustment	Contrast adjustment and image enhancement for clearer microstructural feature identification.	Software practical	CO2, CO4	Observation + data / image record
23	18-09-2026	Friday	UNIT-I	Experiment 5: Quantitative Phase Analysis	Quantitative phase analysis using Image Analyzer software; area fraction/phase measurement concepts.	Software practical + calculation	CO3, CO4	Observation + data / image record
24	18-09-2026	Friday	UNIT-I	Experiment 5: Digital Imaging Report	Prepare digital microstructure plates; document contrast settings and quantitative phase results.	Report + assessment	CO3, CO4	Observation + data / image record
25	25-09-2026	Friday	UNIT-II	Experiment 6: FESEM – Principle & Sample Handling	Scanning Electron Microscopy (FESEM); secondary electron imaging; high magnification structures; sample preparation and instrument safety.	FESEM demonstration	CO4	Observation + data / image record
26	25-09-2026	Friday	UNIT-II	Experiment 6: FESEM Secondary Electron Imaging	Observe secondary electron imaging and high-magnification structures using FESEM.	Instrument observation	CO2, CO4	Observation + data / image record
27	25-09-2026	Friday	UNIT-II	Experiment 6: FESEM Image Interpretation	Interpret topography, morphology, contrast and high-magnification features; compare optical microscopy	Comparative image analysis	CO2, CO4	Observation + data / image record

	25-09-2026	Friday	UNIT-II	Experiment 7: EDX – Principle & Spectrum	and FESEM. Energy Dispersive X-ray Analysis (EDX); elemental analysis of microstructural constituents; spectrum acquisition.	EDX demonstration	CO4	Observation + data / image record
29	09-10-2026	Friday	UNIT-II	Experiment 7: EDX Elemental Identification	Identify elements in microstructural constituents from EDX spectra; qualitative/quantitative interpretation.	Spectrum analysis	CO3, CO4	Observation + data / image record
30	09-10-2026	Friday	UNIT-II	Experiment 8: FESEM Fracture Surface Study	Observe fracture surfaces using FESEM; identify fracture morphology and relate features to failure behaviour.	FESEM fracture analysis	CO3, CO4	Observation + data / image record
31	09-10-2026	Friday	UNIT-II	Experiment 8: Fracture Surface Interpretation	Compare fracture features and document evidence from FESEM images; prepare failure-analysis observations.	Failure analysis + report	CO3, CO4	Observation + data / image record
32	09-10-2026	Friday	UNIT-II	Experiment 9: EBSD – Grain Orientation Mapping	EBSD attached to FESEM; observe grain orientation mapping and understand orientation contrast.	EBSD demonstration	CO4	Observation + data / image record
33	16-10-2026	Friday	UNIT-II	Experiment 9: EBSD – Phase Distribution & Texture	Observe phase distribution and texture in metals using EBSD; interpret orientation/phase maps.	Map interpretation	CO3, CO4	Observation + data / image record
34	16-10-2026	Friday	UNIT-II	Experiment 10: Vickers/Knoop Microhardness	Perform/observe Vickers/Knoop microhardness tests on multiphase regions; select suitable load and indenter.	Microhardness practical	CO3, CO4	Observation + data / image record
35	16-10-2026	Friday	UNIT-II	Experiment 10: Microhardness–Microstructure Correlation	Correlate microhardness with grain size and phases; interpret property–microstructure relationship.	Correlation analysis	CO3, CO4	Observation + data / image record
36	16-10-2026	Friday	UNIT-II	Experiment 11: XRD Demonstration	Demonstrate XRD; diffraction principle, pattern acquisition and peak identification.	XRD demonstration	CO4	Observation + record
37	23-10-2026	Friday	UNIT-II	Experiment 11: XRD & JCPDS Matching	Match diffraction patterns with standard JCPDS cards; identify phases from diffraction peaks.	Pattern analysis	CO3, CO4	Observation + data / image record
38	23-10-2026	Friday	UNIT-II	Experiment 12: TEM Foil Preparation	Transmission Electron Microscopy foil preparation; electro-polishing/ion milling concepts; bulk vs thin sample characterization.	Demonstration + process discussion	CO1, CO4	Observation + data / image record
39	23-10-2026	Friday	UNIT-II	Experiment 12: TEM – Bulk vs Thin Characterization	Understand differences between bulk and thin sample characterization; foil	Conceptual demonstration	CO4	Observation + data / image record

	23-10-2026	Friday	UNIT-II	Experiment 13: TEM Microstructural Observation	thickness and electron transparency. Observe grain boundaries, dislocations and phase contrast in metallic materials using TEM.	TEM observation	CO2, CO3, CO4	Observation + data / image record
41	30-10-2026	Friday	UNIT-II	Integrated Characterization & Final Practical Assessment	Integrate optical microscopy, image analysis, FESEM/EDX, EBSD, microhardness, XRD and TEM; select technique for a given problem; final practical/viva and record verification.	Integrated practical + viva	CO1, CO2, CO3, CO4	Practical assessment / viva
42	30-10-2026	Friday	UNIT-II	Advanced Characterization – Technique Selection Exercise	Given a metallurgical problem, select optical microscopy, image analysis, FESEM/EDX, EBSD, microhardness, XRD or TEM and justify the characterization route.	Case study + technique selection	CO3, CO4	Observation + data / image record
43	30-10-2026	Friday	UNIT-II	Complete Practical Record & Safety Verification	Verify all experiment records, images, calculations, spectra/maps, observations, precautions and conclusions; reinforce laboratory safety and equipment care.	Record audit + viva	CO1, CO2, CO3, CO4	Record submission / verification
44	30-10-2026	Friday	UNIT-II	Final Practical Assessment & Viva	Integrated practical assessment covering sample preparation, optical microscopy, image analysis and advanced characterization; final viva.	Final practical + viva	CO1, CO2, CO3, CO4	Practical assessment / viva

CO Coverage Summary

CO	UNIT-I Conventional Metallography	UNIT-II Advanced Characterization	Overall Coverage
CO1	✓	Supporting	Standard metallographic sample preparation, cutting, mounting, grinding, polishing and etching.
CO2	✓	✓	Optical microscopy and identification of microstructural features; FESEM/TEM observation support.
CO3	✓	✓	Phase composition, grain size, defects, image analysis, EDX, EBSD, microhardness and XRD interpretation.
CO4	Supporting	✓	Image analysis, FESEM/EDX, EBSD, XRD, TEM and industrial/research characterization applications.

Safety Considerations Integrated into the Lesson Plan

Area	Key Safety Requirement	Integrated In Period
General Safety	Safety glasses, gloves and lab coat; hair tied; no synthetic/flammable clothing; operate equipment only when trained/authorized.	Periods 1–4

ent Handling	Use guards/clamps; never leave rotating/polishing machines unattended; keep hands away from moving parts; use holders.	Periods 2–3
-Mounted Samples	Use tongs or heat-resistant gloves.	Period 2
Chemical / Etching Safety	Fume hood/ventilation; specified etchant amount; do not mix without guidance; proper storage.	Period 4
Waste & Clean-up	Designated bins for metallic/abrasive waste; wipe machines; drain polishing water; rinse/dry etched specimens.	Periods 3–4 and throughout
Emergency Protocol	Know emergency shut-off, fire extinguisher and eyewash locations; immediately report malfunction, exposure or injury.	Period 1 and throughout

Assessment & Revision

Timing	Activity	Coverage	CO
After Sample Preparation	Practical observation + record	Cutting, mounting, grinding, polishing, etching and safety	CO1
After Optical Metallography	Microstructure identification viva	Steels, cast irons and non-ferrous alloy microstructures	CO2, CO3
After Image Analysis	Data analysis assessment	Grain size, digital imaging, contrast and quantitative phase analysis	CO3, CO4
After Advanced Characterization	Characterization assignment/viva	FESEM, EDX, EBSD, microhardness, XRD and TEM	CO3, CO4
05 Nov 2026	Final practical/viva + record verification	Complete prescribed syllabus and technique selection	CO1–CO4

Holidays / Non-Teaching Days Considered

Date	Day	Reason	Status
04-09-2026	Friday	Janmashtami	Holiday – no lab periods
02-10-2026	Friday	Gandhi Jayanti	Holiday – no lab periods

Recommended 4-Period Practical Session Architecture

- Period 1: Pre-lab briefing, principle, apparatus/software identification, safety and specimen/sample preparation.
- Period 2: Demonstration / supervised execution / image or spectrum acquisition.
- Period 3: Observation, image/data analysis, calculations and interpretation.
- Period 4: Result discussion, industrial significance, record completion and viva/assessment.

Course Flow

SAMPLE PREPARATION → OPTICAL MICROSCOPY → IMAGE ANALYSIS → FESEM/EDX → FRACTURE → EBSD → MICROHARDNESS → XRD → TEM

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