INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Metallurgical and Materials Engineering

1. **Subject Code:** MTE-101 **Course Title:** Non Destructive Testing
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration(Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Autumn **7. Subject Area:** ESC
8. **Pre-requisite:** Nil
9. **Objective:** To impart the importance of non-destructive testing in engineering components.
10. **Details of the Course:**

S.No.	Contents	Contact Hours
1.	**Introduction:** Non destructive testing (NDT) and its comparison with destructive testing, Defects/ flaws due to primary processing, secondary processing and in-service, Types of defects determined by NDT, Common non-destructive testing techniques, Advantages, limitations and applications of NDT.	4
2.	**Visual Inspection:** Principle of visual Inspection, Defects which can be detected by unaided visual Inspection, Optical aids used for visual inspection, Advantages and limitations of visual inspection.	2
3.	**Liquid Penetrant Test:** Advantages and limitations of Liquid Penetrant Test (LPT), Physical principles of LPT, Procedure employed for LPT, Penetrant methods, Materials used in LPT, Equipment used in LPT, Inspection and evaluation, Applications / case studies of / in LPT.	6
4.	**Magnetic Particle Test:** Advantages and limitations of Magnetic Particle Test (MPT), Procedure of MPT, Magnetizing Magnetic particles and suspending liquids, Detectable discontinuities, Non-relevant indications, Continuous and residual magnetization techniques, Demagnetization after inspection, Magnetic field indicators, Applications / case studies of / in MPT	6
5.	**Eddy Current Test:** Advantages and limitations of Eddy Current Test (ECT), Operation variables, Inspection frequencies, Eddy current instrumentation, Probes shielding and loading, Reference standards, Applications / case studies of / in ECT.	6
6.	**Ultrasonic Test:** Advantages and limitations of Ultrasonic Test (UT), General characteristics of ultrasonic waves, Wave propagation and types of ultrasonic waves, Major variables in UT, Attenuation of ultrasonic beams, Pulse-Echo method, Transmission method, Angle beam techniques, Immersion testing, Copulants, Piezoelectric transducers, Standard reference blocks, Applications / Case Studies of / in UT.	6
7.	**Radiography Test:** Uses/ Applicability of radiography, Advantages and limitations of Radiography Test (RT), Interaction between penetrating radiation & matter (Attenuation), Image conversion media, Film radiography, Real time radiography, Computed tomography, Selection of view, Identification markers and penetrameters, Applications / case studies of / in RT.	6
8.	**Other Non-destructive Inspection Techniques:** Acoustic emission inspection, Microwave inspection, Thermal inspection, Electromagnetic techniques for residual stress measurements, Optical holography, etc.	6
Total		**42**

11. Suggested Books:

S.No.	Name of Authors/Books/ Publisher	Year of Publication/Reprint
1.	"Non Destructive Evaluation and Quality Control", Metals Handbook, Vol. 17, 9th Ed., ASM.	1989
2.	Baldev Raj, Jayakumar T, Thavasimuthu M, Practical Non-Destructive Testing, 3rd Ed., Narosa.	2019
3.	Srivastava, K.C., "Handbook of Magnetic Particle Testing", Oscar Publications.	1998
4.	Hull, B., "Non Destructive Testing", Springer.	2012

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Metallurgical and Materials Engineering

1. **Subject Code:** MTE-102 **Course Title:** Materials Characterization
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration(Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Spring **7. Subject Area:** ESC
8. **Pre-requisite:** Nil
9. **Objective:** To familiarize with fundamentals of various materials characterization techniques.
10. **Details of the Course:**

S.No.	Contents	Contact Hours
1.	**Optical Microscopy:** Introduction, concept of magnification, resolution, airy rings, numerical aperture, depth of field, depth of focus, lens defects and their corrections, principles of phase contrast – bright-field and dark-field contrast, polarized light microscopy, Quantitative microscopy, estimation of grain size, grain boundary area, relevance of light microscopy ideas to electron microscopy.	6
2.	**X-ray Diffractometry:** Introduction; X-rays production and precaution; Absorption of x-rays and concept using filter; Derivation of Bragg's law of X-ray diffraction- concept of lattice directions, planes, interplanar spacing, zone axis, and Bragg's condition of diffraction; Powder diffraction; Factors affecting intensities of x-rays diffraction; X-rays scattering, structure factor calculations, and determination of crystal structures; Application of x-ray diffraction –phase identification, estimation of grain size and lattice strain, lattice parameter calculation, residual stress measurement.	12
3.	**Transmission Electron Microscopy (TEM):** Principle, construction and operation of TEM, Interaction of electrons with specimen, reciprocal space and lattice, Ewald sphere, diffraction from finite crystal, preparation of specimens, bright and dark field imaging, selected area diffraction, indexing of diffraction patterns.	9
4.	**Scanning Electron Microscopy (SEM):** Principle, construction and operation of SEM, study of fractured surfaces, energy- and wavelength dispersive spectroscopy. Concept of EBSD analysis.	6
5.	**Thermal Analysis techniques:** Principles of differential scanning calorimetry (DSC), differential thermal analysis (DTA), Dilatometry, Thermogravimetric analysis (TGA).	4
6.	**Principles of additional Characterization Techniques:** Atomic force microscopy, emission spectroscopy, Atomic Absorption Spectroscopy, Raman Spectroscopy, Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS), X-ray Photoelecton-Spectroscopy (XPS).	5
Total		**42**

11. Suggested Books:

S.No.	Name of Authors/Books/ Publisher	Year of Publication/Reprint
1.	Goodhew, P.J., Humphreys J. and Beanland, R., "Electron Microscopy and Analysis", Taylor and Francis.	2001
2.	Gifkins, R.C., "Optical Microscopy of Metals", Sir Isaac Pitman and Sons.	1970
3.	Cullity, B.D., "Elements of X-Ray Diffraction", Addison–Wesley Publishing Company.	1980
4.	Suryanarayana, C., Norton, M. Grant, "X-Ray Diffraction-A Practical Approach", Springer Science + Business Media, LLC	1998
5.	Brown, M.E., "Introduction to Thermal Analysis: Techniques and Applications", Springer.	2013
6.	Speyer, R., "Thermal Analysis of Materials", 1st edition, CRC Press.	1993

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Metallurgical and Materials Engineering

1. **Subject Code:** MTE-103 **Course Title:** Materials Science
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration(Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS:** 0 **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Both **7. Subject Area:** ESC
8. **Pre-requisite:** Nil
9. **Objective:** To familiarize the students with fundamentals of materials science.
10. **Details of the Course:**

S.No.	Contents	Contact Hours
1.	**Introduction to crystallography:** Bonding in solids, amorphous and crystalline, single crystal and polycrystalline material, polymorphism, lattice, unit cell, Bravais lattice, types of crystals, linear and planer densities, voids in crystalline structures, ceramic crystal structures, crystal defects (point, line, surface and volume defects)	10
2.	**Principles of alloy formation:** Solid solution, Hume-Rothery rules, binary phase diagrams: Gibbs phase rule, lever rule, cooling curves, invariant reactions, types of binary phase diagrams (isomorphous, eutectic, partial-eutectic systems), iron-iron carbide phase diagram	7
3.	**Plastic deformation:** Elastic and plastic deformation and strain hardening with respect to stress-strain Curve, plastic deformation by slip: slip system, critical resolved shear stress, Frank-Read source, work hardening and dynamic recovery, strengthening mechanisms, recovery, recrystallization and grain growth, cold and hot working	5
4.	**Mechanical properties:** Hardness Test (Brinell, Vickers, Rockwell and microhardness tests), tensile test, impact Test (Charpy and Izod specimens, ductile – brittle transition, effect of carbon on ductile-brittle transition in plain carbon steels), fatigue Test (fatigue testing apparatus, S-N Curve for ferrous and non-ferrous, fatigue fracture (transgranular fracture), methods of improving fatigue life, creep Test: creep curve, creep fracture, material consideration for high temperature use.	10
5.	**Heat treatment:** Purpose of heat treatments, equilibrium and non-equilibrium cooling, nucleation, grain growth and kinetics, TTT and CCT diagrams, common heat treatments like annealing, normalizing, hardening and tempering, hardenability: Jominy end-quench test, hardenability curves, martempering and austempering, surface hardening (carburizing, nitriding, flame and induction hardening)	6
6.	**Ceramic, composite and polymeric materials:** Ceramics: types of ceramics, fabrication and processing of ceramics: (i) glass forming processes (ii) particulate forming processes (iii) cementation, composites: advantages of composites, constituents of composites, applications of composites ,classification of composites: based on matrix and reinforcement, polymers: hydrocarbon and polymer molecules, molecular shape and structure, molecular configuration, thermoplastic and thermosetting polymers	4
Total		**42**

11. Suggested Books:

S.No.	Name of Authors /Books/ Publisher	Year of Publication/ Reprint
1.	Balasubramaniam, R. Callister's Materials Science and Engineering", 2nd edition, Wiley	2014
2.	Raghavan V., "Materials Science and Engineering- A first Course," 6th edition , Prentice Hall India Learning Private Limited	2015
3.	Askeland D.R. Fulay P.R, Wright W.J, "The Science and Engineering of Materials, 6th edition, Cengage Learning Inc.	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

Subject Code: MTC-102 **Course Title:** Introduction to Materials Engineering

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course Outline: Crystallography: Alloy formation; Metal Processing; Ceramics, polymers and composites; Material properties; Material degradation; Material applications

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NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

Subject Code: MTC-104 **Course Title:** Metallurgical Thermodynamics and Kinetics

L-T-P: 2-1-0 **Credits:** 3 **Subject Area:** PCC

Course Outline: Introduction; Heat, work and Energy; Thermodynamic functions; Thermodynamics of reactions; Theory and Models of Metallic Solutions; Metallurgical Kinetics:

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTER/SCHOOL: Department of Metallurgical and Materials Engineering

Subject code: MTO-103 **Course Title:** Non Destructive Testing

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** OEC

Course Outlines: Non destructive testing and its comparison with destructive testing, role of NDT in quality control; principles, equipment, advantages, limitations, and applications of: Liquid penetrant inspection, Magnetic particle inspection, Ultrasonic inspection, Eddy current inspection, X-ray radiography; Statistical quality control, Control charts, Control chart attributes and variables, Acceptance sampling, Quality assurance and ISO 9000:2000.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTER/SCHOOL: Department of Metallurgical and Materials Engineering

Subject Code: MTC-203 **Course Title:** Mechanical Behavior of Materials

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PCC

Course Outlines: Stress-strain relations, elastic behavior, Tensile, Hardness, Impact testing; Plastic behavior – yield criteria, dislocation slip and twinning, effect of temperature and strain rate, constitutive equation, strain hardening curve; Different strengthening mechanisms, Ductile fracture, brittle fracture and their transition, Introduction to fracture mechanics; Fatigue – SN curve, low cycle and high cycle fatigue, effects of structural, environmental and metallurgical variables; Creep – Creep curve, stress rupture test, deformation mechanisms, superplasticity; Mechanical response of non-metallic and non-crystalline materials.

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NAME OF DEPARTMENT/CENTER/SCHOOL: Department of Metallurgical and Materials Engineering

Subject Code: MTC-205 **Course Title:** Iron and Steel making

L-T-P: 3-0-2/2 **Credits:** 4 **Subject Area:** PCC

Course Outlines: Basics of Raw material preparation, Metallurgical Reactors, Physico-chemical principles relevant to iron making, Thermodynamics and kinetics of chemical reactions, Blast furnace, Slag making and control, Direct reduction processes, Impurity removal in steelmaking, Basic oxygen furnace, Electric arc furnace, Secondary steel making, Global scenario.

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NAME OF DEPARTMENT/CENTER/SCHOOL: Department of Metallurgical and Materials Engineering

Subject Code: MTC-206 **Course Title:** Engineering Polymers and Composites

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course Outlines: Introduction and classification of polymers; Polymer characteristics; Polymer processing, characterisation and applications; Composites; Fabrication of composites; Characterisation of composites; Joining of Composites; Application of Composites.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Metallurgical and Materials Engineering

Subject Code: MTC-201 **Course Title:** Phase Transformation and Heat Treatment

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PCC

Course Outlines: Equilibrium in a closed binary system. Steady-state diffusion, non-steady state diffusion. Interfacial energy, boundaries in single-phase solids, interphase interfaces in solids. Homogeneous and heterogeneous nucleation, rate of nucleation, growth, eutectic solidification, cellular and dendritic solidification. Diffusional transformations in solids, precipitation. Martensitic transformations, phenomenological theory of martensite crystallography (PTMC).