Department of Metallurgical and Materials Engineering

1.	MAN-001	Mathematics-I	BSC	4
2.	PHN-007	Modern Physics	BSC	4
3.	CEN-105	Introduction to Environmental Studies	GSC	3
4.	HS-001A	Communication Skills (Basic)	HSSC	2
5.	HS-001B	Communication Skills (Advance)	HSSC	2
6.	HSN-002	Ethics and Self Awareness	HSSC	2
7.	MTN-101	Introduction to Metallurgical and Materials Engineering	DCC	2
8.	MTN-103	Computer Programming	ESC	4
9.	CYN-006	General Chemistry-II	BSC	4
10.	MAN-002	Mathematical Methods	BSC	4
11.	MTN-102	Metallurgical Thermodynamics and Kinetics	DCC	4
12.	MTN-104	Structural Metallurgy	DCC	4
13.	MTN-110	Metallography Lab	DCC	2
14.	MIN-108	Mechanical Engineering Drawing	ESC	4
15.	EEN-112	Electrical Science	ESC	4
16.	MTN-201	Transport Phenomena	DCC	4
17.	MTN-203	Phase Transformation and Heat Treatment	DCC	4
18.	MTN-205	Mechanical Behaviour of Materials	DCC	4
19.	MTN-207	Electrical and Electronic Materials	DCC	4
20.	ECN-102	Fundamentals of Electronics	ESC	4
21.	MTN-204	Metal Casting and Joining	DCC	4
22.	MTN-206	Non-ferrous Metallurgy	DCC	4
23.	MTN-208	Engineering Polymers and Composites	DCC	4

24.	MTN-292	Engineering Analysis and Design	DCC	4
25.	MTN-301	Mechanical Working of Metals	DCC	4
26.	MTN-303	Iron and Steel Making	DCC	4
27.	MTN-305	Materials Testing Lab	DCC	2
28.	MTN-307	Materials Characterization	DCC	4
29.	MTN-302	Environmental Degradation of Materials	DCC	4
30.	MTN-304	Ceramics and Metal Powder Processing	DCC	4

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Chemistry**

1. Subject Code: **CYN-006** Course Title: **General Chemistry-II**

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**: CWS** 15 **PRS** 15 **MTE** 30 **ETE** 40 **PRE** 0

5. Credits: 4 6. Semester**: Spring** 7. Subject Area**: BSC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of general chemistry.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Molecular Reaction Dynamics:** Collision theory of bimolecular reactions and its drawbacks, transition state theory and its thermodynamic formulation, comparison of collision theory and transition state theory.	4
2.	**Catalysis:** Homogeneous catalysis – kinetics of acid and base catalyzed reactions with suitable examples, heterogeneous catalysis – surface phenomenon, porosity, derivation of Langmuir adsorption isotherm, Langmuir-Hinshelwood mechanism.	5
3.	**Photochemistry:** Laws of photochemistry, photophysical and photochemical processes and their quantum efficiencies, Franck-Condon principle, photosensitizers and their application to solar cells.	5
4.	**Polymerization:** Synthesis of polymers, properties of polymers − degree of polymerization, molecular mass of polymers, tacticity and glass transition temperature. High temperature and conductive polymers, methods of modifying polymers, biopolymers.	6
5.	**Energy Resources:** Coal − calorific value, analysis, carbonization, petroleum − fractional distillation, gasoline/petrol − classification, knocking, octane number, natural gas.	3
6.	**Organometallic Chemistry**: Factors affecting M–C bond formation, general methods of formation of organometallic compounds, reactions of organometallic compounds, comparison of main group and transition metal organometallics, bonding in transition metal-π alkene complexes. Applications of organometallic compounds in catalytic processes such as hydroformylation, hydrogenation, Ziegler-Natta catalysis, catalytic decarbonylation and olefin metathesis.	6
7.	**Volumetric and Gravimetric Determination of Metals and Non-metals:** Redox titration– iodometric titration, acid-base titration, complexometric titrations, co- and post-precipitation, schematic description of methods for determination of Fe, Cu, Al, Zn, Ni, Pb, Sn, P and S.	5
8.	**Spectroscopic Techniques**: Interaction of electromagnetic radiation with matter, spectroscopic techniques viz., AAS, ICP, UV-Vis, IR and Mass	8

	spectroscopy, and their application to atomic and molecular systems.	
	Total	**42**

List of Experiments:

i)	Determination of sodium carbonate in baking/washing soda.
ii)	Determination of Zn by EDTA− complexometric titration.
iii)	Determination of nitrogen as ammonia in a sample.
iv)	Determination of viscosity of a polymer in a solution /or in a mixture of liquid.
v)	Determination of surface excess concentration of 1-butanol in aqueous solution.
vi)	Kinetics of a reaction between hydrogen peroxide and iodine in acidic medium.
vii)	Photochemical reduction of ferric oxalate in cyanotype blue printing.
viii)	Spectrophotometric determination of [Fe (III)] by using KSCN.
ix)	Synthesis of a polymer.
x)	Characterization of an organic/inorganic compound by UV-Vis and IR spectra.
xi)	Spectrophotometric determination of λ_{max} and concentration of $KMnO_4/K_2Cr_2O_7$.
xii)	pH metry/ potentiometry titration: strong acid – strong base.
xiii)	Preparation of potash alum from scrap aluminium.
xiv)	Synthesis of potassium trisoxalatochromate(III).
xv)	Determination of Cu by iodometric titration.

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Atkins, P.W., "Physical Chemistry", 8th Ed., Oxford University Press.	2006
2.	Turro, N.J., Ramamurthy, V. and Scaiano, J.C., "Modern Molecular Photochemistry of Organic Molecules", University Science Books.	2008
3.	Skoog, D.A., Holler, F.J. and Crouch, S.R., "Principles of Instrumental Analysis", 6th Ed., Thomson Brooks.	2006
4.	Huheey, J.E., Keiter, E.A., Keiter, R.L. and Medhi, O.K. "Inorganic Chemistry: Principles of Structure and Reactivity", 4th Ed., Pearson Education Asia.	2009
5.	Christian, G.D., "Analytical Chemistry", 6th Ed., John Wiley & Sons Inc.	2004
6.	Morrison, R.T., Boyd, R.N. and Bhattacharjee, S.K., "Organic Chemistry", 7th Ed., Pearson Education in South Asia.	2013
7.	Mallick, A., " Engineering Chemistry", Viva Books Pvt. Ltd.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electronics and Communication Engineering**

1. Subject Code: **ECN-102** Course Title: **Fundamentals of Electronics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weightage**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: ESC**

8. Pre-requisite**: Nil**

9. Objective: To impart knowledge of basic principles of electronics to UG students from other disciplines of engineering and science.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Review of properties of metals, dielectrics and semiconductors.	**1**
2.	**Diodes**: Working principle and characteristics and diode applications (rectification with capacitive filter and zener regulation).	**4**
3.	**BJT**: Operation and characteristics, brief overview of DC biasing, 're' model, Amplifier (CE, CB and CC).	**6**
4.	**MOSFET**: Introduction to MOSFET operation and characteristics.	**1**
5.	**Operational Amplifiers**: Input modes and parameters, introduction to concept of negative feedback, negative feedback in OPAMP, bias currents and offsets, open and closed loop responses.	**5**
6.	**Op-Amp A pplications**: Comparator, summing, integrator, differentiator, instrumentation amplifiers, isolation amplifiers, Operational Transconductance Amplifiers, Log and Antilog amplifiers, Converters, Introduction to OPAMP based active filters, Brief description of OPAMP based oscillators.	**8**
7.	**Basic D igital E lectronics**: Binary number system, Boolean algebra, Logic gates, adders, one-bit memory, flip-flops (SR, JK), shift registers, Asynchronous counter.	**8**
8.	**Introduction t o microprocessor**: Four-bit microprocessor architecture, stored program computer, instruction set and basic assembly language programming.	**9**
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Boylstead R.L., Nashelsky L., "Electronic Devices and Circuit Theory", Pearson, 10th Edition.	2009
2.	Floyd T.L., Buchla D.L., "Electronics Fundamentals: Circuits, Devices and Applications", 8th Edition	2010
3.	Millman J., Halkias C.C., Jit S., "Electronic Devices and Circuits", Tata McGraw-Hill, 2nd Edition.	2007
4.	Dorf R.C., Smith R.J., "Circuits, Devices and Systems: A First Course in Electrical Engineering", 5th Edition	1991

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EEN-112** Course Title: **Electrical Science**

2. Contact Hours: **L: 3** **T: 1** **P: 2/2**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**:** **CWS: 15** **PRS: 15** **MTE: 30** **ETE: 40** **PRE: 0**

5. Credits**: 4** 6. Semester**: Both** 7. Subject Area**: ESC**

8. Pre-requisite**: NIL**

9. Objective: To introduce the students to the fundamentals of Electrical Engineering concepts of network analysis, principles of electrical machines, basics of electrical measurement and measuring instruments.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Energy Resources an d U tilization:** Conventional and non-conventional energy resources; Introduction to electrical energy generation from different resources, transmission, distribution and utilization.	**5**
2.	**Network F undamentals**: Types of Sources and elements, Kirchoff's Laws, Mesh and Node Analysis of D.C. Networks, Network Theorems: Thevenin's Theorem, Norton's Theorem, Superposition Theorem, Maximum Power Theorem, Star-Delta Transformation.	**5**
3.	**A.C. F undamentals**: Concept of phasor, impedance and admittance; Mesh and Node analysis of AC networks; Network theorems in AC networks; Active and reactive power in AC circuits; Resonance in series AC circuits; Power factor correction.	**4**
4.	**Three-phase A.C . Circuits**: Analysis of 3-phase balanced start-delta circuits, Power in 3-phase Circuits.	**2**
5.	**Measurement of E lectrical Qu antities**: Measurement of Voltage, Current, and Power; Measurement of 3 phase power; Energy meters.	**5**
6.	**Single P hase T ransformer**: Introduction to magnetic circuit concepts, Basic constructional features, operating principle, phasor diagram, equivalent circuit, voltage regulation; Eddy current and Hysteresis losses, efficiency; Open circuit and Short Circuit tests.	**5**

7.	**D.C. Machines**: Principle of operation, constructional features; Emf and torque equations; Types of excitation; Generator characteristics; Starting and speed control of D.C. motors.	**5**
8.	**AC Machines**: Three-phase Induction Motor - Operating principle, constructional features, torque-speed characteristics, starting and speed control; Single-phase Induction Motor - Operating principle, constructional features, torque-speed characteristics, starting methods.	**5**
9.	**Industrial A pplications an d C ontrol: V** arious industrial loads, traction, heating, lighting; Concept of power electronic control of AC and DC motors.	**6**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Mukhopadhyaya P., Pant A.K., Kumar V. and Chittore D.S., "Elements of Electrical Science", M/s Nem Chand & Brothers.	1997
2.	Vincent Del Toro, "Electrical Engineering Fundamentals", Prentice Hall of India.	2002
3.	Dubey G. K., "Fundamentals of Electric Drives", 2nd Ed., Narosa Publishing House.	2007
4.	Alexander C.K., Sadiku M.N.O., "Fundamentals of Electric Circuits", McGraw Hill, 5th Edition.	2012
5.	Chapman, Stephen, J., "Electric Machinery Fundamentals", McGraw Hill Book Company.	1985
6.	Hughes Edward, "Electrical & Electronic Technology", Pearson Publishing, 8th edition.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-108** Course Title: **Mechanical Engineering Drawing**

2. Contact Hours: L**: 2** T: **0** P**: 4**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weightage: **CWS: 0** **PRS: 25** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits: **4** 6. Semester: **Both** 7. Subject Area: **DCC/ESC**

8. Pre-requisite: **Nil**

9. Objective: The course objective is to teach the basic concepts of Mechanical Engineering Drawing to the students. The emphasis is on to improve their power of imagination.

10. Details of Course:

S. No.	Contents	Contact Hours
1	General Instructions : Sheet Layout, Line Symbols and Groups, Preferred Scales, Technical Sketching	**1**
2	Types of projections: Reference Planes and Quadrants, Orthographic Projection	**2**
3	Projection of point and lines	**3**
4	Projection of plane figures	**2**
5	Projection of solids	**2**
6	Section of solid and development	**2**
7	Shape Description(External): Multiplanar Representation, Systems of Projection, Sketching of Orthographic Views from Pictorial Views, Conventional Practices, Precedence of Views , Precedence of Lines	**2**
8	Uniplaner Representation: Sketching of Pictorial Views (Isometric and Oblique) from Multiplaner Orthographic Views	**2**
9	Shape Description (Internal): Sectioning as an Aid to Understanding internal features, Principles of Sectioning, Types of Sections, Section Lines, Cutting Plane Lines and Conventional Practices	**3**
10	Size Description: Dimensioning, Tools of Dimensioning, Size and Position Dimensions, Unidirectional and Aligned Systems, Principle and Practices of Dimensioning,	**4**
11	Conventional Representation: Representation and	**1**

	Identification of Common Machine Elements and Features	
12	Introduction to Solid Modeling	**4**
	Total	**28**

Practical Exercises:

Topics	**Practice Classes of Two Hour Duration**
Projection of points and lines	04
Projection of plane figures	02
Projection of solids	03
Section and development	02
Sketching of Orthographic Views from Pictorial Views	04
Sketching of Pictorial Views (Isometric and Oblique) from Multiplanar Orthographic Views, Missing Lines Exercise, Missing Views Exercise	04
Sectioning Exercise	02
Dimensioning exercise	02
Identification Exercise	01
Solid Modeling, orthographic views from solid models	04

11. Suggested Books:

S.No.	**Name of Authors / Books / Publishers**	**Year of Publication/ Reprint**
1.	Technical Drawing, Giesecke, Mitchell, Spencer, Hill, Dygdon and Novak, Macmillan Publishing Company	2003
2.	Engineering Graphics, A. M. Chandra and Satish Chandra, Narosa Publishing House, New Delhi	2003
3.	Engineering Drawing and Graphics Technology, T.E. French, C.J. Vierck and R.J. Foster, McGraw-Hill Inc	1993
4.	Fundamentals of Engineering Drawing, W.J. Luzadder, J. Warren and J.M. Duff, Prentice Hall International Editions	1989
5.	SP 46:1988 Engineering Drawing Practice for Schools and Colleges, Bureau of Indian standards	-------

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. Subject Code: MTN-305 **Course Title**: Materials Testing Lab

2. Contact Hours: L: 0; T: 0; P: 3

3. Examination Duration (Hrs): **Theory:** 0 0 **Practical**: 0 3

4. Relative Weightage: **CWS:** 0 0 **PRS:** 5 0 **MTE:** 0 0 **ETE:** 0 0 **PRE:** 5 0

5. Credits: 0 2 **6 Semester:** Autumn

7. Pre-requisite: Nil **8. Subject Area:** DCC

9. Objective: To impart knowledge on the mechanical and non-destructive testing of materials

10. List of Practicals:

1. To determine the hardness of nonferrous metallic samples by Brinell hardness tester
2. To determine the hardness of given metallic sample by Vickers hardness tester
3. To determine the hardness of given metallic sample by Rockwell hardness tester
4. To determine the tensile properties of given steel, brass and aluminium samples
5. To determine the impact strength of low, medium, high carbon steels by Izod and Charpy methods (Room temperature and subzero)
6. To study the deep drawability of given metallic sheet samples by Erichsen Cupping test
7. To carry out indentation creep test
8. To perform fatigue test on mild steel sample
9. To study dynamic mechanical behavior of polymers
10. To detect flaws in materials by liquid penetrant technique
11. To detect flaws in materials by ultrasonic flaw detection technique
12. To detect flaws in steel by magnetic particle inspection

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MTN-307 **Course Title**: Materials Characterization
2. Contact Hours: L: 3 ; T: 0; P: 2

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 0

4. Relative Weightage: **CWS:** 1 5 **PRS:** 2 5 **MTE:** 2 0 **ETE:** 4 0 **PRE:** 0 0

5. Credits: 0 4 **6 Semester:** Autumn

7. Pre-requisite: None **8. Subject Area:** DCC

9. O bjective: To familiarize with fundamentals of various materials characterization techniques.

10 Details of the Course:

Sl. No.	Contents	Contact Hours
1	**Light microscopy:** Introduction, concept of resolution, Airy rings, numerical aperture, magnification, 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, crystal geometry, lattice directions and planes, zone axis, interplaner spacing and angle, Stereographic projection, Bragg's condition of diffraction, X-ray scattering, application of X-ray diffraction – phase identification, estimation of grain size, particle size, residual stress.	8
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.	8
4	**Scanning electron microscopy (SEM):** Principle, construction and operation of SEM, study of fractured surfaces, energy and wavelength dispersive spectroscopy.	7
5	**Thermal an alysis t echniques:** Principles of differential scanning calorimetry (DSC), differential thermal analysis (DTA), Dilatometry, Thermogravimetric analysis (TGA).	7
6	**Additional techniques:** emission spectroscopy, Atomic Absorption Spectroscopy, Inductively Coupled Plasma - Mass Spectroscopy (ICP-MS), Vibrating Sample Magnometer (VSM), SQUID, four probe resistivity measurement.	6
	Total	**42**

List of Practicals

1. Calculation of structure factor of different crystal structures.
2. Determination of cubic crystal structure using powder XRD.
3. Determination of hexagonal crystal structure using powder XRD.
4. Determination of phases in multiphase powder sample using XRD.
5. Precise lattice parameter determination using XRD.
6. Estimation of crystallite size using Scherrer formula.
7. Chemical analysis using energy dispersive X-ray analysis in SEM (spot and line analysis).
8. To demonstrate the TEM sample preparation and TEM analysis.
9. Indexing of selected area diffraction patterns.
10. DSC/DTA analysis.
11. Dilatometry analysis
12. Four probe resistivity measurement.
13. B-H loop measurement.

11. Suggested Books:

S.No.	Name of Author/Book/ 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	Brown, M.E., "Introduction to Thermal Analysis: Techniques and Applications", Springer.	2013
5	Speyer, R., "Thermal Analysis of Materials", 1st ed., CRC Press.	1993

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. Subject Code: MTN-391 **Course Title**: Technical Communication

2. Contact Hours: L: 3; T: 0; P: 0

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 0

4. Relative Weightage: **CWS:** 2 5 **PRS:** 0 0 **MTE:** 2 5 **ETE:** 5 0 **PRE:** 0 0

5. Credits: 0 2 **6 Semester:** Autumn

7. Pre-requisite: Nil **8. Subject Area:** DCC

9. Objective: To impart skills of comprehension and analysis of technical literature, and technical report writing.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Selection of a technical topic of interest	9
2.	Collection of literature (few technical papers) related to the selected topic	12
3.	Review and analysis of papers and preparation of a comprehensive write-up on the topic	12
4.	Preparation of oral presentation using slide design and seminar presentation	9
	Total	**42**

11.Suggested Books:

Sl. No.	Authors/Name of Books/ Publisher	Year of Publications/ Reprint
1	Lannon, J.M., Gurak, L.J., "Technical Communication", 13th Ed., Longman	2013
2	Markel, M., Technical Communication, 10th Ed., Bedford/St. Martin's	2012
3	Anderson, P.V., "Technical Communication", 7th Ed., Cengage Learning	2010
4	Pfeiffer, W.S. , Adkins, K.E., "Technical Communication: A Practical Approach", 8th Ed., Longman	2012
5	Johnson-Sheehan,R.,"Technical Communication Today", 4th Ed., Longman	2011

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MTN-544 **Course Title**: Physical Metallurgy of Light Metals and Alloys

2. Contact Hours: L: 3 ; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 0

4. Relative Weightage: **CWS:** 2 5 **PRS:** 0 0 **MTE:** 2 5 **ETE:** 5 0 **PRE:** 0 0

5. Credits: 0 4 **6. Semester:** Spring

7. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective: To provide the fundamentals of processing-structure-property relationships among commonly used light metals and their alloys

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction**: Definition of light metals, cast and wrought alloys, characteristics of light metals and alloys, trends in applications	2
2	**Physical metallurgy of aluminum alloys:** Work hardening and annealing, forming limit curves, textures, principles of age hardening, microalloying effects, hardening mechanisms, aging processes, mechanical behavior, corrosion behavior	8
3	**Wrought aluminum alloys:** Designation and tempers, heat treatable and non-heat treatable alloys, Li containing alloys, joining, special products- aircraft alloys, automotive alloys, packaging alloys, electrical conductor alloys	7
4	**Cast aluminum alloys:** Designations, tempers and characteristics, alloys based on Al-Si, Al-Cu, Al-Mg, Al-Zn-Mg systems, modification in Al-Si alloys, joining	7
5	**Magnesium alloys:** Introduction to alloying behavior, alloy designations, Zr-free and Zr-containing alloys, wrought magnesium alloys, extrusion alloys, forging alloys, trends in applications of Mg alloys, electrochemical aspects	8
6	**Titanium alloys:** Introduction and classification, basic principles of heat treatment, alpha alloys, α/β alloys, beta alloys, wrought and cast commercial titanium alloys, texture effects, surface treatments, engineering performance- tensile, creep, and fatigue behaviour, applications- general applications, aerospace, power generation, automotive, marine, biomaterials	7
7	**Novel Materials:** Light metal matrix composites, metallic foams, nanophase alloys	3

	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Polmear I.J., Light Alloys, 4th Ed., Elsevier	2004
2	Brandes E.A. and Brook G.B., Smithells Light Metals Handbook, Elsevier	1998
3	Totten G.E. and Mackenzie D.S., Handbook of Aluminum Vol. 1: Physical Metallurgy and Processes, CRC Press	2003
4	Friedrich H.E., Mordike B.L. and Friedrich H., Magnesium Technology, 1st Ed., Springer	2004
5	Ber L.B., Kolobnev N. and Kablov E.N., Heat Treatment of Aluminum Alloys: Advances in Metallic Alloys, CRC Press	2010
6	Lütjering G., Williams J.C., Titanium, 2nd edition, Springer	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MTN-554 **Course Title**: Crystallographic Texture

2. Contact Hours: L: 3 ; T: 1; P: 0

3. Examination Duration (Hrs): Theory: 0 | 3 **Practical**: 0 | 0

4. Relative Weightage: CWS: 2 | 5 **PRS:** 0 | 0 **MTE:** 2 | 5 **ETE:** 5 | 0 **PRE:** 0 | 0

5. Credits: 0 | 4 **6. Semester:** Spring

7. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective: To impart knowledge on crystallographic texture and the evolution of texture during different material processing techniques

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction**: Crystallographic texture- preferred orientation of crystals in a polycrystalline material, effect on different properties of material	4
2	**Representation of texture:** Introduction to stereographic projection pole figure, inverse pole figure, Euler angles, {hkl}<uvw>, orientation distribution function (ODF), grain boundary characteristics	10
3	**Measurement of t exture:** X-ray diffraction technique, electron backscattered diffraction (EBSD)	4
4	**Origin and evolution of texture:** During processing of material by solidification, deformation, annealing, phase transformation, coating processes, thin film deposition	10
5	**Effect of texture:** Mechanical, electrical and magnetic properties	6
6	**Case st udies:** Sheet metal forming of Al, electrical steels, superplastic forming, crack propagation study, recent publications	8
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Randle V., Engler O., Texture Analysis: Macrotexture, Microtexture and Orientation Mapping, Gordon & Breach	2000
2	Bunge H.-J., Texture Analysis in Materials Science, London-Butterworths	1982
3	Cullity B.D., Stock S.R., Elements of X-Ray Diffraction, 3rd Ed., Prentice Hall	2001
4	Kocks U.F., Tomé C., Wenk H.-R., Texture and Anisotropy, Cambridge University Press	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE : **Metallurgical and Materials Engineering**

1. Subject Code:**MTN-501** Course Title: **Structure of Materials**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs): **Theory:3** **Practical:0**

4. Relative Weightage**:** **CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE:0**

5. Credits:**4** 6. Semester: **Autumn** 7. Pre-requisite: **Nil**

8. Subject Area: **PCC**

9. Objective: To provide knowledge of structure property correlations of different materials.

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	**Nature of Geometry of Crystals:** Atomic arrangements in solids, space lattices, coordination number and effective number of atoms for common crystalline structures: FCC, BCC and HCP, indexing of crystallographic planes and directions.	4
2.	**Structure of Ceramics and Polymers:** Atomic arrangements in ceramics and polymers, their influence on mechanical properties.	3
3.	**Principles of Alloy Formation:** Primary and intermediate phases their formation, solid solutions, Hume Rothery rules, electron compounds, normal valency compounds and interstitial compounds.	4
4.	**Solidification:** Solidification of metals and alloys- equiaxed, dendritic and columnar grains; Coring.	3
5.	**Phase Diagrams:** Binary equilibrium diagrams involving isomorphous, eutectic, peritectic and monotectic systems, phase rule, lever rule effect of non-equilibrium cooling on structure and distribution of phases.	8
6.	**Solid State Transformations:** Phase equilibria involving eutectoid and peritectoid transformations, TTT and CCT diagrams, harenability,Heat Treatment of Ferrous and Non Ferrous Alloys viz., annealing, normalizing, quenching, tempering and precipitation hardening.	8
7.	**Diffusion in Solids:** Fick's laws of diffusion, Darken's equation, Kirkendall effect and mechanism of diffusion.	4
8.	**Important Binary Systems:** Cu-Ni, Al-Si, Al-Cu, Pb-Sn, Cu-Zn, Cu-Sn and Fe-C systems, effect of non equilibrium cooling and important alloys belonging to these systems.	8
	Total	**42**

11. Suggested Books:

Sl. N	Name of Authors/ Book/ Publisher	Year of Publicatio Reprint
1.	Avner, S.H., “Introduction to Physical Metallurgy”, McGraw Hill	2005
2.	Lakhtin, Y., “Engineering Physical Metallurgy”, Mir Publishers	1992
3.	Hansen, P., “Physical Metallurgy”, Cambridge University Press	1987
4.	Gulyaev, A., “Physical Metallurgy”, Vol. I and II, Mir Publishers	1980

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Metallurgical and Materials Engineering

1. Subject Code: MTN-503 **Course Title**: Characterization of Materials

2. Contact Hours: L: 3 T: 0 P: 2

3. Examination Duration (Hrs): **Theory:** 3 **Practical**: 0

4. Relative Weightage: **CWS:** 15 **PRS:** 15 **MTE:** 30 **ETE:** 40 **PRE:** 0

5. Credits: 4 **6. Semester:** Autumn

7. Pre-requisite: Nil

9. Objective: To familiarise the students with the basic principles related to materials characterization methods.

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	**X-ray Diffraction and Diffractometry:** Stereographic projection, Laue's equation, Bragg's condition of diffraction, structure factor rules, single phase analysis, multi-phase analysis, estimation of particle size and strain, orientation and texture, residual stress.	10
2.	**Light Microscopy:** Basic principles, estimation of grain size, grain boundary area, volume fraction of second phase.	5
3.	**Transmission Electron Microscopy (TEM):** Reciprocal space and lattice, Ewald sphere, diffraction from finite crystal, bright and dark field imaging, selected area diffraction, indexing of diffraction patterns, contrast from precipitates, dislocations, and stacking faults.	10
4.	**Scanning Electron Microscopy (SEM):** Basic principles of scanning electron microscopy, energy dispersive spectroscopy (EDS), wavelength dispersive spectroscopy (WDS), electron backscattered diffraction (EBSD).	6
5.	**Thermal analyses techniques:** Principles of differential scanning calorimetry (DSC), differential thermal analysis (DTA), Dilatometry, Thermogravimetric analysis (TGA).	6
6.	**Instrumental Analysis:** Emission spectroscopy, AAS, ICP-MS.	5
	Total	**42**

List of Practicals:

1. Sample preparation for optical microscopy: estimation of grain size and volume fraction of second phases in brass.
2. Demonstration of X-ray diffraction equipment.
3. Indexing of the powder pattern obtained by XRD.
4. Demonstration of Transmission Electron Microscope.
5. Indexing of the Selected Area Diffraction (SAD) patterns.
6. Demonstration of Scanning Electron Microscope and EDS.
7. Demonstration of DSC technique.

11. Suggested Books

Sl. No.	Name of Authors/ Book/ Publisher	Year of Publication/ Reprint
1.	Goodhew, P.J., Humphreys, J. and Beanland, R., "Electron Microscopy and Analysis", 3rd Edition, Taylor and Francis	2001
2.	Cullity, B.D. and Stock, S.R., "Elements of X-Ray Diffraction", 3rd Edition, Printice Hall	2001
3.	Williams, D. B. and Carter, C. B., "Transmission Electron Microscopy: A Textbook for Materials Science", 2nd Edition, Springer	2009
4.	Goldstein, J., Newbury, D.E., Joy, D.C., Lyman, C.E., Echlin, P., Lifshin, E., Sawyer, L. and Michael, J.R., "Scanning Electron Microscopy and X-ray Microanalysis", 3rd Edition, Springer	2003
5.	Speyer, R., "Thermal Analysis of Materials", CRC Press	1993
6.	Dehoff, R.T. and Rhines, F.N., "Quantitaive Microscopy", McGraw Hill	1968

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE : Metallurgical and Materials Engineering

1. **Subject Code**: MTN-502 **Course Title**: Modeling, Simulation, and Computer Applications

2. Contact Hours: L: 3 T: 0 P: 2

3. Examination Duration (Hrs): **Theory:** 3 **Practical**: 0

4. Relative Weightage: **CWS:** 15 **PRS:** 15 **MTE:** 30 **ETE:** 40 **PRE:** 0

5. Credits: 4 **6. Semester:** Spring

7. Pre-requisite: NIL **8. Subject Area:** PCC

9. Objective : To impart knowledge on modeling with emphasis on metallurgical systems.

10. **Details of Course**:

Sl. No.	Contents	Contact Hours
1.	**Introduction :** System, environment, input and output variables; State variables and their transition; Hierarchy of knowledge about a system; System identification – structure and parameter identification; Deterministic and stochastic systems; Static and Dynamic Systems; Objectives of modelling and simulation	4
2.	**Physical M odelling:** Dimension analysis, Dimensionless grouping of input and output variables to find empirical relations, similarity criteria and their application to physical models.	5
3.	**Modelling of Sys tems w ith K nown Structure:** Review of conservation laws and the governing equation for heat, mass and momentum transfer, Deterministic models – (a) distributed parameter models in terms of partial differential equations and their solutions and (b) lumped parameter models in terms of differential and difference equations, state space models, transfer functions, block diagrams and subsystems, stability of transfer functions, modelling for control, Stochastic models	10
4.	**Neural N etwork M odelling of Sys tems on ly with I nput-output Database:** Neurons, architecture of neural network, knowledge representation, learning algorithm, Multilayer feed forward network and its back propagation learning algorithm, Application to metallurgical systems.	6
5.	**Fuzzy l ogic modelling of s ystems on ly w ith b road e xpert knowledge:** Fuzzy sets, membership functions, fuzzy linguistic variables, 'IF-THEN' rules, Fuzzy Inference systems (FIS) – (i) Mamdani type and (ii) Sugeno (TSK) type, Application to metallurgical systems.	5
6.	**Neuro-fuzzy M odelling of Systems w ith L imited D atabase:**	4

	Adaptive neuro-fuzzy inference system (ANFIS), hybrid learning algorithm using MATLAB; Co-active neuro-fuzzy system (CANFIS)	
7.	**Optimization and Design of Systems:** Summary of gradient based techniques; Nontraditional optimization techniques – (i) Genetic Algorithm (GA) – coding, GA operators, elitism, application using MATLAB; (ii) Simulated Annealing	4
8.	**Simulation of M etallurgical S ystems:** Monte-Carlo simulation, simulation of solidification and casting, simulation of melt stream disintegration by fluid flow	4
	Total	**42**

List of Practicals:

1. Introduction to programming with MATLAB
2. Find the response of a lumped variable model expressed in terms of transfer function using MATLAB for inputs of (i) unit step function, (ii) unit impact function and (iii) unit ramp function
3. Use of Simulink in MATLAB for metallurgical problems
4. Use of Neural Network in MATLAB for metallurgical problems
5. Use of FIS and ANFIS in MATLAB for metallurgical problems
6. Develop a computer program to determine the temperature of ingot during its solidification.
7. Develop a computer program to determine the temperature of metal slab during its hot rolling.
8. Develop a computer program for Monte Carlo simulation for grain growth.

11. Suggested Books:

Sl. No.	Name of Authors/ Book/ Publisher	Year of Publication/ Reprint
1.	Zeigler, B.P., Praehofer, H. and Kim T.G., "Theory of Modelling and Simulation", 2nd Edition, Academic Press	2000
2.	Szekely, J.S. and Ray, W.H., "Process optimization with applications metallurgy and chemical engineering", Wiley-Interscience	1973
3.	Ogata, K., "Modern Control Engineering", 3rd Edition, Prentice Hall of India	2001
4.	Jang, J.S.R., Sun C.T. and Mizutani E., "Neuro-Fuzzy and Soft Computing", 3rd Edition, Prentice Hall of India	2002
5.	Kuang-O,Y., "Modeling for casting and solidification processing", Marcel Dekker	2002
6.	Irving, W.R., "Continuous casting of steel", Institute of Materials	1993
7.	Pratab, R., "Getting Started with MATLAB", Oxford University Press	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MTN-504 **Course Title**: Phase Transformation

2. Contact Hours: L: 3 ; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 0

4. Relative Weightage: **CWS:** 2 5 **PRS:** 0 0 **MTE:** 2 5 **ETE:** 5 0 **PRE:** 0 0

5. Credits: 0 4 **6. Semester:** Spring

7. Pre-requisite: Nil **8. Subject Area:** PCC

9. Objective

To introduce the fundamentals of phase transformations in metal and alloys.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	**Introduction :** Types and classification of phase transformations, thermodynamic basis of phase transformation, introduction to concept of Gibbs free energy, entropy and enthalpy	2
2	**Thermodynamics an d phase di agram:** Equilibrium in a closed system, effect of temperature and composition, order of transformation, fluctuations, stable unstable and metastable state, single component systems, binary solutions and binary phase diagrams	5
3	**Structural d efects:** Surface free energy, interfaces in solids; boundaries in single phase solids, coherent, semicoherent and incoherent interfaces and interface migration	5
4	**Empirical t ransformations k inetics:** Atomic mechanism of diffusion, rate of atomic processes, empirical rate equation, determination of activation energy	5
5	**Liquid s olid t ransformation:** Introduction, nucleation, rate of nucleation, growth, eutectic solidification, crystallization, cellular and dendritic solidification	9
6	**Diffusional t ransformations in solids:** Polymorphic transformations, massive transformations, order-disorder transformations, recrystallisation, precipitation, pearlitic reaction, cellular transformation, particle coarsening	9
7	**Spinodal decompositions:** Points of inflexion, solubility differences	2
8	**Martensitic transformations:** Thermodynamic of martensitic transformation, phenomenological theory of martensite crystallography (PTMC), effect of composition and temperature	5
	Total	**42**

11. Suggested Books:

Sl. No.	Authors/Name of Books/ Publisher	Year of Publications
1	Porter D.A. and Easterling K.E., Phase Transformations in Metals and Alloys, II edition, Taylor and Francis	2004
2	Jena A.K. and Chaturvedi M.C., Phase Transformations in Materials, Prentice Hall	1992
3	Burke J., The Kinetics of Phase Transformations in Metals, Pergamon Press	1996
4	Phase Transformation in Materials, Editor G. Kostoz, Wiley-VCH Verlag	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MTN-505 **Course Title**: Non Destructive Testing

2. Contact Hours: L: 3 ; T: 1; P: 0

3. Examination Duration (Hrs): Theory: 0 3 **Practical**: 0 0

4. Relative Weightage: CWS: 2 5 **PRS**: 0 0 **MTE**: 2 5 **ETE:** 5 0 **PRE:** 0 0

5. Credits: 0 4 **6 Semester**: Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective: To impart the importance of non-destructive testing in assuring quality control in engineering components.

10. Details of the Course:

Sl.No.	Contents	Contact Hours
1	**Introduction:** Non destructive testing and its comparison with destructive testing, role of NDT in quality control.	5
2	**Liquid penetrant inspection:** its principles, equipment, advantages, limitations and applications.	6
3	**Magnetic particle inspection:** its principles, equipment, advantages, limitations and applications.	6
4	**Ultrasonic inspection:** its principles, equipment, advantages, limitations and applications.	6
5	**Eddy current inspection:** its principles, equipment, advantages, limitations and applications.	6
6	**X-ray radiography:** its principles, equipment, advantages, limitations and applications.	5
7	**Quality control:** Statistical quality control, control charts, control chart attribute and variables and acceptance sampling; Quality assurance and ISO 9000:2000	8
	Total	**42**

11. Suggested Books:

S.No.	Name of Author/Book/ Publisher	Year of Publication/ Reprint
1	"Non Destructive Evaluation and Quality Control". Metals Handbook, Vol. 17, 9th Ed., ASM.	1989
2	Srivastava, K.C., "Handbook of Magnetic Particle Testing", Oscar Publications.	1998
3	Srivastava, K.C., "Handbook of Liquid Penetrant Testing", Oscar Publications.	1997
4	Grant, E.L. and Larenwork, R.S., "Statistical Quality Control", Tata McGraw-Hill.	2000
5	Hull, B., "Non Destructive Testing", Springer.	2012

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MTN-512 **Course Title**: Joining of Materials

2. Contact Hours: L: 3 ; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 0

4. Relative Weightage: **CWS:** 2 5 **PRS:** 0 0 **MTE:** 2 5 **ETE:** 5 0 **PRE:** 0 0

5. Credits: 0 4 **6. Semester:** Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective:

To impart the knowledge of joining different metallic and non-metallic materials

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction:** Arc welding, electrical resistance welding, solid state welding, welding consumables, brazing and soldering, mechanical joining, adhesive joining	6
2	**Thermal and mechanical effects of joining**: Isotherm and thermal cycle, fusion and solidification, heat affected zone, microstructure, fastening, riveting, clinching, distortion and residual stresses in different joints	7
3	**Joining of ferrous and non ferrous metals**: Plain carbon structural steels, high strength low alloy steels, alloy steels, cast iron, stainless steels, aluminium alloys, copper alloys, titanium alloys, nickel alloys, characterization, defects and remedial measures	10
5	**Joining of non metallic materials**: Structural polymers, structural ceramics, composites, defects and remedial measures	5
6	**Joining of dissimilar m aterials**: Structural steel-stainless steel, aluminium-copper, metal-polymer, metal-ceramic, microstructure, defects and remedial measures	6
7	**Quality assessment of joint**: Inspection, mechanical testing, non-destructive testing, standards and codes for joint testing and qualification of joints	8
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publications/ Reprint
1	Larry J., Welding Principles and Applications, 4th Ed., Delmar Publishers	1999
2	Cornu J., Advanced Welding Systems: Consumable Electrode Processes, IFS Publications	1988
3	Koichi M., Analysis of Welded Structures, Pergamon Press.	1980
4	DeGarmo P.E., Black J.T. and Kohser R.A., Materials and Processes in Manufacturing, 8th Ed., Prentice-Hall India	2000
5	Parmer R.S., Welding Engineering and Technology, Khanna Publishers	1997
6	Mittal K.L. and Pizzi A., Adhesion Promotion Techniques, Marcel Dekker	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MTN-518 **Course Title**: Theory of Metal Forming

2. Contact Hours: L: 3 ; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 0

4. Relative Weightage: **CWS:** 2 5 **PRS:** 0 0 **MTE:** 2 5 **ETE:** 5 0 **PRE:** 0 0

5. Credits: 0 4 **6. Semester:** Autumn/Spring

7. Pre-requisite: MT-501 **8. Subject Area:** PEC

9. Objective

To inculcate the ability to calculate load for forming and stress-strain values for a particular metal forming processes

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	**Stress tensor and yield criteria:** Single crystal versus polycrystal, state of stress, representing stress as tensor, principal stresses, stress deviator, yield criteria, comparison of yield criteria, octahedral shear stress and shear strain	8
2	**Fundamentals of metal forming:** Classification of forming processes, mechanics of metal working, flow stress determination, effect of temperature, strain rate and metallurgical structure on metal working, friction and lubrication; Deformation zone geometry, workability, residual stresses, strain rate sensitivity, superplasticity	10
3	**Forging and rolling:** Classification, calculation of forging loads, forging defects- causes and remedies, residual stresses in forging; Rolling- Classification of rolling processes, forces and geometrical relationship in rolling, analysis of rolling load, torque and power, rolling defects	8
4	**Extrusion and drawing:** Direct and indirect extrusion, variables affecting extrusion, deformation pattern, simple analysis of extrusion	8
5	**Sheet metal forming and other processes:** Forming methods - shearing, blanking, bending, stretch forming, deep drawing defects in formed part, sheet metal formability, formability limit diagram	8
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Dieter G.E., Mechanical Metallurgy, McGraw-Hill	1995
2	Avitzur A., Metal Forming - Processes and Analysis, Tata McGraw-Hill	1977
3	Juneja B.L., Fundamentals of Metal Forming Processes, New Age International	2010
4	Taylor A., Soo-Oh I.K. and Gegel H.L., Metal Forming: Fundamentals and Applications, ASM	1983
5	Rowe G.W., Sturgess C.E., Hartley P. and Pillinger I., Finite-Element Plasticity and Metal Forming Analysis, Cambridge University Press	1991

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MTN-522 **Course Title**: Composite Materials

2. Contact Hours: L: 3 ; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 0

4. Relative Weightage: **CWS:** 2 5 **PRS:** 0 0 **MTE:** 2 5 **ETE:** 5 0 **PRE:** 0 0

5. Credits: 0 4 **6. Semester:** Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective

To provide an in-depth knowledge on the constituents that make-up a composite materials and its various applications

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction:** Definition, classification, distribution and topology of constituents and interfacial bonding of matrix and reinforcing components	4
2	**Composite m aterials:** Metal matrix composites, polymer matrix composites and ceramic matrix composites	5
3	**Performance an alysis of c omposites:** Combination effects-summation, complementation and interaction; Quantitative analysis-black box approach and analytical approach - thermoelasticity, plasticity and creep; Composites models- Law of mixtures, shear lag model, laminated plate model and Eshelby's model, others models	6
4	**Strengthening of c omposites:** Strengthening of matrix, role of matrix in continuous fibre composite, stress distribution in fibre and matrix, critical length of fibre for full strengthening, analysis of uniaxial tensile stress-strain curve of unidirectional continuous and short fibre composite, estimation of minimum and critical amount of fibre to gain a composite strength, analysis of strength during angular loading fibre composite, particle strengthening of matrix	6
5	**Fabrication:** Selection of components, wetting of components, chemical reactivity of components, incorporation of reinforcing components in matrix; Metal matrix, polymer matrix and ceramic matrix composites, in-situ composites and inorganic nano filler polymer composites	8
6	**Fracture an d s afety of com posites:** Griffith theory of brittle fracture and modification for structural materials, basic fracture mechanics of composite- fracture toughness, COD and J-integral approaches, fatigue crack growth rate; Fracture mechanics of brittle	6

	matrix fibre composite, fracture mechanics of metal matrix fibre composite, experimental evaluation- fibre composite; Elementary reliability analysis	
7	**Joining o f c omposites:** Welding, brazing, adhesive joining, weld bonding and mechanical fastening	4
8	**Application o f C omposite M aterials:** Civil constructions of structures/pannels, aerospace industries, automobile and other surface transport industries, packaging industries, house hold and sports components	3
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Chawla K.K., Composite Materials, 2nd editions, Springer-Verlag	1987
2	Chawla K.K., Ceramic Matrix Composites, 1st edition, Chapman & Hall	1993
3	Piatti G., Advances in Composite Materials, Applied Science Publishers	1978
4	Shojiro O., Mechanical Properties of Metallic Composites, Marcel Dekker	2002
5	Hull D. and Clyne T.W., An Introduction to Composite Materials, 2nd edition, Cambridge Solid State Science Series	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. **Subject Code**: MTN-514 **Course Title**: Powder Metallurgy

2. Contact Hours: L: 3 ; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:** 0 | 3 **Practical**: 0 | 0

4. Relative Weightage: **CWS:** 2 | 5 **PRS:** 0 | 0 **MTE:** 2 | 5 **ETE:** 5 | 0 **PRE:** 0 | 0

5. Credits: 0 | 4 **6 Semesters:** Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective:
To introduce the concepts of powder metallurgy with special reference to recent development of powder metallurgy products

10. **Details of Course**:

Sl. No.	Contents	Contact Hours
1	**Introduction:** Scope, limitations in making components, application of powder metallurgy	3
2	**Powder pr oduction:** Production methods like physical, chemical, mechanical methods; Single fluid atomization like rotating electrode atomization, roller atomization, rotating disc atomization; Two fluid atomization like gas atomization, water atomization, oil atomization etc. Reduction methods, carbonyl process, hydride-dehydride process, electrolytic method	8
3	**Powder ch aracterization:** Particle size and Size distribution using sieving, sedimentation method, Andreasen pipette method, size distribution functions like normal distribution, log-normal distribution, Rosin-Rammler distribution, particle shape, shape factors, specific surface area of powder, flow rate, tap density, apparent density, compressibility, pyrophoricity, explosivity, toxicity of powder	8
4	**Powder compaction:** Slip casting, slurry casting, Die compaction, isostatic pressing, single level and multi level part compaction, repressing, plane strain compression, powder forging, powder roll compaction, powder extrusion	8
5	**Sintering:** Theory of sintering, sintering practice, furnaces and atmosphere control, activated sintering techniques, after sintering treatments; industrial sintering practice for various and non-ferrous products	6
6	**Application of powder metallurgy:** Self-lubricating bearing, magnetic materials, tungsten carbide tool bits, bearing materials, dispersion	5

	strengthen materials for high temperature applications and manufacture of diamond based cutting tools	
7	**Development of friction material through P/M route**: Clutch plate, and break pads for airplanes	4
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Books/Authors/Publisher	Year of Publication/ Reprint
1	Masuda H., Powder Technology Handbook, Taylor & Francis	2006
2	German R.M., A to Z of Powder Metallurgy, Elsevier	2005
3	Sands R.L. and Shakespeare C.R., Powder Metallurgy Practice and Applications, Newness Publication	1970
4	Powder Metal Technologies and Applications, Metals Handbook, Vol. 7, 9^{th} edition, ASM	1989
5	Hirschhorn J.S., Introduction to Powder Metallurgy, APMI	1975
6	Upadhyaya G.S., Powder Metallurgy Technology, Cambridge Press	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MTN-516 **Course Title**: Principles of Materials Selection

2. Contact Hours: L: 3 ; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 0

4. Relative Weightage: **CWS:** 2 5 **PRS:** 0 0 **MTE:** 2 5 **ETE:** 5 0 **PRE:** 0 0

5. Credits: 0 4 **6. Semesters:** Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective:

To introduce the salient materials selection criteria for various engineering applications

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction :** Selection criteria, service requirement, design fabricability, functionability, structure-property relationship reappraisal of the role of microstructure; Crystal structure and defect structure vis-à-vis properties; Materials and their applications, compositions, codes and properties	6
2	**Ferrous materials:** Applications of important ferrous materials like stainless steels, maraging steels, tool and die steels, high speed steels, and alloyed cast irons: their composition, heat treatment and properties	8
3	**Non-ferrous materials:** Applications of important non ferrous metals like Cu base, Al base, Ti base and Mg base alloys- their compositions, heat treatment, and properties	5
4	**Composites:** Some important composites like metal-matrix and composite, ceramic matrix composites- their composition, preparation, properties and their applications, some important structural ceramics	6
5	**Polymers:** Thermoplastic, thermo-setting polymers and elastomers, structures, properties and specific applications	6
6	**Wear and corrosion resistant materials:** Important wear resistant alloys for hydro and thermal power stations, low and high temperature materials	7
7	**Case studies:** Case studies highlighting selection of materials for specific applications	4
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Books/Authors/Publisher	Year of Publication/ Reprint
1	Raghavan V., Physical Metallurgy: Principles and Practice, 2nd edition, Prentice-Hall of India	2007
2	Callister W.D. Jr., Material Science and Engineering –An Introduction, 5th edition, John Wiley and Sons	2000
3	Askland R., The Science and Engineering of Materials, 2nd Edition, PWS-KENT Publishing	1989
4	Raghavan V., Materials Science and Engineering: A First Course, 5th edition, Prentice-Hall of India	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MTN-526 **Course Title**: Failure Analysis

2. Contact Hours: L: 3 ; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 0

4. Relative Weightage: **CWS:** 2 5 **PRS:** 0 0 **MTE:** 2 5 **ETE:** 5 0 **PRE:** 0 0

5. Credits: 0 4 **6 Semester:** Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective

To impart knowledge on the analysis of the probability of failure under various service conditions and methods to ensure safety

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Sources of f ailure:** Material problems including chemical composition, microstructure, faulty selection, faulty heat treatment, corrosion susceptibility and defects; Mechanical irregularities including faulty design, mismatch and notch effects; Wrong welding fabrication and abnormal service conditions	4
2	**Failure an alysis**: First hand documentation, planning of steps of analysis, collection of back ground data and samples, selection, cleaning and preservation of fracture surface	4
3	**Failure an alysis m ethodology:** Use of advanced instruments, macroscopic and microscopic examinations of fracture surface, selective application of non-destructive testing, mechanical testing and stress analysis, metallographic examination and analysis; Bulk and micro chemical analysis	12
4	**Fracture:** Mechanisms and models of fracture, ductile flat-face and shear-face tensile fractures, brittle inter-granular and trans-granular fractures, embrittlement failure- Strain-age, quench-age, temper, hydrogen, sigma-phase and neutron embrittlement and blue brittleness; Factors influencing different types of fracture	6
5	**Fracture mechanics (FM):** Applications of FM under static and dynamic loading, application of NDT for defect assessment and monitoring, analysis of failure mechanism, safety and residual life estimation	6
6	**Failure m echanism:** Fatigue, corrosion, stress corrosion cracking and elevated or cryogenic temperature failure**-** Metallurgical and	6

	mechanical factors affecting these failures, loading condition and stages of fracture, macroscopic and microscopic salient features of failure	
7	**Result an alysis an d r eporting**: Correlations of observations and evidences, documentation, logical conclusions and remedial measures	4
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Shipley R.J. and Becker W.T., Failure Analysis and Prevention, ASM handbook, Vol. 11, ASM International	2002
2	Colangelo V.J. and Heiser F.A., Analysis of Metallurgical Failure, 2nd edition, Wiley-Interscience	1987
3	Powell G.W. and Mahmoud S.E., Failure Analysis and Prevention, Metals Handbook, Vol. 11, 9th edition, ASM International	1986
4	Cooper T.D., Prevention of structural failure-the role of quantitative nondestructive evaluation, ASM International	1975
5	Sachs N.W., Practical Plant Failure Analysis: A guide to understanding machinery deterioration and improving equipment reliability, Dekker Mechanical Engineering, CRC press	2006
6	Gulati R. and Smith R., Maintenance and Reliability Best Practices, Industrial Press	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MTN-528 **Course Title**: Tribology of Engineering Materials

2. Contact Hours: L: 3 ; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 0

4. Relative Weightage: **CWS**: 2 5 **PRS**: 0 0 **MTE**: 2 5 **ETE:** 5 0 **PRE:** 0 0

5. Credits: 0 4 **6 Semester:** Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective:

The impart knowledge on friction and methods to minimize wear of engineering components

10. Details of Course:

S. No	Contents	Contact Hours
1	**Surface properties and surfaces in contact:** Nature of metallic surface, surface geometry, measurement of surface topography, quantifying surface roughness, contact between surfaces; Friction, the laws of friction, measurement of friction, origin of friction, theories of friction adhesion- theory, extension of the adhesion theory	8
2	**Wear:** Types of wear, adhesive wear, Archard's law, abrasive wear, erosion wear, factors affecting corrosive wear, wear map, various wear testing methods- pin on disc, pin on drum, slurry wear, air jet and water jet erosion as per ASTM standards	12
3	**Tribological p roperties of s olid m aterials:** Hardness, strength, ductility and work hardening rate, effect of crystal structure, effect of microstructure, mutual solubility of rubbing pairs and effect of temperature	11
4	**Surface t reatments t o reduce w ear:** Surface treatments with or without change of composition, surface coating- welding, flame, spraying, plasma spraying, electroplating and electroless coating, chemical vapour deposition (CVD) and physical vapour deposition (PVD), super hard coatings	11
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Hutchings I.M., Tribology – Friction and wear of engineering Materials, Edward Arnold	1992
2	Arnold R.D., Davies P.B., Halling J. and Whomes T.L., Tribology – Principles and Design Applications, Springer Verlag	1991
3	Bhushan B., Introduction to Tribology, John Wiley	2002
4	Bhushan B., Principles and Applications of Tribology, John Wiley	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MTN-532 **Course Title**: Corrosion Protection Methods

2. Contact Hours: L: 3 ; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 0

4. Relative Weightage: **CWS:** 2 5 **PRS:** 0 0 **MTE:** 2 5 **ETE:** 5 0 **PRE:** 0 0

5. Credits: 0 4 **6. Semester:** Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective:

To impart knowledge on the principles related to protection of materials against corrosion

10. Details of Course:

Sl. No.	Contents	Contact Hours
1.	**Introduction:** Importance and economics of corrosion, principles of corrosion	4
2	**Forms of c orrosion:** Classification of different forms of corrosion- general corrosion, selective corrosion including pitting corrosion, crevice corrosion, intergranular corrosion, filiform corrosion, stress corrosion cracking, corrosion fatigue, fretting corrosion, cavitation corrosion, dezincification, dealuminization, graphitization, erosion-corrosion	8
3	**Principle b ehind p rotection of materials agai nst cor rosion:** Protection against corrosion by modifying physical, chemical and/or mechanical aspects of materials- coating, alloying, heat treatment	8
4	**Protection b y modifying the en vironmental p arameters:** Concentration, pH, temperature, velocity, oxidizing agents, suspended particles, use of inhibitors	9
5	**Protection against corrosion by modification of external circuit:** By anodic and cathodic protection, problems encountered, study of mechanisms involved, some case studies	9
6	**Systematic ap proach f or p rotection:** protection with respect to various corrosive environments under different parametric conditions	4
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Fontana M.G., Corrosion Engineering, 3rd Ed., McGraw Hill	2005
2	Plendek R.V., Design and Corrosion Control, The Macmillan Press	1977
3	Annual book of ASTM standards, ASTM	1978
4	Roberge P.R., Handbook of Corrosion Engineering, McGraw Hill	2000
5	Revie W.R. and Uhlig H.H., Corrosion and Corrosion Control, 4th Ed., Willey	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. **Subject Code**: MTN-511 **Course Title**: Thin Film Technology

2. Contact Hours: L: 3; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:** 0 | 3 **Practical**: 0 | 0

4. Relative Weightage: **CWS:** 2 | 5 **PRS:** 0 | 0 **MTE:** 2 | 5 **ETE:** 5 | 0 **PRE:** 0 | 0

5. Credits: 0 | 4 **6 Semester:** Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective

To impart knowledge on the processing and characterization of thin films for device applications

10. **Details of the Course**:

Sl. No.	Contents	Contact Hours
1	**Introduction**: Applications of thin films, process steps.	2
2	**Gas k inetics**: Maxwell-Boltzmann distribution, molecular impingement flux, Knudsen equation, mean free path, transport properties.	6
3	**Evaporation**: thermodynamics of evaporation, evaporation rate, alloys, compounds, sources, deposition monitoring techniques.	5
4	**Deposition**: adsorption, surface diffusion, nucleation, structure development, interfaces, stress, adhesion.	6
5	**Epitaxy**: symmetry, applications, disruption, growth monitoring, composition control, lattice mismatch, surface morphology.	6
6	**Chemical Vapor Deposition**: Gas supply and convection, reaction equilibrium and surface processes, diffusion limited deposition and reactor models.	6
7	**Film A nalysis**: structure-thickness, topography, inhomogeneity, crystallography, bonding, point defects, composition, and optical, electrical and mechanical behavior of thin films.	6
8	**Applications:** Technology of polysilicon thin-film transistors, thin film transistors in active-matrix liquid crystal displays, organic based thin film transistors, vacuum deposited organic thin film transistos based on small molecules	5
	Total	**42**

11. Suggested Books:

Sl. No.	Authors/Name of Books/ Publisher	Year of Publications/ Reprint
1	Ohring, M., "Materials Science of Thin Films", 2nd Ed., Academic Press.	2001
2	Smith D.L., "Thin-Film Deposition: Principles and Practice", McGraw-Hill Professional.	1995
3	Kagan, C.R., Andry, P., "Thin Film Transistors", Marcel Dekker.	2003
4	Eishabini-Riad, A., Barlow, F. D., "Thin Film Technology Handbook", 1st Ed., McGraw-Hill Professional.	1997
5	Siddal, G. (Ed.), "Thin Films Science and Technology", Elsevier.	1984

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. Subject Code: MTN-531 **Course Title**: Electronic Materials

2. Contact Hours: L: 3; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 0

4. Relative Weightage: **CWS:** 2 5 **PRS:** 0 0 **MTE:** 2 5 **ETE:** 5 0 **PRE:** 0 0

5. Credits: 0 4 **6 Semester:** Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective

To introduce fundamental principles of electronic materials, their properties and applications.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	**Electrical and thermal conduction:** Kinetic molecular theory of matter and its application to conduction, Drude Model of electrical conduction, temperature dependence of resistivity, Matthiessen's rule, Nordheim's rule, resistivity of mixtures, Hall effect, thermal and electrical conduction, electrical conductivity of semiconductors and ionic crystals,	9
2	**Modern theory of solids:** Hydrogen molecule, band theory of solids, semiconductors, density of states in an energy band, Boltzmann statistics, Fermi-Dirac statistics, Quantum theory of metals, Fermi energy significance, Contact potential, Seebeck effect, thermionic emission, field emission, Brillouin zones and origin of band gap, conductors, semiconductors and insulators	9
3	**Semiconductors:** Intrinsic and extrinsic semiconductors, temperature dependence of conductivity, Direct and indirect semiconductors, recombination and minority carrier injection, optical absorption, peizorestivity, Schottky junction, Ohmic contacts and thermo-eleciric coolers	9
4	**Dielectric materials**: Polarization and relative permittivity, electronic polarization, polarization mechanisms, dielectric constant and dielectric loss, dielectric breakdown, capacitor dielectric materials, piezoelectricity, ferroelectricity and pyroelectricity	7
5	**Magnetic properties:** Magnetization of matter, magnetic materials classification – diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism, ferrimagnetism, origin of ferromagnetism and exchange interaction, saturation magnetization, Curie temperature, magnetic domains, soft and hard magnetic materials; Superconductivity, Meissner effect, Josephson's effect,	8

	superconducting solenoids, AMR and GMR and their applications	
	Total	**42**

11. Suggested Books:

Sl. No.	Authors/Name of Books/ Publisher	Year of Publications
1	Kasap S.O., Principles of Electronic Materials and Devices, 3rd Ed., McGraw-Hill	2009
2	Hummel R.E., Electronic Properties of Materials, 4th Ed., Springer	2011
3	Streetman B. and Bannerjee S., Solid State Electronic Devices, 6th Ed., Printice Hall	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. **Subject Code**: MTN-517 **Course Title**: High Temperature Materials

2. Contact Hours: L: 3; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:** 0 | 3 **Practical**: 0 | 0

4. Relative Weightage: **CWS:** 2 | 5 **PRS:** 0 | 0 **MTE:** 2 | 5 **ETE:** 5 | 0 **PRE:** 0 | 0

5. Credits: 0 | 4 **6 Semester:** Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective

To impart knowledge on requirements for materials for high temperature use and the behavior of materials at high temperatures.

10. **Details of the Course**:

Sl. No.	Contents	Contact Hours
1	**Introduction:** Need for high temperature materials, historical development of high temperature materials, equipment for material testing at high temperatures, requirements of high temperature materials (mechanical properties and preferred microstructure, environmental resistance, erosion and wear).	5
2	**Principles for high temperature strengthening:** Metallic materials (solid solution strengthening, precipitation strengthening, dispersion strengthening grain size and grain boundary effects) Ceramic materials (phase control, defect tolerance, thermal shock resistance) composite materials.	7
3	**Creep and stress rupture:** Creep test, stress rupture test, structural changes during creep, mechanism of creep deformation, fracture at elevated temperatures.	6
4	**Creep:** fatigue interaction: Modes of high temperature fracture and fatigue fracture, creep-fatigue interaction (creep accelerated by fatigue), fatigue-creep interaction (fatigue accelerated by creep), micro-mechanism of damage, fracture criterion for creep fatigue, creep-fatigue failure mapping, creep-fatigue testing, influence of environment.	7
5	**Materials f or h igh t emperature:** Metals / alloys, superalloys, steels, titanium and its alloys, ceramics (Alumina, Zirconia, Silicon carbide, Silicon nitride, Glass ceramics) composites (Metal matrix composites, ceramic matrix composites) carbon – carbon composites.	7

6	**Coatings for protection against high temperature corrosion and erosion:** Corrosion / oxidation resistant coatings (metallic, ceramic, rare and reactive metal reinforced coatings), high temperature erosion and wear, thermal barrier coats.	6
7	**Case st udies:** Applications in industry, aerospace, defense and nuclear industry.	4
	Total	**42**

11. Suggested Books:

Sl. No.	Authors/Name of Books/ Publisher	Year of Publications/ Reprint
1	Meetham, G. W., Van de Voorde, M. H., "Materials for High Temperature Engineering Applications (Engineering Materials)", 1st Ed., Springer.	2000
2	Chan R. W., "High temperature structural materials", Chapman & Hall.	1996
3	Reed R. C., "The Super-alloys: Fundamentals and Applications", Cambridge University Press.	2008
4	Birks, N., Meier, G. H., and Pettit, F. S., "Introduction to the High Temperature Oxidation of Metals", Cambridge University Press.	2009
5	Bose, S., "High Temperature Coatings" , Butterworth-Heinemann.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MTN-542 **Course Title**: Biomaterials

2. Contact Hours: L: 3 ; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 0

4. Relative Weightage: **CWS:** 2 5 **PRS:** 0 0 **MTE:** 2 5 **ETE:** 5 0 **PRE:** 0 0

5. Credits: 0 4 **6. Semester:** Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective

To impart knowledge on structure-property relationship in biomaterials and their applications as implants

10. Details of Course:

S. No	Contents	Contact Hours
1	**Introduction:** Historical background, construction materials, impact of biomaterials, strength of biological tissues, performance of implants, tissue response to implants, interfacial phenomena, safety and efficacy testing	4
2	**Metallic and Ceramic materials:** Stainless steels, Co-Cr alloys, Ti-based alloys, Nitinol, biological tolerance of implant metals, ceramic implant materials, alumina, yittria stabilized zirconia, hydroxyapatite glass ceramics carbons, restorable ceramics, composites	6
3	**Polymeric implant materials:** Polymers in biomedical use, polyethylene, polypropylene, acrylic polymer, hydrogels, polyurethans, polyamides, biogradable synthetic polymers, silicon rubber, micro-organisms in polymeric implants, polymer sterilization	6
4	**Dental Materials:** Tooth composition and mechanical properties, impression materials, bones, liners, and varnishes for cavities, filling and restorative materials, oral implants, use of collagen in dentistry	4
5	**Cardiovascular and Orthopedic implants:** Artificial heart, aorta and valves, geometry of circulation, vascular implants, cardiac pace makers, bone composition and properties, fracture healing, joint replacement, knee joint repair, bone regeneration with restorable materials	6
6	**Tissue Engineering Materials and Regeneration**: Substrate scaffolds materials, cellular aspects, viability, stem cells, bladder regeneration, cartilage regeneration, skin regeneration, regeneration in cardiovascular system	6
7	**Tissue response to implants:** Normal wound healing process, body response to implants, blood compatibility, carcinogenicity	3

8	**Degradation of Materials in the biological environment:** Chemical and biochemical degradation of polymers, degradation effects on metals and ceramics, pathological classification of biomaterials	4
9	**Case studies:** Selection and design of biomaterials, implant and device failures	3
	Total	**42**

10. Suggested Books:

S. No.	Name of Authors/Books/Publisher	Year of Publication/ Reprint
1	Park J.B. and Bronzino J.D., Biomaterials: Principals and Applications, CRC Press	2003
2	Park J.B., Biomaterials Science and Engineering, Springer Press	1984
3	Rattner B.D., Hoffman A.S, Schoen F.J., Lemons J.E., Biomaterials Science: An Introduction to Materials in Medicine, Academic Press	2004
4	Park J.B. and Lakes R.S., Biomaterials: An Introduction, 3rd edition, Springer press	2007
5	Bhat, S.V., Biomaterials, 2nd edition, Narosa Publishing	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MTN-530 **Course Title**: Nanomaterials and Applications

2. Contact Hours: L: 3 T: 1 P: 0

3. Examination Duration (Hrs): **Theory:** 3 **Practical**: 0

4. Relative Weightage: **CWS:** 25 **PRS:** 00 **MTE:** 25 **ETE:** 50 **PRE:** 00

5. Credits: 04 **6. Semester:** Autumn/Spring

7. Pre-requisite: MTN-501 **8. Subject Area:** PEC

9. Objective

To impart knowledge on the synthesis and properties of nanostructured materials and their importance as advanced materials

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Nanomaterials:** Introduction, Classification: 0D, 1D, 2D, 3D nanomaterials and nano-composites, their mechanical, electrical, optical, magnetic properties; Nanomaterials versus bulk materials	5
2	**Thermodynamics and kinetics of nanostructured materials:** Size and interface/interphase effects, interfacial thermodynamics, phase diagrams, diffusivity, grain growth, and thermal stability of nanomaterials	8
3	**Processing:** Bottom-up and top-down approaches for the synthesis of nanomaterials, mechanical alloying, chemical routes, severe plastic deformation, and electrical wire explosion technique	8
4	**Structural characteristics**: Principles of emerging nanoscale X-ray techniques such as small angle X-ray scattering and X-ray absorption fine structure (XAFS), electron and neutron diffraction techniques and their application to nanomaterials; Grain size, phase formation, texture, stress analysis	8
5	**Deformation B ehavior:** Elastic and plastic deformation, mechanisms of plastic deformation- lattice dislocation motion, evolution of grain boundary defect structures, comparison between deformation mechanisms and effect of grain size distribution, grain boundary sliding and triple junction migration, triple junction diffusion, abnormal Hall-Petch effect dependence, localization of plastic flow and rotational plastic deformation in nanostructured materials. Nanoindentation techniques- principles and measurement of elastic and plastic properties of nanomaterials	9
6	**Case st udies:** Design issues and applications of nanomaterials in	4

	various industries	
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Poole C.P, and Owens F.J., Introduction to Nanotechnology, John Wiley	2003
2	Nalwa H.S., Encyclopedia of Nanoscience and Nanotechnology, American Scientific Publishers	2004
3	Koch C.C., Nanostructured Materials: Processing, Properties and Applications, William Andrew	2006
4	Zehetbauer M.J. and Zhu Y.T., Bulk Nanostructured Materials, Wiley	2008
5	Wang Z.L., Characterization of Nanophase Materials, Wiley	2000
6	Gutkin Y., Ovid'ko I.A. and Gutkin M., Plastic Deformation in Nanocrystalline Materials, Springer	2004
7	Fischer A.C., Nanoindentation, Springer	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MTN-558 **Course Title**: Energy Storage Materials

2. Contact Hours: L: 3 ; T: 1; P: 0

3. Examination Duration (Hrs): Theory: 0 3 **Practical**: 0 0

4. Relative Weightage: CWS: 2 5 **PRS:** 0 0 **MTE:** 2 5 **ETE:** 5 0 **PRE:** 0 0

5. Credits: 0 4 **6. Semester:** Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective

To impart knowledge on different types of energy storage materials, their functions and applications

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Introduction**: Basics of solid state chemistry, defect structure of solids, surface and interface analysis	6
2	**Materials for energy storage:** Fuel cells, different types, materials used, mechanism of operation, applications; Solar cells – introduction on photovoltaics, materials used, principle of operation, applications; Storage batteries – battery technology, assembly, electrochemical tests; Supercapacitors – theory, high power super capacitor from carbon nanotubes; Hydrogen storage materials – mechanism of hydrogen storage	12
3	**Material Analysis:** Thermal, structural and morphological analysis of the energy storage materials, different experimental techniques used	6
4	**Rechargable lithium ion battery:** Intercalation compounds, anodes and composite anodes, cathode materials, polymeric electrolyte, currents trends of lithium ion batteries for consumer applications	8
5	**Nanoscale materials:** Nano crystalline materials, nanocomposites, nanotubes, energy storage capacity of the nanostructured materials	6
6.	**Magnetocaloric materials**: Different types of materials, application of the magnetocaloric effect	4
	Total	**42**

11. Suggested Books:

Sl. No.	Name of Authors/ Books/ Publisher	Year of Publication/ Reprint
1	Nazri G.A., Pistoia G., Lithium Batteries: Science and Technology, Kluwer Academic Publishers	2004
2	Kumta P.K., Supercapacitors: Fundamentals, Systems, Applications, Emerging trends, Wiley-VCH Verlag	2009
3	Markvart T. and Castaner L., Solar cells: Materials, Manufacture and Application, Elsevier	2003
4	Walker G., Solid State Hydrogen Storage: Materials and Chemistry, Woodhead Publishing	2008
5.	Tishin A.M. and Spichkin, Y.I., The Magnetocaloric Effect and its Applications, IOP publishing	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MTN-513 **Course Title**: Engineering Ceramics

2. Contact Hours: L: 3 ; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 0

4. Relative Weightage: CWS: 2 5 **PRS:** 0 0 **MTE:** 2 5 **ETE:** 5 0 **PRE:** 0 0

5. Credits: 0 4 **6. Semesters:** Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** PEC

9. Objective:
To impart knowledge on ceramic materials, their properties, processing and engineering applications.

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	Introductory overview: General characteristics of ceramics, ceramic microstructures, ceramic crystal structures.	3
2	Ceramic powder preparation and characterization: Powder synthesis by mechanical methods and chemical methods; Powder characterization: (1) Physical characterization relating particle shape, size, size distribution, surface area, porosity; (2) chemical characterization relating to chemical compositions, phase composition	7
3	Colloidal Processing: Types of colloids; Electrostatic stabilization: charges on particles in a liquid, origins of electrical double layer, repulsion between two double layers; Polymeric stabilization: Steric stabilization, stability and sterically stabilized suspensions; Rheology of colloidal suspensions: rheological properties, viscosity of colloidal suspensions; Industrial application of colloidal methods.	6
4	Powder consolidation and shape forming processes: Dry and semidry pressing methods: die compaction, isostatic pressing; Casting methods: slip casting, pressure casting, tape casting; Additives in forming process, plastic forming methods: extrusion and injection moulding.	6
5	Sintering of ceramics: Defects and defect chemistry; Solid state sintering, atomic mechanisms, coarsening, densification, sintering kinetics: sintering stages, coarsening and grain growth kinetics; Liquid phase sintering: introduction, the different stages, controlling kinetics	8

	and thermodynamic factors; Problems of sintering.	
6	Ceramic phase diagrams: Binary systems: complete solid solubility, eutectic diagrams with partials solid solubility and no intermediate compounds, partial solid solubility with formation of intermediate compounds; Ternary systems.	4
7	Mechanical behavior of ceramics: Theory of brittle fracture; cracking; strength variability; properties: Hardness, compressive strength, flexural strength, elastic modulus, fracture toughness; toughening mechanisms.	4
8	Glasses : Glass formation : kinetics and criteria for glass formation; glass structure; glass properties: glass transition temperature, thermodynamic considerations; Glass-ceramics: processing, properties and industrial applications.	4
	Total	42

11. Suggested Books:

S. No.	Name of Authors /Books/ Publisher	Year of Publication/ Reprint
1.	Barsoum M. W., Fundamentals of Ceramics, The McGraw-Hill Companies, Inc.	1997
2.	Kingery W.D., Bowen H.K. and Uhlmann D.R., Introduction to Ceramics, 2nd Ed., John Wiley	1991
3.	Richerson, D.W., "Modern Ceramic Engineering – Properties, Processing and use in Design", Marcel Dekker, Inc.	1992
4.	Rahaman, M. N., "Ceramic Processing and Sintering", Marcel Dekker Inc.	1995

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. **Subject Code**: MTN-523 **Course Title**: Casting and solidification

2. Contact Hours: L: 3; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 0

4. Relative Weightage: **CWS:** 2 5 **PRS:** 0 0 **MTE:** 2 5 **ETE:** 5 0 **PRE:** 0 0

5. Credits: 0 4 **6 Semester:** Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** DEC

9. Objective

To understand fundamentals of metal casting & solidification related to the foundry industry and quality control of the cast product.

10. **Details of the Course**:

Sl. No.	Contents	Contact Hours
1	**Introduction:** Metal casting as a manufacturing process, Foundry industry in India, Challenges for foundry industry in India, Important industrial sectors using casting.	2
2	**Moulding Processes, Equipments and Mechanization:** Different types of Moulds, Moulding Materials and Moulding processes, Pattern and other mould making equipments, forces acting on moulds, Mould factors in metal flow, Moulding factors in casting design. ; Different types of binders and their use in mould and core-making.	6
3	**Melting of Metals and Alloys for casting:** Brief mention of various melting units, melting and post melting treatments, melting practices as adopted for a few metals and alloys such as Al, Cu, steel, cast irons.	7
4	**Solidification of Metals and Alloys:** Nucleation, Growth, Role of alloy constitution, Thermal conditions and inherent nucleation and growth conditions in the liquid melt, Significance and practical control of cast structure.	9
5	**Principles of Gating and Risering:** Feeding characteristics of alloys, Types of Gates and Risers, Time of solidification and Chowrinov rule, Wlodawer system for feeder head Calculations, Gating ratio, Concept of directionality in solidification, Yield of casting and prescription for its augmentation.	7
6	**Special casting Methods:** Investment casting, Die casting, Centrifugal casting, Full mould casting, Vacuum sealed casting.	6
7	**Casting Defects & quality control:** A detailed analysis of casting defects, Their causes and Prescription of remedial measures.	5
	Total	**42**

11. Suggested Books:

Sl. No.	Authors/Name of Books/ Publisher	Year of Publications/ Reprint
1	P. R. Beeley, Foundry Technology, Newnes-Buttterworths.	2001
2	P. L. Jain, Principles of Foundry Technology, Tata McGraw-Hill Edu.	2003
3	T. V. Ramana Rao, Metal Casting, principles and practice, New Age International (P) Ltd.	2003
4	P. D. Webster, Fundamentals of Foundry Technology, Portwillis press, Red Hill.	1980
5	P. C. Mukherjee, Fundamentals of Metal casting Technology, Oxford IBH.	1980
6	R. W. Hein, C.R. Loper and P.C. Rosenthal, Principles of Metal casting, Mc Graw Hill.	1976

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. Subject Code: MT-103 **Course Title**: Electrical and Electronic Materials

2. Contact Hours: L: 3; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 0

4. Relative Weightage: **CWS:** 2 5 **PRS:** 0 0 **MTE:** 2 5 **ETE:** 5 0 **PRE:** 0 0

5. Credits: 0 4 **6 Semester:** Autumn

7. Pre-requisite: Nil **8. Subject Area:** ESC

9. O bjective: To familiarise the students with fundamentals of electrical and electronic materials.

10. **Details of the Course**:

Sl.No.	Contents	Contact Hours
1	**Introduction to crystallography** Bonding in Solids- Ionic, 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	8
2	**Principles of alloy formation** Solid solution, Types of solid solutions: interstitial and substitutional, Hume-Rothery rules, Binary phase diagrams: Gibbs phase rule, lever rule, cooling curves, Invariant reactions, Types of Binary phase diagrams: Isomorphous and Eutectic systems, Pb-Sn system	4
3	**Electrical and Thermal Conduction in Solids:** Kinetic molecular theory of matter and its application to conduction, temperature dependence of resistivity of metals, Mathiessen's rule, resistivity of two-phase Ag-Ni alloy and electrical contacts, electrical conductivity of semi-conductors, ionic crystals and glasses, Drude model of electrical conduction, Quantum free electron theory, Brillouin zones, Band theory of conduction, conductors, semiconductors and insulators	9
4	**Semi-conductors:** Energy band and intrinsic semiconductors, electrons and holes, extrinsic semi-conductors, temperature dependence of conductivity, recombination and minority carrier injection, Direct and indirect semiconductors, diffusion and conduction equations, continuity equation, optical absorption, luminescence, Schottky junctions, Ohmic contacts and thermo-electric coolers	9

5	**Dielectric Materials and Insulation:** Matter polarization and relative permittivity, electronic polarization, polarization mechanisms, dielectric constant and dielectric loss, dielectric strength and insulation breakdown, capacitor dielectric materials, piezoelectricity, ferro electricity and pyro electricity;	6
6	**Magnetic Materials:** Magnetization of matter and classification of magnetic materials, origin of ferromagnetism and exchange interaction, saturation magnetization and curie temperature, magnetic domains in ferromagnetic materials, soft and hard magnetic materials, superconductors as a diamagnetic material and its applications	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books/ Publisher	Year of Publication/ Reprint
1	Callister W.D., "Materials Science and Engineering" Wiley India (P) Ltd. ISBN:978-81-265-21-43-2	2012
2	Kasap S. O., "Principles of Electronic Materials and Devices", 3rd Ed., Tata McGraw Hill. ISBN-10: 0073104647	2007
3	Askeland D.R., "The Science and Engineering of Materials, 5th edition, ISBN: 978-81-315-0321-8	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. Subject Code: MT-106 **Course Title**: Materials Science

2. Contact Hours: L: 3; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 0

4. Relative Weightage: **CWS:** 2 5 **PRS:** 0 0 **MTE:** 2 5 **ETE:** 5 0 **PRE:** 0 0

5. Credits: 0 4 **6 Semester:**

7. Pre-requisite: Nil **8. Subject Area:** ESC

9. Objective: To familiarize the students with fundamentals of materials science

10. Details of the Course:

Sl.No.	Contents	Contact Hours
1	**Introduction to crystallography** Bonding in Solids: Ionic, 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 (Engineering stress-strain curve: Y.S, U.T.S, work hardening, ductility, resilience and toughness, True stress-strain curve, Ductile and brittle fracture), 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: Hydrocabon and Polymer molecules, Molecular shape and structure, Molecular configuration, Thermoplastic and Thermosetting polymers	4
	Total	**42**

11. Suggested Books:

Sr. No.	Name of Authors /Books/ Publisher	Year of Publication/ Reprint
1	Callister W.D., "Materials Science and Engineering" Wiley India (P) Ltd. ISBN:978-81-265-21-43-2	2010
2	Raghavan V.,"Materials Science and Engineering- A first Course," 5th edition, ISBN:978-81-203-2455-8	2011
3	Askeland D.R., "The Science and Engineering of Materials, 5th edition, ISBN: 978-81-315-0321-8	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. Subject Code: MTN-101 **Course Title**: Introduction to Metallurgical and Materials Engineering

2. Contact Hours: L: 2; T: 0; P: 0

3. Examination Duration (Hrs): **Theory:** 0 | 2 **Practical**: 0 | 0

4. Relative Weightage: **CWS:** 1 | 5 **PRS:** 0 | 0 **MTE:** 3 | 5 **ETE:** 5 | 0 **PRE:** 0 | 0

5. Credits: **0 | 2** **6 Semester:** Autumn

7. Pre-requisite: Nil **8. Subject Area:** DCC

9. Objective

To explore the critical role of materials, including their evolution, limitations and future projections in various engineering applications, in order to stimulate interest in Materials Engineering.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	**History of Metals**: Metals in civilization, metallurgical industry and national development	4
2	**Metal Extraction:** Mineral resources in India, major extraction processes, recent developments in iron and steel making.	6
3	**Material Processing:** Solidification and casting, welding, rolling, forging, extrusion, wire drawing etc.	6
4	**Material Applications:** Load bearing and structural applications, materials for transportation, electronic and magnetic materials materials in energy sector and health care	6
5	**Material Degradation:** Corrosion, wear and erosion, irradiation damage, material recycling	6
	Total	**28**

11. Suggested Books:

Sl. No.	Authors/Name of Books/ Publisher	Year of Publications/ Reprint
1	Jones D.R.H., and Ashby M. F., Engineering Materials 1, An Introduction to Properties, Applications and Design, 4th Ed., Butterworth-Heinemann, ISBN-10: 0080966659	2011
2	Jones D.R.H., and Ashby M. F., Engineering Materials 2, An Introduction to Microstructures, Processing and Design, 3rd Ed., Butterworth-Heinemann, ISBN-10: 0750663812	2005

3	Martin J., Materials for Engineering, 2nd Ed., Woodhead Publishing	2002
4	Polmear I.J., Light Alloys, 3rd Ed., Edward Arnold	1995
5	Llewellyn D.T., Steels – Metallurgy and Applications, Butterworth	1992

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: **Department of Metallurgical and Materials Engineering**

1. Subject Code: **MTN-102** Course Title: **Metallurgical Thermodynamics and Kinetics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs): **Theory: 3** **Practical**: **0**

4. Relative Weightage: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits: **4** 6. Semester: **Autumn/Spring** 7. Subject Area: **DCC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the laws of thermodynamics and their applications to chemical equilibrium conditions.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	**Introduction:** Basic concept and definitions, concept of state, reversible and irreversible processes, path and state functions, extensive and intensive properties, thermodynamic equilibrium, zeroth law of thermodynamics	**4**
2	**Heat, work and Energy:** First Law of Thermodynamics: Internal energy, Enthalpy, Constant volume and pressure process; Isothermal and adiabatic process, Second Law of Thermodynamics, Entropy, Third law of thermodynamics.	**6**
3	**Thermodynamic functions:** Auxiliary functions, Maxwell's relations, Gibbs-Helmholtz equation,	**4**
4	**Thermodynamics of reactions:** Criterion for equilibrium. Enthalpy of reactions, Kirchhoff's law, Variation of Gibbs energy with temperature and pressure, Clausius-Clapeyron equation; Thermodynamic properties of mixtures of ideal and imperfect gasses; reaction in gas mixtures, reaction of pure condensed phases with gas mixture, Standard Gibbs energy of reactions.	**8**
5	**Theory and Models of Metallic Solutions:** Raoult's and Henry's law, activity of a component, Gibbs-Duhem equation, non-ideal solutions, regular solutions, fugacity, quasi-chemical model of solutions, activity and alternative standard state; Reaction equilibrium in condensed systems, Gibbs phase rule; Derivation of binary phase diagrams, ternary phase diagrams.	**8**
6	**Relation Between Chemical and Electrical Driving Forces:** Nernst equation, concentration and formation cells, Thermodynamics of point defects, Thermodynamics of surfaces.	**5**

7	**Metallurgical Kinetics:** Heterogeneous reaction; Gas-solid, solid-liquid, liquid-liquid and solid-solid systems. Empirical and Semi-empirical Kinetics, Concept of Johnson-Mehl equation, Thermal analysis.	**7**
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1	Dehoff R.T., Thermodynamics in Materials Science, 2nd Ed., CRC Press.	2006
2	Gaskell D.R., Introduction to Metallurgical Thermodynamics 3rd Ed., McGraw-Hill.	1995
3	Ghosh A., Textbook of Materials and Metallurgical Thermodynamics, Prentice Hall of India.	2003
4	Upadhyaya G.S. and Dube R.K., Problems in Metallurgical Thermodynamics and Kinetics, Pergamon Press.	1985
5	Balluffi R.W., Allen S.M. and Carter W.C., Kinetics of Materials, John Wiley and Sons.	2005
6	Poirier D.R. and Geiger G.H., Transport Phenomena in Materials Processing Minerals, Metals and Materials Society.	1994

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. Subject Code: MT-102 **Course Title**: Metallurgical Thermodynamics and Kinetics

2. Contact Hours: L: 3; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 0

4. Relative Weightage: **CWS:** 2 5 **PRS:** 0 0 **MTE:** 2 5 **ETE:** 5 0 **PRE:** 0 0

5. Credits: 0 4 **6 Semester:** Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** DCC

9. Objective

To introduce the laws of thermodynamics and their applications to chemical equilibrium conditions.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	**Introduction:** Basic concept and definitions, concept of state, reversible and irreversible processes, path and state functions, extensive and intensive properties, thermodynamic equilibrium, zeroth law of thermodynamics	4
2	**Heat, work and Energy:** First Law of Thermodynamics: Internal energy, Enthalpy, Constant volume and pressure process; Isothermal and adiabatic process, Second Law of Thermodynamics, Entropy, Third law of thermodynamics.	6
3	**Thermodynamic functions:** Auxiliary functions, Maxwell's relations, Gibbs-Helmholtz equation,	4
4	**Thermodynamics of reactions:** Criterion for equilibrium. Enthalpy of reactions, Kirchhoff's law, Variation of Gibbs energy with temperature and pressure, Clausius-Clapeyron equation; Thermodynamic properties of mixtures of ideal and imperfect gasses; reaction in gas mixtures, reaction of pure condensed phases with gas mixture, Standard Gibbs energy of reactions.	8
5	**Theory and Models of Metallic Solutions:** Raoult's and Henry's law, activity of a component, Gibbs-Duhem equation, non-ideal solutions, regular solutions, fugacity, quasi-chemical model of solutions, activity and alternative standard state; Reaction equilibrium in condensed systems, Gibbs phase rule; Derivation of binary phase diagrams, ternary phase diagrams.	8
6	**Relation Between Chemical and Electrical Driving Forces:** Nernst equation, concentration and formation cells, Thermodynamics of point defects, Thermodynamics of surfaces.	5

7	**Metallurgical K inetics:** Heterogeneous reaction; Gas-solid, solid-liquid, liquid-liquid and solid-solid systems. Empirical and Semi-empirical Kinetics, Concept of Johnson-Mehl equation, Thermal analysis.	7
	Total	**42**

11. Suggested Books

Sl. No.	Authors/Name of Books/ Publisher	Year of Publications/ Reprint
1	Dehoff R.T., Thermodynamics in Materials Science, 2nd Ed., CRC Press.	2006
2	Gaskell D.R., Introduction to Metallurgical Thermodynamics 3rd Ed., McGraw-Hill.	1995
3	Ghosh A., Textbook of Materials and Metallurgical Thermodynamics, Prentice Hall of India.	2003
4	Upadhyaya G.S. and Dube R.K., Problems in Metallurgical Thermodynamics and Kinetics, Pergamon Press.	1985
5	Balluffi R.W., Allen S.M. and Carter W.C., Kinetics of Materials, John Wiley and Sons.	2005
6	Poirier D.R. and Geiger G.H., Transport Phenomena in Materials Processing Minerals, Metals and Materials Society.	1994

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. Subject Code: MTN-103 **Course Title**: Computer Programming

2. Contact Hours: L: 3; T: 0; P: 2

3. Examination Duration (Hrs): **Theory:** 0 | 3 **Practical**: 0 | 0

4. Relative Weightage: **CWS:** 1 | 5 **PRS:** 1 | 5 **MTE:** 3 | 0 **ETE:** 4 | 0 **PRE:** 0 | 0

5. Credits: 0 | 4 **6 Semester:** Autumn

7. Pre-requisite: Nil **8. Subject Area:** **ESC**

9. Objective: To familiarise the students with fundamentals of computer programming using C++ and basics of data structure

10. Details of the Course:

Sl.No.	Contents	Contact Hours
1	**Introduction:** Computer architecture, operating system and programming language; conversion between binary, octal and hexadecimal numbers.	2
2	**Introduction to C++ programming:** the structure of a program files like including header, hash definitions, main and other functions like printf, scanf, cin, cout etc., function call, comments, compiling, linking and debugging a program. Good practices in programming in order to minimize bugs like appropriate tabs etc.	2
3	**Variables, operators a nd s tatements:** Data types, operators, type conversion, variables naming convention and definition, local, global and static variables, static variables defined in another program file, multidimensional arrays and pointers, expressions and lvalue, statement, null statement	2
4	**Decision making:** comparison operators, statement block, compound condition, if, else if, else, switch statements.	3
5	**Looping:** while, do while, for, break, comtinue, goto statements	3
6	**Functions:** function declaration, definition and call. Void function, inline function, function overloading, recursive function, default argument, variable argument, standard C++ library functions.	5
7	**Arrays, pointers and references:** pointers, defining and initializing array, array index, multidimensional array, accessing array elements using pointers. Reference and dereference operators, references, dynamic memory allocation, argument passing and return values using pointers and references in functions, arrays of pointers, pointer to array, pointer to pointer, pointer to function, string handling standard library functions.	6

8	**Object oriented programming using C++:** structure, class, object, access specifiers (public and private), constructor and initialization list, destructor, copy constructor, default constructor and destructor, friend function, static data members, static function members, pointer to objects, function overloading, operator overloading, composition and inheritance, access specifier (protected), overriding inherited members, virtual function and polymorphism, pure virtual function, virtual destructor, abstract classes, exception handling, templates, stream input/output and file processing	14
9	**Data structure and algorithms:** stack, linked list, searching and sorting algorithms	5
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books/ Publisher	Year of Publication/ Reprint
1	Hubbard J.R., Programming with C++, Tata McGraw Hill, ISBN: 9780071353465	2009
2	Stroustrup B., The C++ programming language, AT&T, ISBN-10: 0201700735	1997
3	Malik D.S., Data structure using C++, Cengage Learning, ISBN-13 9788131501061	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. **Subject Code**: MTN-103 **Course Title**: Electrical and Electronic Materials

2. Contact Hours: L: 3; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:** 0 | 3 **Practical**: 0 | 0

4. Relative Weightage: **CWS:** 2 | 5 **PRS:** 0 | 0 **MTE:** 2 | 5 **ETE:** 5 | 0 **PRE:** 0 | 0

5. Credits: 0 | 4 **6 Semester:** Autumn

7. Pre-requisite: Nil **8. Subject Area:** ESC

9. O bjective: To f amiliarise th e s tudents w ith f undamentals o f electrical an d el ectronic materials.

10. **Details of the Course**:

Sl.No.	Contents	Contact Hours
1	**Introduction to crystallography** Bonding in Solids- Ionic, 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	8
2	**Principles of alloy formation** Solid solution, Types of solid solutions: interstitial and substitutional, Hume-Rothery rules, Binary phase diagrams: Gibbs phase rule, lever rule, cooling curves, Invariant reactions, Types of Binary phase diagrams: Isomorphous and Eutectic systems, Pb-Sn system	4
3	**Electrical and Thermal Conduction in Solids:** Kinetic molecular theory of matter and its application to conduction, temperature dependence of resistivity of metals, Mathiessen's rule, resistivity of two-phase Ag-Ni alloy and electrical contacts, electrical conductivity of semi-conductors, ionic crystals and glasses, Drude model of electrical conduction, Quantum free electron theory, Brillouin zones, Band theory of conduction, conductors, semiconductors and insulators	9
4	**Semi-conductors:** Energy band and intrinsic semiconductors, electrons and holes, extrinsic semi-conductors, temperature dependence of conductivity, recombination and minority carrier injection, Direct and indirect semiconductors, diffusion and conduction equations, continuity equation, optical absorption, luminescence, Schottky junctions, Ohmic contacts and thermo-electric coolers	9

5	**Dielectric Materials and Insulation:** Matter polarization and relative permittivity, electronic polarization, polarization mechanisms, dielectric constant and dielectric loss, dielectric strength and insulation breakdown, capacitor dielectric materials, piezoelectricity, ferro electricity and pyro electricity;	6
6	**Magnetic Materials:** Magnetization of matter and classification of magnetic materials, origin of ferromagnetism and exchange interaction, saturation magnetization and curie temperature, magnetic domains in ferromagnetic materials, soft and hard magnetic materials, superconductors as a diamagnetic material and its applications	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books/ Publisher	Year of Publication/ Reprint
1	Callister W .D., "M aterials S cience and E ngineering" Wiley I ndia (P) Ltd. ISBN:978-81-265-21-43-2	2012
2	Kasap S. O., "Principles of Electronic Materials and Devices", 3rd Ed., Tata McGraw Hill. ISBN-10: 0073104647	2007
3	Askeland D .R., "The S cience an d E ngineering o f M aterials, 5 th edition, ISBN: 978-81-315-0321-8	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. Subject Code: MT-104 **Course Title**: Structural Metallurgy

2. Contact Hours: L: 3; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 0

4. Relative Weightage: **CWS:** 2 5 **PRS:** 0 0 **MTE:** 2 5 **ETE:** 5 0 **PRE:** 0 0

5. Credits: 0 4 **6 Semester:** Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** DCC

9. Objective

To impart knowledge on the arrangement of atoms in materials, defect structures and their characterization techniques

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	**Atomic structure of Solids**: Atomic Bonding; Crystal systems and space lattice; Crystal structure of metals; Indexing crystallographic planes and directions, stereographic projections; Diffraction methods, Bragg law	7
2	**Crystal imperfections:** Point defects – vacancies and self interstitial, substitutional and interstitial solid solution; Line defects – Burger's vector; Frank-Reed source, slip systems, climb and cross-slip, critical resolved shear stress, dislocation interactions; Surface defect – phase boundary, grain boundary, twin boundary, stacking faults, volume defect	7
3	**Diffusion**: Diffusion in ideal solution; Kirkendall effect; Darken's Equation; Fick's second law; Mantano method; Determination of intrinsic diffusivities; Temperature dependence of diffusion coefficient; Chemical diffusion; Grain boundary and surface diffusion	6
4	**Phase diagrams:** solubility limit, evolution of microstructure, Phase rule and lever rule. Unary, binary and ternary phase diagrams. Isomorphous, eutectic, eutectoid peritectic, monotectics, intermediate phases	6
5	**Microstructure**: nucleation and growth kinetics, Structural hierarchy; Solidification microstructure; Solid-solid transformation; Deformation microstructure; plain carbon steel	6
6	**Characterization techniques**: Imaging – Optical microscopy, scanning electron microscopy, transmission electron microscopy, scanning probe (STM, AFM); Structure – X-ray diffraction, Low energy electron diffraction (LEED); Composition – X-ray	10

	photoelectron spectroscopy (XPS), X-ray energy dispersive spectroscopy (EDS), Auger electron spectroscopy (AES), secondary ion mass spectroscopy (SIMS), Rutherford backscattering (RB); Thermal analysis	
	Total	**42**

11. Suggested Books:

Sl. No.	Authors/Name of Books/ Publisher	Year of Publications/ Reprint
1	Reed-Hill R.E., Physical Metallurgy, 2nd Ed., East-West Press	2008
2	Allen S.M. and Thomas E.L., The Structure of Materials, Wiley	1999
3	Gottstein G., Physical Foundations of Materials Science, New Age	2004
4	Raghavan V., Materials Science and Engineering: A First Course, 5th Ed., PHI	2009
5	Balasubramaniam R., Callister's Materials Science and Engineering, 8th Ed., Wiley	2010
6	Askeland R.D. and Askeland D., Materials Science and Engineering, Ceneage	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: **Department of Metallurgical and Materials Engineering**

1. Subject Code: **MTN-104** Course Title: **Structural Metallurgy**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs): **Theory: 3** **Practical**: **0**

4. Relative Weightage: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE:0**

5. Credits: **4** 6 Semester: **Autumn/Spring** 7. Subject Area: **DCC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge on the arrangement of atoms in materials, defect structures and their characterization techniques

10. Details of the Course:

Sl.No.	Contents	Contact Hours
1	**Atomic structure of Solids**: Atomic Bonding; Crystal systems and space lattice; Crystal structure of metals; Indexing crystallographic planes and directions, stereographic projections; Diffraction methods, Bragg law	7
2	**Crystal imperfections:** Point defects – vacancies and self interstitial, substitutional and interstitial solid solution; Line defects – Burger's vector; Frank-Reed source, slip systems, climb and cross-slip, critical resolved shear stress, dislocation interactions; Surface defect – phase boundary, grain boundary, twin boundary, stacking faults, volume defect	7
3	**Diffusion**: Diffusion in ideal solution; Kirkendall effect; Darken's Equation; Fick's second law; Mantano method; Determination of intrinsic diffusivities; Temperature dependence of diffusion coefficient; Chemical diffusion; Grain boundary and surface diffusion	6
4	**Phase diagrams:** solubility limit, evolution of microstructure, Phase rule and lever rule. Unary, binary and ternary phase diagrams. Isomorphous, eutectic, eutectoid peritectic, monotectics, intermediate phases	6
5	**Microstructure**: nucleation and growth kinetics, Structural hierarchy; Solidification microstructure; Solid-solid transformation; Deformation microstructure; plain carbon steel	6
6	**Characterization techniques**: Imaging – Optical microscopy, scanning electron microscopy, transmission electron microscopy, scanning probe (STM, AFM); Structure – X-ray diffraction, Low	10

	energy electron diffraction (LEED); Composition – X-ray photoelectron spectroscopy (XPS), X-ray energy dispersive spectroscopy (EDS), Auger electron spectroscopy (AES), secondary ion mass spectroscopy (SIMS), Rutherford backscattering (RB); Thermal analysis	
	Total	**42**

11. Suggested Books:

Sl. No.	**Authors/Name of Books/ Publisher**	**Year of Publications/ Reprint**
1.	Reed-Hill R.E., Physical Metallurgy, 2nd Ed., East-West Press	2008
2.	Allen S.M. and Thomas E.L., The Structure of Materials, Wiley	1999
3.	Gottstein G., Physical Foundations of Materials Science, New Age	2004
4.	Raghavan V., Materials Science and Engineering: A First Course, 5th Ed., PHI	2009
5.	Balasubramaniam R., Callister's Materials Science and Engineering, 8th Ed., Wiley	2010
6.	Askeland R.D. and Askeland D., Materials Science and Engineering, Ceneage	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. **Subject Code**: MTN-106 **Course Title**: Materials Science

2. Contact Hours: L: 3; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:** 0 3 **Practical**: 0 0

4. Relative Weightage: **CWS:** 2 5 **PRS:** 0 0 **MTE:** 2 5 **ETE:** 5 0 **PRE:** 0 0

5. Credits: 0 4 **6 Semester:**

7. Pre-requisite: Nil **8. Subject Area:** ESC

9. Objective: To familiarize the students with fundamentals of materials science

10. **Details of the Course**:

Sl.No.	Contents	Contact Hours
1	**Introduction to crystallography** Bonding in Solids: Ionic, 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 (Engineering stress-strain curve: Y.S, U.T.S, work hardening, ductility, resilience and toughness, True stress-strain curve, Ductile and brittle fracture), 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: Hydrocabon and Polymer molecules, Molecular shape and structure, Molecular configuration, Thermoplastic and Thermosetting polymers	4
	Total	**42**

11. Suggested Books:

Sr. No.	Name of Authors /Books/ Publisher	Year of Publication/ Reprint
1	Callister W .D., "M aterials S cience and E ngineering" Wiley India (P) Ltd. ISBN:978-81-265-21-43-2	2010
2	Raghavan V .,"Materials S cience and E ngineering- A first C ourse," 5th edition, ISBN:978-81-203-2455-8	2011
3	Askeland D.R., "The Science and Engineering of Materials, 5th edition, ISBN: 978-81-315-0321-8	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: **Department of Metallurgical and Materials Engineering**

1. Subject Code: **MTN-110** Course Title: **Materials Characterization Lab I**

2. Contact Hours: **L: 0** **T: 0** **P: 3**

3. Examination Duration (Hrs): **Theory: 0** **Practical**: 3

4. Relative Weightage: **CWS: 0** **PRS: 50** M**TE: 0** **ETE: 0** **PRE: 50**

5. Credits: **2** 6. Semester: **Spring** **7**. Subject Area: **DCC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge on the microstructural analysis using standard metallographic practice

10. List of Practicals:

1. To study the metallurgical microscope
2. To prepare the metallic sample for metallographic examination (3 turns)
3. To study the microstructure of various steel samples
4. To study the microstructure of various cast iron samples
5. To study the microstructure of modified and unmodified aluminium silicon alloys
6. To study the microstructure of various copper base alloys
7. To study the microstructure of Pb-base and Sn-base bearing alloys
8. To determine the grain size of given metallic sample by quantitative Metallography
9. Microstructural study using SEM – secondary and back scattered electron imaging
10. Chemical analysis using SEM – energy dispersive spectroscopy
11. Ductile and brittle fracture surface study using scanning electron microscope

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: **Department of Metallurgical and Materials Engineering**

1. Subject Code: **MTN-201** **Course Title**: **Transport Phenomena**

2. Contact Hours: L: **3** T: **1** P: **0**

3. Examination Duration (Hrs): **Theory:3** **Practical**:0

4. Relative Weightage: **CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE:0**

5. Credits:4 **6 Semester:** **Autumn**

7. Pre-requisite: Nil **8. Subject Area:** **DCC**

9. Objective

To familiarize the students with heat, mass and momentum transfer in various metallurgical processes.

10. Details of the Course:

Sl. No.	contents	Contact Hours
1	**Introduction of M etallurgical S ystems:** Concept of unit operations in chemical metallurgy, engineering fundamentals of unit processes.	6
2	**Momentum T ransfer:** Differential and overall balances and their applications in flow through pipes, inclined planes, packed beds and flow measuring devices such as orifice meter, Venturi meter, flow nozzles, pitot tube, rotameter, concept and working principle of supersonic nozzles; momentum transfer in turbulent flow situation.	12
3	**Heat T ransfer:** Conduction- Steady state heat conduction problems in slabs, hollow cylinders, spheres, composite walls, composite pipes etc, unsteady heat transfer in metallic specimens (lumped system) Convection- Free and forced convection, heat transfer coefficient, dimensional analysis problems. Radiation- Emissivity, absoptivity, Planck's distribution law, Wein's displacement law, Stefen-Boltzman law, radiative heat transfer between two black bodies and concept of view factor.	12
4	**Mass T ransfer:** Diffusive mass transfer, diffusivity, Fick's law, representation of mass fluxes, differential and overall mass balance equations and their applications, diffusion in solids and stationary media. Differential equation of convective mass transfer, concept of mass transfer coefficient and its determination by the application of dimensional analysis; interface mass transfer theories.	12
	Total	**42**

11. Suggested Books:

Sl. No.	Authors/Name of Books/ Publisher	Year of Publications/ Reprint
1	Bird R.B., Stewart E.S. and Lightfoot E.N., Transport Phenomena, John Wiley	2002
2	Geiger G.H. and Poirier D.R., Transport Phenomena in Metallurgy, Addison-Wesley	1973
3	Kou S., Transport Phenomena in Materials Processing, John Wiley	1996
4	Coulson J.M. and Richardson J.F., Chemical Engineering, Vol. 1.	1990
5	Mohanty A.K., Rate Processes in Metallurgy, Prentice-Hall	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: **Department of Metallurgical and Materials Engineering**

1. Subject Code: **MTN-203** **Course Title**: **Phase Transformation & Heat Treatment**

2. Contact Hours: L: **3**; T**: 1**; P**: 2/2**

3. Examination Duration (Hrs): Theory:3 **Practical**:0

4. Relative Weightage: CWS:15 **PRS:15** **MTE:30** **ETE:40** **PRE:0**

5. Credits: 4 **6 Semester: Autumn**

7. Pre-requisite: Nil **8. Subject Area: DCC**

9. Objective

To introduce the fundamental principles of phase transformations in metal and alloys.

10. **Details of the Course**:

Sl. No.	Contents	Contact Hours
1.	**Phase Equilibrium:** Equilibrium in a closed system, effect of temperature and composition, stable, unstable and metastable states, single component systems, binary solutions and binary phase diagrams, Gibbs phase rule	2
2	**Crystal interfaces and microstructure**: Interfacial energy, solid/vapour interfaces, boundaries in single phase solids, interphase interfaces in solids, and interface migration	8
3	**Liquid-solid transformation:** Nucleation – homogeneous and heterogeneous, rate of nucleation, growth, eutectic solidification, cellular and dendritic solidification, rapid solidification, crystallization of amorphous materials, melting and zone refining	8
4	**Diffusional transformations in solids:** Polymorphic transformations, massive transformations, order-disorder transformations, recrystallisation, precipitation, pearlitic reaction, cellular precipitation, coarsening, spinodal decomposition, bainite reaction	8
5	**Martensitic transformations:** Thermodynamics of martensitic transformation, phenomenological theory of martensite crystallography (PTMC), orientation relationship, athermal and isothermal kinetics, reversibility, nucleation and growth mechanism, transformation kinetics, shape memory effect,	6
6	**Heat treatment**: Precipitation or age hardening, austenite to pearlite transformation, TTT diagram and CCT diagram of eutectoid steel, hypo-eutectoid steels, hyper-eutectoid steels, tempering, austempering, martempering, spherodization, surface hardening, hardenability, thermo-mechanical processing, intercritical treatment, case studies of some alloys and steels	10
	Total	**42**

List of Practicals:

1. Determination of phase diagram of lead –tin system by Direct Cooling Curves.
2. Determination of grain growth exponent in a given material and activation energy of grain growth.
3. To study the effect of case carburizing on microstructure and hardness of steel samples.
4. To determine the hardenability of given steel by Jominy-End-Quench test method.
5. To study precipitation hardening of Al-4 wt% Cu alloy on isothermal ageing.

11. Suggested Books:

Sl.No.	Authors/Name of Books/ Publisher	Year of Publication
1	Porter D.A., Easterling K.E., and Sherif M.Y., Phase Transformations in Metals and Alloys, III edition, First Indian Reprint, CRC Press, Taylor and Francis	2009
2	Jena A.K. and Chaturvedi M.C., Phase Transformations in Materials, Prentice Hall	1992
3	Reed-Hill, R.E. and Abbaschian, R., Physical Metallurgy Principles III edition, Thomson Asia Pte Ltd., Singapore	2003
4	Burke J., The Kinetics of Phase Transformations in Metals, Pergamon Press	1996
5	Phase Transformation in Materials, Editor G. Kostoz, Wiley-VCH Verlag	2001
6	Heat Treatment Principles and Technique, Rajan T.V., Sharma V.P., Sharma A., Prentice-Hall of India Pvt.Ltd., N. Delhi	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: **Department of Metallurgical and Materials Engineering**

1. Subject Code: MTN-204 **Course Title: Metal Casting and Joining**

2. Contact Hours: **L: 3;** **T: 0;** **P: 2**

3. Examination Duration (Hrs): **Theory:3** **Practical:0**

4. Relative Weightage: **CWS:15** **PRS:15** **MTE:30** **ETE:40** **PRE:0**

5. Credits:4 **6 Semester:** **Spring**

7. Pre-requisite: Nil **8. Subject Area:** **DCC**

9. Objective: To familiarize the students with fundamentals of metal casting and materials joining processes.

10. Details of the Course:

Sl.No.	Contents	Contact Hours
1	**Introduction:** Application and advantages of metal casting processes and classification of foundries. Types of patterns, patterns materials patterns allowances, and color codification	5
2	**Mould and core making**: Ingredients: sand, clay, binders, and moisture, characterization of moulding sand, general requirement, and sand conditioning. Classification of moulding methods based on technique used viz., green sand, dry sand, CO_2 process, shell moulding etc. and machine moulding, floor and pit moulding	6
3	**Solidification:** Gating and risering; various component of gating system, types of gates, principle and practice of gating and risering for various metals and alloys, methods for directional solidification, plane front vs dendritic solidification, and concept of constitutional supercooling	5
4	**Special casting processes:** Die casting, centrifugal casting, squeeze casting, investment casting, rheocasting etc.	3
5	**Casting defects causes and remedies:** Defects due to pattern, moulding sand, improper designing of gating system *viz.* lap, scab, rattail, pipe, and porosity	3
6	**Melting furnaces and melting practice:** Various types of furnaces used in foundry technique, melting practice of cast iron, steel, Al and its alloys, Cu and its alloys	3
7	**Welding : W**elding processes- gas, arc, resistance and plasma welding, welding consumables: flux, gas, electrode, fillet weld, butt weld, weld thermal cycle, weld testing, microstructure, and weld properties. Scope of micro joining, resistance-spot, laser welding, ultrasonic welding, micro-plasma welding, and properties Mechanisms of soldering and brazing, brazing materials and properties	8

8	**Adhesives f or s tructural j oints**: Scope and applications, bonding between adhesive and substrate, properties of adhesive polymers, bonding procedures, joints design and applications	3
9	**Similar an d di ssimilar j oining of c eramics:** Scope of applications, ceramic-ceramic joining, ceramic-metal joining, brazing materials, mechanical and materials aspects	2
10	**Mechanical j oining :** Riveting, bolting, fastening, designing of joints, and properties	2
11	**Application or iented co mparison of j oining p rocesses :** Properties of different joints, efficiency of joints, merits and demerits, maintenance, life and reliability	2
	Total	**42**

List of Practicals:

1. Preparation of green sand mould.
2. To estimate AFS grain fineness number for dry silica sand.
3. To estimate the clay content in the sand.
4. To estimate the moisture content in the green sand.
5. To estimate the permeability of the green sand.
6. To estimate hardness, compressive, shear and tensile strength for core sand.
7. To estimate refractoriness of the sand.
8. To study the effect of gas and arc welding processes on microstructure and hardness of given steel samples
9. To study the effect of various parameters of soldering and brazing processes on strength of joint.
10. To study the effect of TIG and MIG welding processes on microstructure and hardness of given metallic samples.

11. Suggested Books:

S. No.	Name of Authors /Books/ Publisher	Year of Publication/ Reprint
1	Heine, R.W., Loper C.R. and Rosenthal, P.C. Principles of Metal Casting, Tata McGraw-Hill	2002
2	Mukherjee, P.C., Fundamentals of Metal Casting Technology, Oxford and IBH Publishing Company	1996
3	Welding and Brazing, Metals Handbook, Vol. 6, ASM	1996
4	Parmar, R.S., Welding Engineering and Technology, Khanna Publishers	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: **Department of Metallurgical and Materials Engineering**

1. Subject Code: MTN-205 **Course Title: Mechanical Behaviour of Materials**

2. Contact Hours: **L: 3;** **T: 1;** **P: 0**

3. Examination Duration (Hrs): **Theory:3** **Practical:0**

4. Relative Weightage: **CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE:0**

5. Credits:4 **6 Semester:** **Autumn**

7. Pre-requisite: Nil **8. Subject Area:** **DCC**

9. Objective: To impart knowledge on the response of engineering materials to mechanical loading

10. Details of the Course:

S.No.	Contents	Contact Hours
1	**Introduction:** Basic assumptions in strength of materials approach**,** stress and strain relations, tensile testing, elastic behavior, hardness testing	5
2	**Elements of plasticity:** flow curve, strain hardening, strain rate, temperature dependence of flow stress	5
3	**Plastic deformation:** slip in crystals, critical resolved shear stress, dislocations, dislocation motion, deformation by twinning	5
4	**Strengthening mechanisms**: strengthening from grain boundaries, solid solution strengthening, strengthening from fine particles, strain hardening	6
5	**Fracture:** Theoretical strength of materials, types of fracture, brittle fracture, Griffith theory of brittle fracture of material, ductile fracture, notch effects, introduction to fracture mechanics	6
6	**Fatigue**: S-N curve, low cycle and high cycle fatigue, structural features, surface effects, metallurgical variables	6
7	**Creep**: creep curve, stress rupture test, structural changes, creep mechanisms, creep resistant materials, superplasticity	6
8	**Mechanical b ehavior of non-metallic m aterials**: Ceramics, glasses, polymers, composite materials	3
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books/ Publisher	Year of Publication/ Reprint
1	Dieter, G. E., "Mechanical Metallurgy", 3rd Ed., McGraw Hill Education India.	2010
2	Courtney, T.H., "Mechanical Behavior of Materials", 2nd Ed., McGraw Hill.	1990
3	Meyers, M.A. and Chawla, K.K., "Mechanical Behavior of Materials", Prentice Hall.	1999
4	Hull, D. and Bacon, D.J., "Introduction to Dislocations", 4th Ed., Butterworth-Heinemann.	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: **Department of Metallurgical and Materials Engineering**

1. Subject Code: MTN-206 **Course Title: Non-ferrous Metallurgy**

2. Contact Hours: **L: 3;** **T: 1;** **P: 0**

3. Examination Duration (Hrs): **Theory:3** **Practical:0**

4. Relative Weightage: **CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE:0**

5. Credits:4 **6 Semester:** **Spring**

7. Pre-requisite: Nil **8. Subject Area:** **DCC**

9. Objective: To impart knowledge on extraction and refining of the common non-ferrous metals.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
	Pyro-metallurgical Processes:	
1	**Calcination:** Principles and considerations governing temperature and pressure of calcinations for carbonates and hydroxides	2
2	**Roasting:** Physico-chemical principles of oxidizing and sulphatising roasting, factors which govern their formation, decomposition and applications, Ellingham Diagrams	7
3	**Smelting:** Reduction smelting, matte smelting, role of fluxes in governing the smelting temperature and quality of slag	5
4	**Converting:** Converting of metals as a refining technique and converting of matte as metal production technique, basic differences in the designs of converters in the above cases	3
5	**Refining:** Fire-refining, distillation, liquation, drossing and tossing	2
	Hydrometallurgical Processes:	
6	**Leaching:** Principles and objectives, factors which govern solubility of salts and leaching efficiency, choice of leaching reagents. Conventional pressure and bacterial leaching – their principles, mechanisms, scopes and limitations	4
7	**Purification of Leach-liquor:** Principles of ion exchange and solvent extraction as purification, concentration and separation technique. Principles of cementation	3
8	**Recovery of val ues f rom l each-liquor:** Gaseous reduction and cementation, their principles, mechanisms scopes and limitations	3
	Electro-metallurgical Processes:	

9	**Electrowinning:** Extraction from aqueous salt solutions, hydrogen over voltage, criteria for selection of anode and cathode. Extraction from fused salt solutions, criteria for selection of electrolyte compositions, anode effects – causes and remedial measures	5
10	**Electrorefining:** Refining using aqueous salt bath and fused salt baths, criteria for selection of anode, cathode and electrolyte	3
11	**Extraction of metals:** like Magnesium, aluminum, tin, copper, lead, zinc, nickel, titanium, rare earths, uranium, thorium, plutonium, beryllium, zirconium, gold, silver and platinum	5
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books/ Publisher	Year of Publication/ Reprint
1	Dennis W.H., Non-ferrous Metallurgy, Pitman	1980
2	Bray J.L., Non-ferrous Production Metallurgy, Wiley	1985
3	Biswas A.K. and Davenport W.G., Extractive Metallurgy of Copper, Pergamon Press	2002
4	Emley E.F., Principles of Magnesium Technology, Pergamon Press	1981
5	Mantell C.L., Electro-chemical Engineering, Tata-McGraw Hill	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. Subject Code: MTN-207 **Course Title: Electrical & Electronic Materials**

2. Contact Hours: **L: 3;** **T: 1;** **P: 0**

3. Examination Duration (Hrs): **Theory:3** **Practical:0**

4. Relative Weightage: **CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE: 0**

5. Credits:4 **6 Semester: Autumn**

7. Pre-requisite: Nil **8. Subject Area: DCC**

9. Objective

To introduce the fundamentals of electrical and electronic materials, their properties and devices.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	**Electrical and thermal conduction:** Classical theory, temperature dependence of resistivity, Matthiessen's rule, Nordheim's rule, resistivity of mixtures, Hall effect, thermal conduction, electrical conductivity of semiconductors and ionic crystals	6
2	**Modern t heory of s olids:** Hydrogen molecule, band theory of solids, semiconductors, density of states in an energy band, Boltzmann statistics, Fermi-Dirac statistics, Quantum theory of metals, Fermi energy significance, thermionic emission, photons	6
3	**Semiconductors:** Intrinsic and extrinsic semiconductors, temperature dependence of conductivity, recombination and minority carrier injection, optical absorption, peizorestivity, Schottky junction	6
4	**Semiconductor d evices:** Ideal *pn* junction, *pn* junction band diagram, depletion layer capacitance of the *pn* junction, reverse breakdown, bipolar transistor, junction field effect transistor, metal-oxide-semiconductor field effect transistor, light emitting diodes, solar cells	5
5	**Dielectric m aterials**: Polarization and relative permittivity, electronic polarization, polarization mechanisms, dielectric constant and dielectric loss, dielectric breakdown, capacitor dielectric materials, piezoelectricity, ferroelectricity and electrostriction	5
6	**Magnetic p roperties:** Magnetization of matter, magnetic materials classification – diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism, ferrimagnetism, saturation magnetization and Curie temperature, magnetic domains, soft and hard magnetic materials; Superconductivity - Zero resistance and the Meissner effect, critical current density	6
7	**Optical p roperties:** Light waves, refractive index, Snell's Law, total internal reflection, Fresnel's equation, light absorption, light	5

	scattering, polarization, optical fibers, LEDs	
8	**Thermal p roperties:** Heat, work, energy; Heat capacity – Einstein model, Debye model, Electronic contribution; Thermal conduction in metals and alloys, thermal expansion	3
	Total	**42**

11. Suggested Books:

Sl. No.	Authors/Name of Books/ Publisher	Year of Publications
1	Kasap S.O., Principles of Electronic Materials and Devices, 3rd Ed., McGraw-Hill	2009
2	Hummel R.E., Electronic Properties of Materials, 4th Ed., Springer	2011
3	White M.A., Physical Properties of Materials, 2nd Ed., CRC Press	2011
4	Kwok H.L., Electronic Materails, PWS Publications	1997
5	Streetman B. and Bannerjee S., Solid State Electronic Devices, 6th Ed., Printice Hall	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: **Metallurgical and Materials Engineering**

1. Subject Code: **MTN-208** Course Title: **Engineering Polymers and Composites**

2. Contact Hours: L: **3** T: **1** P: **0**

3. Examination Duration (Hrs): Theory:**3** Practical:**0**

4. Relative Weightage: CWS:**25** PRS:**0** MTE:**0** ETE:**50** PRE:**0**

5. Credits: **4** 6. Semester: **Spring** 7. Pre-requisite: **Nil**

8. Subject Area: **DCC**

9. Objective: To impart basic knowledge about the preparation, characterisation, application and reliability of engineering polymers and composites.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	**Introduction and classification and synthesis of polymers**: Basic definitions and nomenclature, molar mass and degree of polymerization, synthesis, glass transition temperature and crystallinity in polymers, structure and its relation to thermal, chemical, electrical and optical properties.	6
2	**Mechanical and thermomechanical characteristics**: General characteristics, viscoelasicity, deformation behaviour of elastomers, deformation mechanisms, fractures, and toughened polymers.	5
3	**Polymer processing, characterisation and applications:** Introduction, plastics, elastomerics and fibres, compounding and processing techniques, practical aspects of polymer blending, standards and engineering applications of polymers.	6
4	**Composites:** Definition of composite material, constituents of composites, interfaces and interphases; Distribution of constituents and their synergy; Classification of composite – continuously and discontinuously reinforced composites, metal, ceramic and polymer based composites.	3
5	**Fabrication of composites:** (a) Metal matrix composites – solid state and solidification processing routes; Powder metallurgy route. (b) Ceramic matrix composites - vapour deposition; liquid phase method; hot pressing or ceramic method. (c) Polymer matrix composites and (d) Nano-composites.	6

6	**Characterisation of c omposites:** Control of particle distribution and defects, particle segregation ; microstructure ; particle-matrix interfacial reactions ; Mechanical properties ; Composite models ; Fibre strengthening **;** Fracture behaviour of fibre reinforced composite.	5
7	**Joining o f c omposite :** Induction heating, fusion bonding, ultrasonic welding, gas tungsten arc welding, gas metal arc welding, resistance spot and seam welding, resistance brazing, resistance spot joining, resistant spot brazing, resistance welding of thermoplastic- composite, weld bonding, brazing of MMC	4
8	**Application of composite materials :** Civil constructions of structures/pannels, aerospace industries, automobile and other surface transport industries, packaging industries, house hold and sports components.	2
9	**Fracture mechanics an d s afety of com posite:** Griffith theory of brittle fracture and modification for structural materials, basic fracture mechanics of composite (fracture toughness, COD and J-integral approaches, fatigue crack growth rate).	5
	Total:	**42**

11. Suggested Books :

S. No.	Name of Authors /Books/ Publisher	Year of Publication/ Reprint
1	Chawla, K.K., "Ceramic Matrix Composites", Chapman & Hall, London	1993
2	"Composites", Metals Handbook ,Vol. 21, 9th Ed., ASM.	1989
3	Rudin, A., "The Elements of Polymer Science and Engineering", Academic Press.	1999
4	Young, R.L. and Lovell, P.A., "Introduction to Polymers", Stanley Thornes Publishers Ltd.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. **Subject Code**: MTN-210 **Course Title**: Materials Characterization Lab II

2. Contact Hours: L: 0; T: 0; P: 3

3. Examination Duration (Hrs): **Theory:0** **Practical**:3

4. Relative Weightage: **CWS:0** **PRS:50** **MTE:**0 **ETE:0** **PRE: 50**

5. Credits:2 **6 Semester:** Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** DCC

9. Objective:

To impart knowledge on the mechanical and non-destructive testing of materials

10. **List of Practicals**:

1. To determine the hardness of nonferrous metallic samples by Brinell hardness tester
2. To determine the hardness of given metallic sample by Vickers hardness tester
3. To determine the hardness of given metallic sample by Rockwell hardness tester
4. To determine case depth of a case hardened steel using Vickers microhardness tester
5. To determine the tensile properties of given steel, brass and aluminium samples
6. To determine the impact strength of low, medium, high carbon steels by Izod and Charpy methods
7. To study the ductile to brittle transition in mild steel
8. To study the deep drawability of given metallic sheet samples by Erichsen Cupping Test
9. To carry out constant load creep test on lead sample
10. To perform fatigue test on mild steel sample
11. To study dynamic mechanical behavior of polymers
12. To detect flaws in materials by ultrasonic flaw detection technique
13. To detect flaws in steel by magnetic particle inspection

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: **Department of Metallurgical and Materials Engineering**

1. Subject Code: MTN-292 **Course Title: Engineering Analysis and Design**

2. Contact Hours: L: 3 **T: 0** **P: 2**

3. Examination Duration (Hrs): Theory: 3 **Practical:0**

4. Relative Weightage: CWS:25 **PRS:0** **MTE:25** **ETE:50** **PRE:0**

5. Credits: 4 **6. Semester: Spring**

7. Pre-requisite: Nil **8. Subject Area: DCC**

9. Objective:
To introduce with the basic principles and applications of Engineering analysis & Design of metallurgical processes.

10. **Details of the Course**:

Sl. No.	Contents	Contact Hours
1.	**Experimental setup and design:** rigorous physical setup, semi-rigorous setup, ad-hoc setup, similarity criteria, dimensional analysis.	7
2	**Pilot p lants design:** definition and their developments**,** process analysis and design with fundamentally based mathematical models, semi-empirical models, empirical models, transport equations, multidimensional rigorous analysis, and factorial design analysis.	9
3	**Process Simulation:** Monte carlo simulation, Phase field theory, thermo-mechanical simulation, simulation of melt stream disintegration by fluid flow.	3
4	**Design w ith ar tificial in telligence:** neural networks, fuzzy logic, genetic algorithm	6
5	**Use of S oftware in de signing:** Introduction to Matlab, themocalc, anasys, Java etc.	4
6	**Design ve rification:** Measurement techniques for design verification e.g. techniques to measure fluid flow rate, gas jet velocity, temperature, pressure, reaction rates etc for verification of design.	5
7	**Aplications:** Design of continuous casting, hot rolling,	8

	powder rolling, powder forging, powder pressing, melt spinning, ingot solidification, droplet solidification, nano-system design, atomistic level designs etc.	
	Total	**42**

List of practicals:

1. To design and develop a software to simulate melt flow from a tundish.
2. To correlate process parameters and design of tundish flow through its mathematical model.
3. To develop a software to solve a second order differential equation.
4. To design and develop a software to predict the temperature variation in an atomized melt droplet cooling during its flight in a gas stream. (PART-1)
5. To design and develop a software to predict the temperature variation in an atomized melt droplet cooling during its flight in a gas stream. (PART-2)
6. To design and develop a software to predict the temperature of metal slab during its hot rolling. (PART-1)
7. To design and develop a software to predict the temperature variation in metal slab during its hot rolling. (PART-2)
8. To design and develop a software to determine the temperature variation in an ingot during its solidification. (PART-1)
9. To design and develop a software to determine the temperature variation in an ingot during its solidification. (PART-2)
10. To analyze a process of your choice and then design its back propagation neural network using MATLAB software.
11. To analyze any problem of metallurgical thermodynamics and solve it using THERMOCALC software. (PART-1)
12. To analyze any problem of metallurgical thermodynamics and solve it using THERMOCALC software. (PART-2)
13. To design and develop a software of a system or process of your choice. (PART-1)
14. To design and develop a software of a system or process of your choice. (PART-2)

11. Suggested Books:

Sl. No.	Authors/Name of Books/ Publisher	Year of Publication
1	Kuang-O Yu., Modeling for casting and solidification processing, Marcel Dekker	2002
2	Dym, L. Au. Clive, Principles of mathematical modeling, Elsevier	2006
3	Szekely J.S. & Ray W.H., Process optimization with applications metallurgy and chemical engineering, Wiley-Interscience	1973
4	Irving W.R,, Continuous casting of steel, Institute of Materials	1993
5	Polukhin V.P.,, Mathematical simulation and computer analysis of thin-strip rolling mills, Mir Publishers	1975
6	Rajasekaran, S., Neural networks, fuzzy logic, and genetic algorithms synthesis and application, Prentice-Hall	2004
7	Chapra, Steven.C., Au., Numerical methods for engineers, McGraw-Hill	1990

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. Subject Code: MTN-301 **Course Title: Mechanical Working of Metals**

2. Contact Hours: **L: 3;** **T: 0;** **P: 2**

3. Examination Duration (Hrs): **Theory:3** **Practical:0**

4. Relative Weightage: **CWS:15** **PRS:15** **MTE:30** **ETE:40** **PRE:0**

5. Credits:4 **6 Semester: Autumn**

7. Pre-requisite: Nil **8. Subject Area: DCC**

9. Objective: To introduce various metal forming processes and their effect on the structure and properties of metals

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	**Fundamentals of metalworking:** Yield criteria, Levi-Mises equation, classification of forming processes, mechanics of metal working, temperature in metal working, hot working vs. cold working, strain rate effects, recovery and recrystallization, preferred orientation, sliding and sticking friction, workability.	6
2	**Forging:** General aspects, closed-die and open-die forging, spread law, different types of drop and press forging equipment, forging loads, forging defects, powder forging, case studies.	6
3	**Rolling:** Terminology of rolled products, different kinds of rolling mills, forces and geometrical relationship in rolling, draft Ekelund's expression for no-slip angle, forward slip, rolling variables, problem and defects in rolled products, roll pass sequences used in rolling of blooms to billets and various structural shapes, billets to bars or rods, roll pass, powder rolling.	6
4	**Extrusion:** Direct and indirect extrusion, impact extrusion and Hooker process, hydrostatic extrusion, equipment, extrusion variables, derivation of extrusion pressure, deformation, lubrication and defects in extrusion, production of seamless tubes by extrusion process, powder extrusion.	6
5	**Rod, wire an d t ube dr awing:** Processes and equipments, hydrodynamic lubrication, maximum possible reduction in a pass under ideal condition, draw stress with friction and back tension, effect of diameter, angle and mode of flow on drawing stress, shaving defects.	6
6	**Other conventional processes**: Piercing, punching, and blanking, stretch forming spinning, embossing and coining, powder performs. forging	4
7	**High E nergy Rate Forming Processes:** Brief descriptions of explosive forming, electro-discharge forming, and electro-	4

	magnetic forming.	
8	**Advanced Forming Processes:** Outline of superplastic forming, severe plastic deformation techniques, mechanical alloying.	4
	Total	42

11. List of Practicals:

1. Study of variation of coefficient of spread with bite ratio and correlation between microstructure, hardness and processing conditions.
2. Study of effect of hot forging on the microstructure and hardness (through thickness) of aluminium and steel specimens and to determine the effect of lubrication on the deformation.
3. Study of microstructure and hardness profile of mild steel bar during hot rolling (including interrupted rolling) and as a function of cooling rate.
4. Study of microstructure and hardness with forging condition and annealing temperatures for steel and aluminium specimens.
5. Observation of deformation process in Thermo-Mechanical Simulator and correlating microstructure with process parameters and hardness.

12. Suggested Books:

S. No.	Name of Authors /Books/ Publisher	Year of Publication/ Reprint
1	Dieter G.E., Mechanical Metallurgy, McGraw Hill Education India	2010
2	Rowe R., Principles of Metal Working, Edward Arnold Publications Ltd	1965
3	Metal Working, Metals Handbook, Vol.14 A&B, 9th Ed., ASM	1989
4	Wilson F.W., High Velocity Forming of Metals, Prentice Hall	1980
5	Burhanettin S. Altan (Ed.), Severe Plastic Deformation – Towards Bulk Production of Nanostructured Materials, Nova Publishers	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: **Department of Metallurgical and Materials Engineering**

1. Subject Code: MTN-302 **Course Title: Environmental Degradation of Materials**

2. Contact Hours: **L: 3;** **T: 0;** **P: 2**

3. Examination Duration (Hrs): **Theory:3** **Practical:0**

4. Relative Weightage: **CWS:15** **PRS:15** **MTE:30** **ETE:40** **PRE: 0**

5. Credits:4 **6 Semester: Autumn/Spring**

7. Pre-requisite: Nil **8. Subject Area: DCC**

9. Objective

To impart knowledge on various materials degradation phenomena and related remedial measures.

10. Details of the Course:

Sl.No.	Contents	Contact Hours
1	**Introduction:** Definitions, costs of materials degradation, forms of materials degradation.	2
2	**Thermodynamics of corrosion**: Electrochemical nature of corrosion, processes at interface and Gibbs energy change, EMF and galvanic series, Nernst relationship, Pourbaix diagrams.	6
3	**Kinetics of electrode reactions:** Exchange current density, Evans diagram, corrosion rates; activation and concentration polarization, anodic, cathodic, mixed control, Tafel equation, passivation.	6
4	**Forms of corrosion**: Uniform, galvanic, crevice, pitting, intergranular, stress corrosion, hydrogen cracking, corrosion fatigue, erosion-corrosion, fretting; Effect of metallurgical variables and environments on different forms of corrosion.	6
5	**Corrosion protection:** Corrosion prevention methods-anodic and cathodic protection, inhibitors, protective coatings, corrosion control by design.	4
6	**Corrosion testing**: Immersion and salt spray testing, Electrochemical techniques-Tafel extrapolation, polarization resistance technique, electrochemical impedance spectroscopy.	6
7	**Hot corrosion:** High temperature oxidation of metals and alloys, laws governing oxidation, molten salt corrosion, liquid metal corrosion, thermogravimetric technique.	6
8	**Degradation of polymers, ceramics and other materials-** Polymeric materials- swelling and dissolution, bond rupture, weathering, other processes, polymer cycling and degradation; Forms of ceramic and glass degradation,	6

	cement and concrete; Composite materials- galvanic effects, matrix nature, reinforcement. nature, prevention	
	Total	**42**

List of Experiments:

1. Determination of electrode potentials.
2. Corrosion rate measurements by potentiostat/Galvanostat.
3. Effect of alloying elements on passivity.
4. To study the effect of cathodic protection on given couple of metallic samples.
5. To study the effect of intergranular corrosion on microstructure of given metallic samples.
6. To study the effect of various inhibitors on corrosion protection.
7. To study the effect of various environmental conditions on degradation of coatings.
8. To study the macro/micro structure of crevice corroded metallic samples.
9. To study stress corrosion cracking behavior of steels.
10. To study degradation kinetics of Polymers using DSC/TGA.
11. To study ageing behavior of ceramics using autoclave.

11. Suggested Books:

S. No.	Name of Authors /Books/ Publisher	Year of Publication/ Reprint
1	Kutz M., Handbook of Environmental Degradation of Materials,William Andrew Publishing	2005
2	Fontana, M.G. and Greene, N.D., Corrosion Engineering, McGraw Hill.	2005
3	Uhlig H.H. and Revie R.W., Corrosion and Corrosion Control, 3rd Ed., John Wiley	1985
4	Corrosion, Metals Handbook, Vol.13 A&B, 9th Ed., ASM International	1989
5	Hihara L.H. and Adler R.P.I., Environmental Degradation of Advanced and Traditional Engineering Materials, CRC Press	2012

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: **Department of Metallurgical and Materials Engineering**

1. Subject Code: MT-303 **Course Title: Iron and Steel Making**

2. Contact Hours: **L: 3;** **T: 1;** **P: 0**

3. Examination Duration (Hrs): **Theory:3** **Practical:0**

4. Relative Weightage: **CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE:0**

5. Credits: 4 **6 Semester:** **Autumn/Spring**

7. Pre-requisite: Nil **8. Subject Area:** **DCC**

9. Objective

To understand fundamental principles and practices involved in iron and steel making processes.

10. **Details of the Course**:

Sl. No.	Contents	Contact Hours
	Iron Making	
1	Physico-chemical principles relevant to iron making: Direct and indirect reduction, C-O, Fe-C-O, Fe-H-O equilibria diagrams, Rist diagram, physic-chemical properties of slag- effect of alumina, silica, CaO, MgO and FeO on quality of slag. Thermodynamics and kinetics of chemical reactions	10
2	Agglomeration: A brief introduction to sintering and pelletization	2
3	Blast furnace design, gas cleaning system, hot blast stoves	3
4	Modern developments in blast furnace	2
5	A brief introduction to blast furnace irregularities and remedies	2
6	Direct reduction processes: coal based and gas based processes	2
	Steel Making	
7	Physico-chemical principles: Removal of C, Si, Mn, P and S	5
8	A brief introduction to Bessemer and Open hearth processes.	2
9	Basic oxygen furnace processes: LD converter, LD-AC, Kaldo	5
10	Electric arc furnace and Induction furnace steel making	3
11	Secondary steel making: vacuum degassing, inert gas blowing, synthetic slag, blowing with powdered material, ladle furnace, vacuum argon degassing, vacuum oxygen decarburization, combined processes, vacuum arc remelting, electroslag refining	4
12	Casting: Ingot casting and continuous casting	2
	Total	**42**

11. Suggested Books:

Sl. No.	Authors/Name of Books/ Publisher	Year of Publications/ Reprint
1	Fruehan R.J. (Ed), "The Making, Shaping and Treating of Steel", Vol 1 – 3, 11th edition, AISE	1998-1999
2	Ghosh A., Chatterjee A., "Ironmaking and Steelmaking, theory and practice", PHI	2008
3	Kudrin V., "Steelmaking", MIR	1985
4	Chakrabarti A.K., Steel Making, PHI	2007
5	Chatterjee A., Sponge iron production by direct reduction of iron oxide, PHI	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: **Department of Metallurgical and Materials Engineering**

1. Subject Code: MTN- 304 **Course Title: Ceramics and Metal Powder Processing**

2. Contact Hours: **L: 3;** **T: 0;** **P: 2/2**
3. Examination Duration (Hrs): **Theory:3** **Practical:0**

4. Relative Weightage: **CWS:15** **PRS:15** **MTE:30** **ETE:40** **PRE:0**

5. Credits: 4 **6. Semester: Autumn/Spring**

7. Pre-requisite: Nil **8. Subject Area: DCC**

9. Objective:

To impart knowledge on ceramics and metal powder processing, their properties, production and engineering applications

10. Details of Course:

Sl. No.	Contents	Contact Hours
1	**Ceramics overview:** General characteristics of ceramics, ceramic microstructures, ceramic crystal structures.	3
2	**Ceramic and metal powder preparation and characterization :** Synthesis by mechanical methods, and chemical methods; Powder characterization : physical characterization relating particles shapes, size, size distribution, surface area, porosity; flow rate, tap density, apparent density, compressibility; chemical characterization relating to chemical compositions, phase composition and surface characterization.	7
3	**Colloidal Processing** : Types of colloids; Electrostatic stabilization; Polymeric stabilization; Rheology of colloidal suspensions.	4
4	**Ceramic phase diagrams**: Binary systems : complete solid solubility, eutectic diagrams with partials solid solubility and no intermediate compounds, partial solid solubility with formation of intermediate compounds; Ternary systems.	5
5	**Sintering of powder compacts:** Defects and defect chemistry; Solid state sintering, atomic mechanisms, coarsening, densification, sintering kinetics: sintering stages, coarsening and grain growth growth kinetics; Liquid phase sintering : introduction, the different stages, controlling kinetics and thermodynamic factors; Prolems of sintering; Sintering furnaces and their classifications, sintering atmosphere, vacuum sintering.	7
6	**Powder consolidation and shape forming processes :** Die	6

	compaction, isostatic pressing; Casting methods : slip casting, pressure casting, tape casting; Additives in forming process, plastic forming methods : extrusion and injection moulding.	
7	**Glasses :** Glass formation : kinetics and criteria for glass formation; glass structure; glass properties: glass transition temperature, thermodynamic considerations; Glass-ceramics : processing, properties and industrial applications.	5
8	**Powder pr oducts an d selected ap plications:** Sintered carbides and carbide tools; Cermets; Dispersion strengthened materials; Electrical contact materials; Friction materials.	5
	Total	**42**

List of Practicals:

1. To determine the density of oxide ceramic powder using liquid pycnometric method.
2. To study ceramic powder processing and role of additives
3. To prepare green compacts of ceramic powder using uniaxial pressing method
4. To study the green density of the samples as a function of applied load.
5. To study solid state sintering behaviour of the green compacted samples at different temperatures and soaking time periods.
6. To study the linear shrinkage of the samples due to sintering and study their densification characteristics.
7. To estimate crystallite size of the fine ceramic powder using X-ray diffraction line broadening technique.
8. To study microstructure of the sintered ceramic samples.
9. To determine the average grain size from the micrographs of ceramic samples by linear interception method.
10. To study voltage vs. current (V-I) characteristics of ceramic varistor samples and determine the varistor characteristics viz. nonlinear exponent and breakdown voltage.

11. Suggested Books:

Sl. No.	**Name of Books/Authors/Publisher**	**Year of Publication/ Reprint**
1	Kingery W.D., Bowen H.K. and Uhlmann D.R., Introduction to Ceramics, 2nd Ed., John Wiley	1991
2	Richerson, D.W., "Modern Ceramic Engineering – Properties, Processing and use in Design", Marcel Dekker, Inc.	1992
3	Rahaman, M. N., "Ceramic Processing and Sintering", Marcel Dekker Inc.	1995
4	Masuda H., Powder Technology Handbook, Taylor & Francis	2006
5	German R.M., A to Z of Powder Metallurgy, Elsevier	2005
6	Sands R.L. and Shakespeare C.R., Powder Metallurgy Practice and	1970

	Applications, Newness Publication	
7	Powder Metal Technologies and Applications, Metals Handbook, Vol. 7, 9^{th} edition, ASM	1989
9	Upadhyaya G.S., Powder Metallurgy Technology, Cambridge Press	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: **Department of Metallurgical and Materials Engineering**

1. Subject Code: MTN-310 **Course Title: Materials Characterization Lab III**

2. Contact Hours: **L: 0;** **T: 0;** **P: 3**

3. Examination Duration (Hrs): **Theory:0** **Practical:3**

4. Relative Weightage: **CWS:0** **PRS:50** **MTE:0** **ETE:0** **PRE:50**

5. Credits:2 **6 Semester:** **Autumn/Spring**

7. Pre-requisite: **Nil** **8. Subject Area:** **DCC**

9. Objective

To acquaint the student with advanced materials characterization techniques.

10. **List of Practicals:**

1. To study the X-ray diffractometer.
2. Calculation of structure factor of different crystal structures.
3. Determination of cubic crystal structure using powder XRD.
4. Determination of hexagonal crystal structure using powder XRD.
5. Determination of phases in multiphase powder sample using XRD.
6. Precise lattice parameter determination using XRD.
7. Estimation of crystallite size using Scherrer formula.
8. Chemical analysis using energy dispersive X-ray analysis in SEM (spot and line analysis).
9. To demonstrate the TEM sample preparation and TEM analysis.
10. Indexing of selected area diffraction patterns.
11. DSC/DTA analysis.
12. Four probe resistivity measurement.
13. B-H loop measurement.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MT-502 **Course Title**: Principles of Solidification

2. Contact Hours: L: 3 ; T: 1; P: 0

3. Examination Duration (Hrs): Theory:3 Practical:0

4. Relative Weightage: CWS:25 PRS:0 MTE:25 ETE:50 PRE:0

5. Credits: 4 **6. Semester:** Autumn/Spring

7. Pre-requisite: None **8. Subject Area:** DEC

9. Objective: This course aims to provide advanced concepts of solidification in materials and their applications in real life situations.

10 Details of the Course:

Sl.No.	Contents	Contact Hours
1.	The liquid phase, crystal structure of liquid; Thermodynamics of solidification processes, nucleation, atom transfer at solid/liquid interface, structure and characteristics of solid liquid interface, energies, kinetics and topography of interfaces.	9
2.	Heat extraction during solidification, Planar growth, rate of nucleation solidification microstructures, capillarity effects.	4
3.	Interface instability in pure substances, constitutional undercooling and interface instability of alloys, cells and dendrites, equiaxed and columnar structures.	5
4.	Eutectic solidification, regular and irregular eutectics, coupled growth, competitive growth of dendrites and eutectics, Peritectic growth.	5
5	Defect formation, solute redistribution, micro- , macro-, normal, inverse and gravity segregation,	4
4	Effect of rate of cooling on the microstructure and properties of single phase and multiphase alloys; growth of single crystals, Structure of cast ingot: chilled zone, columnar zone and equiaxed zone.	8
5	Structure and properties of metals and alloys in special casting techniques such as rheocasting, compocasting and spray forming; interdendritic fluid flow, Effect of vibration during solidification on structure and properties on metals and alloys.	7
	Total	**42**

11. Suggested Books:

S.No.	Name of Author/Book/ Publisher	Year of Publication/ Reprint
1	Kurz W. and Fisher D. J. “Fundamentals of Solidification”, Trans Tech Publications.	1998
2	Glicksman M. E. Än introduction to modern casting and crystal growth”, Sringer	2010
2	Flemings M. C., “Solidification Processing”, Tata-McGraw Hill	1974
3	Stefanescu D. M., “Science and Engineering of Casting Solidification”, Springer.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT : Metallurgical and Materials Engineering

1. Subject Code: MTN-505 **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:**25 PRS:0 MTE:25 ETE:50 PRE: 0**

5. Credits: 4 **6 Semester**: Autumn/Spring

7. Pre-requisite: Nil 8. Subject Area: GSEC

9. Objective: To impart the importance of non-destructive testing in assuring quality control in engineering components.

10. Details of the Course:

Sl.No.	Contents	Contact Hours
1.	Introduction: Non destructive testing and its comparison with destructive testing, role of NDT in quality control.	5
2.	Liquid penetrant inspection: its principles, equipment, advantages, limitations and applications.	6
3.	Magnetic particle inspection: its principles, equipment, advantages, limitations and applications.	6
4.	Ultrasonic inspection: its principles, equipment, advantages, limitations and applications.	6
5.	Eddy current inspection: its principles, equipment, advantages, limitations and applications.	6
6.	X-ray radiography: its principles, equipment, advantages, limitations and applications.	5
7.	Quality control: Statistical quality control, control charts, control chart attribute and variables and acceptance sampling; Quality assurance and ISO 9000:2000	8
	Total	**42**

11. Suggested Books:

S.No.	Name of Author/Book/ Publisher	Year of Publication/ Reprint
1.	"Non Destructive Evaluation and Quality Control". Metals Handbook, Vol. 17, 9th Ed., ASM.	1989
2.	Srivastava, K.C., "Handbook of Magnetic Particle Testing", Oscar Publications.	1998
3.	Srivastava, K.C., "Handbook of Liquid Penetrant Testing", Oscar Publications.	1997
4.	Grant, E.L. and Larenwork, R.S., "Statistical Quality Control", Tata McGraw-Hill.	2000

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. Subject Code: MTN-511 **Course Title**: Thin Film Technology

2. Contact Hours: L: 3; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:3** **Practical**:0

4. Relative Weightage: **CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE:0**

5. Credits:4 **6 Semester:** Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** DEC

9. Objective

To impart knowledge on the processing and characterization of thin films for device applications

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	**Introduction**: Applications of thin films, process steps	2
2	**Gas k inetics**: Maxwell-Boltzmann distribution, molecular impingement flux, Knudsen equation, mean free path, transport properties.	6
3	**Evaporation**: thermodynamics of evaporation, evaporation rate, alloys, compounds, sources, deposition monitoring techniques.	5
4	**Deposition**: adsorption, surface diffusion, nucleation, structure development, interfaces, stress, adhesion.	6
5	**Epitaxy**: symmetry, applications, disruption, growth monitoring, composition control, lattice mismatch, surface morphology.	6
6	**Chemical V apor D eposition**: Gas supply and convection, reaction equilibrium and surface processes, diffusion limited deposition and reactor models.	6
7	**Film A nalysis**: structure-thickness, topography, inhomogeneity, crystallography, bonding, point defects, composition, and optical, electrical and mechanical behavior of thin films.	6
8	**Applications:** Technology of polysilicon thin-film transistors, thin film transistors in active-matrix liquid crystal displays, organic based thin film transistors, vacuum deposited organic thin film transistos based on small molecules	5
	Total	**42**

11. Suggested Books:

Sl. No.	Authors/Name of Books/ Publisher	Year of Publications/ Reprint
1	Ohring M., Materials Science of Thin Films, 2nd edition, Academic Press	2001
2	Smith D.L., Thin-Film Deposition: Principles and Practice, McGraw-Hill Professional	1995
3	Kagan C.R. and Andry P., Thin Film Transistors, Marcel Dekker	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. Subject Code: MTN-513 **Course Title**: Microfabrication Technology

2. Contact Hours: L: 3; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:3** **Practical**:0

4. Relative Weightage: **CWS:25** **PRS:0** **MTE:25** **ETE:** 50 **PRE:0**

5. Credits:4 **6 Semester:** Autumn/spring

7. Pre-requisite: Nil **8. Subject Area:** DEC

9. Objective

To impart knowledge on the microfabrication techniques to synthesize electronic devices

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	**Overview**: Block level process flow, Introduction to process integration, Crystal Growth and Doping, Wafer Preparation	4
2	**Oxidation a nd D iffusion**: Diffusion in concentration gradient (Si/GaAs), Diffusion Equation, Diffusion Systems for Silicon, Growth Mechanism and Thin Oxide, Oxidation Systems and techniques, Oxidation Induced Defects	8
3	**Epitaxy an d L ithography**: Vapour Phase Epitaxy (VPE), Molecular Beam Epitaxy (MBE), Epitaxial Evaluation, Optical, Electron and Ion-Beam Lithography, X-ray and Blue Lithography Reactive Ion and Plasma Etching and its techniques	8
4	**Ion implantation and M etallization:** Range and straggle, Implantation Equipments, Annealing, Physical Vapour Deposition (PVD), Patterning, Multi Level Metallization.	7
5	**Process Simulation and Integration:** Simulation Techniques for process flow in Silicon and III-V, Flow Integration for Device Fabrication, Future trends in device fabrication: 3D process flow, CMOS IC Flow, MOS Memory IC Flow	8
6	**Device Characterization and Reliability:** MOS-CV curve – x_{ox}, N_a, V_{FB}; V_t implant – threshold voltage, shallow versus deep V_t implant; mobility, body effect, latch-up; Yield Loss Mechanism and its Modelling, Poisson model, Accelerated Testing	7
	Total	**42**

11. Suggested Books:

Sl. No.	Authors/Name of Books/ Publisher	Year of Publications/ Reprint
1	Jaeger R.C., Introduction to Microelectronic Fabrication, Addison-Wesley	1987
2	Campbell S.A., The Science and Engineering of Microelectronic Fabrication, 2nd Ed., Oxford	2006
3	Sze, S.M., VLSI Technology, Mc. Graw Hill, 2nd Ed.	2006
4	Ghandhi, S.K., VLSI Fabrication Principles, John Wiley and Sons, 4th Ed.	2004
5	Madou M.J., Fundamentals of Microfabrication: The Science of Miniaturization, 2nd Ed., CRC Press	2002
6	Feanssila S., Introduction to Microfabrication, 2nd Ed., Wiley	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. Subject Code: MTN-515 **Course Title**: Microsensors, MEMS and Smart Devices

2. Contact Hours: L: 3; T: 1; P: 0

3. Examination Duration (Hrs): Theory: 3 Practical:0

4. Relative Weightage: CWS:25 PRS:0 MTE:25 ETE:50 PRE:0

5. Credits:4 **6 Semester:** Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** DEC

9. Objective

To impart knowledge on microsensor systems including recent developments in smart devices

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	**MEMS materials**: Atomic structure and periodic table; Metals, metallization; Semiconductors – electrical and chemical properties, growth and deposition; Ceramic and polymeric materials	5
2	**Microstereolithography**: photopolymerisation, microstereolitho-graphy, classical MSL, IH process, two-photon MSL, mask-projection MLS, polymeric MEMS architecture with silicon, metal and ceramics, combined silicon and polymeric structures, examples of microactuators, microconcentrator and microdevices	6
3	**Thermal and mechanical sensors**: Thermocouples, thermodiodes and thermotranstors, SAW themperature sensor; Photoconductive devices, photovoltaic devices, pyroelectric devices, microantenna; Pressure micorsensors, microaccelerometers, microgyrometers, flow microsensors	6
4.	**Interface circuitry and Microsystems:** Microsensor Systems, Microsensor system applications to automotive, biomedical, environmental, industrial control and household appliances. Interface circuit architecture, Analog Front End, ADC, Digital processing and output interface	6
5.	**Magnetic and biochemical sensors:** Magnetogalvanic microsensors, magnetoresistive devices, magnetodiodes and magnetotransistors, acoustic devices and SQUIDs; Conductimetric devices, potentiometric devices	6

6	**IDT Mi crosensor**: SAW devices, acoustic wave propagation, particle displacement and strain, stress, piezoelectric effect; Strain, temperature, pressure and humidity sensor	6
7	**MEMS-IDT Microsensor**: Principles, fabrication and testing of MEMS-IDT accelerometer; Smart sensor – electronic nose, tongue, finger, skin;	4
8	**Microrobotics:** Introduction, Applications, Microassembly, making of Microrobots, Microrobotic Devices, Multirobot System	3
	Total	**42**

11. Suggested Books:

Sl. No.	Authors/Name of Books/ Publisher	Year of Publications/ Reprint
1	Gardner J.W., Varadan V.K. and Awadelkarim O.O., Microsensors, MEMS and Smart Devices, Wiley	2001
2	Gad-el-Hak M., The MEMS Handbook: MEMS Applications, Taylor and Francis	2006
3	Korvink J.G. and Paul O., MEMS: A Practical Guide to Design, Analysis and Applications, Springer	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. Subject Code: MTN-517 **Course Title**: High Temperature Materials

2. Contact Hours: L: 3; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:3** **Practical**:0

4. Relative Weightage: **CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE:**0

5. Credits:4 **6 Semester:** Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** DEC

9. Objective

To impart knowledge on requirements for materials for high temperature use and the behavior of materials at high temperatures.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	**Introduction**: Need for high temperature materials, Historical development of high temperature materials, Equipment for material testing at high temperatures, Requirements of high temperature materials (Mechanical properties and preferred microstructure, environmental resistance, erosion and wear)	5
2	**Principles for high temperature strengthening**: Metallic materials (solid solution strengthening, precipitation strengthening, dispersion strengthening grain size and grain boundary effects) Ceramic materials (phase control, defect tolerance, thermal shock resistance) Composite materials	7
3	**Creep and stress rupture**: Creep test, Stress rupture test, Structural changes during creep, Mechanism of creep deformation, Fracture at elevated temperatures	6
4	**Creep – fatigue interaction**: Modes of high temperature fracture and fatigue fracture, Creep-fatigue interaction (creep accelerated by fatigue), Fatigue-creep interaction (fatigue accelerated by creep), Micro-mechanism of damage, Fracture criterion for creep fatigue, Creep-fatigue failure mapping, Creep-fatigue testing, Influence of environment	7
5	**Materials for high temperature**: Metals / alloys, Superalloys, Steels, Titanium and its alloys, Ceramics (Alumina, Zirconia, Silicon carbide, Silicon nitride, Glass ceramics) Composites	7

	(Metal matrix composites, Ceramic matrix composites) Carbon – Carbon composites	
6	**Coatings for protection against high temperature corrosion and erosion:** Corrosion / oxidation resistant coatings (metallic, ceramic, rare and reactive metal reinforced coatings)**,** High temperature erosion and wear, Thermal barrier coats	6
7	**Case studies**: Applications in industry, aerospace, defense and nuclear industry	4
	Total	**42**

11. Suggested Books:

Sl. No	Authors/Name of Books/ Publisher	Year of Publications/ Reprint
1	G. W. Meetham and M. H. Van de Voorde, Materials for High Temperature Engineering Applications (Engineering Materials), Springer; 1 edition	2000
2	R. W. Chan, High temperature structural materials, Chapman & Hall,	1996
3	R. C. Reed, The Super-alloys: Fundamentals and Applications, Cambridge University Press; 1 edition	2008
4	N. Birks, G. H. Meier, and F. S. Pettit, Introduction to the High Temperature Oxidation of Metals by (Paperback)	2009
5	S. Bose, High Temperature Coatings, , Butterworth-Heinemann; 1 edition	2007
6	S. Somiya, Handbook of Advanced Ceramics, Parts 1 and 2, , Academic Press, 2006	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. Subject Code: MTN-519 **Course Title**: Electro-Ceramics

2. Contact Hours: L: 3; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:3** **Practical**:0

4. Relative Weightage: **CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE:0**

5. Credits: 4 **6 Semester:** Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** DEC

9. Objective

To impart knowledge on electrical and electronic properties of ceramic materials, their processing and applications.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	**Introduction:** Electrical and electronic conduction in ceramics; crystal chemistry and crystal structures of ceramics; processing and microstructures; defect structure in solids; ionic conductivity; ceramic electrolytes and super ionic conductors; ceramic insulators	8
2	**Dielectrics:** Low, medium and high permittivity ceramics; ceramic capacitors; piezoelectric, ferroelectric, pyroelectric materials and their applications	6
3	**Magnetic ceramics**: Origin of magnetism in solids; introduction to hard and soft magnetic materials; ferrites, hexagonal ferrites and garnets – processing, properties and applications	6
4	**Ceramic sensors:** Introduction, positive temperature coefficient and negative temperature coefficient ceramics – thermistors, gas sensors, humidity sensors, pressure sensors	5
5	**Varistors:** ZnO-varistors – microstructure and fabrication, varistor mechanism, applications	2
6	**Ceramic thick film:** Introduction to thick film technology, materials and processing	4
7	**Electroceramic thin film:** Introduction to thin film technology, materials and deposition methods	4
8	**Optical and electro-optic materials:** Introduction to optical behaviour of ceramics, electro-optic materials, PLZT ceramics	5
9	**Glass ceramics:** Processing and applications	2
	Total	**42**

11. Suggested Books:

Sl. No.	Authors/Name of Books/ Publisher	Year of Publications/ Reprint
1	Moulson A.J. and Herbert J. M., Electroceramics: Materials, Properties and Applications, 2nd Ed., Wiley	2003
2	Hench L.L. and West J.K., Principles of Electronic Ceramics, John Wiley	1990
3	Richerson D.W., Modern Ceramic Engineering: Properties, Processing and use in Design, 3rd Ed., CRC / Taylor and Francis	2006
4	Reed J.S., Principles of Ceramic Processing, 2nd Ed., John Wiley	1995
5	Ohring M., Materials Science of Thin Films: Deposition and Structure, 2nd Ed., Academic Press	2002
6	Solymer L. and Walsh D., Electrical Properties of Materials, 7th Ed., Oxford University Press	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. Subject Code: MTN-521 **Course Title**: Materials for Renewable Energy

2. Contact Hours: L: 3; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:3** **Practical**:0

4. Relative Weightage: **CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE:0**

5. Credits: 4 **6 Semester:** Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** DEC

9. Objective

To explore various renewable energy applications and understand the critical role of materials in renewable energy.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	**Introduction**: Importance of energy, conventional energy sources, World's energy problem, what is renewable/green energy, sources of renewable energy, energy future	3
2	**Nuclear Energy:** Basic science and technology of nuclear energy, materials used in nuclear energy generation.	6
3	**Biofuels:** Introduction and classification of materials for biofuels, artificial photosynthesis.	3
4	**Solar Energy:** Solar thermal and solar photovoltaic energy, structures of solar cells, varieties of solar cells, basic mechanisms, importance of materials in solar energy.	10
5	**Geothermal:** Source, advantages and limitations	3
6	**Hydropower:** Hydro-electric (dam) power, advantages and limitations, materials used in hydro-electric power, ocean energy	4
7	**Wind Energy:** Source, situation in our country, advantages and limitations, importance of materials in wind energy generation	3
8	**Energy Storage:** Energy storage devices – battery , capacitor, basic mechanisms, materials used in energy storage devices	6
9	**Present Status of Renewable Energy:** Commercialization of different renewable energy sources in national and international level, future research directions	4
	Total	**42**

11. Suggested Books:

Sl. No.	Authors/Name of Books/ Publisher	Year of Publications/ Reprint
1	Renewable Energy – A First Course, By Robert Ehrlich, CRC Press	2013
2	Renewable Energy: Power for a Sustainable Future, By Godfrey Boyle, Oxford University Press, ISBN-13: 978-0199545339	2012
3	The Science of Renewable Energy, By Frank R. Spellman; Revonna M. Bieber, CRC Press	2011
4	Eco- and Renewable Energy Materials, By Yong Zhou (Ed.), Springer, ISBN-13: 978-3642334962	2013
5	Renewable Energy (Open access book), By T J Hammons (Ed.), In-Tech, http://www.intechopen.com/books/renewable-energy	2009
6	Materials for Renewable and Sustainable Energy Open access journal http://www.springer.com/materials/journal/40243	

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. Subject Code: MTN-531 **Course Title**: X-ray Diffraction Techniques

2. Contact Hours: L: 3; T: 1; P: 0

3. Examination Duration (Hrs): Theory:3 Practical:0

4. Relative Weightage: CWS:25 PRS:0 MTE:25 ETE:50 PRE:0

5. Credits:4 **6 Semester:** Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** DEC

9. Objective

To impart knowledge on the applications of X-ray diffraction for structural and chemical characterization

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	**Introduction:** Properties of X-rays, absorption, filters, production and detection	4
2	**Crystal Geometry:** Crystal systems, lattice direction and planes, crystal structure, atom sizes and coordination, twinned crystals, stereographic projection	6
3	**X-ray diffraction:** Bragg's Law, X-ray spectroscopy, diffraction methods; X-ray scattering by electron and atom, structure factor calculation, multiplicity factor, Lorentz factor, absorption factor, temperature factor, intensities of powder pattern lines	8
4	**Experimental Methods:** Laue methods, Debye-Scherrer method, focusing cameras, choice of radiation, background radiation, measurement of line position and intensity; Proportional counters, Geiger counter, scintillation counters, semiconductor counters	6
5	**Structure determination:** Single crystal orientation determination, crystal size determination, texture of wire and sheet, indexing patterns of cubic and non-cubic crystals, effect of distortion, unit cell determination	8
6	**Chemical analysis:** Quantitative analysis of single and multi-phase, wavelength dispersion, energy dispersion, microanalysis	6
7	**Residual stress measurement:** Applied stress and residual stress, diffractometer method, calibration, precision and accuracy	4
	Total	**42**

11. Suggested Books:

Sl. No.	Authors/Name of Books/ Publisher	Year of Publications/ Reprint
1	Cullity B.D. and Stock S.R., Elements of X-ray Diffraction, 3rd Ed., Prentice Hall	2001
2	Suryanarayana C. and Norton M.G., X-ray Diffraction: A Practical Approach, Springer	1998
3	Murphy B. and Seeck O.H., X-ray Diffraction: Modern Experimental Techniques, Pan Stanford Publishing	2011
4	Warren B.E., X-ray Diffraction, Dover Publications	1990
5	Guinier A., X-ray Diffraction: In Crystals, Imperfect Crystals and Amorphous Bodies, Dover Publications	1994
6	Habbar K.R., Basics of X-ray Diffraction and its Applications, I K International Publishing	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

1. Subject Code: MTN-533 **Course Title**: Electron Microscopy

2. Contact Hours: L: 3; T: 1; P: 0

3. Examination Duration (Hrs): **Theory:3** **Practical**:0

4. Relative Weightage: **CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE:** 0

5. Credits:4 **6 Semester:** Autumn/Spring

7. Pre-requisite: Nil **8. Subject Area:** DEC

9. Objective

To introduce the fundamentals of scanning and transmission electron microscopes as indispensable material characterization tools

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	**Introduction**: Human eye, optical microscope, transmission electron microscope (TEM), scanning electron microscope (SEM), scanning transmission electron microscope (STEM), analytical electron microscopes, scanning-probe microscopes	6
2	**TEM**: The electron gun, imaging system, theoretical limit, chromatic and spherical aberration, astigmatism, dept of field/focus, kinematics of scattering by atomic nuclei, electron-electron scattering, scattering contrast from amorphous and polycrystalline specimen, dark-field images, selected area diffraction technique, phase contrast, specimen preparation	10
3	**TEM image contrast**: Inelastic and elastic electron scattering, Kikuchi patterns, absorption and phase contrast, diffraction contrast, dynamical theory and solution for perfect crystal, grain boundary fringes, stacking fault fringes, Moiré fringes, dislocations, small loops, vacancy aggregates, precipitates	10
4	**SEM**: Operating principle, depth of field, noise, resolution, penetration of electrons into a solid, secondary-electron image, backscattered-electron image, other imaging modes, specimen preparation, environmental SEM, electron-beam lithography	8
5	**Analytical electron microscopy**: The Bohr atom model, X-ray emission spectroscopy, X-ray energy-dispersive spectroscopy, quantitative analysis in the TEM and SEM, X-ray wavelength-dispersive spectroscopy, auger electron spectroscopy (AES), electron energy-loss spectroscopy (EELS)	8
	Total	**42**

11. Suggested Books:

Sl. No.	Authors/Name of Books/ Publisher	Year of Publications/ Reprint
1	Goodhew P.J., Humphreys J. and Beanland R., Electron Microscopy and Analysis, 3rd Ed., Taylor and Francis	2000
2	Thomas G., Transmission Electron Microscopy of Materials, Techbooks	1990
3	Reimer L., Scanning Electron Microscope: Physics of Image Formation and Microanalysis, 2nd Ed., Springer	1998
4	Goldstein J., Newbury D.E., Joy D.C., Lyman C.E., Echlin P., Lifshin E., Sawyer L. and Michael J.R., Scanning Electron Microscopy and X-ray Microanalysis, 3rd Ed., Springer	2003
5	Carter C.B. and Williams D.B., Transmission Electron Microscopy: A Textbook for Materials Science, 2nd Ed., Springer	2009
6	Egerton R., Physical Principles of Electron Microscopy: An Introduction to TEM, SEM and AEM, Springer	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject code: **CEN-105** Course Title: **Introduction to Environmental Studies**
2. Contact Hours: **L: 3 T: 0 P: 0**
3. Examination Duration (Hrs): **Theory:** 3 **Practical:** 0
4. Relative Weightage: **CWS:** 15 **PRS:** 0 **MTE:** 35 **ETE:** 50 **PRE:** 00
5. Credits: **3** 6. Semester: **Autumn** 7. Subject Area: **GSC**
8. Pre-requisite: **Nil**
9. Objective: To introduce fundamentals of environmental pollution and its control.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Overview: Environment and Natural Processes; Development (Resource Utilization & Waste Generation); Environmental issues; Concept of Sustainable Development; Issues affecting future development (population, urbanization, health, water scarcity, energy, climate change, toxic chemicals, finite resources etc.); Environmental units	6
2.	Air –Water interaction: (Liquid phase-gas phase equilibrium) Henry's Law Constant with units, Dimensionless Henry's Law Constant	3
3.	Water –Soil Interaction: Carbonate System (Alkalinity and buffering capacity); Major ions in water; Natural Organic Matter (NOMs); Water quality parameters; Physical processes (Mass Balance): Spatio-temporal variation in quality of river water, lake water, ground water; Water quality standards	9
4.	Wetlands, water treatment and wastewater treatment .	6
5.	Air resources: Atmosphere; Air pollutants; Emissions and control of air pollutants; Atmospheric meteorology and dispersion; Transport of air (global, regional, local); Air/ atmospheric stability; Plume shape; Gaussian modeling; Air quality standards	9
6.	Land pollution and solid waste management	3
7.	Ecosystem: Structure and function; Energy flow in ecosystem; Material flow in ecosystem; Biodiversity and ecosystem health; Bio-amplification and bio-magnification	3
8.	Hazardous Waste: Definition; Classification; Storage and management; Site remediation; Environmental Risk: assessment, and management	3
Total		**42**

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication/ Reprint
1.	Davis M. L. and Cornwell D. A., "Introduction to Environmental Engineering", McGraw Hill, New York 4/e	2008
2.	Masters G. M., Joseph K. and Nagendran R. "Introduction to Environmental Engineering and Science", Pearson Education, New Delhi. 2/e	2007
3.	Peavy H. S., Rowe D.R. and Tchobanoglous G., "Environmental Engineering", McGraw Hill, New York	1986
4.	Mines R. O. and Lackey L. W. ""Introduction to Environmental Engineering", Prentice Hall, New Yark	2009
5.	Miheicic J. R. and Zimmerman J. B. " Environmental Engineering: Fundamentals, Sustainability, Design" John Wiley and Sons, Inc.	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Humanities & Social Sciences**

1. Subject Code: **HS-001A** Course Title: **Communication Skills (Basic)**

2. Contact Hours: **L: 1** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weight**:** **CWS** 25 **PRS** 00 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 2 6. Semester**: Autumn/Spring** 7. Subject Area**: HSS**

8. Pre-requisite**: NIL**

9. Objective:
The course intends to build the required communication skills of the students having limited communicative abilities, so that they may communicate effectively in real-life situations

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Understanding the Basics of Communication Skills: Listening, Speaking, Reading & Writing, Scope and Importance	**01**
2.	Grammar & Composition: Time and Tense, Agreement, Active-Passive, Narration, Use of Determiners, Prepositions & Phrasal Verbs	**05**
3.	Vocabulary Building & Writing: Word-formation, Synonyms, Antonyms, Homonyms, One-word Substitutes, Idioms and Phrases, Collocations, Abbreviations of Scientific and Technical Words	**02**
4.	Introduction to Sounds (Vowels & Consonants) Organs of Speech, Place and Manner of Articulation, Stress & Intonation, Listening Comprehension (Practical Sessions in Language Laboratory)	**02**

5.	Speaking, Countering Stage-fright and Related Barriers to Communication.	**02**
6.	Reading and Comprehension: Two lessons to be identified by the department.	**02**
	Total	**14**

List of Practicals:

1. Ice-breaking Exercises
2. Assignments on Time and Tense, Agreement, Active-Passive
3. Laboratory Session on Narration, Use of Determiners, Prepositions & Phrasal Verbs, Revisionary Exercises & Quiz
4. Laboratory Session on Synonyms, Antonyms, Homonyms
5. Assignments and Practice Sheets on One-word Substitutes, Idioms and Phrases, Collocations, Abbreviations of Scientific and Technical Words
6. Laboratory Session on Practice of sounds, Intonation and Stress, Listening Comprehension
7. Individual presentation, debates, Extempore & Turncoats
8. Exercises in Composition and Comprehension

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Murphy, Raymond. *Intermediate English Grammar*, New Delhi, Cambridge University Press.	**2009**
2.	Quirk, Randolph & Sidney Greenbaum. *A University Grammar of English*, New Delhi, Pearson.	**2009**
3.	McCarthy, Michael & Felicity O' Dell. *English Vocabulary in Use*, New Delhi, Cambridge University Press	**2010**
4.	Jones, Daniel. *The Pronunciation of English*, New Delhi, Universal Book Stall.	**2010**
5.	Birchfield, Susan M. *Fowler's Modern English Usage*, New Delhi, OUP.	**2004**
6.	Llyod, Susan M. *Roget's Thesaurus of English Words and Phrases*. New Delhi: Penguin.	**2010**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Humanities & Social Sciences**

1. Subject Code: **HS-001B** Course Title: **Communication Skills (Advanced)**

2. Contact Hours: **L: 1** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weight**:** **CWS** 25 **PRS** 00 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 2 6. Semester**: Autumn/Spring** 7. Subject Area**: HSS**

8. Pre-requisite**: NIL**

9. Objective: The course intends to train the learners in using both verbal and non-verbal communication effectively.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Advanced Communication Skills: Scope, Relevance, & Importance	01
2.	Soft Skills: Interpersonal Communication; Verbal & Non-verbal, Persuasion, Negotiation, Neuro-Linguistic Programming	03
3.	Communication and Media (Social and Popular), The Social and Political Context of Communication, Recent Developments and Current Debates in Media	04
4.	Cross-cultural and Global Issues in Communication: Race, Ethnicity, Gender & Diaspora	03
5.	Rhetoric and Public Communication, Audience Awareness, Emotionality	03
	Total	14

List of Experiments:

1. Discussion on the Process of Communication in Personal and Professional Life
2. Group Discussion, Case Studies and Role-Play
3. Assignments on E-mail Etiquette, Social Networking, Blog Writing, Discussions on Current Issues
4. Non-Verbal Communication in Cross-Cultural Situations, Case Studies, Group Discussions and Readings on Topics Related to Race, Ethnicity , Gender and Diaspora
5. Individual Presentations (Audience Awareness, Delivery and Content of Presentation)

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Rentz, Kathryn, Marie E. Flatley & Paula Lentz. *Lesikar's Business Communication CONNECTING IH A DIGITAL WORLD*, McGraw-Hill, Irwin	**2012**
2.	Bovee, Courtland L & John V. Thill. *Business Communication Today*. New Delhi, Pearson Education	**2010**
3.	McMurrey, David A. & Joanne Buckley. *Handbook for Technical Writing*, New Delhi, Cengage Learning.	**2009**
4.	Jones, Daniel. *The Pronunciation of English*, New Delhi, Universal Book Stall.	**2010**
5.	Allan & Barbara Pease. *The Definitive Book of Body Language*, New York, Bantam	**2004**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Humanities and Social Sciences**

1. Subject Code: **HSN-002** Course Title: **Ethics and Self-awareness**

2. Contact Hours: **L: 01** **T: 0 1** **P: 0**

3. Examination Duration (Hrs.): **Theory 2** **Practical 0**

4.Relative Weight**: CWS:25 PRS:0 MTE:25 ETE:50 PRE:0**

5. Credit **02** 6. Semester**: Autumn** 7. Subject Area**: HSSC**

8. Pre-requisite**: NIL**

9. Objective: To introduce the concepts pertaining to ethical and moral reasoning and action and to develop self - awareness.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction**: Definition of Ethics; Approaches to Ethics: Psychological, Philosophical, Social.	**1**
2	**Psycho-social t heories of m oral d evelopment**: View of Kohlberg; Morality and Ideology, Culture and Morality, Morality in everyday context.	**3**
3	**Ethical C oncerns**: Work Ethics and Work Values, Business Ethics, Human values in organizations.	**3**
4	**Self-Awareness**: Self Concept: Johari Window, Self and Culture, Self Knowledge, Self-Esteem; Perceived Self-control, Self-serving bias, Self-presentation, Self-growth: Transactional Analysis and Life Scripts.	**4**
5.	**Self D evelopment**: Character strengths and virtues, Emotional intelligence, Social intelligence, Positive cognitive states and processes (Self-efficacy, Empathy, Gratitude, Compassion, and Forgiveness).	**3**
	Total	**14**

11. Suggested Books:

S.No.	Name of Authors / Books / Publishers	Year of Publication
1.	Hall, Calvin S., Lindzey, Dardner., & Cambell, John B.,"Theories of Personality",Hamilton Printing Company.	1998
2.	Car Alan, "Positive Psychology: The Science of Happiness and Human Strengths", Brunner-Routledge.	2004
3.	Leary M.R., "The Curse of Self: Self-awareness, Egotism and the Quality of Human Life", Oxford University Press.	2004
4.	Louis P. P., "The Moral Life: An Introductory Reader in Ethics and Literature", Oxford University Press.	2007
5.	Corey, G., Schneider Corey, M., & Callanan, P., "Issues and Ethics in the Helping Professions", Brooks/Cole.	2011
6.	Snyder, C.R., Lopez, Shane, J., & Pedrotti, J.T., "Positive Psychology" Sage, 2nd edition.	2011

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MAN-001** Course Title: **Mathematics I**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 00 25 50 0

5. Credits**:** 4 6. Semester**: Autumn** 7. Subject Area**: BSC**

8. Pre-requisite**:** **None**

9. Objective: **To provide essential knowledge of basic tools of Differential Calculus, Integral Calculus , Vector Calculus and Matrix Algebra for degree students.**

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Matrix Algebra:** Elementary operations and their use in getting the Rank, Inverse of a matrix and solution of linear simultaneous equations. Orthogonal, Symmetric, Skew-symmetric, Hermitian, Skew-Hermitian, Normal & Unitary matrices and their elementary properties. Eigen-values and Eigenvectors of a matrix, Cayley-Hamilton theorem, Diagonalization of a matrix.	**8**
2.	**Differential Calculus:** Limit, Continuity and differentiability of functions of two variables, Euler's theorem for homogeneous equations, Tangent plane and normal. Change of variables, chain rule, Jacobians, Taylor's Theorem for two variables, Error approximations. Extrema of functions of two or more variables, Lagrange's method of undetermined multipliers	**12**
3.	**Integral Calculus:** Review of curve tracing and quadric surfaces, Double and Triple integrals, Change of order of integration. Change of variables. Gamma and Beta functions. Dirichlet's integral. Applications of Multiple integrals such as surface area, volumes, centre of gravity and moment of inertia..	**12**
4.	**Vector Calculus:** Differentiation of vectors, gradient, divergence, curl and their physical meaning. Identities involving gradient, divergence and curl. Line and surface integrals. Green's, Gauss and Stroke's theorem and their applications.	**10**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	E. Kreyszig, Advanced Engineering Mathematics, 9th edition, John Wiley and Sons, Inc., U.K.	2011
2.	R.K. Jain and S.R.K. Iyenger, Advanced Engineering Mathematics, 2nd Edition, Narosa Publishing House.	2005
3.	M.D. Weir, J. Hass, F.R. Giordano, Thomas' Calculus, 11th Edition, Pearson Education.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE **:** PHYSICS

1. Subject Code**: PHN-007** Course Title**: Modern Physics**

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory** | 0 | 3 | **Practical** | 0 | 0 |

4. Relative Weightage**: CWS** 10 **PRS** 15 25 50 00

5. Credits**:** | 0 | 4 | 6. Semester**: Autumn** 7. Subject Area**: BSC**

8. Pre-requisite**: None**

9. Objective:
The objective of the course is to present the basic elements of electrodynamics, quantum mechanics, electric and magnetic properties and lasers.

10. Details of Course:

S. No.	Particulars	Contact Hours
1	**Electrodynamics** Basic principles of electrostatics and magnetostatics, Maxwell's equations in differential form, physical significance of Maxwell's equations., wave equation and its solution for a dielectric medium, plane waves in a dielectric, concept of polarization, linear, circular and elliptical polarization, the Poynting vector, energy density and intensity of an e-m wave, reflection and refraction at the interface of two dielectrics	**12**
2	**Quantum mechanics** Basic postulates of quantum mechanics and meaning of measurement, Schrodinger wave equation, physical meaning of wave functions. Expectation values, probability current density, stationary states, particle in a 1-D box, 1-D step potential, reflection and transmission by a barrier and tunneling, 1-D harmonic oscillator.	**9**
3	**Electric and magnetic properties** Free electron theory of metals: allowed k values using periodic boundary conditions for 3-dimensional case, Fermi energy, Density of states and average energy, electrical conductivity of metals ; Electron in periodic potentials, velocity and effective mass of	**15**

	electrons, origin of the energy gap, Band theory of solids, classification of solids into metals, semiconductors and insulators. Magnetic properties of solids: derivation for diamagnetism and paramagnetism, ferromagnetism (qualitative description), Magnetostriction, Properties of dia, para and ferro magnetic materials - Langevin's theory of diamagnetism and paramagnetism - Weiss theory of ferromagnetism-antiferrimagnetism and ferrimagnetism	
4	**Laser Physics:** Basic properties of lasers, spontaneous and stimulated emissions, main components of a laser, ruby and He-Ne laser, semiconductor diode laser	**6**
	Total	**42**

List of experiments:

1. Study of magnetic field of a pair of coils in Helmholtz arrangement
2. Determination of e/m
3. Determination of first excitation potential of a gas by Frank-Hertz experiment
4. Determination of Stefan's constant
5. Determination of Planck's constant by radiation
6. To study and verify Malus' law
7. Study of polarization of light using quarter wave plate
8. Determination of Brewster's angle at glass-air interface
9. Determination of width of a slit by single-slit diffraction pattern
10. Four probe method of finding resistivity of semiconductor
11. Quinck'e Method for determining mass susceptibility
12. Wavelength of Na light by Newton's ring method

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1	D. J. Griffiths, "Introduction of Electrodynamics," PHI Learning Pvt. Ltd.	2009
2	M. N. O. Sadiku," Elements of Electromagnetics," Oxford Univ. Press	2009
3	Arthur Besiser, Concepts of Modern Physics, , Tata Mc Graw Hill	2003
4	Karl F Renk, Basics of Laser Physics, Springer-Verlag, Berlin	2012
5	S P Sukhatme, J K Nayak, Solar energy - Tata McGraw - Hill Publishing Company Ltd., New Delhi. 1st Reprint	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-002** Course Title: **Mathematical Methods**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory : 3** **Practical : 0**
4. Relative Weightage**:** **CWS: 25** **PRS: 0** **MTE : 25** **ETE : 50** **PRE: 0**
5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: BSC**
8. Pre-requisite**: Nil**
9. Objective: To provide knowledge of essential mathematical tools applied in solving ordinary and partial differential equations, initial and boundary value problems.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Ordinary Differential Equations:** Solution of linear differential equations with constant coefficients. Euler-Cauchy equations, Solution of second order differential equations by changing dependent and independent variables. Method of variation of parameters, Introduction to series solution method.	**10**
2.	**Partial Differential Equations:** Formation of first and second order partial differential equations. Solution of first order partial differential equations: Lagrange`s equation, Four standard forms of non-linear first order equations .	**6**
3.	**Laplace Transform:** Laplace and inverse Laplace transform of some standard functions, Shifting theorems, Laplace transform of derivatives and integrals. Convolution theorem, Initial and final value theorem. Laplace transform of periodic functions, error functions, Heaviside unit step function and Dirac delta function. Applications of Laplace transform.	**10**
4.	**Z - Transform:** Z – transform and inverse Z-transform of elementary functions, Shifting theorems, Convolution theorem, Initial and final value theorem. Application of Z- transform to solve difference equations.	**5**
5.	**Fourier series:** Trigonometric Fourier series and its convergence. Fourier series of even and odd functions. Fourier half-range series. Parseval`s identity. Complex form of Fourier series.	**5**
6.	**Fourier Transforms:** Fourier integrals, Fourier sine and cosine integrals. Fourier transform, Fourier sine and cosine transforms and their elementary properties. Convolution theorem. Application of Fourier transforms to BVP.	**6**
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Kreyszig, E., "Advanced Engineering Mathematics", Johan Wiley & Sons	2011
2.	Jain, R. K. and Iyenger, S. R. K., "Advanced Engineering Mathematics", Narosa Publishing House	2009
3.	Amarnath, T., "An Elementary Course in Partial Differential Equations", Narosa Publishing House (II Edition)	2012
4.	Hildebrand F. B., "Methods of Applied Mathematics", Courier Dover Publications	1992
5.	Rao, K. S., "Introduction to Partial Differential Equations", PHI Learning Pvt. Ltd. (II Edition)	2010
6.	Sneddon, I. N., " Elements of Partial Differential Equations", McGraw-Hill Book Company	1988
7.	Simmons, G. F. and Krantz, S. G., Differential Equations:Theory, Technique and Practice" , Tata McGraw-Hill Edition	2007