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NATIONAL INSITUTE OF TECHNOLOGY RAIPUR
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Phone : (0771) 2254200
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Courses for Semester V (Year 3)

National Institute of Technology, Raipur (C. G.)													
Course of Study and Scheme of Examination (NEW)							**B. Tech. V semester**					**METALLURGICAL ENGG.**	
S. No.	**Board of Studies**	**Sub. Code**	**Name of Subject**	Period/Week			Examination Scheme					Total Marks	Credits L+(T+P)/2
				L	T	P	TA	FE	SE	T.C.A.	ESE		
1	**METALLURGY**	MT20511(MT)	Heat Treatment Technology	3	1	-	20	15	15	50	70	120	4
2		MT20512(MT)	Metal Joining Processes (Welding, Brazing and Soldering))	3	1	-	20	15	15	50	70	120	4
3		MT20513(MT)	Ferrous Extractive Metallurgy II (Steel Making and Continuous casting)	3	1	-	20	15	15	50	70	120	4
4		MT20514(MT)	Deformation theories of metals and alloys	4	1	-	20	15	15	50	70	120	5
5		MT20515(MT)	Foundry Technology	3	1	-	20	15	15	50	70	120	4
6		MT2053X(MT)	***Optional I***	3	1	-	20	15	15	50	70	120	4
7		MT20521(MT)	Foundry Technology Lab	-	-	3	30	-	-	30	20	50	2
8		MT20522(MT)	Metal Joining Processes Lab	-	-	3	30	-	-	30	20	50	2
9		MT20523(MT)	Heat Treatment Technology lab	-	-	3	30	-	-	30	20	50	2
10	Humanities	EN20524(MT)	Managerial Skill	-	-	2	25	-	-	25	0	25	1
11	Metallurgy	MT20525(MT)	Technical Visit/ Practical Training	-	-		25	-	-	25	0	25	1
TOTAL				**19**	**6**	**11**	**260**	**90**	**90**	**440**	**480**	**920**	**33**

TA= Teacher Assessment, FE= First Exam. , SE= second Exam., T.C.A.= Total of continuous assessment, ESE=End Sem. Exam.

Choices for optional courses in Semester in V (Year 3)

Optional	Subject Code	Course
Optional I	1020531(MT)	Powder metallurgy
	1020532(MT)	Solidification of metals and alloys

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Name of the Subject	Heat Treatment Technology	Subject Code	MT20511(MT)
Semester	V	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	-	4 (Th)

HEAT TREATMENT TECHNOLOGY

Objective and variables of heat treatment, Limitation of Fe-Fe_3C Phase Diagram, Thermodynamics and Kinetics of phase transformation , Formation of Austenite, Bainitic and Martensitic transformations. Heat treatment furnaces and furnace atmosphere TTT and CCT Diagram, Types of TTT Diagram. ; Application of TTT Diagrams (Martempering, Austempering and Patenting). Annealing (Full, Homogenising, Spheroidization and Stress-relieving annealing), Normalising, Comparison of Annealing and Normalising, Hardening and Tempering of plain and alloy steels, Hardening (Objective, Austenitizing temperature and Internal stresses), Quenching Mediums and Methods, Retained austenite and Defects in Hardening, Tempering of steels, Aims and stages of tempering, Effects of Carbon and alloying elements, Tempering of alloy steels and Multiple tempering, Quenching mediums and Methods, Retained austenite and Defects in Hardening. Tempering of steels, Aims and stages of tempering, Effects of Carbon and alloying elements, Tempering of alloy steels and Multiple tempering. ; Thermo-mechanical Treatment of steels: Principles and Practices, Ausforming and Isoforming. Embrittlement during tempering, Hardenability and its determination, Factors affecting. ; Case and Surface hardening: Carburising, Nitriding and Carbonitriding, Induction and Laser Hardening. ; Heat treatments of general engineering steels: Spring, Bearing steels, Tool steels, HSLA steel and Managing steels, Dual phase steels and Stainless steels, Heat Treatments of Al-alloys, Cu-alloys and Ti- alloys. ; Age-Hardening: Types and sequence of precipitates, Mechanism and Kinetics of precipitation. ; Heat treatment defects and their rectification. ; Advances of heat treatment technology.

Essential Reading:

1. B. Zakharov, Heat Treatment of Metals, CBS Publishers.
2. Principles of Heat Treatment of Steels, ASM.
3. Heat Treatment of Metals- Vijendar Singh, Standard Publishers Distributors, Delhi

Supplementary Reading:

1. C.R. Brooks, Principles of the Heat Treatment of Plain Carbon and Low Alloy Steels, ASM International.
2. R. Kumar, Physical Metallurgy of Iron and steels, Asia Publishing House.
3. G. Krauss, Steels: Processing, Structure and Performance, ASM International.
4. K E Thelning, Steel and Its Heat Treatment, Butterworth.
5. W C Leslie, The Physical Metallurgy of Steels, McGraw-Hill International.

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Name of the Subject	Metal Joining Processes (Welding, Brazing and Soldering))	Subject Code	MT20512(MT)
Semester	V	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	-	4 (Th)

METAL JOINING PROCESS (WELDING, BRAZING AND SOLDERING)

Scope of metal joining, welding processes and their influence on the design, welding terms, and characteristics, basic principles of solidification, solidification of single phase and multiphase metals and alloys, Denderitic and cellular structure, Segregation, brittleness in materials. Weld preparation and design of welding joints, Metal Joining Operation: Soldering, Brazing and welding.

Heat flow in welding temperature distribution, peak temperature, cooling rate, welding metallurgy, structure of weld metal, weld composition, the heat affected zone, weldability, fracture behaviour, weldability test, welding defects and remedies, Problem based on welding.

Gas welding & arc welding general, shielded metal arc welding, submerged arc welding gas tungsten arc welding, gas metal arc welding, plasma arc welding, stud welding, resistant welding, electro-slag welding, electron beam welding.

Forge welding, cold welding, diffusion welding, carbon arc welding, atomic hydrogen welding, friction welding, induction welding, flash welding, laser welding, thermit welding, explosive welding, ultrasonic welding. Recent trend in welding technology,

Welding of specific alloys: Welding of cast iron, welding of copper alloy, aluminium alloy, stainless steel welding of dissimilar metal, welding of heat resistant alloy, residual stresses and distribution, testing and inspection

Text Books:

1. The Science and practice of welding – A C Davies
2. Welding and welding technology – Richard L. Little
3. Welding process and technology – Raman and Eric N. simons
4. Modern metal joining technique – M Schwart
5. The metallurgy of welding – John Wiley

References;

1. Weldability of Ferritic Steels – Norman Bailey
2. Solidification and Casting – G J Davis

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Name of the Subject	Ferrous Extractive Metallurgy II (Steel Making and Continuous casting)	Subject Code	MT20513(MT)
Semester	V	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	-	4 (Th)

FERROUS EXTRACTION METALLURGY II (STEEL MAKING AND CONTINOUS CASTING)

World and Indian steel scenario, Detailed layout of steel making plant, Intergrated Vs mini steel plant, Raw Materials and refractories for steel making, External treatment of hot metal, Brief idea about Historical steel making – Bessemer, open hearth and modified open hearth steel making.

Thermodynamics and kinetics of steel making Reactions, Laws of thermodynamics and application to the treatment of ferrous melts and slags, Reactions of carbon, silicon, manganese, phosphorous and sulphur; Steel furnace slags, properties, and slag control, Slag theories: Molecular & Ionic theories; Interpretation of the above reactions in terms of ionic theory of slag; Deoxidation practice, Refining of ferrous – melt under oxygen jet; Mechanism of refining and kinetics.

Basic oxygen furnace (BOF) STEEL MAKING, top and bottom down blown oxygen steel making furnaces, thermal balance in oxygen converter, process control in L. D. converter, some characteristics of LD blow viz. Emulsion formation, Slopping, Lance height for dephosphorisation & decarbunisation, treatment of high phosphorous iron in modified L. D. processes.

Mechanism of solidification & Ingot casting, Types of steel- killed, semi-killed & rimmed steel, ingot structure and defects.

Evolution of Continuous casting of steel, different types of caster, continuous casting theory and practice, teeming practice and recent advances- EMS, mould level controller, near net casting

Electric Arc Furnace – Advantages, Charging, melting & refining practices for plain carbon & Alloy steel, Use of DRI in arc furnace & it's effect on performance.

Brief introduction of Secondary Advance and Emerging Technologies for Steelmaking, steelmaking challenges

Text Books

1. Steel Making Technology – Kudrin
2. Tupkary R.H. : "Introduction to Modern Steel Making" Khanna Publishers, Delhi
3. Bodsworth : "The Physical Chemistry of Steel Making"

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Reference Books:

1. G. Oike : "Converter and open hearth steel manufacture", Mir Publishers.
2. Jackson A. : "Oxygen steel making for steel Makers", George newries Ltd., London.
3. A.I.M.E. : "Electric furnace steel Making", Vol. I and II.
4. Camp and Francis : "The Making, shaping and Treating of steel", (USS)
5. Blast Furnace Theory – l Practice Strauff

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Name of the Subject	Deformation theories of metals and alloys	Subject Code	MT20514(MT)
Semester	V	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
4	1	-	5 (Th)

DEFORMATION THERIES OF METALS AND ALLOYS

Plastic deformation of metals Elastic Behaviour: Concept of elasticity in three dimensions, Generalised Hook's Law, Plane stress and plane strain state, Strain energy, Stress intensity factor, Concept of finite element method. ; Theory of Plasticity: Flow curve, Yield criteria, Plastic stress strain relationship. ; Dislocation Theory: Line defects, Deformation by slip, Theoretical shear strength, Critical resolved shear stress, Burger□s vector and dislocation loop, Edge, Screw, Mixed and Partial dislocations, Dislocation reactions, Dislocations in fcc and bcc crystals, Cross slip and climb of dislocations, Interaction of dislocations, Energy of dislocations, Forces on dislocations, Dislocation sources and multiplication of dislocations. ; Dislocation pile-ups and Bauschinger's effect, Strain hardening in single crystals and polycrystals, Yield point phenomenon, Strain aging, Dynamic strain aging, Strengthening mechanisms. ; Deformation Twinning: Classification, Slip vs. twinning, Stress for twinning

Failures – Types and their characteristics, nucleation of cracks and their propagation, theoretical cohesive strength of metals, Griffith theory of brittle failure, dislocation theory of fracture, ductile of brittle transition.

Text book

Mechanical metallurgy, George E. Dieter

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Name of the Subject	Foundry Technology	Subject Code	MT20515(MT)
Semester	V	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	-	4 (Th)

FOUNDRY TECHNOLOGY

Introduction: Casting as a process of Manufacturing. 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. ; 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 CI, Al, Cu steel, cast irons. ; 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 ; Principles of Gating and Rise ring: 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. ; Special casting Methods: Investment casting, Die casting, Centrifugal casting, Full mould casting, Vacuum sealed casting. ; Casting Defects: A detailed analysis of casting defects, their causes and Prescription of remedial measures.

Essential Reading:

1. P. R. Beeley, Foundry Technology, Newnes-Buttterworths, 2001.
2. P. D. Webster, Fundamentals of Foundry Technology, Portwillis press, Red Hill, 1980.

Supplementary Reading:

1. P. C. Mukherjee, Fundamentals of Metal casting Technology, Oxford IBH, 1980.
2. R. W. Hein, C.R. Loper and P.C. Rosenthal, Principles of Metal casting, Mc Graw Hill, 1976.

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Optional I MT2053X(MT)

Name of the Subject	Powder metallurgy	Subject Code	MT20531(MT)
Semester	V	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	-	4 (Th)

POWDER METALLURGY

Introduction of ceramics, Common ceramics crystal structures: silicates, clay, minerals, graphite and carbides. Classification and applications of ceramics materials. Raw materials preparation,

Different structural ceramics: their properties and applications. ; Mechanical behavior of different structural ceramics-brittleness of ceramics, Concept of fracture toughness and different toughness measurement techniques, Elastic modulus, Strength measurement, Weibull theory. ;

Processing and properties of ceramics composites, Powder preparation: Powder flow, Compressibility and porosity measurements, Powder forming, Consolidation and different powder processing routes, Behavior of powder during compaction: Die compaction. Different modern powder compaction methods: Hot isostatic pressing, Spark plasma sintering, and Microwave sintering. Sintering of powders and evaluation of sintered products. Sintering theories, Sold and liquid phase sintering,

Characterization of powders: composition and their structure, Particle size and shape determination; Applications of sintered products: Thermal, friction, High temperature, Corrosion, Bearing, Magnetic and electrical applications.

Essential Reading:

1. W.D. Kingery, H. K. Bowen, D. R. Uhlmann, Introduction to Ceramics, Wiley Publishers, 1986.
2. R. German, Powder Metallurgy, John Wiley & Sons, 2006.

Supplementary Reading:

1. M.N. Rahaman, Ceramic processing & Sintering, Marcel Dekker, 1995.

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Name of the Subject	Solidification of metals and alloys	Subject Code	MT 20532(MT)
Semester	V	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	-	4 (Th)

SOLIDIFICATION OF METALS AND ALLOYS

Importance of solidification in metal casting processes , Heat Flow and Heat evolution in Solidification: Growth of signal crystals, directional solidification, crystal growth etc., Nucleation and interface kinetics: Solidification in casting and ingots, Solidification of alloys, Problems in multi dimensional heat flow

Plane front solidification of single phase alloy:, Equilibrium solidification, NO solid Diffusion, Limited liquid diffusion, Effect of convection, Czochralski growth, Zone melting, the facets effect,

Cellular solidification, constitutional super cooling and cell formation, Cell structure, formation of dendrites,

Plane front solidification of Polyphase alloy: lamellar eutectic growth, rod eutectic growth, Interface stability, non steady state growth, Solidification in casting and ingots

Fluid Flow, Thermodynamics of solidification, Nucleation and interface kinetics, introduction to FEM of modelling of solidification of metals and alloys, Process and properties

Text book:

Solidification Processing by Merton C. Flemings , Mcgraw-Hill College (June 1974)