

***Proposed New Scheme and Syllabus for the
Academic Programme (B. Tech) In
Metallurgical Engineering
NIT Raipur (C. G.)
2011-2012***



राष्ट्रीय प्रौद्योगिकी संस्थान रायपुर
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**Brief highlight of the Courses offered by the Department of Metallurgical Engineering for the program
 B. Tech in Met Engineering during 2nd, 3rd and 4th year**

	Semester III	Semester IV	Semester V	Semester VI	Semester VII	Semester VIII	
Theory Papers	1	Numerical Analysis and Computer Programming	Testing of Materials	Heat Treatment Technology	Engg. Economics & Industrial management	Corrosion Engineering	Fracture and Failure Analysis
	2	Fundamentals of Electrical Technology and Electronics	Physical Metallurgy	Metal Joining Processes (Welding, Brazing and Soldering))	Metal Forming Processes	Phase Transformation and Phase Equilibrium	Alloy Design and Application
	3	Introduction to Materials Science	Ferrous Extractive Metallurgy I (Iron Making)	Ferrous Extractive Metallurgy II (Steel Making and continuous casting)	Secondary & special steel making	Optional III [Ceramics Engineering/ Polymers Engineering/ Composite Materials]	Optional V (X-ray Diffraction and electron microscopy/ Application of soft computing in Materials Engineering/Hydro and Electro Metallurgy)
	4	Metallurgical Thermodynamics	Engineering of Non-metallic Materials (ceramics, glasses, polymers and fluids)	Deformation theories of metals and alloys	Materials Modelling and Simulation	Optional IV (Light metals and alloys/ Advanced Materials/ Introduction to Nanoscience and Nanotechnology)	Optional VI (Surface Engineering/ Nuclear Materials/ Solar Energy Materials)
	5	Fuel, Furnaces and Refractory	Principles of Non Ferrous Extractive Metallurgy	Foundry technology	Material Characterization Technique	-----	-----
	6	Minerals and Ores Beneficiation	Transport phenomena in metallurgical processes	Optional I (Powder metallurgy/Solidification of metals and alloys/..)	Optional II (Biomaterials/ Non destructive evolution of materials/....)	-----	-----
Practical	1	Fuel, Furnaces and Refractory Lab	Physical Metallurgy Lab	Foundry technology Lab	Metal Forming Processes Lab	Corrosion Engineering lab	Fracture and Failure Analysis Lab
	2	Numerical Analysis and Computer Programming Lab	Testing of Materials Lab	Metal Joining Processes Lab	Material Characterization lab	Phase Transformation Lab	Alloy Design and Application lab
	3	Minerals and Ores Beneficiation lab	Transport phenomena in metallurgical processes Lab	Heat Treatment Lab	Materials Modelling and Simulation Lab	Minor Project	Major Project

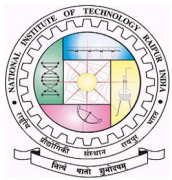


Basic structure of the 4 years B. Tech Metallurgical Engineering Program

Courses for Semester III (Year 2)

National Institute of Technology, Raipur (C. G.)													
Course of Study and Scheme of Examination (NEW)				B. Tech. III 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	MT20311(MT)	Numerical Analysis and Computer Programming	3	1	-	20	15	15	50	70	120	4
2	Electrical	EL20312(MT)	Fundamentals of Electrical Technology an Electronics	3	1	-	20	15	15	50	70	120	4
3	Metallurgy	MT20313(MT)	Introduction to Materials Science	3	1	-	20	15	15	50	70	120	4
4	Metallurgy	MT20314(MT)	Metallurgical Thermodynamics	4	1	-	20	15	15	50	70	120	5
5	Metallurgy	MT20315(MT)	Fuel, Furnaces and Refractory	3	1	-	20	15	15	50	70	120	4
6	Metallurgy	MT20316(MT)	Minerals and Ores Beneficiation	3	1	-	20	15	15	50	70	120	4
7	Metallurgy	MT20321(MT)	Numerical Analysis and Computer Programming Lab	-	-	3	30	-	-	30	20	50	2
8	Metallurgy	MT20322(MT)	Minerals and Ores Beneficiation lab	-	-	3	30	-	-	30	20	50	2
9	Metallurgy	MT20323(MT)	Fuel, Furnaces and Refractory Lab	-	-	3	30	-	-	30	20	50	2
10	Humanities	EN20324(MT)	Value Education	-	-	2	25	-	-	25	0	25	1
11	Metallurgy	MT20325(MT)	Discipline	-	-		25	-	-	25	0	25	1
TOTAL				19	6	11	260	90	90	440	480	920	33

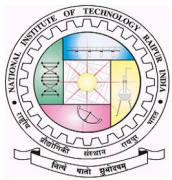
TA= Teacher Assessment, FE= First Exam. , SE= second Exam., T.C.A.= Total of continuous assessment, ESE=End Sem. Exam.



Courses for Semester IV (Year 2)

National Institute of Technology, Raipur (C. G.)													
Course of Study and Scheme of Examination (NEW)				B. Tech. IV 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	MT20411(MT)	Testing of Materials	3	1	-	20	15	15	50	70	120	4
2	Metallurgy	MT20412(MT)	Physical Metallurgy	3	1	-	20	15	15	50	70	120	4
3	Metallurgy	MT20413(MT)	Ferrous Extractive Metallurgy I (Iron Making)	3	1	-	20	15	15	50	70	120	4
4	Metallurgy	MT20414(MT)	Engineering of Non-metallic Materials (ceramics, glasses, polymers and fluids)	3	1	-	20	15	15	50	70	120	4
5	Metallurgy	MT20415(MT)	Principles of Non Ferrous Extractive Metallurgy	3	1	-	20	15	15	50	70	120	4
6	Metallurgy	MT20416(MT)	Transport phenomena in metallurgical processes	4	1	-	20	15	15	50	70	120	5
7	Metallurgy	MT20421(MT)	Physical Metallurgy Lab	-	-	3	30	-	-	30	20	50	2
8	Metallurgy	MT20422(MT)	Testing of Materials Lab	-	-	3	30	-	-	30	20	50	2
9	Metallurgy	MT20423(MT)	Transport phenomena in metallurgical processes Lab	-	-	3	30	-	-	30	20	50	2
10	Humanities	EN20424(MT)	Personality Development	-	-	2	25	-	-	25	0	25	1
11	Metallurgy	MT20425(MT)	Discipline	-	-		25	-	-	25	0	25	1
TOTAL				19	6	11	260	90	90	440	480	920	33

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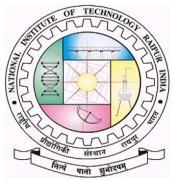
Courses for Semester V (Year 3)

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		MT20512(MT)	Ferrous Extractive Metallurgy II (Steel Making and Continuous casting)	3	1	-	20	15	15	50	70	120	4
4		MT20512(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)	<i>Optional I</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

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

Optional	Subject Code	Course
<i>Optional I</i>	1020531(MT)	Powder metallurgy
	1020531(MT)	Solidification of metals and alloys



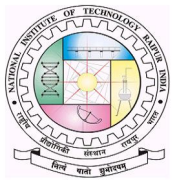
Courses for Semester VI (Year 3)

National Institute of Technology, Raipur (C. G.)													
Course of Study and Scheme of Examination (NEW)				B. Tech. VI 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	MT20611(MT)	Engineering Economics and Industrial Management	3	1	-	20	15	15	50	70	120	4
2		MT20612(MT)	Metal Forming Processes	4	1	-	20	15	15	50	70	120	5
3		MT20613(MT)	Secondary & Special Steel Making	3	1	-	20	15	15	50	70	120	4
4		MT20614(MT)	Materials Modeling and Simulation	3	1	-	20	15	15	50	70	120	4
5		MT20615(MT)	Material Characterization Technique	3	1	-	20	15	15	50	70	120	4
6		MT2063X(MT)	<u>Optional II</u>	3	1	-	20	15	15	50	70	120	4
7		MT20621(MT)	Metal Forming Processes Lab	-	-	3	30	-	-	30	20	50	2
8		MT20622(MT)	Material Characterization lab	-	-	3	30	-	-	30	20	50	2
9		MT20623(MT)	Materials Modeling and Simulation Lab	-	-	3	30	-	-	30	20	50	2
10	Humanities	EN20624(MT)	I & E Skill	-	-	2	25	-	-	25	0	25	1
11	Metallurgy	MT20625(MT)	Discipline	-	-		25	-	-	25	0	25	1
TOTAL				19	6	11	260	90	90	440	480	920	33

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

Optional	Subject Code	Course
<u>Optional II</u>	1020631(MT)	Biomaterials
	1020632(MT)	Non Destructive Evolution of Materials



Courses for Semester VII (Year 4)

National Institute of Technology, Raipur (C. G.)													
Course of Study and Scheme of Examination (NEW)				B. Tech. VII 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	MT20711(MT)	Corrosion Engineering	4	1	-	20	15	15	50	70	120	5
2		MT 20712(MT)	Phase Transformation and Phase Equilibrium	3	1	-	20	15	15	50	70	120	4
3		MT 2073X(MT)	<u>Optional III</u>	3	1	-	20	15	15	50	70	120	4
4		MT 2074X (MT)	<u>Optional IV</u>	3	1	-	20	15	15	50	70	120	4
5		MT 20721(MT)	Corrosion Engineering lab	-	-	3	30	-	-	30	20	50	2
6		MT 20722(MT)	Phase Transformation Lab	-	-	3	30	-	-	30	20	50	2
7		MT 20723(MT)	Practical training	-	-	-	50	-	-	50	-	50	2
8		MT 20724(MT)	Minor Project	-	-	12	100	-	-	100	50	150	6
9		MT 20725(MT)	Seminar And Report writing	-	-	2	50	-	-	50	-	50	1
TOTAL				13	4	20	340	60	60	460	370	830	30

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

Optional	Subject Code	Course
<u>Optional III</u>	1020731(MT)	Ceramics Engineering
	1020732(MT)	Polymers Engineering
	1020733(MT)	Composite Materials
<u>Optional IV</u>	1020741(MT)	Light metals and alloys
	1020742(MT)	Advanced Engineering Materials
	1020743(MT)	Introduction to Nanoscience and Nanotechnology



Courses for Semester VIII (Year 4)

National Institute of Technology, Raipur (C. G.)													
Course of Study and Scheme of Examination (NEW)				B. Tech. VIII 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	MT 20811(MT)	Fracture and Failure Analysis	3	1	-	20	15	15	50	70	120	4
2		MT 20812(MT)	Alloy Design and Application	4	1	-	20	15	15	50	70	120	5
3		MT 2083X(MT)	<i>Optional V</i>	3	1	-	20	15	15	50	70	120	4
4		MT 2084X(MT)	<i>Optional VI</i>	3	1	-	20	15	15	50	70	120	4
5		MT 20821(MT)	Fracture and Failure Analysis Lab	-	-	3	30	-	-	30	20	50	2
6		MT 20822(MT)	Alloy Design and Application Lab	-	-	3	30	-	-	30	20	50	2
7		MT 20823(MT)	Major Project	-	-	16	100	-	-	100	100	200	8
8		MT 20824(MT)	Discipline	-	-		50	-	-	50	-	50	1
TOTAL				13	4	22	290	60	60	410	420	830	30

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 VIII (Year 4)

Optional	Subject Code	Course
<i>Optional V</i>	1020831(MT)	X-ray Diffraction and electron microscopy
	1020832(MT)	Application of soft computing in Materials Engineering
	1020833(MT)	Hydro and Electro Metallurgy
<i>Optional VI</i>	1020841(MT)	Surface Engineering
	1020842(MT)	Nuclear Materials
	1020843(MT)	Solar Energy Materials



Name of the Subject	Numerical Analysis and Computer Programming	Subject Code	MT20311(MT)
Semester	III	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	3	4 (Th) + 2 (P)

Numerical Analysis

Approximations and round off errors, Truncation errors and Taylor Series, Determination of roots of polynomials and transcendental equations by Newton-Raphson, Secant and Bairstow's method.

Solutions of linear simultaneous linear algebraic equations by Gauss Elimination and Gauss- Siedel iteration methods, Curve fitting- linear and nonlinear regression analysis.

Backward, Forward and Central difference relations and their uses in Numerical differentiation and integration, Application of difference relations in the solution of partial differential equations. Numerical solution of ordinary differential equations by Euler, Modified Euler, Runge-Kutta and Predictor-Corrector method

Computer Programming

Introduction to computer programming in C and C++ languages. Arithmetic expressions, Simple programs. Example of some simple C program. Dissection of the program line by line. Concepts of variables, program statements and function calls from the library (printf for example) C data types, int, char, float etc.

C expressions, arithmetic operations, relational and logic operations. C assignment statements, extension of assignment to the operations. C primitive input output using getchar and putchar, exposure to the scanf and printf functions. C statements, conditional execution using if, else. Optionally switch and break statements may be mentioned.

Concepts of loops, example of loops in C using for, while and do-while. Optionally continue may be mentioned.

One dimensional arrays and example of iterative programs using arrays, 2-d arrays. Use in matrix computations.

Concept of Sub-programming, functions. Example of functions. Argument passing mainly for the simple variables.

Pointers, relationship between arrays and pointers. Argument passing using pointers. Array of pointers, Passing arrays as arguments.

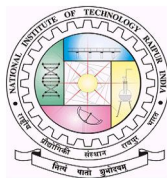
Strings and C string library. Structure and unions. Defining C structures, passing structures as arguments. Program examples. File I/O. Use of fopen, fscanf and fprintf routines.

Suggested Text Books & References.



Suggested Text Books & References.

- Shastry, S.S., "Numerical Methods", Prentice Hall Inc., India, 1998.
- Noble Ben, "Numerical Methods", New York International Publications, New York, 1964.
- Stanton Ralph G., "Numerical Methods for Engineering", Englewood cliffs, N.J., Prentice Hall Inc., 1961.
- Buckingham R.A., "Numerical Methods", Sir Isaac Pitman Sons. Ltd., London, 1957.
- Bakhvalov, N .S., "Numerical Methods", Mir. Pub., Moscow, 1977.
- Grewal, B.S., "Numerical Methods", Khanna Pub., New Delhi, 1998.
- Sudhit Kaicker, "The Complete ANSI C", BPB Publications, New Delhi, 1996.
- Kernighan, B. W. and D .M. Ritchie, "The C Programming Language", Prentice Hall of India, 1998.
- Byron, S. Gottfreid, "Programming with C", Tata McGraw Hill, 2nd edition 1998.



Name of the Subject	Fundamentals of Electrical Technology and Electronics	Subject Code	EL20312(MT)
Semester	III	Board of Studies	Electrical
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	-	4 (Th)

D.C. Motors – Operating principles, classification, characteristics, (Elect & Mechanical) starting method 3point & 4 point starter, speed control -ward Leonard control braking Application

A.C. motors –(a) Construction and operating principles of three phase induction motor, equivalent circuit, Torque slip characteristics, Star delta starter. (b) Three phase synchronous motor- working principles, starting, application.(c) Single phase Induction Motor fractional horse power motors, their applications

Semiconductors and Transistors – Intrinsic and extrinsic semiconductors, PN junction diodes, zener diode, junction transistors PNP and NPN transistors and their working in CB CE and CC configurations, Half wave and Full wave rectifier circuits using semiconductors, Basic amplifier circuit.

Electric Heating – Modes of transfer of heat, Classification of electrical heating method. Resistance heating, Infrared heating Arc furnaces Induction heating, High frequency eddy current heating, Dielectric heating, choice of frequency.

Electric welding – Resistance welding, electric arc welding, ultrasonic welding, electron beam welding, laser beam welding Requirements of good weld. Preparation of work electrodes, Electric welding equipment

Text Books:

1. Electrical Technology Vol-I & II B.L. Theraja
2. Basic Electronics – Theraja

Reference Book

1. Basic electronics – V.K. Mehata (S.Chand & Co.)
2. Basic Electronics – Tata McGraw Hill



Name of the Subject	Introduction to Materials Science	Subject Code	MT20313(MT)
Semester	III	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	-	4 (Th)

Role of metals and materials in the service of mankind, brief history of materials science and metallurgical engineering, Introduction, Significance of Structure-Property correlation

Classification of materials: Metals & Alloys, Ceramics, Polymers, Composites and Semiconductors, Comparison of general spectrum of their physical, mechanical and electrical properties. Atomic Structure & Inter-atomic Bonding: Fundamentals of Atomic Structure and Chemical Bonding; Atomic Bonding in Solids Ionic, Covalent, and Metallic bonding.

Mechanical Properties of Materials: Elastic, Plastic and Viscoelastic Behaviour of materials, Stress-strain relationship, Concept of true stress, true strain flow curve,

Thermal properties of materials: Heat capacity, Thermal expansion and thermal conductivity. Electrical properties of materials: Electronic and Ionic conduction; Energy Band structures in solids ; Electron Mobility ; Temperature variation of conductivity.

Dielectric behaviour: Capacitance ; Types of polarization ; Frequency dependence of dielectric constant, Ferroelectricity and Piezoelectricity in materials.

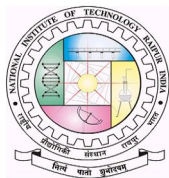
Magnetic properties: Diamagnetic; Ferromagnetic, anti-ferromagnetic and Ferrimagnetic behaviour of Materials, soft and hard magnetic materials, superconductivity.

Optical properties: Light interaction with solids; Absorption, Transmission and Reflection, Luminescence; Photoconductivity, Lasers. Environmental Degradation of materials: Oxidation and Corrosion; Thermal and Photo Degradation, Chemical Degradation, Radiation Damage.

Materials selection: Material properties and Engineering Design parameters; General effects of processing on parameters, selection of structural, Electronic and Magnetic Materials – case studies.

Books:

1. V Raghavan – Materials Science & Engineering. – Prentice Hall of India Pvt. Ltd., New Delhi.
2. Murthy & Jena: Structure and properties of Engineering Materials ,TMH New Delhi
3. W D Callister, Jr. – Materials Science & Engineering – An Introduction – John Willey & Sons, Inc, New York.
4. J F Shackelford – Introduction to Materials Science for Engineers – Maxwell Macmilan International Editions, Singapore.



Name of the Subject	Metallurgical Thermodynamics	Subject Code	MT20314(MT)
Semester	III	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
4	1	-	5 (Th)

Scope and concept – Energy and its forms systems, path and state properties, Thermodynamics processes, Thermodynamic equilibrium, Reversible and Irreversible processes. First law of thermodynamics, Internal energy, Specific heat, Enthalpy and their derivative; Thermo-chemistry – Thermo-chemical laws and applications.

Second law of thermodynamics – Entropy and its derivative; Concept of free energy, Criterion of equilibrium, thermodynamic potential; Zeros and third law of thermodynamics; Heat Capacity and Entropy Changes. Sensible Heats, Transformation Heats, Reaction Heats, ΔC_p , $\Delta H=f(T)$, $\Delta S=f(T)$, Adiabatic Flame Temperatures, Heat Balances.

Chemical Potential, Gibbs - Helmholtz Equation, Criteria of Equilibria, Phase Equilibria in One Component Systems, Clausius - Claperyon Equation, Heats of Vaporization from Vapor Pressure Data, Shift in Transformation Temperature with Pressure. Fugacity, activity and equilibrium constant, Vant Hoff's isotherm, **Ellingham diagrams for oxides, sulphides, halides etc. and their applications to metallurgical processes.**

The Behavior of Gases. Compressibility Factor, Law of Corresponding States, Equations of State, Fugacity. Reactions Equilibria - The effect of temperature and pressure on equilibrium constant. Equilibria in Gaseous Systems, The Equilibrium Constant and ΔG° , Reaction Extent Problems, Equilibria in Systems Containing Condensed Phases,

Solution Thermodynamics - Thermodynamic solutions. Raoult's law. Henry's law. Sievert's law. Absolute and Partial and Integral Molar Quantities, Relative and Partial Integral Molar Quantities, Ideal Solutions, Excess Quantities, Gibb's-Duhem Equation, Tangent Intercept Method, Change in Reference State, 1 wt % Reference State Interaction Parameters. Actual solutions. Regular solutions.

Application of the laws of thermodynamics to metallurgical processes, Thermodynamics of Electro-chemical Cell and Application. ,interfacial phenomena, extraction and refining of materials. Kinetics of Metallurgical reactions; Collision theory; Theory of absolute reaction rates. Chemical Kinetics - Order and molecularity of reaction; Arrhenuis equation

Books:

1. Introduction to Metallurgical Thermodynamics, David R. Gaskell.
2. Problems in Thermodynamics & Kinetics, G. S. Upadhyaya and R. N. Dubey.

Reference:



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1. Chemical Metallurgy, J.J. Moore
 2. Physical Chemistry of Metals, L. S. Darken and G. Gurry, Tata Mc-Graw hill.
 3. Metallurgical Thermodynamics, ML Kapoor Part I & II
 4. Dr. Tupkary R.H.; Introduction to Metallurgical Thermodynamics
 5. A. Ghosh; Text book of Materials & Metallurgical Thermodynamics; Prentice Hill of India, Delhi, 2003



Name of the Subject	Fuel, Furnaces and Refractory	Subject Code	MT20315(MT)
Semester	III	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	3	4 (Th) + 2 (P)

Metallurgical coke, manufacture, specifications, testing and properties; Coking and Non-coking coals; Characterization of coal properties (caking and swelling indices, calorific value, proximate and ultimate analysis, etc); Coal carbonization and effects of different parameters; Properties of coke, char and graphite; Fuel combustion and the effects of different factors; Combustion calculations; Alternative source of energy (viz. ferro coke, formed coke, charcoal, solar, wind, tidal, etc.) and their suitability for metallurgical and power industries. Fuel for Sponge Iron and thermal power Plants

Liquid fuels, their properties, testing and metallurgical applications. Gaseous fuels, their properties, testing and metallurgical application, manufacture of producer gas and water gas. Coke Oven Gas, Blast Furnace Gas and natural Gas. Factors affecting the choice of fuels.

Acid, basic and neutral refractories, their composition and properties; Methods of production of fire clay, silica, magnesite, chrome- magnesite, dolomite and insulation bricks; special refractories;. Testing of Refractories, Factors deciding the choice of refractory for a particular furnace and its parts.

Metallurgical furnaces, classification and uses. Thermal performance and Heat losses in Furnaces. Furnace efficiency and heat balance computation, Sankey Diagrams, Flame characteristics in combustion. Variable affecting heat utilization in flame furnaces. Burner Designs and selection. Radiant tubes & their uses. Bouyancy movement of gases; types of drafts and draft control. Large pressure drop conditions, uses of high pressure blowers and compressed air blast. Flow through tuyeres/lances. Jet movement of gases and patterns flow. Radiant heat transfer in gases and flames. Calculation of transient condition of heating of charge by Heisler Charts.

Heat recovery aspects, Waste Heat Utilization methods, Recuperator and Regenerator calculations, types of Recuperators and Regenerators and Checker brick work. Vacuum production in furnaces. Ingot heating soaking pits. Continuous Pusher type furnaces, walking beam furnaces, Roller Hearth furnaces; Bell type furnaces and other heat treatment furnaces. Direct –arc melting furnaces, salt bath furnaces.

Text Books:

1. Metallurgical furnaces- Krivadin and Markov
2. A. Rashid Chisti, Refractories. Prentice-Hall of India private ltd.
3. Elements of fuels, Refractories and Furnaces – O.P. Gupta.

Reference Book

1. Gilchrist, J.D. fuels & Refractories, Macmillan, 1963



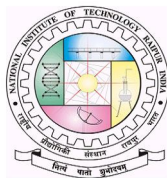
राष्ट्रीय प्रौद्योगिकी संस्थान रायपुर
NATIONAL INSTITUTE OF TECHNOLOGY RAIPUR
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G.E.Road, Raipur – 492010 (C.G.)

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2. Norton, Fo H. Refractories, McGraw- Hill, N.Y. 1958
 3. Butt A Metallurgical problems McGraw-Hill, Book Company London 194
 4. Efficient use of fuels, HMSO London 1953



Name of the Subject	Minerals and Ores Beneficiation	Subject Code	MT20316(MT)
Semester	III	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	3	4 (Th) + 2 (P)

Mineralogy: Physical Properties of Minerals; Classification of various Rock Forming Minerals, Introduction and Preliminary study of Principle Rock Forming Mineral Groups; Quartz, Feldspar, Mica, Pyroxenes, Amphibole, Garnet, Feldspathoids. Mode of Occurrence, Origin, Distribution, Association, and Industrial uses of important Metallic (Al, Au, Cu, Cr, Fe, Mn, Sn, Pb and Zn)

COMMINUTION: Jaw and Gyratory crushers, roll crusher and their performance. Ball & rod mills - capacities and reduction ratios Hammer mills, gravity stamps and Disc crushers. Grinding - Dry and wet grinding. Open and closed circuit grinding. Laws of crushing and work index. Theory of Ball Mill operation, Rittinger's, Kick's and Bond's laws of crushing and grinding. Screening, sizing and sampling.

GRAVITY CONCENTRATION TECHNIQUES: Theory of settling, Elementary concepts of movement of solids in fluids. Stokes and Newtons Laws. Reynold's number. Free and hindered settling. Classification and its application in mineral dressing. Practice of Hydraulic and mechanical classification, working of thickeners. Hydrocyclones and Rotary filters. Heavy media separation. Principles of jigging and Tabling. Magnetic and Electro static separation. Processes with equipments used. Important controlling factors in operation.

FLOTATION TECHNIQUES: Application Froth flotation. Frothers. Collectors. Depressants. Aciivators. Ph modifiers etc., multistage flotation - Principle, equipments, and application. Differential flotation. Flotation circuits. Study of basic de-watering techniques like-sedimentation – filtration – drying., Simple flow sheets for Beneficiation of Fe, Mn, Cr, Cu, Pb, Zn and beach sands.

Text books:

1. Principles of Mineral Dressing, Gaudin, A.M.
2. Mineral Processing Technology – B.A. Wills
3. Text Book of Geology – G.B. Mahapatra

References:

1. Mineral Processing Technology, S. K. Jain
2. Unit operation in Chemical Engineering.



Name of the Subject	Testing of Materials	Subject Code	MT20411(MT)
Semester	IV	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	3	4 (Th) + 2 (P)

Plastic deformation of metals – Lattice defects, deformation by slip and twinning, critical resolved shear stress for slip, yield point phenomenon, strain hardening ,

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

Material Testing: Importance and application of testing methods, role of specifications and standard for materials.

Tensile Test – Flow curve, engineering and true stress – true strain curve, yield stress and proof stress universal tensile testing machine and tensometer, principle of stress and strain measurement, bend test measurement of ductility and formability.

Hardness Test – Principles and machines used – Brinell, Vickers, Rockwell, Scleroscope and micro hardness testing.

Impact Test – Izod and Charpy Notched bar impact test, Metallurgical factors affecting brittle to ductile transition.

Fatigue and Creep Testing – Elementary treatment of fatigue phenomenon, S – N curve and corrosion fatigue, fatigue testing principle

Signification of Creep, testing procedure creep curve and its interpretation, stress-rupture test

Metallurgical and mechanical factors affecting, creep and fatigue failures.

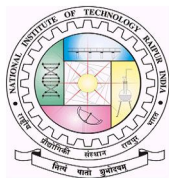
Non-destructive testing – Importance, scope, advantages and limitations – Dye penetrant, radiographic magnetic, ultrasonic and eddy current testing and their application.

Text Books

1. Mechanical Metallurgy – George E. Dieter
2. Testing of Metallic Materials – A V K Suryanarayan

Reference Books

1. Testing and Inspection of Engineering Materials- Davies, Taroxall and Wiscosil
2. Mechanical Testing of Metallic Materials – D A Beument.
3. Engineering Materials Science – C W Richards
4. Non Destructive testing – Bac Gonnagle.



Name of the Subject	Physical Metallurgy	Subject Code	MT20412(MT)
Semester	IV	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	3	4 (Th) + 2 (P)

Atomic Arrangement in Materials: Concept of crystalline and amorphous solids, Space lattice and Unit cell, Crystal system and Bravais Lattices, Atomic packing Crystal Systems Crystal Structures of metals, Packing efficiency, Crystallographic planes and directions, Miller Indices, Determination of crystal structures.

Crystal defects, Point defects, Vacancies, Substitution and Interstitialices, Schottky and Frankel defects, Line defects, Dislocations, Edge & Screw dislocations, Burgers vector. Planer defects stacking fault and volume defects, impurities in solids.

Solid solution, definition and types of solid solution, Substitutional and Hume Rothery Rules, Intermetallic compounds, Normal valency compounds, Electron compounds, Interstitial compounds. Interaction of dislocation and solute atom.

Definitions and basic concept phase diagram, Single component or Unary phase diagram, Binary Phase Diagrams: Isomorphous, Eutectic, Peritectic, Eutectoid, Monotectic & Syntectic reactions, Phase rule and Lever rule. Free energy and phase diagrams of ideal binary solutions. Common tangents to free energy curves.

Iron-Cementite Equilibrium diagrams and physical metallurgy of iron-carbon alloys, Microstructural features, Interpretation of microstructure and details of microstructures, Microstructure chemistry and properties correlation, Monocomponent and binary systems non-equilibrium system, Binary equilibrium diagrams of various systems with complete and partial solid solubilities involving eutectic and peritectic and other reactions.

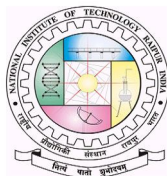
Introduction of ternary diagrams, order-disorder transformations, Experimental determination of liquids, solids and solvus lines, phase diagram and application in crystalline and non-crystalline solids. Detailed study of Cu-Ni, Zn-Sn, Fe-C, Cu-Sn, Cu-Zn, Pb-Sn, Al-Si, Al-Cu and other important non-ferrous alloys

Nucleation, Homogeneous and Heterogeneous nucleation, Kinetics of nucleation, Growth and overall transformation kinetics,

Study of Metallurgical Microscope, Metallographic specimen preparation, Polishing and Etching techniques, Cold Mounting and Hot Mounting of Metallic samples, High Temperature Microscopy: - Necessity, importance and associated details Macroscopic analyse of metallurgical specimen.

Books

1. Physical metallurgy Principles, R. E Reed-Hill, Thomson
2. Physical metallurgy, Vijendra singh, Standard Publishers, 2004
3. Physical metallurgy, V. Rghvan



Name of the Subject	Ferrous Extractive Metallurgy I (Iron Making)	Subject Code	MT20413(MT)
Semester	IV	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1		4 (Th)

Brief details of coke making, Beneficiation of iron ores and metallurgical coals, Sizing of iron ores, Agglomeration of iron ore fines, sintering and pelletising. Importance of sizing & beneficiation of raw materials, Evaluation of properties of blast furnace burden materials and application to blast furnace performance, Functions/Role of Coke in blast furnace.

Chemical processes in Blast Furnace, Reactions in Tuyere, hearth and bosh zone. Reduction and coke gasification, Reactions in stack and exit gases. Thermodynamics of Blast furnace process requirement in Blast furnace, critical hearth temperature, temp. profile in the furnace. Free energy and equilibrium consideration in Blast furnace A brief discussion on blast furnace stoichiometry and enthalpy balance. Basic idea of Blast furnace aerodynamics.

Blast furnace plant and operation-Modern blast furnace, plant layout, Details of construction of blast furnace and its main accessories; gas cleaning system, hot blast generation. Blast furnace refractories and blast furnace cooling system. Blowing in, Blowing out and banking of blast furnace, Role of burden charging and distribution in iron extraction. Irregularities in Blast furnace operation and their remedies. Blast furnace products Their quality control and disposal, coke rate and fuel efficiency of B.F. operations.

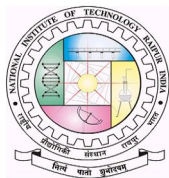
Modern trends in Blast furnace practice-Production of super flux sinter, pellets, super flux and cold bonded pellets. Auxiliary fuel injection in the blast furnace. High temp. blast, humidified and oxy generated blast, Detailed discussion of high top pressure, Desulphurization of hot metal & decrepitation.

Alternate route for iron making: charcoal blast furnace, low shaft furnace and electro thermal processes of iron making. Direct reduction processes, their classification, choice of DR process. Applicability and present status of Technology in India.

Production of Ferro-alloy, Ferro Alloy industry in India. Beneficiation of indigenous raw materials for ferro alloy industry. Production of various ferro-alloys Fe-Mn, Fe-V, Fe-Cr etc. uses of ferro-alloys in iron and steel industry.

Text Books:

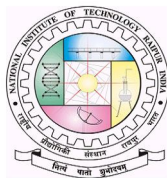
1. The manufacture of Iron – G.R. Bashforth
2. Modern Iron Making – Dr. R.H. Tupkary



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3. Principles of Blast Furnace iron making – Dr. A K Biswas
 4. production of ferro-alloys-Riss and Lipnitzky
 5. Steel Making – AK chakrabarti, Prentice-Hall of India Pvt. Ltd, New Delhi, 2007

Reference Books:

1. Making Shaping and Treating of steel – US. Steel
2. Physical chemistry of iron and manufacture steel – Bods Worth C.h.S. Bell
3. The reduction of iron – Boadandy L. V. and S.j. Engell
4. The theory and practice – Blast Furnace ltd. – J.H. Siressearger



Name of the Subject	Engineering of Non-metallic Materials (ceramics, glasses, polymers and fluids)	Subject Code	MT20414(MT)
Semester	IV	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1		4 (Th)

Fundamentals of ceramics, Methods of shape forming ceramic powders, Properties and tests, Sintering of ceramics, Alumina ceramics, Magnesia ceramics, Zirconia ceramics, Aluminum titanate ceramics, Non-oxide ceramics, Silicate ceramics, Carbon materials, Applications of ceramics, Properties of ceramics

Polymer materials (Introduction), Polymer structure, Elastomers, Thermoplastics, Thermosets, Thermoforming, Extrusion of polymers, Injection molding of polymers, Blow molding, Compression molding of polymers, Transfer molding of polymers, Vulcanization, Shore (Durometer) hardness test, Adhesives, Paints, Ion exchange resins, Plastics recycling, Properties of polymers.

Classification of composites, Structure of composites, Estimations of composite materials properties, Metal Matrix Composites, Ceramic Matrix Composites, Polymer Matrix Composites, fiberglass, Carbon Fiber Reinforced Polymer Composites, Kevlar, Properties of composites

Lubricants, Classification of lubricants, Additives in lubricating oils, Engine oils, Gear oils, Hydraulic oils, Cutting fluids (coolants), Way lubricants, Compressor oils, Rust protection oils, Quenching and heat transfer oils, Transformer oils (insulating oils), Solvents, Gases, Dispersions, Properties of fluids

Reference / Text Books :

1. Material Science & Engineering – William F Smith, Javed Hashemi, Ravi Prakash (4th Ed. TMC)



Name of the Subject	Principles of Non Ferrous Extractive Metallurgy	Subject Code	MT20415(MT)
Semester	IV	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1		4 (Th)

General methods of extraction in Pyrometallurgy - Drying, Calcination, Roasting, Smelting, Carbothermic and Metllothermic reduction, Refining techniques like Liquefaction, Distillation, Vacuum Distillation etc

Principles of hydro and electrometallurgy with suitable examples

Leaching techniques, Leaching solvents, Theory of leaching, Bacterial leaching, Electrochemical nature of leaching, Gold and silver extraction.

Pressure leaching, Sherritt - Gordon process for Copper, Nickel, Cobalt ores; Solvent extraction, Ion exchange.

Electrometallurgy - Electrolysis of aqueous solutions and fuses salts, Cell design, Recovery of metal values by Cementation, Electro-winning, Electro-refining etc. Principles and important applications.

Extraction of metals from oxides - Magnesium and Titanium extraction,

Bayer's process, Hall Heroult process.

Extraction of meals from sulphides: , Extraction of Copper, Lead, Zinc, Nickel.

Reference / Text Books :

- 1) Ray H.S., Sridhar R., Abraham K.P.; Extraction of Non-ferrous Metals; West Publin., 1990
- 2) Rosenquist T; Principles of Extractive Metallurgy; McGraw Hill Koga Kusha, 1985.
- 3) Serynkova; General Metallurgy
- 4) Volsky A.; Theory of Metallurgical Processes; Mir Publication, 1971.
- 5) Philipova N.; Theory of Metallurgical Processes, Mir Publication; 1975.
- 6) Jackson Eric; Hydrometallurgical Extraction; John Wiely & Sons, 1986.
- 7) Bray J.L.; Extraction of Non-ferrous Metals; John Wiely & Sons, 1959
- 8) Dr. Venkatachalam; Hydrometallurgy; Narosa Publishline House, 1998.



Name of the Subject	Transport phenomena in metallurgical processes	Subject Code	MT20416(MT)
Semester	IV	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
4	1	3	5 (Th) + 2 (P)

Fluid Flow: Classification of fluids, Differential and total energy balances, Laminar and Turbulent flows. Flow through pipes and ducts, and beds of solids. Flow measurement, Application of dimensional analysis of fluid flow. Concept of boundary layer. Miscellaneous topics such as Bed and Particulate fluidization, Macroscopic mechanical energy balances, Chimney draft, air leakage from openings, molecular of Knudsen flow, etc. as in problems and exercises.

Heat Transfer I: Steady –state and Transient conduction in solids. One dimensional steady state problems of heat flow through composite walls, Cylinder and Spheres. Unsteady conduction in one dimensional system examples of heating and cooling of plates and cylinders, Use of Heisler charts and applications. Convective heat transfer, equation of energy, free and forced convections. Application of dimensional analysis to convection problem. Concept of heat Example, problems and exercises on the above.

Heat Transfer II: Radiation , Nature of thermal radiation, Black and Grey bodies, Stefan and Boltzmann law, Kirchoffs laws, Intensity of radiation, lamberts law, View factor. Heat transfer between two black walls in an enclosure. Radiation shields, Radiation through opening in furnaces, radiation from flames and gases. Combined effect of convection, conduction and radiation. Over all heat transfer coefficient. Example problems and exercises on systems of steady heat flow important in Metallurgy.

Mass transfer and kinetics: Importance in Heterogeneous metallurgical systems of reactions. Steady one dimensional mass diffusion of component through stationary media. Convective mass transfer in fluids ,concept of concentration boundary layer, Mass transfer coefficient. Heterogeneous reactions of metallurgical importance, Their rate controlling steps. Discussion of the following examples from metallurgical systems: Nucleation and growth and bubble formation phenomenon, Interfacial reaction, Carbon gasification by CO₂, slag-metal reaction at the interface, Topo-chemical model of gas-sokid reaction.

Process Rate Calculation in Reactor Engineering:

Metallurgical reactors, classification with examples, Staged Operations of metallurgical engineering, Pyro metallurgical reactors. Introduction to reactor kinetics, concept of retention times and other parameters of reactors, Analysis of rates in batch – type semi-batch type/cocurrent and counter current mode reactors. Introductory remarks on mixing and residence time-distribution in metallurgical reactors, determination of the value of E.

Essential Readings:



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1. R.B. Bird, W.E. Stewart and E.N.Lightfoot, Transport Phenomena, Wiley, 1994.
 2. G.H. Geiger and D.R. Poirier, Transport Phenomena in Materials Processing, Addison Wesley, Mass, 1994.

Supplementary Readings:

1. J.R. Welty, R.E. Wilson and C.E. Wicks, Fundamentals of Momentum Heat and Mass Transfer, Wiley, 1976.
2. R.I.L. Guthrie, Engineering in Process Metallurgy, Oxford Science, 1992.