MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF METALLURGICAL AND MATERAILS ENGINEERING

Curriculum Structure for B.Tech with Minor Specialization in "Process Metallurgy"

Semester V

S. N.	Course Code	Course Title	Category	L	T	P	Credits	Contact Hrs	Total Credits
1	22MTT203	Introduction to Extractive Metallurgy	PC	3	1	0	4	4	
2	22MTT205	Metallurgical Thermodynamics and Kinetics	PC	3	1	0	4	4	

Semester VI

1	22MTT211	Iron Making	PC	3	1	0	4	4	

Semester VII

1	22MTP208	*Mineral Processing Lab*	PC	0	0	2	1	2	
2	22MTP306	*Extractive Metallurgy and Thermodynamics Lab*	PC	0	0	2	1	2	

Semester VIII

1	22MTT313	Non-Ferrous Extractive Metallurgy	PC	3	1	0	4	4	

Prof. Upender Pandel
(Head of the Department)

for **Dr. Krishna Kumar**
(DUGC Convener)

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MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT203	Introduction to Extractive Metallurgy	4	3	1	0	0

PREREQUISITE: Mineral Processing

COURSE OBJECTIVE:

- To provide basic understanding about different extraction routes of primary metal productions especially non- ferrous metals from their resources. To provide basic knowledge about individual processes involved in different stages of extraction.

COURSE OUTCOMES:

CO1	Understand different extraction routes for metal production.
CO2	Infer thermodynamics and kinetics involved in different extraction routes.
CO3	Classify different refining process of metals keeping in view of cost effectiveness.
CO4	Identify different lean metals and alloys *produced by using electro winning & electro refining processes.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
d)	Weekly submissions/assignments/Quiz	20%
e)	Mid- term examination	40%
f)	End Semester Examination	40%

COURSE CONTENTS:

Unit I The sources of metals, Minerals and Ores, Primary metal production plants in India especially non- ferrous metals like Al, Cu, Zn and Pb, Unit Processes and Unit Operations, Features of Metal Extraction, Simplified flow sheets for the production of Al, Cu, Zn and Pb. Material Balances in Metallurgical Processes.

(No. of lectures - 8)

Unit II Unit processes in pyrometallurgy - Calcinations, Roasting, Agglomeration (Pelletizing and sintering), Reduction smelting, Matte smelting, Converting, Distillation, Importance of Ellingham diagrams in metal extraction by pyrometallurgy, Refining with suitable examples.

(No. of lectures - 10)

Unit III: Hydrometallurgical processes: Principles and types of leaching, Purification of leach liquor, Solvent extraction and ion exchange process, Techniques of metal recovery from aqueous phase and their applications. Hydrometallurgy for extraction of metals like cu, Zn, Pb.

(No. of lectures - 8)

Unit IV: Unit Processes in Electrometallurgy: aqueous and fused salts, electrochemistry of Aqueous solutions, Cell types and Potentials, Electro- winning and Electro- refining in reference to non- ferrous metals like Al, Cu, Zn and Pb, Current and Energy efficiency & problems related to this.

(No. of lectures - 9)

Unit V: Recent advances and practices for metal extraction in Industry.

(No. of lectures - 5)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Extraction of non- ferrous Metals by H.S. Ray, R. Sridhar and K.P. Abraham, Affiliated East West Press Pvt. Ltd., New Delhi & 2007.
2. Principles of Extractive metallurgy by Terkel Rosenqvist, McGraw Hill, New York & 1983
3. Extractive metallurgy 2nd Edition by J.D. Gilchrist, Oxford; New York: Pergamon Press & 1980.
4. Principles of extractive metallurgy by H.S. Ray and A. Ghosh, Wiley Eastern Ltd., New Delhi & 1991.
5. Principles of Extractive Metallurgy, Vol.1 by F. Habashi, Gordon and Breach, New York & 1969.

ONLINE/E RESOURCES:

1. https://nptel.ac.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT205	Metallurgical Thermodynamics and Kinetics	4	3	1	0	0

PREREQUISITES: Basic Sciences, Introduction to physical metallurgy

COURSE OBJECTIVES:

- To provide the fundamental principles of materials thermodynamics
- To train them to explain and apply the laws of thermodynamics on metallurgical reactions.

COURSE OUTCOMES:

CO1	Understand the role of thermodynamics laws on metallurgical reactions
CO2	Analyze the systems from the viewpoint of heat, work, enthalpy, free energy and entropy
CO3	Apply the laws of thermodynamics in metallurgical engineering applications

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Thermodynamic state and state variables, intrinsic and extrinsic properties, isothermal and adiabatic expansion of a perfect gas, Carnot's Engine

(No of Lecture - 3)

Unit II: Laws of thermodynamics: Zeroth and First law of thermodynamics, Hess's law, Kirchhoff's law.

(No of Lecture - 3)

Unit III: Second law of thermodynamics. Reversible and irreversible processes. Criterion for equilibrium. Entropy, its statistical nature and its role on equilibrium, variation in entropy with temperature, Helmholtz and Gibbs free energy.

(No of Lecture - 5)

Unit IV: Gibbs Helmholtz equation, Maxwell equations, Third law of thermodynamics, Phase equilibrium and phase transformation in Metals under high pressures, Clausius-Clapeyron equation

(No of Lectures: 7)

Unit V: Homogeneous and Heterogeneous equlibria, fugacity, activity, Equilibrium constant, Free energy- temperature diagrams (Ellingham diagrams) for the formation of oxides, sulphides, and chlorides and their applications

(No of Lectures: 8)

Unit VI: Partial molar properties, Chemical potential, Gibbs – Duhem equation, Thermodynamics of solutions: Ideal and non- ideal solutions, Regular solutions, Principles of activity determination, Raoult's law, Henry's law and Sieverts law, Thermodynamics of electrochemical cells.

(No of Lectures: 9)

Unit VII: Kinetics: Order of reaction and molecularity. Arrhenius Equation. Theories of reaction kinetics, Collision theory and theory of absolute reaction rate

(No of Lectures: 5)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Problems in Metallurgical Thermodynamics and Kinetics, G. S. Upadhyay and R.K. Dube, Pergamon, 1st Edition, 1977
2. Principles of Metallurgical Thermodynamics, S.K. Bose and S.K.Roy, Universities Press India Pvt. Ltd 2014
3. Introduction of Metallurgical Thermodynamics, Gaskell, Taylor & Francis Inc; 2nd edition 1981
4. Physical Chemistry of Metals, Darken and Gurry, CBS; 1st edition, 2002
5. Principles of Extractive Metallurgy, Rosenquvist, Tapir Academic Press, 2004
6. Chemical and Metallurgical Thermodynamics, Vol. I, M. L. Kapoor, McGraw Hill Education; Fifth edition, 2017

ONLINE RESOURCES

1. https://nptel.ac.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT211	Iron Making	4	3	1	0	0

PREREQUISITES: Introduction to Engineering Materials & Physical metallurgy

COURSE OBJECTIVES:

- To develop an in- depth understanding of the iron making process.
- To familiarize the students with BF operations and they will learn how to improve the quality of hot metal.

COURSE OUTCOMES:

CO1	Understand the physicochemical principles involved in iron making.
CO2	Understand the concepts of various modern blast furnace operations.
CO3	Relate the practical aspect of agglomeration process.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Historical prospects: History of iron making; General overview of iron making across the world; Distribution of iron ores in India; Beneficiation of Indian iron ores.

(No. of lectures - 3)

Unit II Burden preparation: Importance of burden distribution on the performance of blast furnace Agglomeration of iron ores: Sintering and pelletizing, types of sinter, mechanism of bonding in sintering and pelletizing, Testing of burden materials used in BF.

(No. of lectures - 6)

Unit III Blast furnace overview: Design of furnace, different zones, blast furnace refractories, bell- less charging system; Regenerative principles of blast heating- Cowper stoves.

(No. of lectures - 5)

Unit IV Physicochemical processes in blast furnace: blast furnace reactions; physical chemistry of reduction of iron oxide within blast furnace; Reaction in stack, bosh and hearth;

indirect and direct reduction in iron making. Slag- metal equilibrium within blast furnace, de-sulphurisation, de-siliconisation.

(No. of lectures - 10)

Unit V Modern trend in the BF: Oxygen enrichment and humidification of air blast- its importance in blast furnace performance; Injection of fuel through tuyers and its impact on blast furnace efficiency; Effect of high top pressure on furnace performance; Preheating of air blast in iron production.

(No. of lectures - 8)

Unit VI Blast furnace irregularities: hanging, scaffolding etc., remedial measures to Control of blast furnace operation. Modeling and simulation as tool to improve the performance of blast furnace. Modern iron making practices. Plant practice for green iron making processes.

(No. of lectures - 8)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Iron Making and Steelmaking: Theory and Practice, Ghosh, and A. Chatterjee, PHI Learning (P) Ltd., 2008.
2. Introduction to Physical chemistry of iron and steel making, R. G. Ward, ELBS, 1962.
3. Physical Chemistry of Iron & Steel Manufacturer, Bodsworth C., CBS Publishers, 2014.
4. Principles of blast furnace Iron Making, A. K. Biswas, SBA Pub., Kolkata, 1984.

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1. https://nptel.ac.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTP208	Mineral processing lab	1	0	0	2	0

PREREQUISITE: Principles of Mineral Processing

COURSE OBJECTIVE:

To familiarize the students with different mineral dressing processes and equipment.

COURSE OUTCOMES:

CO1	Distinguish different types of crushers.
CO2	Contrast on sizing and classification.
CO3	Analyse various types of concentration methods.
CO4	Analyze different ways of separating solids from fluids.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following four components.

S. No.	Component	Weightage
a)	Mid- term examination	20%
b)	End Semester Examination	20%
c)	Continuous evaluation (Laboratory performance, record submission etc.)	60%

COURSE CONTENTS:

1. Study of various minerals and ores.
2. To study the construction and operation of Blake type jaw crusher, and to find its reduction ratio and production capacity.
3. To study the construction and operation of roll crusher and to find out its reduction ratio, angle of nip and production capacity.
4. To study the construction and operation of disc pulverizer and to find the grindability index of given feed.
5. To study the construction and operation of ball mill and find the grindability index of the given feed.

6. To study the construction and operation of rod mill and find the grindability index of the given feed.
7. To study the single deck and double deck vibrating screens and to find screen efficiency.
8. To find the percentage of iron scrap present in a given feed using magnetic separator.
9. To study the construction and operation of froth floatation cell.
10. To study the construction and operation of mineral jig.
11. To study the construction and operation of pneumatic classifier.
12. To study the construction and operation of spiral classifier.
13. To study the construction and operation of Wilfley table, Richard hindered settling classifier and thickener.
14. To study the process of flocculation.

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Mineral processing laboratory manual

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTP306	Extractive Metallurgy and Thermodynamics Lab	1	0	0	2	0

PREREQUISITE: Introduction to extractive metallurgy

COURSE OBJECTIVES:

- To provide practical knowledge on extractive metallurgy techniques
- To demonstrate various aspects of extractive metallurgy techniques

COURSE OUTCOMES:

CO1	Understand the engineering knowledge of extraction of metals
CO2	Apply and integrate the knowledge of extractive metallurgy to the processing of different alloys

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	PRS (Practical Sessionals)	60%
b)	PRM (Practical Mid Term Exam)	20%
c)	PRE (Practical End Term Exam)	20%

COURSE CONTENTS:

1. To study the effect of time on roasting of Zinc Sulphide
2. To study the effect of temperature on roasting of Zinc Sulphide
3. To determine Heat Transfer Coefficient
4. To find viscosity of molten metal/ slag by inclined plane method
5. To find viscosity of molten metal/ slag by Brookfield viscometer
6. To find the efficiency of electrolyte cell for copper refining
7. To study the effect of time & temperature on leaching of copper oxide
8. To study the effect of time on cementation of copper
9. To study the effect of time on reduction of mill scale by coal
10. To study the effect of temperature on reduction of mill scale by coal

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Lab Manuals

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Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT313	Non- Ferrous Extractive Metallurgy	4	3	1	0	0

PREREQUISITE: Mineral Processing, Introduction to Extractive Metallurgy

COURSE OBJECTIVE:

- To familiarize the students with basic knowledge about various non- ferrous metals and their route of extraction

COURSE OUTCOMES:

CO1	Differentiate Pyrometallurgical, Hydrometallurgical & Electrometallurgical methods of extraction of Non- ferrous Metals.
CO2	Identify suitable processes of extraction depending on Non- Ferrous Metals to be extracted.
CO3	Apply knowledge of various extraction processes to get the final product.
CO4	Suggest proper non- ferrous metals for various applications

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following four components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Aluminium: Occurrence of bauxite, Bayer's process for production of alumina. Alternatives to Bayer's Process. Hall-Heroult Process- Conventional and New Materials for construction of aluminium reduction cell, Nature of electrolyte, Electrolysis of alumina with emphasis on physicochemical principles and secondary- reactions. Factors affecting current efficiency. Alternatives to Hall-Heroult Process. Refining of aluminium. Advances in the extraction of aluminium, Methods to treat low grade ores.

(No. of lectures - 12)

Unit II Copper: Occurrence of copper ores. Roasting, Matte smelting, converting and refining process as applied to copper production and their physico-chemical aspects. Single step and multistep continuous processes. Hydrometallurgical process for production of

primary copper. Recovery of copper from copper slag. Treatment of refractory copper ores. Newer processes in the extraction of copper

(No. of lectures - 12)

Unit III Lead, Zinc and Cadmium: Occurrence of Lead and Zinc ores. Pyrometallurgical and Hydrometallurgical Processes for lead and zinc production and their physico-chemical aspects. Refining of lead and zinc, Recovery of by- products. Imperial smelting process, Recovery of cadmium as a by- product

(No. of lectures - 12)

Unit IV Recent Advances: Advanced processes currently employed in the Industry

(No. of lectures - 4)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Extraction of Non- ferrous Metals, H.S. Ray, R. Sridhar and K.P. Abraham, Affiliated East West Press (P) Ltd., 2015.
2. Extractive Metallurgy of Non- ferrous Metals, R. Raghvan, V. N. Publication, 2016.
3. Non- ferrous Production Metallurgy, John L Bray, John Wiley &Sons; First Edition, 1941
4. Principles of Extractive Metallurgy, Rosenquist, Terkel, Techbooks; Reprint Edition, 1991
5. Lead-Zinc-Tin '80: Proceedings of a World Symposium on Metallurgy and Environmental Control, John M. Cigan, Thomas S. Mackey, Thomas J. O'Keefe, Metallurgical Society of AIME, 1979.

ONLINE/E RESOURCES:

1. https://nptel.ac.in
2. Expert lectures from the industry

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