



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Metallurgy Engineering

Course / Subject Code: DI03021061

Course / Subject Name: Non-ferrous Extractive Metallurgy

w.e.f. Academic Year:	2024-25
Semester:	3 rd
Category of the Course:	PCC

Prerequisite:	Basic Knowledge of Mineral Processing, Engineering Mathematics, and Chemistry
Rationale:	Non-ferrous metals are important for manufacturing, sustainability, and economic growth. They are irreplaceable for many automotive, aerospace, mechanical engineering, and construction products. The curriculum is designed to introduce students to the fundamentals of non-ferrous extractive metallurgical processes and related metal refining processes. Non-ferrous metals were the first metals used by humans for metallurgy. Therefore, students of a diploma in metallurgical engineering must be aware of the occurrence, importance, characteristics, application, and extraction process for non-ferrous metals. This course aims to equip the student with the knowledge of various non-ferrous metal extraction processes that lead to effective management in non-ferrous metal industries.

Course Outcome:

After Completion of the Course, students will be able to:

No	Course Outcomes	RBT Level
01	Discuss the importance of extraction metallurgy.	R
02	Describe various extractive metallurgy processes.	U
03	Suggest a suitable process for the extraction of metals from oxide ores.	U
04	Explain processes for the extraction of metals from sulphide ores.	U
05	Describe processes for the extraction of metals from halide ores.	U
06	Suggest relevant practices to be adopted for the sustainable development of non-ferrous metals production.	A

*Revised Bloom's Taxonomy (RBT)

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
L	T	PR		C	Theory		Tutorial / Practical	
			ESE (E)		PA(M)	PA(I)	ESE (V)	
3	0	0	3	70	30	00	00	100



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Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	1.1. Metallurgy and its classification 1.2. Classification of Metals: Ferrous and Non-ferrous 1.3. Non-ferrous metals – classification and importance 1.4. Source of metals – Ores and Minerals of Non-ferrous Metals 1.5. Role of mineral processing for extractive metallurgy 1.6. Extractive metallurgy and its Scope 1.7. Extraction processes and their classification 1.8. Importance, advantages, and disadvantages (or limitations) of pyrometallurgy, hydrometallurgy, and electrometallurgy.	8	18
2.	2.1. Introduction and Principles of Pyrometallurgy 2.3.1. Drying 2.3.2. Calcination 2.3.3. Roasting and its types 2.3.4. Smelting and its types 2.3.5. Converting 2.3.6. Extraction of metal from sulphide ores 2.3.7. Reduction of oxides: <i>Carbothermic reduction, Reduction by H₂ or CO or both gases, and Metallothermic reduction</i> 2.3.8. Refining and its methods 2.2. Introduction and Principles of Hydrometallurgy 2.3.1. Leaching and its types 2.3.2. Solvent extraction processes 2.3. Introduction and Principles of Electrometallurgy 2.3.1. Classification of electrometallurgy 2.3.2. Electrochemical cell 2.3.3. Half-cell reactions 2.3.4. Faraday's law – calculations and problems based on it 2.3.5. Electrolysis of fused salts 2.3.6. Electro refining 2.3.7. Electro-winning metals from leaching solutions	14	30
3.	Extraction of Metals from oxide ores 3.1. Extraction of aluminum from its ore – Bayer and Hall-Heroult processes 3.2. Flow sheet for the extraction of aluminum 3.3. Extraction of Magnesium from its ore – Pidgeon process 3.4. Flow sheet for the extraction of magnesium	7	16
4.	Extraction of Metals from Sulphide Ores (<i>Pyrometallurgical and Hydrometallurgical extraction processes</i>)	8	18



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	4.1. Extraction of copper from its ore 4.2. Flow sheet for the extraction of copper 4.3. Extraction of zinc from its ore 4.4. Flow sheet for the extraction of zinc 4.5. Extraction of lead from its ore 4.6. Flow sheet for the extraction of lead		
5.	Extraction of Metals from Halide Ores 5.1. Extraction of Uranium from its ore 5.2. Flow sheet for the extraction of Uranium 5.3. Extraction of Thorium from its ore 5.4. Flow sheet for the extraction of Thorium	6	14
6	6.1. Sustainable development in non-ferrous metals production 6.2. Challenges and limitations of sustainable development in non-ferrous metals production 6.3. Utilization of metallurgical wastes in secondary metal production	2	4
Total		45	100

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	U Level	A Level	N Level	E Level	C Level
40	40	20	0	0	0

Where R: Remember; U: Understanding; A: Application, N: Analyze, and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

Sr. No.	Title of Book	Author / Editor	Publication with place, year, and ISBN
1	Extractive Metallurgy Processes and Applications	S. K. Dutta, A. B. Lele, Y. B. Chokshi	PHI Learning Pvt. Ltd., Delhi, 2017; ISBN: 9387472043
2	Principle of Extractive Metallurgy [3 rd Ed.]	A. Ghosh, H. S. Ray	New Age Int. Pub., New Delhi 2018; ISBN: 9386418452
3	Extraction Of Nonferrous Metals	H. S. Ray, R. Sridhar K. P. Abraham	Affiliated East-west Press Pvt. Ltd., Delhi, 2008; ISBN: 8185095639
4	Extraction of Nuclear and Non-ferrous Metals	S. K. Dutta, D. R. Lodhari	Springer Nature Singapore Pte Ltd., Singapore, 2018; ISBN: 978-9811051715



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(b) Open source software and website:

1. <https://archive.nptel.ac.in/courses/113/105/113105021/>
2. <https://www.youtube.com/watch?v=-SA55zz4Lno&list=PLC3F0FC4543ADAC48>
3. https://www.youtube.com/watch?v=HJ6iyO_JbFo&t=1136s
4. https://www.youtube.com/watch?v=YpTJMYQ_beE
5. <https://www.youtube.com/watch?v=K2cHd5oKOys>
6. https://youtu.be/K2cHd5oKOys?si=dB_x4Rs4qYLDSDM5

Suggested Course Practical List: NOT APPLICABLE

List of Laboratory/Learning Resources Required: NOT APPLICABLE

Suggested Project List:

- a. Prepare a chart for the locations of mines for ore minerals.
- b. Collect the samples of ore minerals.
- c. Prepare a flowchart for the extraction of various non-ferrous metals.

Suggested Activities for Students:

Students should conduct the following activities in a group: a) Visit nearby industries engaged in the extraction of non-ferrous metals (if any) and study the processes being used; b) Create small models of the various extraction furnaces for a better understanding of the process.

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