



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: Under Graduate

Branch: Metallurgy

Subject Code : BE05021021

Subject Name: Non Ferrous Extractive Metallurgy

w. e. f. Academic Year:	2024-25
Semester:	5
Category of the Course:	Professional Core Course

Prerequisite:	Nil
Rationale:	Non-ferrous metals and alloys are in great demand in industry to overcome issues related with efficiency, pollution and cost. The student will be able to understand the basic principle behind metals extraction. This course covers major non-ferrous metal extraction from source to applications. Also the course focuses on the production scenario of non-ferrous metals in India and worldwide.

Course Outcome:

After Completion of the Course, Student will able to:

Sr. No	Course Outcomes	Marks % weightage
CO-1	Understand the Principles of Metal Extraction	20
CO-2	Understand and apply Principles of Metal Extraction for Oxide Ores	40
CO-3	Understand and apply Principles of Metal Extraction for Sulphide Ores.	40

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
L	T	P	PBL*	Total no of hours per semester		Theory		Tutorial / Practical			
						ESE (E)	PA / CA (M)	PA/ CA (I)	PBL* (I)	ESE (V)	
45	0	30	15	90	03	70	30	20	30	50	200

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, ESE = End Semester Examination, PA = Progressive Assessment

* Problem Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.



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Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	History & role of metal in human life: Different sources of metals, Scope and need of Non Ferrous Metals in Engineering sector, Thermodynamic principles and Ellingham diagram for general Methods of Metal Extraction	08	17
2.	Aluminum Extraction from Oxide Ores: Source, Ores and Minerals, Bayer Process, Hall-Heroult process and other processes, Extraction flow chart, applications, Production scenario in India and world.	09	20
3.	Magnesium Extraction from Oxide Ores: Source, Ores and Minerals, Methods of extraction, Pidgeon process, Extraction flow chart, applications, Production scenario in India and world.	06	13
4.	Copper Extraction from Sulphide Ores: Source, Ores and Minerals, Extraction and refining processes and flow chart, precious metal recovery, applications, Production scenario in India and world.	10	23
5.	Lead, Zinc and Nickel Extraction from Sulphide Ores: Source, Ores and Minerals, Extraction processes and flow chart, applications, Production scenario in India and world. Gold and Silver: Occurrence, Various methods of production from their ores and other sources.	12	27
Total		45	100

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
25	30	40	05	0	0

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

The syllabus of Non Ferrous Extractive Metallurgy directly contributes to:

SDG No.	SDG statement
SDG 4	Quality Education
SDG 9	Industry, Innovation and Infrastructure
SDG 12	Responsible Consumption and Production



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References/Suggested Learning Resources:

(a) Books:

1. Extraction of Non-ferrous Metals, H. S. Ray, R. Sridhar and K. P. Abraham, Affiliated East-West Press.
2. Principles of Extractive Metallurgy -A. Ghosh and H. S. Ray, New Age International Publisher.
3. Extractive Metallurgy of Non-Ferrous Metals - R. Raghavan, Vijay Nicole Imprints
4. Extractive Metallurgy by Joseph Newton, John Wiley & Sons.
5. Principles of Extractive Metallurgy., T. Rosenquist, McGraw Hill
6. Metallurgy of the Non ferrous metals, by W.H. Dennis, Pitman, London 1963.

(b) Open source software and website:

1. <http://nptel.iitm.ac.in/>

Suggested Course Practical List:

1. To use the Ellingham diagram for metal extraction.
2. Comparative Study of Primary Ores and Global Deposits for Non-Ferrous Metallurgy.
3. To collect and interpret production statistics of Non Ferrous Metals.
4. To understand and prepare flowchart for Aluminum Extraction.
5. To understand and prepare flowchart for Magnesium Extraction.
6. To understand and prepare flowchart for Copper Extraction.
7. To understand and prepare flowchart for Lead Extraction.
8. To understand and prepare flowchart for Zinc Extraction.
9. To understand and prepare flowchart for Nickel Extraction.
10. To understand the extraction of Gold & Silver.
11. To understand the precious metal recovery from copper anode slime.
12. Industrial visit/Expert session.

List of suggested activities for Problem Based Learning:

Sr. No.	PBL Category	Name of the activity	No. of hours	Evaluation Criteria
1	Industry / Research Laboratory Visit	Industry / Research laboratory Visit	Visit = 5hrs, Report preparation = 5hrs Total = 10hrs	Based on report submitted. Report should contain observations and calculations based on industry/ lab data.
2	Video Based Learning	Technical Video based learning related to the subject (MOOC/	Duration of video = 5hrs Report preparation = 5hrs	Report /presentation based on the video learning outcomes.



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		NPTEL Video)	Total = 10hrs	
		Self-learning on-line course	Minimum duration of the course should be 10hrs.	Examination based assessment at the end of course. Based on the certificate produced.
		Annotated Video Explanation of Concept/Problem	10hrs (Preparation + Recording + Submission)	Based on accuracy of explanation, clarity, and presentation style.
3	Assignment/ Technical Writing / Research Writing	Assignment writing. Numerical based assignment is preferable.	5 assignments of 2hrs each. Total = 10hrs	Based on the assignment submitted.
		Blog or Technical Article Writing	10hrs (Research – 6hrs, Writing – 4hrs)	Based on originality, technical content, references cited, and clarity of communication.
4	Complex Problem-Solving targeting relevant SDGs. / Mini Project	Complex problem solving	Maximum 2 problem. Study of the problem and solution finding, Total = 15 hrs	Based on the depth of the solution submitted.
5	Research Paper Review / Analysis	Discussion on research paper based on relevant subject (Indexed Journal)	5 research paper = 20 hrs	Summarize research paper and evaluate critical parameters
6	Poster/ Chart/ Power point presentation	Poster/chart/power point preparation on technical topics	Duration = 6 hrs	Based on poster/chart preparation and presentation skills



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7	Micro Project	Working/non-working model on technical topics	Working = 10 hrs Non-working = 10 hrs	Based on inter department/external evaluation
8	Group Discussion / Quiz / Simulation	Group Discussion on emerging/trending technical topics based on subject	Duration = 1 hrs each	Based on performance in group discussion, technical depth, knowledge etc.
		Online Technical Quizzes/ MCQ test/ Simulations	Multiple quizzes summing up to 10hrs	Based on quiz score and reflection summary.
9	Case Study Analysis / Seminar	Real world case studies-based learning	Duration of data collection/study = 5hrs Report preparation = 5hrs Total = 10hrs	Based on in-depth study, technical depth, data collected, fact finding, etc.
10	Other	Patent Search and Innovation Gap Identification	10hrs (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.

Note:

1. In alignment with Outcome-Based Education (OBE) and NBA accreditation requirements, the subject Non Ferrous Extractive Metallurgy incorporates;

- Mini Project – 10 Marks
- Micro Project and – 5 Marks
- Seminar activities – 10 Marks

These activities are incorporated as integral Project-Based Learning (PBL) components. These activities are designed to foster experiential learning, encourage innovation, and strengthen problem-solving skills by engaging students in practical applications of power converter design, simulation, and analysis. The inclusion of PBL ensures that learners develop higher-order cognitive abilities mapped to Bloom's taxonomy, while



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simultaneously enhancing teamwork, communication, and research competencies essential for professional engineering practice.

2. The hours allocated to specific activities should be proportionate to the total no. of PBL hours and marks.

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