GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester-IV

Course Title: Non-Ferrous Extractive Metallurgy
(Course Code: 4342105)

Diploma Programme in which this course is offered	Semester in which offered
Metallurgy Engineering	4th Semester

1. RATIONALE

Non-ferrous metals such as aluminium, copper, or zinc are important for the manufacturing industries, sustainability, and economic growth. They are irreplaceable for many products in the automotive, aerospace, mechanical engineering, and construction sectors. The curriculum is designed to introduce students to the fundamentals of the extractive metallurgical processes, non-ferrous metal extraction process along with related metal refining process. Non Ferrous metals were the first metals used by humans for metallurgy, therefore, student or diploma engineers must be aware of the occurrence, Importance, characteristics, application and extraction process of the non-ferrous metals. This course aims to equip the student with the knowledge of various non-ferrous metal extraction processes that leads to effective management in non-ferrous metal industries.

2. COMPETENCY

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire the following competency:

- **Use metal extraction and refining processes for production of various non-ferrous metals.**

3. COURSE OUTCOMES (COs)

At the end of the study of this course the student will be able to:

1. Discuss the importance of extraction metallurgy.
2. Explain various extraction processes.
3. Suggest suitable process for extraction of copper, aluminum, tin, zinc, and lead.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme	Total Credits	Examination Scheme

(In Hours)			(L+T+P/2)	Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
2	0	0	2	30*	70	--	--	100

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

***Legends:** **L**-Lecture; **T**–Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit; **CA** - Continuous Assessment; **ESE** -End Semester Examination.*

5. AFFECTIVE DOMAIN OUTCOMES

The following sample Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned Cos. More could be added to fulfill the development of this course competency.

1. Work as a team member / a leader.
2. Follow ethical practices.
3. Practice environmentally friendly methods and processes.

6. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of Revised Bloom's taxonomy that are formulated for development of the COs and competency. If required, more such UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Major Learning Outcomes	Topics and Sub-topics
UNIT – I Introduction to Extractive metallurgy	1.a. Discuss the needs of Extractive metallurgy.	1.1 Define extractive metallurgy 1.2 Scope of extractive metallurgy 1.3 Classification of Extraction metallurgy
UNIT – II Extraction metallurgy processes	2.a. Explain Pyrometallurgical process. 2.b. Describe Hydrometallurgical process. 2.c. Discuss Electrometallurgy.	2.1. Pyrometallurgical operations; Drying, Calcination, Roasting, Smelting, Converting, Extraction of metal from sulphide ores, Reduction of Oxides. 2.2. Basic Principles of Hydrometallurgical process 2.2.1. Types of leaching 2.2.2. Solvent extraction processes 2.3. Principles of Electrometallurgy

		2.3.1. Electrolysis of fused salts 2.3.2. Electro refining 2.3.3. Electro wining metals from leaching solutions
UNIT – III Extraction of copper and aluminium	3.a. Discuss extraction process of copper and aluminium in detail. 3.b. Use flow sheet for copper and aluminium extraction	3.1. Extraction of copper from its ore 3.2. Flow sheet for the extraction of copper. 3.3. Extraction of aluminium from its ore. 3.4. Flow sheet for the extraction of aluminium
UNIT – IV Extraction of tin, zinc and lead	4.a. Explain extraction of tin, zinc and lead. 4.b. Interpret a flowchart for extraction of tin, zinc and lead	4.1. Production of tin from its ore 4.2. Flow sheet for the extraction of tin 4.3. Production of zinc from its ore 4.4. Flow sheet for the extraction of zinc 4.5. Production of lead from its ore 4.6. Flow sheet for the extraction of lead

7. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of theory marks			
			R Level	U Level	A Level	Total Marks
I	**Introduction to Extractive metallurgy**	3	04	02	01	07
II	**Extraction metallurgy processes**	12	14	10	06	30
III	**Extraction of copper and aluminium**	8	10	06	04	20
IV	**Extraction of tin, zinc and lead**	5	06	04	03	13
	Total	**28**	**34**	**22**	**14**	**70**

Legends: *R = Remember; U = Understand; A = Apply and above levels (Bloom's revised taxonomy)*

Notes:

a) This specification table shall be treated as a general guideline for students and Teachers. The actual distribution of marks in the question paper may slightly vary from the above Table.

b) Ask the questions from each topic as per marks weightage. Optional questions must be asked from the same topic.

8. SUGGESTED STUDENT ACTIVITIES

Other than the classroom learning, following are the suggested student-related co-curricular activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group.

a) Visit nearby industries engaged in extraction of non ferrous metals (if any) and study the processes are being used.
b) Create small models of the various extraction furnaces for a better understanding of the process.

9. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

Sr. No.	Unit Title	Strategies
I	Introduction to Extractive metallurgy	Real life examples. Demonstration of real systems. Movies/Animations.
II	Extraction metallurgy processes	
III	Extraction of copper and aluminium	
IV	Extraction of tin, zinc and lead	

10. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be individually undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should not exceed three.

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain a dated work diary consisting of individual contributions in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than 16 (sixteen) student engagement hours during the course. The student ought to submit a micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

1. Prepare a chart for locations of mines for ore minerals.

2. Collect the samples of ore minerals.
3. Prepare a flowchart for extraction of various non-ferrous metals.

11. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author / Editor	Publication with place, year and ISBN
1	Principle of Extractive metallurgy [Second edition]	A. Ghosh and H. S. Ray	New Age International(P) Limited, Publisher, 1991 ISBN: 9788122403220, 8122403220
2	Extraction Of Nonferrous Metals	H.S.Ray, R. Sridhar K.P.Abraham	Affiliated East-west Press Pvt Ltd (1 January 2008) ISBN-10 : 8185095639 ISBN-13 : 978-8185095639
3	Extractive Metallurgy Processes and Applications	S. K. Dutta, A. B. Lele, Y. B.Chokshi	PHI learning private limited, Delhi2017 (ISBN: 978-81-203-0000-0)
4	Elements of metallurgy	D. Swarup and M. N. saxena	Rastogi Publications, kolkota, Dec- 2005 ISBN-10: 8171338135 ISBN-13: 978-8171338139
5	Metallurgy of the Non ferrous metals	W.H.Dennis	Pitman, London 1963

12. SOFTWARE/LEARNING WEBSITES

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

13. PO-COMPETENCY-CO MAPPING

Semester IV	Non-Ferrous Extractive Metallurgy [Course Code: 4342105]
	Pos

Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design / development of solutions	PO 4 Engineering tools, Experimentation & Testing	PO 5 Engineering practices for society, Sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency	**Use metal extraction and refining processes for production of various non-ferrous metals.**						
Course Outcomes							
CO1: Discuss the importance of extraction metallurgy.	3	-	-	-	-	-	2
CO2: Explain various extraction processes.	3	1	1	1	-	1	2
CO3: Suggest suitable process for extraction of copper, aluminum, tin, zinc, lead.	3	2	2	2	1	1	2

*Legend: '**3'** for high, '**2**' for medium, **'1'** for low or **'-'** for the relevant correlation of each competency, CO, with PO/ PSO*

14. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons:

Sr. No.	Name and Designation	Institute	Email
1	Ms. Vidhi A. Mistry, Lecturer Metallurgy	Lukhdhirji Engineering College (Polytechnic), Morbi	vidhimistry2610@gmail.com
2	Mr. Nirmal G Patel Lecturer Metallurgy	Dr. S. & S. S. Ghandhy College of Engineering & Technology, Surat	nirgpatel@gmail.com
3	Mr. Rohan J Patel, Lecturer Metallurgy	Government Polytechnic, Bhuj	patelrohan930@gmail.com

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