GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Mineral Processing
(Course Code: 4332101)

Diploma Programme in which this course is offered	Semester in which offered
Metallurgy Engineering	Third

1. RATIONALE

Mineral Processing is the art and the science of handling ores and minerals that are excavated from the crust of the Earth. As ores grade reduces day by day, the requirement of metallurgy and mining engineers are increasing. Mineral-processing involves the liberation of valuable minerals from valueless minerals by commination, and then their subsequent separation by various concentration methods. In order to produce metal economically and commercially, the mineral processing plays a vital role in the exploitation of a country's natural ore reserves. Thus, this subject is most important to study in the metallurgy.

2. COMPETENCY

The purpose of this course is to help the student to attain the following competency through various teaching learning experiences:

- Apply the knowledge of various mineral processing operations in industries.

2. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

a) Corelate minerals on the basis of their properties and uses.
b) Use crushing and grinding operations for comminution of the ores.
c) Select appropriate sizing, classification and separation process as per requirement.
d) Suggest relevant practices to be adopted for sustainable development of mineral processing.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	0	2	4	30*	70	25	25	150

(*): 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. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the sub-components of the COs. Some of the PrOs marked '*' are compulsory, as they are crucial for that particular CO. These PrOs need to be attained at least at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify minerals on the basis of their physical & chemical characteristics.	I	02
2	Demonstrate the principle, construction and working of the jaw crusher and gyratory crusher.	II	02
3	To determine the capacity of roll crusher and calculate the nip angle for the laboratory crushing rolls.	II	04
4	Perform ball mill grinding operations on given a given mineral and calculate critical speed of ball mill.	III	02
5	Perform sieve analysis on various materials.	IV	02
6	Demonstrate the principle, construction and working of tube classifier and hydraulic Classifier.	IV	04
7	To study the magnetic separator and determine its efficiency by varying the current.	V	02
8	Perform heavy media separation operation of a given material.	V	02
9	Concentrate given mineral with the help of tabling process.	V	02
10	Demonstrate Froth floatation process.	V	02
11	Perform electrostatic separator and observe the separation of different minerals.	V	02
12	To study the effect of water content on pelletizing characteristics of a given mineral powder.	V	02
	Total hours		**28 Hrs.**

Notes:

i. *More* ***Practical Exercises*** *can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*
ii. *The following are some* ***sample*** *'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed* ***Practical Exercises*** *of this course required which are embedded in the COs and ultimately the competency.*

Sr.	Sample Performance Indicators for the PrOs.	Weightage in %

No.		
1	Identification of the raw material	20
2	Operate equipment and set-up carefully	20
3	Observation and recording of results	20
4	Interpretation of the result and conclusion	20
5	Submission of report within time limit and attendance in the laboratory	20

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

These major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to user in uniformity of practical's in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	Jaw Crusher Crusher size: 4" to 12" Feed size: 25 mm to 90 mm Discharge size: 5 mm to 30 mm Capacity: 150 to 500 kg/hr	2
2	Gyratory Crusher Feed opening: 25 to 80 mm Discharge size: 5 to 25 mm Capacity: 100 to 500 kg/hr	2
3	Ball Mill Jar capacity: 2 to 10 kg Grinding ball material: Stainless steel/Hardened steel Grinding jar material: Stainless steel/Hardened steel Movement: One way	3,4
4	Sieve shaker Sieve material: Brass or stainless steel Sieve size: 3" to 12" Mesh size range: 75 µm to 9.5 mm or as per ASTM E11 Capacity: 0.05g to 15 kg	5
5	Tube Classifier	6
6	Hydraulic Classifier	6
7	Magnetic Separator Drum size: Ø 300 – 400 mm and 200 to 350 mm width Rotating speed: 5 to 30 RPM	7
8	Wilfley Table	9
9	Electrostatic Separator	11

10	Laboratory Disc pelletizer Disc material: Stainless steel Disc angle: 45° Disc speed range: 5 to 50 RPM Pellet size: 1 mm to 20 mm	12

7. AFFECTIVE DOMAIN OUTCOMES

The following sample Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfil the development of this competency.

a) Aware about the different characteristics of minerals their availability and all operations involved in its processing.
b) Participates in class discussion related to various mineral processing operations.
c) Work as independently individuals, displays teamwork, displays leadership quality and professional commitment to ethical practice on daily basis.
d) Proposes ideas for sustainable development of mineral processing.

The ADOs are best developed through the laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year
iii. 'Characterization Level' in 3rd year.

8. 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 Mineral Processing**	1.a Explain the need of mineral processing. 1.b Differentiate ores, minerals and metals. 1.c Identify minerals based on their characteristics.	1.1 Sources of metals 1.2 Compare ores, minerals and metals 1.3 Mineral wealth of India 1.4 Physical & chemical characteristics of minerals 1.5 Need of mineral processing 1.6 Flowsheet of mineral processing
Unit – II **Crushing**	2.a Understand the different laws of comminution. 2.b Classify crushers. 2.c Discuss various types of crushers used in mineral processing.	2.1 Laws of comminution i.e. Rittinger's law, kick's law, bond's law 2.2 Crushing definition 2.3 Classification of crushers 2.4 Primary crushers: jaw crusher,

		gyratory crusher 2.5 Secondary crushers: cone crusher, roll crusher 2.6 Special crushers: steam stamp, disc crusher, toothed roll, hammer crusher
Unit – III **Grinding**	3.a Understand grinding of ores and minerals. 3.b Describe various types of grinding mills used in mineral processing. 3.c Discuss factors influencing the efficiency of tumbling mill 3.d Compare various types of grinding mills used in mineral processing.	3.1 Grinding definition 3.2 Classification of tumbling mills 3.3 Factors influencing the capacity of a tumbling mill 3.4 Ball mill 3.5 Variables in ball mill 3.6 Rod mill 3.7 Autogenous grinding 3.8 Tube mill
Unit – IV **Sizing and Classification**	4.a Describe sizing methods. 4.b Classify screening techniques. 4.c Separate the minerals using different classification techniques.	4.1 Purpose of sizing 4.2 Screening technique: hand screening and automatic screening by machine. 4.3 Stationary screens, moving screens, vibrating screens 4.4 Classification techniques: sedimentation, elutriation 4.5 Sorting classifier, sizing classifier
Unit – V **Ore Concentration Methods**	5.a Categories different ore concentration methods. 5.b Explain froth flotation, magnetic separation and electrostatic separation. 5.c Distinguish agglomeration methods.	5.1 Gravity concentration method i.e. Jigging, tabling, heavy-media separation 5.2 Froth flotation 5.3 Magnetic separation 5.4 Electrostatic separation 5.5 Agglomeration i.e. Sintering, pelletizing, nodulizing and briquetting
Unit – VI **Environmental Impact of Mineral Processing**	6.a Identify challenges related to sustainable development in mineral processing	6.1 Sustainable development in mineral processing 6.2 Challenges related to sustainable development in mineral processing

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to Mineral Processing	04	02	04	02	08
II	Crushing	08	06	04	02	12
III	Grinding	08	06	04	02	12
IV	Sizing and Classification	10	08	06	02	16
V	Ore Concentration Methods	10	08	06	04	18
VI	Environmental Impact of Mineral Processing	02	02	02	00	04
Total		**42**	**32**	**26**	**12**	**70**

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

Notes:

1. 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 above Table.
2. Ask the questions from each topic as per marks weightage. Numerical questions are to be asked only if it is specified. Optional questions must be asked from the same topic.

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory 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

1. Make a model on the basis of physical and chemical properties of different minerals.
2. Draw flowchart of mineral processing operations.
3. Draw flowchart for beneficiation process of a mineral
4. Compare crushers on the basis of their industrial applications.
5. Compare ball mill, rod mill, pebble mill and tube mill on the basis of their industrial applications.
6. Industrial visit of mineral processing industries.
7. Group discussion on advanced mineral processing operations.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the

various outcomes in this course:

a) Massive open online courses (MOOCs) may be used to teach various topics/sub topics.
b) Guide student(s) in undertaking micro-projects.
c) 'L" in section No. 4 means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) About 20% of the topics/sub-topics which are relatively simpler or descriptive in nature is to be given to the students for self-learning, but to be assessed using different assessment methods.
e) With respect to section No.10, teachers need to ensure to create opportunities and provisions for co-curricular activities.
f) Guide students on how to address issues on environment and sustainability using the knowledge of this course
g) Encourage students to read ore name of different metals.

12. 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 dated work diary consisting of individual contribution 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 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. Measure hardness of different minerals on Mohs scale and compare it.
2. Map the location of minerals available in India and around the world.
3. Collect minerals of different metals and prepare a report.
4. Prepare chart of minerals which are used in different areas.
5. Apply sizing operation on a mineral.
6. Make the agglomerates of mineral and characterized it.
7. Make a report on environmental impact of mining and mineral processing.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN

1	Mineral Processing: (Including Mineral dressing, Experiments and numerical)	Vandana Rao, Sonam Patel, Avinash Lele	I. K. International Publishing House Pvt. Ltd., New Delhi, 2017, ISBN 978-9385909504
2	Principle of Mineral Dressing	Gaudin A.M.	McGraw-Hill Inc., US, 1939 ISBN-978-0070230309
3	Extraction Of Nonferrous Metals	H. S. Ray, S. Sridhar, K. P. Abraham	Affiliated East-west Press Pvt Ltd., 2008, ISBN 978-8185095639
4	Handbook of Mineral Dressing; Ores and Industrial Minerals	Arthur F. Taggart	John Wiley & Sons, 1945, ISBN 978-0471843481
5	Wills' Mineral Processing Technology	Barry A. Wills	Butterworth-Heinemann, 2006, ISBN 978-0750644501
6	Mineral Processing	S. K. Jain	CBS, 2001, ISBN **978-8123907536**
7	Principles of Mineral Processing	Maurice C. Fuerstenau, Kenneth N. Han (Editor)	Society for Mining, Metallurgy, and Exploration, 2003 ISBN 978-0873351676
9	Textbook of Mineral Processing	D. V. Subba Rao	Scientific Publishers, New Delhi, 2017 ISBN 9789387741027
10	Environmental Impact of Mining and Mineral Processing Management, Monitoring, and Auditing Strategies	Ravi K. Jain, Zengdi Cindy Cui, Jeremy K. Domen	Butterworth-Heinemann, Elsevier, USA, 2016 ISBN 978-0128040409

14. SOFTWARE/LEARNING WEBSITES

1. https://mg-nitk.vlabs.ac.in/exp/identification-of-minerals/
2. https://www.prit.ac.in/virtual-labs
3. https://www.youtube.com/watch?v=aj6otFQMUvA
4. https://www.britannica.com/technology/mineral-processing
5. https://www.youtube.com/channel/UCUiup4A7jGvAgE_4kdD0yxg
6. https://www.youtube.com/watch?v=hUcrKHgglRk
7. https://www.youtube.com/watch?v=7ZLsF8LRuMQ
8. https://savree.com/en/encyclopedia/ball-mill
9. https://www.youtube.com/watch?v=jJeKGdy-Eds
10. https://www.youtube.com/watch?v=dmR3NgEj_vo
11. https://www.youtube.com/watch?v=IlbGScXeMjs
12. https://www.youtube.com/watch?v=E2Ln8KgrhpA

15. PO-COMPETENCY-CO MAPPING

Semester II	Physical Metallurgy-I (Course Code:)
	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		***Apply the knowledge of various mineral processing operations in industries.***						
Course Outcomes								
CO1:	Corelate minerals on the basis of their properties and uses.	3	-	-	1	-	1	3
CO2:	Use crushing and grinding operations for comminution of the ores.	3	-	-	2	-	2	3
CO3:	Select appropriate sizing, classification and separation process as per requirement.	3	-	-	2	-	2	3
CO4:	Suggest relevant practices to be adopted for sustainable development of mineral processing.	2	1	1	-	3	2	2

Legend: '**3'** for high, '**2**' for medium, **'1'** for low or **'-'** for no correlation with CO and PO

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

Sr. No.	Name and Designation	Institute	Contact No.	Email
1.	Ms. Sonam Patel Lecturer, Metallurgy Engineering	Dr. S. & S. S. Ghandhy College of Engineering and Technology, Surat	9904138938	sonampatel22@gmail.com
2.	Mr. Mandar Joshi Lecturer, Metallurgy Engineering	Dr. S. & S. S. Ghandhy College of Engineering and Technology, Surat	8469875634	jmandar96@gmail.com

3.	Mr. Falgun Suthar Lecturer, Metallurgy Engineering	Government Polytechnic, Rajkot	7990702954	falgun0712@gmail.com

****