

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)**Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)**

Semester-VI

Course Title: Underground Metalliferous Mining

(Course Code: 4362202)

Diploma programmer in which this course is offered	Semester in which offered
Mining Engineering	VI

1. RATIONALE

Metal extraction was started from the ancient times in the history of first civilization. Metal is the prime requirement for economic growth and development of any nation. In India metal deposits are segregated in various parts and extraction of metallic minerals are increasing day by day to fulfill the need of the nation. So, a holistic and clear understanding of latest metalliferous mining techniques is the crucial need for Mining engineer at present time.

The subject is designed to highlight the various processes, techniques and methods used for selection and extraction metallic ore from belowground areas. Latest prevailing techniques for selecting mode of approach, development and stopping methods of ore blocks for their economic extraction in different geo-technical conditions.

The course is designed to help the student to adopt safe and sustainable working practices in underground metalliferous mining for minimizing extraction losses and improving recovery ratios for the sustainable growth of metalliferous industries.

2. COMPETENCY

The course content should be taught and with the aim to develop required skills in the students so that students are able to acquire following competency:

- **Supervise Underground Metalliferous Mine working.**
- **Adopt suitable practice for extraction of ore blocks.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge, and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

CO1: Identify major metal deposits with their organisation across India.

CO2: Select a suitable method for development of a metalliferous deposit.

CO3: Justify the selection of unsupported underground metalliferous mining method.

CO4: Justify the selection of supported underground metalliferous mining method.

CO5: Select appropriate caving and special underground metalliferous mining method.

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	
4	0	2	5	70	30	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 at the ‘Precision Level’ of Dave’s Taxonomy related to ‘Psychomotor Domain’.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Draw a general outline of Indian metalliferous deposits with location, organization, production and major problem related details.	I	4
2	Determine the length of a drift based on various geo-technical parameters and direction, plot a graph showing all technical details.	II	6
3	Estimate amount of explosive charge required to make a vertical raise by drop raising method and draw section plan of the raise showing all technical details.	II	6
4	Design a blast layout of burn cut pattern for a drift drivage based on the given criteria and pull required per blast. Draw a graph of blast pattern showing all technical parameters.	II	6
5	Calculate the quantity of broken ore dispatched after each round of blast from a shrinkage stope by measuring swelling factor of various ore.	III	6
Total			28

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	Jaw crusher	5
2	Hammer	5
3	Sieves	5
4	Weighing machine	5
5	Measuring scale	5

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.

- Uses and objective approach in problem solving.
- Displays a professional commitment to ethical practice.
- Work as a leader/a team member.

8. UNDERPINNING THEORY

Only the major Underpinning Theory is formulated as higher level Uos of *Revised Bloom's taxonomy* in order development of the Cos and competency is not missed out by the students and teachers. If required, more such higher level Uos could be included by the course teacher to focus on attainment of Cos and competency.

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Unit – I Introduction of Metalliferous Mining	1a. Explain historical development and trend of underground metal mining. 1b. Identify measure metallic deposit and organizations across India. 1c. Compare underground coal and metal mining.	1.1 Historical development of metalliferous mining, Trend of Mining of metallic ore deposits in India 1.2 Geographical distribution of important economic metallic deposits in India 1.3 Major underground metal mining industries across India 1.4 Comparison between Underground coal and metal mining

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Unit-II Development of Underground Metalliferous Mines	<p>2a. Explain general terminology used in underground metal mining.</p> <p>2b. Explain various mode of entries with applicability conditions.</p> <p>2c. Explain all development parameters used for ore block preparation.</p>	<p>2.1 General Terminology: Country rock, Footwall, Hangwall, Drift, Cross-cut, level, Stope, Crown pillar, Rib pillar, Sill pillar, Manway, Ore passes with its size, Ore bins, Waste bins, and Winze.</p> <p>2.2 Mode of entries to underground deposits- Constructional features and applicability conditions of Adit, Shaft, Incline and Decline.</p> <p>2.3 Drilling patterns – Burn cut and Wedge cut</p> <p>2.4 Development parameters</p> <p>2.4.1 Selection of level interval and its governing parameters.</p> <p>2.4.2 Method of Horizontal Drivage – Drift/Cross-cut, main level, sub-level and companion level etc.</p> <p>2.4.3 Method of Vertical Drivage:</p> <p>2.4.3.1 Raising methods - Open raising, Compartment method, Drop raising, Raising by Alimak raise climber and Raise borers with their cycle of operations.</p> <p>2.4.3.2 Winzing method with their cycle of operations.</p>
Unit-III Unsupported Stoping Methods	<p>3a. Explain classification and applicability of unsupported stoping methods.</p> <p>3b. Explain various unsupported stoping methods.</p>	<p>3.1 Classification of unsupported stoping methods with their applicability conditions</p> <p>3.2 Open stoping methods:</p> <p>3.2.1 Stull mining</p> <p>3.2.2 Breast stoping</p> <p>3.2.3 Room and pillar</p> <p>3.2.4 Sublevel stoping</p> <p>3.2.5 Shrinkage stoping</p> <p>3.2.6 Blast hole stoping</p> <p>3.2.7 VCR stoping</p>

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Unit-IV Supported stopping methods	4a. Explain classification and applicability of supported stopping methods. 4b. Explain various supported stopping methods.	4.1 Classification of supported stopping methods with their applicability conditions 4.2 Supported Stopping Methods: 4.1.1 Post pillar method 4.1.2 Cut and fill method 4.1.3 Square set stopping
Unit-V Caving and special methods	5a. Explain various caving methods with their applicability conditions. 5b. Explain various special method of underground metalliferous mining.	5.1 Caving methods with applicability conditions: 5.1.1 Top slicing 5.1.2 Sub level caving 5.1.3 Block caving 5.2 Special method: 5.2.1 Extraction of underground pillar 5.2.2 In-situ leaching

9. 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 of Metalliferous Mining	04	7	4	0	11
II	Development of Underground Metalliferous Mines	14	7	5	4	16
III	Unsupported Stopping Methods	16	10	4	3	17
IV	Supported stopping methods	10	7	3	3	13
V	Caving and special methods	12	7	3	3	13
Total		56	38	19	13	70

Legends: R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)

Note: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary slightly from above table.

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 and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

- a) Visit nearby underground metalliferous mine.
- b) Attend workshops and seminars related with concerned topic of underground metalliferous mining.
- c) Attend expert lectures organize by department on concerned topics.
- d) Make group discussion on relevant topic of underground metalliferous mining technology.
- e) Watch video lectures based on methods of underground metalliferous mining.
- f) Undertake micro-project

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.11**, teachers need to ensure to create opportunities and provisions for **co-curricular activities**.
- f) Guide students on how to address issues on minimizing extraction losses in underground metalliferous mining.
- g) Video lectures showing various stoping methods.
- h) Guide students on how to address geo-technical issues during development of underground metalliferous mining.
- i) Documentaries on various special methods of underground metalliferous mining.

12. SUGGESTED MICRO-PROJECT LIST

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 is 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:

- a) Prepare a poster showing various elements of underground metal mining.
- b) Prepare a model showing development of underground metalliferous ore block.
- c) Prepare an illustrative diagram of sublevel stoping method.
- d) Prepare a banner showing underground metalliferous mining industries of India.
- e) Presentation on any case study related to any underground metalliferous mining industry.
- f) Prepare a poster showing special method of underground metalliferous mining.
- g) Make slides showing history of metal extraction from ancient times.
- h) Prepare a banner showing all transport arrangement used in underground metalliferous mining.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Elements of Mining Technology Vol. II	D. J. Deshmukh	Denett & Co., Nagpur Year: 2008 ISBN-13: 978-8189904333
2	Surface and Underground Excavations	R.R.Tatiya	CRC Press Year: 2013 ISBN-13: 978-0415621199
3	Introductory Mining Engineering	H.L.Hartman	John wiley and sons ISBN: 0-47162804
4	A study metalliferous mining methods	Y.P.Chachakar	Lovely Prakashan
5	Underground mining methods hand book	W.A.Hustrulid	Society of mining engineer of the American institute of mining metallurgical and petroleum engineer, New york

14. SOFTWARE/LEARNING WEBSITES

- a) NPTEL videos on Topic: - Underground Metalliferous Mining
<https://archive.nptel.ac.in/courses/123/105/123105006/#>
- b) Principles of Room and Pillar Method: <https://youtu.be/MCNjcNMojYQ>
- c) Sublevel Stoping method: <https://youtu.be/Ruo0YrLGAWA>
- d) Cut and Fill Method: <https://youtu.be/D4yPsbkBg2M>
- e) Block caving method: <https://youtu.be/PFVUqy3a6WQ>
- f) Sublevel caving method: <https://youtu.be/NG2Zinhpe9s>
- g) https://www.researchgate.net/publication/301833045_Underground_mining_Methods
- h) <https://www.britannica.com/technology/mining>
- i) https://en.wikipedia.org/wiki/Underground_hard-rock_mining

- j) [Chromextension://efaidnbmnnnibpcajpcgclefindmkaj/https://miningandblasting.files.wordpress.com/2009/09/mining_methods_underground_mining.pdf](https://efaidnbmnnnibpcajpcgclefindmkaj/https://miningandblasting.files.wordpress.com/2009/09/mining_methods_underground_mining.pdf)
- k) <https://globalroadtechnology.com/australian-underground-mines/>

15. PO-COMPETENCY-CO MAPPING:

Semester VI	Underground Metalliferous Mining (Course Code:4362202)								
	POs and PSOs								
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledg e	PO 2 Problem Analysis	PO 3 Design/ developm ent of solutions	PO 4 Engineeri ng Tools, Experime ntation &Testing	PO 5 Engineeri ng practices for society, sustainabi lity & environm ent	PO 6 Project Managem ent	PO 7 Life- long learning	PSO 1 Student will be able to operate flame safety lamp effectively.	PSO 2 Student will be able to test percentag e of inflamma ble gas.
Competency	<ul style="list-style-type: none"> Supervise Underground Metalliferous Mine working. Adopt suitable practice for extraction of ore blocks. 								
CO1: Identify major metal deposits with their organisation across India.	3	-	-	-	-	-	2	-	-
CO2: Select a suitable method for development of a metalliferous deposit.	2	1	2	-	-	-	2	-	-
CO3: Justify the selection of unsupported underground metalliferous mining method.	2	-	2	-	-	-	2	-	-
CO4: Justify the selection of supported underground metalliferous mining method.	2	-	2	-	-	-	2	-	-
CO5: Select appropriate caving and special underground metalliferous mining method.	2	-	2	-	-	-	2	-	-

Legend: '3' for high, '2' for medium, '1' for low and '-' for no correlation of each CO with PO.

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE**GTU Resource Persons**

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