GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Underground Mining of Coal
(Course Code:4362201)

Diploma programme in which this course is offered	Semester in which offered
Mining Engineering	6th Semester

1. RATIONALE

Underground coal mining is very much different from surface mining methods. It is also a risky task for a mining engineer to work in a very restricted area below ground facing all the difficulties of ventilation, light, noxious gasses, heat, and humidity. Therefore, for making safe practice in underground mines this subject is very essential to train the students about all geo-technical and engineering parameters used for underground coal extraction process.

The subject is designed to highlight the various process techniques and methods used for extracting coal from belowground areas. The prevailing support system used in different conditions. The production of coal with its transportation up to the surface as well as backfilling the excavated zone by suitable stowing material.

The course is designed to help the student to adopt safe and sustainable working practices in underground coal mines with modern coal mining methods, their applicability conditions, merits and demerits.

2. COMPETENCY

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

- **Supervise underground coal mine working for safety.**
- **Adopt an economical stowing process.**

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: Classify the rank and mining methods of coal seams.
CO2: Calculate all designing parameters used for bord and pillar development.
CO3: Justify the selection of safe and economical depillaring method.
CO4: Select suitable longwall mining method depending upon geotechnical parameters.
CO5: Adopt suitable stowing practices for underground excavated areas.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T/2+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA*	ESE	CA	ESE	
4	-	2	5	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 at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Appox. Hrs. Required
1	Draw a general outline of Indian coal sectors with location, organization, production and major problem related details.	I	*04
2	Calculate percentage extraction of coal during development of coal seam for a given depth with comparison with CMR 2017 standards.	II	*06
3	Design a bord and pillar panel layout from given incubation period and seam thickness and assuming other necessary data and draw a plan of panel showing dimensions of pillar, gallery, barrier and panel.	II	*06
4	Calculate the quantity of sand and water required for stowing underground working areas in lab conditions.	V	*06
5	Find out the compaction ratio of various stowing materials by lab testing method.	V	*06
	Total		28

Note

*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. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Basic knowledge of selected procedure for performing practical.	10
2	Accuracy in observation of all details needed for completion of practical.	30
3	Correctness in answering the questions.	30
4	Submission of practical in time.	10
5	Effective participation in practical group	20
	Total	**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	Metal Measurement Scale (1 Foot)	5
2	Plastic rectangular water tank with tap (20 L)	5
3	PVC Rectangular Tray (5kg Material Holding Capacity)	5
4	Water quantity measuring PVC Cup (2 L capacity)	5
5	G I Frame Sieves Set (Size 125mm, 106mm, 100mm, 90mm, 80mm, 75mm, 63mm, 53mm, 50mm, 45mm)	5
6	Steel Handle Rubber Grip Hammer (Medium size)	5
7	Laboratory Jaw Crusher (1 no)	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 fulfill the development of this competency.

a) Act as a team member/ individual in the decision-making process.
b) Displays a professional commitment to ethical practice on a daily basis.
c) Adopt economical and productive methods in mines.
d) Verify the mitigation measures taken against surface destruction due to underground mining.

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 **Fundamentals of Coal and Its Mining**	1a. Understand the geological processes contributing to the origin of coal. 1b. Differentiate between various coal ranks. 1c. Describe the banded constituents within coal and impact on coal quality. 1d. Evaluate the consumption of coal in different industries. 1e. Analyze the distribution of coal reserves in India and lignite reserves in Gujarat.	1.1 Origin of coal, Rank of Coal 1.2 Banded Constituents of Coal 1.3 Coal Analysis 1.3.1 Ultimate Analysis 1.3.2 Proximate Analysis 1.4 Consumptions of coal in various Industries 1.5 Coal reserves in India 1.6 Lignite reserves in Gujarat 1.7 Classification of various underground coal mining methods. 1.8 Factors affecting selection of underground coal mining methods.
Unit – II **Bord & Pillar Method – Development**	2a. Identify the applicability conditions for the bord and pillar method in underground coal mining. 2b. Evaluate the advantages and disadvantages associated with the bord and pillar mining technique. 2c. Define and describe the basic elements of the bord and pillar mining. 2d. Assess the advantages of the panel system within the bord and pillar mining framework. 2e. Classify the bord and pillar mining system based on method of approach to seam. 2f. Calculate the appropriate sizes for panels, extraction percentage and strength of pillars.	2.1 Applicability conditions of the bord and pillar method 2.2 Advantages and disadvantages of bord and pillar 2.3 Basic elements of bord and pillar mining method: pillar, gallery, junction, dip, strike, face, panel, barrier, roof, floor 2.4 Classification of bord and pillar mining system 2.5 Advantages of panel system of bord and pillar mining 2.6 Design of bord and pillar working 2.6.1 size of panel 2.6.2 size of barrier 2.6.3 size of pillars 2.6.4 width of galleries 2.7 Development 2.7.1 by blasting of solids 2.7.2 by coal cutting machines 2.7.3 by gathering arm loaders and shuttle car 2.7.4 by continuous miner 2.8 In bord and pillar working calculate 2.8.1 Percentage of extraction of coal 2.8.2 Size of the panel 2.8.3 Number of faces

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Unit– III **Bord & Pillar Mining– Depillaring**	3a. Understand the preparatory arrangements necessary before depillaring operations. 3b. Evaluate the factors that influence the choice of pillar extraction method. 3c. Differentiate depillaring techniques suitable for both thin and thick coal seams. 3d. Implement precautions and safety measures to prevent fire and inundation incidents during the depillaring process.	3.1 Preparatory arrangement before Depillaring. 3.2 Principles of pillar extraction techniques 3.3 Factors influencing choice of pillar extraction method 3.4 Depillaring in thin and thick seam 3.5 Local fall, main fall, air blast, line of goaf. 3.6 Precautions against fire and inundation during depillaring
Unit-IV **Longwall Mining**	4a. Identify the applicability conditions for the longwall mining method. 4b. Analyze the governing factors influencing the selection of longwall face layout. 4c. Classify longwall mining systems based on the direction of face advancement. 4d. Compare the working, merits, and demerits of advancing and retreating longwall faces. 4e. Demonstrate an understanding of longwall working with a shearer.	4.1 Longwall mining: Applicability conditions, elementary terms used in longwall mining 4.2 Classification of Longwall methods 4.3 Governing factors for selection of longwall method 4.4 Advancing and Retreating longwall faces: working method, merits and demerits 4.5 Single unit and double unit face: working method, merits and demerits 4.6 Longwall working with shearer 4.6.1 Shearer installation at longwall face 4.6.2 Sumping operation of shearer -- by drilling and blasting -- by snaking method 4.6.3 Face advancing method by shearer -- by full face cutting -- by half face cutting (zigzag method)

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Unit- V **Stowing Practice**	5a. Identify the governing conditions for stowing in underground coal mining. 5b. Evaluate the advantages associated with stowing methods. 5c. Classify stowing techniques based on their characteristics and applications. 5d. Assess the applicability conditions and working methods for both pneumatic and mechanical stowing.	5.1 Governing conditions for stowing 5.2 Advantages of stowing 5.3 Classification of stowing 5.4 Hydraulic stowing: 5.4.1 Applicability conditions 5.4.2 Hydraulic Profile Line and H:L ratio 5.4.3 Underground stowing arrangements and operation 5.4.4 Concentration of sand and water 5.4.5 Rate of stowing 5.4.6 Problems during sand stowing 5.5 Pneumatic stowing 5.5.1 Applicability conditions 5.5.2 Working methods 5.6 Mechanical stowing 5.6.1 Applicability conditions 5.6.2 Working methods

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamentals of Coal and Its Mining	06	4	4	0	08
II	Bord & Pillar Method – Development	18	4	8	10	22
III	Bord & Pillar Mining– Depillaring	10	3	6	3	12
IV	Longwall Mining	11	7	3	4	14
V	Stowing Practice	11	4	7	3	14
Total		**56**	**22**	**28**	**20**	**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 a nearby underground coal mine.
b) Attend an expert lecture based on underground coal mining methods.
c) Participate in a quiz competition related to underground coal mining techniques.
d) View online videos showing longwall and bord and pillar mining methods.
e) Make a group discussion on major issues of underground coal mining.
f) Undertake a micro project.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES

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 impact of underground mining on environment and sustainability.
g) Video lectures showing operational principles of various underground coal mining operations.
h) Guide students on how to address issues on underground mine supports.
i) Animated documentaries on various sand stowing practices.

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 one 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 coalfields of India.
b) Prepare an illustration banner related to panel designing and extraction.
c) Presentation on any case study related to longwall working.
d) Prepare a poster showing underground coal mine support.
e) Make slides showing pillar extraction techniques.

f) Design a layout of bord and pillar and longwall working.
g) Prepare a chart showing stowing surface arrangements.
h) Prepare a sheet showing the working cycle of the shearer in the longwall face.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Elements of Mining Technology Vol. I	D. J. Deshmukh	Denett & Co., Nagpur Year: 2008 ISBN-13: 978-8189904333
2	Principles and Practices of Modern Coal Mining	R. D. Singh	New Age International (P) Limited Year: 2010 ISBN 13: 9788122409741
3	Modern Coal Mining Technology	Samir Kumar Das	Lovely Prakashan Year: 1994
4	Underground Winning of Coal	T. N. Singh	Oxford & IBH Publishing Co Pvt.Ltd Year: 1992 ISBN: 978-8120404908
5	Underground Coal Mining Methods	Dr. J.G. Singh	Braj-Kalpa Publishers Year: 2000 ISBN: 978-8175252042

14. SOFTWARE/LEARNING WEBSITES

a) https://nptel.ac.in MOOC Course
b) Coal mines in India - major coal fields list for competitive exams. BYJUS. https://byjus.com/govt-exams/coal-mines-india/
c) Kumar, A., Vivek, Y., Gopal, M. K., Pradeep, D., & Raju, G. (2021). A STUDY ON HYDRAULIC STOWING. Journal of Emerging Technologies and Innovative Research, 8(7). https://www.jetir.org/papers/JETIR2107660.pdf
d) Longwall | Komatsu. (n.d.). https://www.komatsu.com/en/products/longwall/
e) Longwall Mining Overview | Introduction | underground COAL. (n.d.). http://www.undergroundcoal.com.au/fundamentals/07_overview.aspx
f) Ministry of Coal, Government of India. (n.d.-a). https://coal.gov.in/en/about-us/history-background
g) Ministry of Coal, Government of India. (n.d.-b). https://coal.gov.in

15. PO-COMPETENCY-CO MAPPING

Semester VI	Underground Mining of Coal (Course Code:4362201)								
	POs and PSOs								
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**	**PSO 1**	**PSO 2**
Competency	• Supervise underground coal mine working for safety. • Adopt an economical stowing process.								
Course Outcomes CO1: Classify the rank and mining methods of coal seams.	3	-	-	2	1	-	2	-	-
CO2: Calculate all designing parameters used for bord and pillar development.	2	2	2	3	1	2	-	-	-
CO3: Justify the selection of safe and economical depillaring method.	-	2	2	-	1	-	-	-	-
CO4: Select suitable longwall mining method depending upon geotechnical parameters.	2	2	2	-	1	2	-	-	-
CO5: Adopt suitable stowing practices for underground excavated areas.	2	2	1	3	2	-	-	-	-

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

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

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