



NATIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF GEOLOGICAL, MINING AND METALLURGICAL
ENGINEERING

MINING ENGINEERING PROGRAM

MI753 – UNDERGROUND MINING EXPLOITATION METHODS

I. GENERAL INFORMATION

CODE	: MI753 Underground Mining Exploitation Methods
SEMESTER	: 7
CREDITS	: 5
HOURS PER WEEK	: 7 (Theory–Practice)
PREREQUISITES	: MI636 Tunnels and Materials Movement
CONDITION	: Compulsory
DEPARTMENT	: Mining Engineering

II. COURSE DESCRIPTION

The course prepares students for understanding the concepts and methods of underground mining taking into consideration the physical, chemical and geological characteristics of the mineralized deposit. Students analyze the different stages of a mine project (since initial exploration to closure plan) including mine preparation, cutoff grades, sampling and dilution, mine cycle, safety in underground mines, underground mine planning. Several underground exploitation methods are analyzed: self-sustaining, artificial sustaining and caving. Students select the most suitable method on the basis of deposit physical conditions, as well as technical, economic and environmental considerations.

III. COURSE OUTCOMES

At the end of the course, students:

1. Select, plan and apply the most suitable method of underground exploitation on the basis of the actual conditions of an ore deposit; also, care about technical, economic considerations and compliance with safety and environmental standards.
2. Understand and explain the basics for the selection of an underground mining method: profitability, productivity, safety and maximum recovery mining.
3. Interpret the information that is required for the selection of the mining method.
4. Build alternatives to determine the proper mining method according to the type of ore deposit.
5. Analyze alternatives to make the best decision about underground mining method selection.
6. Evaluate and identify the best technic-economic alternative satisfying restrictions and limitations.

IV. LEARNING UNITS

1. MINING PROCESS STAGES

Introduction / Peruvian mining production / Mining historic importance / Mining process stages from a modern mining outlook, since prospective analysis to mines closure / Diamantine drilling, preliminary information for the conceptual application of mining exploitation / Deposits geological modeling.

2. DEVELOPMENT PROGRAMS IN UNDERGROUND MINING. DILUTION AND SAMPLING

Horizontal and vertical development programs in underground mines / Horizontal and vertical development / Cubication rate of mineral reserves obtained in underground mines / Minerals reserve inventory vs. production and reserves balance at the production process

end / Horizontal and vertical development costs / Sampling and dilution importance in underground mines exploitation / Impact in mineral value and final costs of exploitation process / Determination of dilution basic causes. / Fishbone diagram.

3. CUT-OFF GRADE

Importance of cut-off grade in economic management of underground mining exploitation / Reserves estimation and cut-off law / Mineral resources and reserves classification / JORC code. / Mineral reserves estimation methods / Mineral tonnage curves vs. ore grade. / Principal factors to determinate the cut-off grade / Cut-off grade determination / Income, costs and sensibility analysis / Basics of mining processes optimization from the cut-off grade outlook.

4. MINING CYCLE AND BASIC ELEMENTS OF SAFETY MANAGEMENT SYSTEMS

Basic concepts of drilling, blasting, cleaning, cartage and other complementary activities of the mining cycle / Mining cycle in mine fronts and exploitation / Consequences of optimum/deficient unit activities in mine cycle / Drilling by hand, mechanized mining / Blasting in mines / Mineral cleaning and cartage: by hand, with equipment / Mineral transportation: mining trucks, winches, lifting and conveyor belts / Staff safety importance in underground mining operations / Safety statistics and common accidents in underground exploitation: Fall of rocks / Losses causality diagram / Accidents analysis / General Law of Mining. / Underground mining operation management.

5. UNDERGROUND MINING AND SURFACE MINING, PLANNING AND DESIGN. CRITERIA FOR UNDERGROUND EXPLOITATION METHOD SELECTION, CLASSIFICATION

Differences between surface and underground mining. Analysis / General planning and design of the principal structure in an underground mine / Surface vs. underground mining / Basic determination of D/M rate in surface mining / Short-term, medium-term and long-term planning in underground mining / Surface and underground principal structure for underground mine / Most important factors to care about in underground mining exploitation methods / Classification of underground exploitation methods / Nicholas methodology for underground exploitation method determination.

6. UNDERGROUND EXPLOITATION METHODS

Self-sustained or Natural Sustained Exploitation Methods / Methods applied to rocks with high geomechanic strength / Open stopes / Self-sustaining underground exploitation methods / Room and pillar method / Sub level stoping / Application condition, preparing activities, forms and sequences of exploitation / Advantages and disadvantages of each method.

Underground Exploitation Methods With Artificial Enforcement / Methods applied to rocks with lower geomechanic strength / Importance of safety considerations in these methods / Applications / Over cut and fill / Under cut and fill / Mine backfill / Square setting method / Shrinkage method. / Application conditions, preparing activities, exploitation sequence, dilution effects / Advantages and disadvantages of each method.

Underground Exploitation Caving or Collapse Method / Methods applied to rocks with too lowest geomechanic strength that could cause collapse / Sub level caving. / Application condition preparing activities, drilling and blasting of rings, mining sequence / Advantages and disadvantages / Design fundamentals. / Block caving. / Application condition, preparing activities, mineral extraction, advantages and disadvantages.

V. LABORATORY AND PRACTICE SESSION

1. **Session 1:** Prospection and new underground projects explorations in Peru. Mining Norm D.S. 065-EM, related to underground exploitation.
2. **Session 2:** Unit costs determination of horizontal and vertical developments using conventional equipment and mechanized methods.
3. **Session 3:** Cut-off grade sensibility test.
4. **Session 4:** Dilution problems in veins, porphyry and mineralized materials. Dilution economic impact on minerals value.
5. **Session 5:** Software application for the design and planning of underground mining.

VI. METHODOLOGY

Theory classes are conducted using Power Point presentations and videos of actual underground mining developments. Student analysis and discussion of methods is promoted in class. Compulsory reading, in order to enrich and complement in-class presentations. Student active participation is promoted. Technical visits to underground mines in Peru: students present a technical report to describe the application of underground mining methods

VII. GRADING FORMULA

The Final Grade PF is calculated as follow:

$$PF = (EP + EF + PP) / 3$$

EP: Mid-term Exam
PP: Practical Work

EF: Final Exam

VIII. BIBLIOGRAPHY

1. H.L HARTMAN.
SME, Mining Engineering Handbook – 4nd Edition, 2012.
2. W.A. HUSTRULID.
AIME, Underground mining Methods Handbook, 2012.
3. CUMMINS-GIVEN.
SME, Mining Engineering Handbook