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

MINING ENGINEERING PROGRAM

MI742 – ROCK MECHANICS

I. GENERAL INFORMATION

CODE	**:**	MI742 Rock Mechanics
SEMESTER	**:**	7
CREDITS	**:**	3
HOURS PER WEEK	**:**	5 (Theory–Practice–Laboratory)
PREREQUISITES	**:**	GE511 Structural Geology MI636 Tunnels and Materials Movement
CONDITION	**:**	Compulsory
DEPARTMENT	**:**	Mining

II. COURSE DESCRIPTION

The course prepares students for the analysis and characterization of rock mass and rock structure, geo-mechanical classification of rock mass, stress-strain theory and relationships, in-situ and induced stress, strength of rock and of rock mass, strength of discontinuities, design of rock excavations. Students apply the methods of materials mechanics to the particular case of rocks present in excavations.

III. COURSE OUTCOMES

1. Organize and process information on geo-mechanics related to rock excavations.
2. Explain and determines the factors affecting the stability of rock excavations.
3. Understand and apply the concepts of mechanical behavior of rock related to rock excavations.
4. Interpret geo-mechanical parameters obtained through laboratory tests, simulations or other technological means.
5. Construct geo-mechanical models to represent the engineering problems in the mining industry and apply them to formulate realizable solutions.

IV. LEARNING UNITS

1. INTRODUCTION / 4 hours

General concepts and definitions / Intact rock, discontinuities, rock mass / Structure concept applied to rock excavations / Complexities inherent to rock mechanics / Implementation of rock mechanic programs.

2. STRUCTURE OF ROCK MASS / 8 hours

Introduction / Major and minor structural features / Quantitative description of structural discontinuities / Collecting structural data / Field visits: in-situ recognition of rocks and of rock mass, instruments for field study, geo-mechanical mapping of rock mass / Presentation of structural data / Technics of stereographic projection / Computer processing of structural data / Field data processing (geo-mechanical maps) for characterization of rock mass.

3. GEOMECHANICAL CLASSIFICATION OF ROCK MASS / 8 hours

Classification or rock mass for site characterization and engineering design / Initial classification of rock mass / RMR Bieniawski geo-mechanical classification / Barton Q

System / Hoek GSI / Laubscher / Other classifications / Field data processing (geo-mechanical maps) for classification of rock mass / Applications of geo-mechanical classifications .

4. **STRESS AND STRAIN THEORY / 8 hours**

Definitions / Components of stress and strain in a point / Representations of stress and strain / Relationship between stress and strain: one, two and three dimensional cases / Basic equations of elasticity theory / Elasticity theory applied to the design of rock structures.

5. **IN-SITU AND INDUCED STRESS / 8 hours**

Definitions / In-situ stress / Methods for measuring in-situ stress / Analysis of induced stress: closed solution case / Numerical methods for stress computing and analysis / Stress problems in rock excavations.

6. **INTACT ROCK STRENGTH, DISCONTINUITIES AND ROCK MASS / 12 hours**

Definitions / Strength of intact rock / Laboratory test of intact rocks / Shear stress of rough surfaces / Shear stress of filled discontinuities / Laboratory tests of discontinuities surface / Influence of water / Strength of fractured rock mass / Estimation of Geological Strength Index GSI based on classification of rock mass / Fault criteria / Software applications.

7. **SIMPLE AND MULTIPLE UNDERGROUND EXCAVATION DESIGN**

Simple excavations: general design methodology / In mass-design elastic rock / Stratified rock design / Design in fractured rock / Energy changes in underground mining / Multiple excavations, chambers and pillars: average stress on a pillar / Concentrations of stresses on pillars / Strength of the pillars / Calculation of safety factor / Considerations for pseudo-continuous and discontinuous media.

8. **UNDERGROUND EXCAVATIONS SUPPORT**

Definitions / Principles of reinforcement and support / Support materials and techniques / Support estimation using geo-mechanical classifications / Calculation of the support by: limit balance, RSI, NATM and numerical methods complemented by the use of software / Pre-reinforced rock masses / Mine filling.

9. **SELECTION AND GEO-MECHANIC DESIGN OF MINING METHODS**

Introduction / Selection of the mining method / Naturally sustained mining methods / Artificially sustained mining methods / Mine collapse methods / Subsidence induced by mining / Mining-induced seismicity.

10. **STABILITY OF SLOPES IN SURFACE MINING**

General concepts / Factors affecting the stability of slopes / Modes or mechanisms of failure of slopes / Calculation methods for the analysis of slope stability / Software for analysis of stability of slopes / Problems handling of instability of slopes.

11. **INSTRUMENTATION AND MONITORING OF EXCAVATION STABILITY**

General concepts / Susceptible factors for instruments control / Instrumentation for applications in underground excavations / Instrumentation for applications in surface excavations.

V. METHODOLOGY

The course is conducted with theory, practice, computer lab sessions, as well as study visits to mining fields. In theory sessions, the instructor introduces the concepts, principles and applications. In practice sessions, different problems are solved and their solution are analyzed. In the laboratory sessions, a specialized simulation software is used to solve problems and analyze their solution. Field study visits are carried out at least three times in the semester.

VI. GRADING FORMULA

The Average Grade PF is calculated as follow:

PF = (EP + EF + PPL) / 3 **PF = (PL1 + PL2 + PL3+ PL4) / 4**

EP: Mid-Term Exam
EF: Final Exam
PPL: Average of laboratories

VII. BIBLIOGRAPHY

1. **BRADY B.H.G., and BROWN E.T.**
   Rock Mechanics for Underground Mining
2. **HOEK, and BROWN E.T.**
   Underground Rock Excavations

IX. COURSE CONTRIBUTIONS TO STUDENT OUTCOMES ATTAINMENT

Course contributions to Student Outcomes are shown in the following table:

Level 1: Know
Level 2: Comprehend, calculate
Level 3: Model, apply, solve
Level 4: Apply at advanced level, design. Achievement of Student Outcome

Outcome	Contribution
1. Engineering Design Design and integrate mining systems and components satisfying requirements and needs as well as given technical, economic, social and legal constraints and limitations.	
2. Problem solving Identify, formulate and solve engineering problems properly using the methods, techniques and tools of mining engineering.	3
3. Sciences Application Apply the knowledge and skills of mathematics, sciences and engineering to solve mining engineering problems.	3
4. Experimentation and Testing Conceive and conduct experiments and tests, analyze data and interpret results.	3
5. Modern Engineering Practice Use and apply techniques, methods and tools of modern engineering necessary for the practice of mining engineering.	3
6. Engineering Impact Understand the impact of mining engineering solutions on people and society in local and global contexts.	3
7. Project Management Determine the budgets, schedules and feasibility of engineering projects, and participate in its management for the attainment of goals.	
8. Environmental Appraisal Take into account the importance of preserving and improving the environment in the development of their personal and professional activities	
9. Lifelong Learning Recognize the need to keep their knowledge and skills up-to-date according to advances of mining engineering and engage in lifelong learning.	
10. Contemporary Issues Know and analyze relevant contemporary issues in local, national and global contexts.	3
11. Ethics and Professional Responsibility Evaluate their decisions and actions from a moral perspective and assume responsibility for the executed projects.	3
12. Communication Communicate clearly and effectively in oral, written and graphical formats, interacting with different types of audiences.	3
13. Teamworking Appraise the importance of teamworking and participate actively and effectively in multidisciplinary teams.	3