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

METALLURGICAL ENGINEERING PROGRAM

GE413 – CRYSTALLOGRAPHY

I. GENERAL INFORMATION

CODE	:	GE413 Crystallography
SEMESTER	:	4
CREDITS	:	4
HOURS PER WEEK	:	6 (Theory–Practice–Laboratory
PREREQUISITES	:	MA124 Basic Mathematics II, GE001 General Geology
CONDITION	:	Compulsory

II. COURSE DESCRIPTION

This theoretical-practical course allow students understand the origin of minerals in Earth crust, differentiate minerals and rocks, interpret crystal laws, relate crystal morphology with crystalline systems and the corresponding symmetry, model compact packing, describe crystalline structure of minerals, identify the type of bonds, know the polyhedrons of ionic coordination and covalent, compute the Madelung constant and the lattice energy of ionic crystals, stereographically project crystals of different systems, recognize and interpret the physical properties of minerals.

III. COURSE OUTCOMES

At the end of the course, the student:

1. Explain the origin of minerals based on their crystal structure.
2. Recognize crystalline structures and symmetry classes and formulate models of crystalline structures.
3. Carry out stereographic projections of crystals.
4. Relates minerals physical properties with crystalline structures.
5. Apply crystal-chemical properties for solving crystal related problems.

IV. LEARNING UNITS

1. MINERAL GENESIS

Volcano and hydrothermal activity / Occurrence of minerals in diverse environments / Crystallization / Crystallization degree.

2. STRUCTURAL CRYSTALLOGRAPHY

Introduction to mineral crystallography / Definitions: mineral, rock, crystal, crystalline structure, crystalline system / Main laws governing crystals formation / Models of lineal, bi-dimensional and three-dimensional packing / Unitary cells or Bravais networks / Miller index and Weiss index (plane and three-dimensional) / Inter-plane distance. X-ray diffraction crystallography / Structure of high efficiency compact packing (cubic and hexagonal) / Cubic structures of low and medium efficiency (P-type and I-type) / Theoretical and real content. Volumen of basic cells / Coordination number, packing efficiency and density, computing mineral density / Mono-atom structures: gold group, chrome group. Rhenium group, carbon group.

3. CHEMICAL CRYSTALLOGRAPHY

Introduction. Crystal-chemical characteristics of minerals. Electron configuration. Chemical composition. Coordination numbers and polyhedrons / Types of chemical bonds: covalent, ionic, Van der Walls, hydrogen bridge. Relation of cation and anion radius. Applications / Poly-atom structures of cubic system: halite type, sphalerite type, fluorite type, CdCI type, cuprite type, pyrite type / Structure of other crystalline systems: rutile type, schelite type, nickelite type / Lattice energy. Mie potential. Computing Madelung constant / Isomorphism, polymorphism, pseudomorphism, ionic substitutions. Rules of ionic substitutions. Atomic substitutions, natural alloys of native elements / Phase diagram. Gibbs rule. Binary diagrams (isomorph mixings) / Generation of polymorph and isomorph minerals. Examples.

4. MORPHOLOGICAL CRYSTALLOGRAPHY

Introduction / Spherical, gnomonic and stereographic projections / Crystal orientation of different crystalline systems / Placing poles and planes in stereographic projections. Measurement of angles between poles and planes / Elements of crystal symmetry (axis, planes, centers). Symmetry operations and fundamental theorems. Symmetry classes / Crystalline forms (open, closed) / Rationality law. Determination of stereographic coordinates of poles using Milles indexes / Miller indexes of diverse crystalline forms and composed forms / Tautozone faces and zone axis / Stereographic projection of crystals with low symmetry grade.

5. PHYSICAL CRYSTALLOGRAPHY

Introduction / Physical properties of minerals: morphology, color, brightness, refraction index, fracture, cleavage, tenacity, fragility, malleability, elasticity, luminescence, electrical properties (piezo-electricity, pyro-electricity), magnetism, radioactivity / Recognition of mineral species according to their physical properties and their relationship to crystalline structures.

V. PRACTICAL EXPERIENCE

1. Graded practice of structural crystallography.
2. Graded practice of chemical crystallography
3. Graded practice of morphologic crystallography
4. Graded practice of physical crystallography

VI. METHODOLOGY

This course is carried out in theory, practical and laboratory sessions. In theory sessions, the instructor introduces concepts, theorems and applications. In practical sessions, several problems are solved and their solution is analyzed. In laboratory sessions, students analyze the crystalline structure of different minerals and materials. At the end of the course, students should hand in and expose an integrating paper and project. In all sessions, students' active participation is encouraged.

VII. GRADING FORMULA

The Final Grade PF is calculated as follow:

PF = (EP + EF + PP) / 3

EP: Mid-term Exam EF: Final Exam
PP: Average of 5 practical works.

VIII. BIBLIOGRAPHY

1. Flint
   Principles of Crystallography.
2. Borchardt-Ott Walter
   Crystallography
3. Sands Donald
   Intoduction to Crystallography

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 systems and components for the discovery and development of subsurface earth resources, and construction of earthworks, satisfying requirements, and given technical, economic, social and legal constraints.	
2. Problem solving Identify, formulate and solve engineering problems properly using the methods, techniques and tools of geological engineering.	2
3. Sciences Application Apply the knowledge and skills of mathematics, sciences and engineering to solve geological engineering problems.	2
4. Experimentation and Testing Conceive and conduct experiments and tests, analyze data and interpret results.	2
5. Modern Engineering Practice Use and apply techniques, methods and tools of modern engineering necessary for the practice of geological engineering.	2
6. Engineering Impact Understand the impact of geological engineering solutions on people and society in local and global contexts.	2
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.	2
9. Lifelong Learning Recognize the need to keep their knowledge and skills up-to-date according to advances of geological engineering and engage in lifelong learning.	2
10. Contemporary Issues Know and analyze relevant contemporary issues in local, national and global contexts.	2
11. Ethics and Professional Responsibility Evaluate their decisions and actions from a moral perspective and assume responsibility for the executed projects.	
12. Communication Communicate clearly and effectively in oral, written and graphical formats, interacting with different types of audiences.	2
13. Teamworking Appraise the importance of teamworking and participate actively and effectively in multidisciplinary teams.	2