



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

**MINING ENGINEERING PROGRAM**

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**GE413 – CRYSTALLOGRAPHY**

**I. GENERAL INFORMATION**

|                       |                                  |
|-----------------------|----------------------------------|
| <b>CODE</b>           | : GE413 Crystallography          |
| <b>SEMESTER</b>       | : 4                              |
| <b>CREDITS</b>        | : 4                              |
| <b>HOURS PER WEEK</b> | : 6 (Theory–Practice–Laboratory) |
| <b>PREREQUISITES</b>  | : GE001 Geology                  |
| <b>CONDITION</b>      | : Compulsory                     |
| <b>DEPARTMENT</b>     | : Geological Engineering         |

**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 Waals, hydrogen bridge. Relation of cation and anion radius. Applications / Poly-atom structures of cubic system: halite type, sphalerite type, fluorite type, CdCl type, cuprite type, pyrite type / Structure of other crystalline systems: rutile type, schelite type, nickelite type / Lattice energy. 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 Miller 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  
Introduction to Crystallography