NATIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF ENVIRONMENTAL ENGINEERING
SANITARY ENGINEERING PROGRAM

SA225 – USE OF UNDERGROUND WATER I

I. GENERAL INFORMATION

CODE	**:**	SA225 Use of Underground Water I
SEMESTER	**:**	7
CREDITS	**:**	3
HOURS PER WEEK	**:**	5 (Theory – Practice)
PREREQUISITES	**:**	HH113 General Hydrology HH223 Fluid Mechanics I
CONDITION	**:**	Mandatory

II. COURSE DESCRIPTION

This theoretical and practical course prepares students for the identification, extraction and use of underground water for multiple purposes. Groundwater is water present beneath Earth surface in soil pore spaces and in fractures of rock formations. Students analyze the geological and hydrogeological aspects of underground water, analyze hydrogeological parameters such porosity, permeability, hydraulic conductivity and transmissivity. Students also model the motion of water in porous media, model and analyze the characteristics of different type of aquifers, analyze pumping systems and pumping tests, and determine and interpret the quality of underground water according to quality norms and criteria. Along the course, student complete practical work on underground hydraulics and analysis of pumping tests.

III. COURSE OUTCOMES

At the end of the course, students:

1. Understand and analyze the geological and hydrogeological aspects governing the use of underground water resources.
2. Understand and interpret the hydrogeological parameters of underground water.
3. Apply methods for analyzing the characteristics and properties of the behavior and motion of underground water.
4. Analyze aquifers, their types, and calculates groundwater flows and aquifer storage.
5. Assess the quality of underground water considering its intended use and purpose.

IV. LEARNING UNITS

1. INTRODUCTION

Definition of underground water. Importance. Aquifers. Types of aquifers. Underground water reserves and distribution. Chemical and biological characteristics of underground water. Hard and soft water.

2. GEOLOGICAL ASPECTS

Geological aspect related to underground water. Igneous, sedimentary and metamorphic rocks. Analysis fo geodynamic aspects.

3. HYDROGEOLOGICAL ASPECTS AND HYDROGEOLOGICAL PARAMETERS

Hydro-geology. Distribution and movement of underground water. Hydrograms. Iso-pieces. Hydrogeological parameters: porosity, permeability, hydraulic conductivity coefficient. transmissivity. Water head. Water content. Hydrogeological models.

4. WATER MOTION IN POROUS MEANS
General motion equation in porous means. Assumptions and restrictions. Types of flow: radial and one-directional. Darcy law. Groundwater flow equation. Calculation of groundwater flow.

5. AQUIFERS
Aquifers. Permeable and porous aquifers. Confined aquifers. Modeling of confined aquifer. Semi-confined aquifer. Modeling of semi-confined aquifers. Free aquifer. Modeling of free aquifer. Water storage in an aquifer. Aquifer water table. Seasonal aquifer recharge.

6. INTERPRETATION OF PUMPING TESTS
Initial considerations. Pumping tests. Pressure-flow-power curves of pumping systems. Types of pumps. Data gathering, analysis and interpretation.

7. AUXILIARY TECHNIQUES IN HYDROGEOLICAL STUDIES
Main auxiliary techniques. Specific storage and specific yield. Contaminant transport properties. Hydrodynamic dispersion. Molecular diffusion. Retardation by absorption.

8. QUALITY OF UNDERGROUND WATER
Quality parameters of underground water. Chemical and biological characteristics. Minerals and gases in underground water. Main ions and anions. Soft and hard water. Interpretation of graphs and curves. Water quality norms and standards. Contamination of underground water.

V. METHODOLOGY

The course develops through theory and practice sessions. In theory session, the instructor presents the concepts and methods. In practice sessions students, under the guidance of the instructor, apply concept and methods to solve different problems related to geological and hydrogeological aspects of underground water, analysis of water motion, aquifer modeling, analysis of pumping systems for water extraction, analysis of water quality. At the end of the course, students present a group report which is orally defended. Active student participation is encouraged throughput the course.

VI. EVALUATION FORMULA

The average grade PF is calculated as follows:

PF = (PC1 + PC2 + PC3 + FT) / 4

PC: Quizzes TF: Final report

VII. BIBLIOGRAPHY

1. **HYDRAULICS OF UNDERGROUND WATER**
   Rodolfo Saenz Forero, CEPIS Editions, Peru.

2. **PRACTICAL HYDROGEOLOGY**
   J, Pulido Carrillo, Urmo Editions, Bilbao, Spain.

3. **HANDBOOK OF GROUND WATER**
   MODELS AND COMPUTERS IN GROUND-WATER ANALYSIS
   Environmental Protection Agency. Washington DC, USA.