NATIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF PETROLEUM AND PETROCHEMICAL ENGINEERING

PETROLEUM ENGINEERING PROGRAM

PP513 – ENHANCED RECOVERY OF OIL WELLS

I. GENERAL INFORMATION

CODE	**:**	PP513 Enhanced Recovery of Oil Wells
SEMESTER	**:**	9
CREDITS	**:**	5
HOURS PER WEEK	**:**	6 (Theory, Practice)
PREREQUISITES	**:**	PP422 Natural Gas and Condensates II
CONDITION	**:**	Compulsory

II. COURSE DESCRIPTION

The course prepares students in the application of the concepts, methods and techniques of petroleum enhanced recovery. Reservoir concepts are applied for predicting fluid production (petroleum and water), as well as the volume of required fluids to complete the project. Different prediction techniques of injection-production are analyzed, as well as the theoretical assumptions, limitations, required information, and the outcomes of the methods and techniques. Prediction techniques are applied to estimate the requirements of injection fluids, as well as the fluids produced in the processes of enhanced recovery through proper data processing according to the selected method. Diverse real problems are analyzed and solved.

III. COURSE OUTCOMES

At the end of the course, students:

1. Interpret results of relative permeability tests and capillary pressure tests and use them in production forecast.
2. Select the proper prediction method according to the quality and quantity of available data.
3. Plan pilot projects for obtaining the required information to be used in large-scale projects.
4. Forecast fluid production levels (petroleum and water), as well as the required volume of liquids for enhanced recovery projects.
5. Identify and compile relevant data to be properly processed for designing enhanced recovery projects.

IV. LEARNING UNITS

1. INTRODUCTION AND BASIC CONCEPTS / 8 HOURS

Mechanisms of natural production / Scope of primary recovery / Enhanced recovery / Historic evaluation of injection of water, gas and immiscible liquids.

2. ROCK PROPERTIES AND RESERVOIR FLUIDS / 8 HOURS

Density, PVT analysis, viscosity / Miscibility and immiscibility / Porosity and permeability / Wettability / Capillary pressure / Fluids saturation / Relative permeability / Fluids distribution in the reservoir.

3. IMMISCIBLE DISPLACEMENT / 12 HOURS

Forward displacement theory / Fractional flow / Forward advancement theory / Other displacement theories / Applications of displacement theory / Miscible displacement / Capillary number theory / Revision of methods for in-situ petroleum determination / Estimation of petroleum to be recovered

by enhanced recovery / Mobility ratio / Scanning efficiency / Flooding patterns / Factors affecting areal scanning

4. OIL WELL HETEROGENEITY / 8 HOURS

Types of heterogeneities / Vertical variations, permeability areals / Vertical stratification / Permeability variation coefficient / Lorenz coefficient / Efficiency of vertical scanning / Effect of gravity force relation mobility / Capillary forces / Cross flow between layers / Efficiency of volumetric scanning / Compliance efficiency / Effect of production rates / Petroleum recovery by inhibition.

5. WATER INJECTION PREDICTION METHODS / 8 HOURS

Perfect prediction methods / Methods associated to reservoir heterogeneity / Methods associated to scanning area / Methods associated to displacement mechanisms / Prediction methods involving mathematical models / Empirical methods for prediction / Pilot injection / Advantages and disadvantages.

6. MISCIBLE DISPLACEMENT / 8 HOURS

Recovery by miscible displacements / Determination of miscibility conditions / Displacement with enriched gas / Miscible covers / Carbon dioxide / Partially miscible systems / Thermal recovery.

V. METHODOLOGY

The course is carried out in theory, practical and lab sessions. In theory sessions, the instructor introduces concepts, theorems and applications. In practical sessions, several problems are solved and their solution is analyzed. At the end of the course, students should submit and defend a project Enhanced Recovery of Oil Wells. In all sessions, students' active participation is encouraged.

VII. GRADING FORMULA

The final grade PF is calculated as follows:

PF = (EP + EF + PC)/3

EP: Mid-Term Exam EF: Final Exam
PC: Average of 5 practice work reports

VIII. BIBLIOGRAPHY

1. **Richard Wheaton**
   Fundamentals of Applied Reservoir Engineering: Appraisal, Economics and Optimization. Elsevier, 2015
2. **Forrest F. Craig Jr.**
   Aspects of Water Injection, 2010
3. **H. C. Slider**
   Practical Petroleum Reservoir Engineering Methods, 2012