



خطة مقرر: الطرق المحسنة للإنتاج

**Course Plan (Syllabus): Enhanced Oil Recovery**

**I. Information about Faculty Member Responsible for the Course :**

<b>Name</b>	Dr. Khaled Saeed Ba-Jaalah	<b>Office Hours</b>					
<b>Location &amp; Telephone No.</b>	Hadhramout Univ. 701915823	<b>SAT</b>	<b>SU N</b>	<b>MO N</b>	<b>TUE</b>	<b>WED</b>	<b>THU</b>
<b>E-mail</b>	kbajaalah@hotmail.com						

**II. General information about the course:**

<b>1</b>	<b>Course Title</b>	<b>Enhanced Oil Recovery</b> الطرق المحسنة للإنتاج					
<b>2</b>	<b>Course Code and Number</b>	PNGE 453					
<b>3</b>	<b>Credit Hours</b>	<b>Credit Hours</b>					<b>Total</b>
		<b>Theoretical</b>	<b>Practical</b>	<b>Seminar/Tutorial</b>	<b>Training</b>		
		2		1		3	
<b>4</b>	<b>Study Level and Semester</b>	Level Four – First Semester					
<b>5</b>	<b>Pre-requisites (if any)</b>	PNGE 351					
<b>6</b>	<b>Co-requisites (if any)</b>	N.A.					
<b>7</b>	<b>Program (s) in which the course is offered</b>	Petroleum and Natural Gas Engineering					
<b>8</b>	<b>Language of teaching the course</b>	English					
<b>9</b>	<b>Location of teaching the course</b>	Faculty of Petroleum and Natural Resources					

**III. Course Description:**

Basic theoretical and design aspects of water flooding processes. Review of capillary phenomena and relative permeability characteristics of reservoir rocks. Theory of immiscible displacement including piston-like and frontal advance mechanisms. Injectivity analysis and performance prediction of linear and pattern flooding. Principles of thermal recovery, chemical flooding and miscible gas displacement methods, performance prediction. Advantages and drawbacks of each displacement methods. Selection criteria for target reservoirs.

**IV. Course Intended Learning Outcomes (CILOs):**

**After completing the course, the student will be able to:**

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Quality Assurance Unit  
Assoc.Prof. Adel Al-Matary

Dean of the Faculty  
Assoc.Prof. Bassim  
AlKhirbash

Dean of the Development  
& Quality Assurance Center  
Assoc.Prof. Huda Al-Emad

Rector of Sana'a University  
Prof. Dr. Al Qaseem Mohammed Abas



a1.	Understand the general rock properties and its relation to fluid flow in porous media.
a2.	Understand of the technical and economic constraints that govern the performance of a water flooding project.
a3.	Understand the basic features and technical foundations of the most common EOR methods.
b1.	Compute the various rock properties.
b2.	Perform the principle of math, science and engineering to predict the performance of a linear or pattern water flood in a homogeneous reservoir.
b3.	Select an optimum EOR method.
c1.	Analyze and interpret water flooding data and EOR data.
c2.	Develop recovery expectations and choose appropriate methods for improving oil recovery.
d1.	Improve leadership skills and work effectively in teams.
d2.	Improve communication skills through writing and presenting an engineering report.

V. Course Content:				
A. Theoretical Aspect:				
Order	Topic List / Units	Sub Topics List	Number of Weeks	Contact Hours
1	Introduction	- Stages of recovery. - Development of water flooding.	1	2
2	Fundamentals of Rock and Fluid Interaction	- Review of rock properties	1	2
		- Reservoir types.	1	2
3	Flow of Immiscible Fluids	- Types of flow. - Fluids Permeabilities. - Residual Oil Saturations.	1	2
4	Prediction of Linear Immiscible Displacement	- Fractional flow curve. - Frontal advance theory.	1	2
		- Linear water flood performance prediction.	1	2
5	Mid-term Exam		1	2
6	Areal Sweep Efficiency and Flood	- Injection patterns and areal sweep efficiency.	1	2
		- Pattern water flood performance prediction.	1	2

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	Patterns			
7	<b>Thermal EOR Methods</b>	<ul style="list-style-type: none"> <li>- Steam Injection</li> <li>- Hot Water Injection</li> <li>- In-Situ Combustion</li> </ul>	1	2
8	<b>Miscible Gas Displacement Methods</b>	<ul style="list-style-type: none"> <li>- HC Miscible Flooding.</li> <li>- CO2 Miscible Flooding.</li> </ul>	1	2
		<ul style="list-style-type: none"> <li>- N2 &amp; Flue Gas Flooding.</li> </ul>	1	2
9	<b>Chemical Flooding Methods</b>	<ul style="list-style-type: none"> <li>- Polymer Flooding.</li> <li>- Alkaline Water Flooding.</li> </ul>	1	2
		<ul style="list-style-type: none"> <li>- Alkaline Water Flooding.</li> <li>- Surfactant Flooding.</li> </ul>	1	2
<b>Number of Weeks /and Contact Hours Per Semester</b>			<b>14</b>	<b>28</b>

### B. Practical Aspect (if any)

Order	Practical / Exercises/ Tutorials topics	Number of Weeks	Contact Hours
1	Calculate the various rock properties:- <ul style="list-style-type: none"> <li>- Fluids Permeabilities</li> <li>- Residual Oil Saturation</li> <li>- Wettability calculation</li> <li>- Capillary Pressure calculation</li> </ul>	2	4
2	Estimating Displacement Performance <ul style="list-style-type: none"> <li>- Oil Displaced, <math>N_p</math></li> <li>- Production Rates, <math>q_o</math> &amp; <math>q_w</math></li> <li>- WOR, <math>F_{wo}</math></li> <li>- Time Required for Displacement</li> </ul>	2	4
3	Prediction of Displacement Performance <ul style="list-style-type: none"> <li>- Estimating Injection Rates</li> </ul>	1	2
4	Immiscible Displacement in Two Dimensions – Areal:- <ul style="list-style-type: none"> <li>- Displacement in a Five-Spot Pattern</li> <li>- Correlations Developed From Scaled Laboratory Models</li> <li>- Streamtube Models</li> </ul>	2	4
5	Reservoirs with Vertical Heterogeneity:- <ul style="list-style-type: none"> <li>- 2D Displacement in Uniform Stratified-Reservoirs-Layered Reservoirs.</li> <li>- Approximation of 2D Flow With Thickness-Averaged Properties .</li> <li>- Vertical Equilibrium of Capillary &amp; Gravity Forces .</li> </ul>	2	4

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6	Injectivity and Injection Rates:- - Injection Rates of Liquid Filled Patterns – M=1 - Injection Rates of Liquid Filled Patterns – M≠1 - Injection Rates of Depleted Reservoirs – M≠1	2	4
7	Small project <i>presentation</i>	2	4
8	Practical Exam	1	2
<b>Number of Weeks /and Contact Hours Per Semester</b>		<b>14</b>	<b>28</b>

<b>VI. Teaching Strategies:</b>	
<ol style="list-style-type: none"> <li>1. Discussion</li> <li>2. Group discussions</li> <li>3. Independent readings</li> <li>4. Lecture</li> <li>5. Oral presentation</li> <li>6. Problem solving</li> <li>7. Project</li> <li>8. Small group working</li> <li>9. Tutorial</li> <li>10. Videos</li> </ol>	

<b>VII. Tasks and Assignments :</b>				
<b>No</b>	<b>Assignments/ Tasks</b>	<b>Type of Assignment</b>	<b>Mark</b>	<b>Week Due</b>
1	Exercises & Home works	personal	5	By-weekly basis
2	Small project	Cooperative	10	12
<b>Total Score إجمالي الدرجة</b>			<b>15</b>	

<b>VIII. Learning Assessment :</b>				
<b>No.</b>	<b>Assessment Tasks</b>	<b>Week due</b>	<b>Mark</b>	<b>Proportion of Final Assessment</b>
1	Exercises & Home works	By-weekly basis	15	10 %
2	Quiz (1)	W6	5	3.3 %
3	Midterm Exam	W8	25	16.7 %
4	Quiz (2)	W12	5	3.3 %
5	Final Exam (practical)	W 15	30	20 %
6	Final Exam (theoretical)	W16	70	46.7 %
<b>Total</b>			<b>150</b>	<b>%100</b>

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## IX. Learning Resources :

### 1- Required Textbook(s) :

1. Don W Green and Willhite G P, 1998, Enhanced Oil Recovery, SPE International, 553 pp.
2. G. Paul Willhite, 1986, "Waterflooding", Society of Petroleum Engineers, Textbook Series, Vol. 3, Richardson, Texas.

### 2- Essential References :

1. F. F. Craig, 1993, 'The Reservoir Engineering Aspects of Waterflooding', Monograph Series Vol. 3, Society of Petroleum Engineers, Richardson, Texas.
2. Larry W. Lake, Russell Johns, Bill Rossen & Gary Pope, 2014, Fundamentals of Enhanced Oil Recovery, SPE, 496 pp.

### 3- Electronic Materials and Web Sites etc. :

1. Sites of society petroleum engineers. <https://www.spe.org/en/>
2. Journal of Petroleum Science and Engineering.

<https://www.journals.elsevier.com/journal-of-petroleum-science-and-engineering>

## X. Course Policies :

<b>1</b>	<p><b>Class Attendance:</b></p> <p>A student should attend not less than 75 % of total hours of the subject, otherwise he/she will not be able to take the exam and will be considered as exam failure. If the student is absent due to illness, he/she should bring a proof statement from university Clinic. If the absent is more than 25% of a course total contact hours, student will be required to retake the entire course again.</p>
<b>2</b>	<p><b>Tardy:</b></p> <p>For late in attending the class, the student will be initially notified. If he repeated lateness in attending class, he/she will be considered as absent.</p>
<b>3</b>	<p><b>Exam Attendance/Punctuality:</b></p> <p>A student should attend the exam on time. He/she is permitted to attend an exam half one hour from exam beginning, after that he/she will not be permitted to take the exam and he/she will be considered as absent in exam.</p>
<b>4</b>	<p><b>Assignments &amp; Projects:</b></p> <p>In general one assignment is given to the students after each chapter, the student has to submit all the assignments for checking on time, mostly one week after given the assignment.</p>
<b>5</b>	<p><b>Cheating:</b></p> <p>For cheating in exam, a student will be considered as fail. In case the cheating is repeated</p>



	three times during his/her study the student will be disengaged from the Faculty.
6	<b>Plagiarism:</b> Plagiarism is the attending of a student the exam of a course instead of another student. If the examination committee proofed a plagiarism of a student, he/she will be disengaged from the Faculty. The final disengagement of the student from the Faculty should be confirmed from the Student Council Affair of the university or according to the university roles.
7	<b>Other policies:</b> <ul style="list-style-type: none"><li>- Mobile phones are not allowed to use during a class lecture. It must be closed, otherwise the student will be asked to leave the lecture room.</li><li>- Mobile phones are not allowed in class during the examination.</li><li>- Lecture notes and assignments might be given directly to students using soft or hard copy.</li></ul>