Faculty of Engineering

School of Minerals and Energy Resources Engineering

Course Outline

PTRL4012/5012
Enhanced Oil and Gas Recovery

Dr. Ryan T. Armstrong

CONTENTS

1. INFORMATION ABOUT THE COURSE

Course Code:	PTRL4012/5012	Term:	T1	Level:	UG/G	Units/Credits	6 UOC
Course Name:	**Enhanced Oil and Gas Recovery**						

Course Convenor:	***Dr. Ryan Armstrong***		
Contact Details	School of Minerals and Energy Resources Engineering	EMAIL:	ryan.armstrong@unsw.edu.au
		Phone:	Email only
Contact times	**Lecture and Tutorials (office hours will be announced during lecture)**		

1.1. Course Description

This course introduces the background knowledge in enhanced oil and gas recovery (EOR/EGR) techniques that have been widely applied in petroleum industry and research. The learning outcomes are for the student to (1) gain knowledge and skills needed to solve reservoir engineering problems, (2) apply integrated knowledge of math and basic sciences including physics, chemistry, and microbiology to the solution of problems related to EOR/EGR performance and predictions.

1.2. Course Completion

Course completion requires submission of all assessment items; failure to submit all assessment items can result in the award of an Unsatisfactory Failure (UF) grade for the Course.

1.3. Assumed Knowledge

Prerequisite: PTRL 3001 (Reservoir Engineering B) and PTRL 3002 (Reservoir Characterization and Simulation)

1.4. Attendance

To pass this course it is expected that you will attend at least 80% of tutorials and lectures. *If your attendance is below 80% you will not be admitted to the final exam*. Attendance will be recorded when applicable. Normally, there is no make-up work for poor attendance. If you have misadventure or ill-health, please contact your course coordinator soon as possible. The attendance requirement is not meant to be punitive. It is included because participation is an important part of achieving the course outcomes.

2. AIMS, LEARNING OUTCOMES AND GRADUATE ATTRIBUTES

2.1. Course Aims

The aim of this course is to provide insight on enhanced oil recovery; to introduce you to important rock and fluid characteristics; and to assist you to answer key questions related to enhanced oil recovery.

2.2. Learning Outcomes

At the conclusion of this course, students should be able to understand:

- **A)** **Petrophysical Properties Related To EOR**: capillary pressure saturation curves, pore-scale displacement, relative permeability, capillary pressure desaturation curves and wettability.
- **B)** **Phase Behavior Related to EOR:** fundamentals of phase-equilibrium, phase behavior of pure components, phase behavior of mixtures, ternary diagrams, quantitative representation of two-phase equilibrium.
- **C)** **Displacement and Sweep Efficiency**: fractional flow theory, pore-scale multiphase flow, immiscible displacement, dissipation in immiscible displacement, ideal miscible displacements, dissipation in miscible displacements, generalization of fractional-flow theory, application to three-phase flow, modeling EOR processes with two-phase fractional-flow theory, areal sweep efficiency, measures of heterogeneity, displacements with no vertical communication, vertical equilibrium, special cases of vertical equilibrium, instability phenomena, gravity segregation in gas EOR.
- **D)** **Solvent Methods**: solvent properties, solvent and crude-oil properties, solvent-water properties, solvent phase-behavior experiments, dispersion and slug processes, two-phase flow in solvent floods, solvent floods with viscous fingering, solvent flooding and residual oil saturation, estimating field recovery.
- **E)** **Polymer Methods**: polymer properties, profile control, polymer degradation, fractional flow in polymer floods, elements of polymer-flood design, and field studies.
- **F)** **Surfactant Methods**: surfactants and surfactant selection, surfactant/oil/bring phase behavior, non-ideal effects, phase behavior and IFT, other phase properties, high-capillary-number relative permeabilities, alkaline/surfactant flooding, surfactant formation, displacement mechanisms, rock-fluid interactions, fractional-flow theory in SP and ASP floods, typical production responses, and designing SP/ASP floods.
- **G)** **Thermal Methods**: physical properties, fractional flow in thermal displacement, heat losses from equipment and wellbores, heat losses to over-burden and under-burden, steam-drives, steam soak, in-situ combustion, and SAGD.
- **H)** **Fractional Flow Theory:** advanced fractional flow theory applied to EOR applications.

3. REFERENCE RESOURCES

3.1. Reference Materials

Support material for this course including, whenever available, copies of lecture notes, recommended readings, etc. can be found on Moodle.

The lecture note may be viewed and downloaded from the UNSW-Moodle http://moodle.telt.unsw.edu.au/.

3.2. Textbooks

Following are the recommended books for this course.

- Enhanced Oil Recovery, Larry W. Lake, Prentice Hall, 1996, ISBN 978- 01328160143.
- Fundamentals of Reservoir Engineering, L.P. Dake, Developments in Petroleum Science 8, 1978, Elsevier Science, ISBN 0-444-41830.
- Thermal Recovery, Michael Prats, SPE Henry L. Doherty Textbook Series Vol.7, 1985, ISBN 978-0-89520-325-0.
- Other readings will be posted on Moodle.

3.3. Other Resources (if applicable)

Links to websites etc.

The University and the Faculty provide a wide range of support services for students, including:

- UNSW Learning Centre (http://www.lc.unsw.edu.au)
- Counselling support - http://www.counselling.unsw.edu.au
- Library training and support services - http://www.library.unsw.edu.au/
- OnePetro – (http://www.onepetro.org)

3.4. Online Resources

There are numerous articles / information sources on EOR on the web. Many of them are sound, but many are either very lightweight or contain errors. Be very careful in your choice of web sources. Remember, UNSW librarians are usually happy to help you locate articles or make suggestions regarding possible material to help you in your academic work. You can also access basic online help at http://www.library.unsw.edu.au/

4. COURSE CONTENT AND LEARNING ACTIVITIES

4.1. Course content

1. Introduction to EOR
2. Petrophysics and Phase Behavior
3. Multi-Component and Multi-Phase Systems
4. Fractional Flow Theory
5. Displacement and Sweep Efficiency
6. Chemical EOR
7. Polymer EOR
8. Thermal EOR
9. EOR Presentations

4.2. Learning Activities Summary

UNSW Wk	Activity	Content	Presenter (optional)
1	**Lecture + In class activities**	• Course Introduction and Expectations • Introduction to EOR • Decline Curve Analysis • Selection Criteria	**RTA**
2	**Lecture + In class activities**	• EOR related Petrophysics • EOR related Phase Behavior • Capillary Desaturation Curve • Ternary Phase Diagrams	**RTA**
3	**Lecture + In class activities**	• Multi-Component and Multi-Phase Systems • Conservation of Mass	**RTA**
4	**Lecture + In class activities**	• Fractional Flow Theory • Immiscible and Miscible Displacements	**RTA**
5	**Lecture + In class activities**	• Displacement Efficiency • Sweep Efficiency • Mobilization Efficiency	**RTA**
6	**Flexibility Week**	• Review Sessions • Help with Homework	**TA**
7	**Exam Week**	• Exam covering materials from W1-W5.	**RTA**
8	**Lecture + In class activities**	• Chemical EOR • Miscibility and Interfacial Tension • Minimum Miscibility Pressure • PG Presentations	**RTA**
9	**Lecture + In class activities**	• Polymer EOR • Mobility number • Displacement Efficiency • PG Presentations	**TA**
10	**Lecture + In class activities**	• Thermal EOR • PG Presentations • Review of Materials	**RTA**

Other UNSW Key dates: https://student.unsw.edu.au/new-calendar-dates

5. COURSE ASSESSMENT

5.1. Assessment Summary

Assessment task	Due date / week	Weight	Assessment
1	Weeks 6 & 11	15% (7.5% x 2)	**Homework**
2	Any Week	5%	**Participation**
3	Week 5	20%	**QUIZ (EOR Basics covering weeks 1-5)**
4	Weeks 7-9	10%	**PG Group Presentations** Group presentations on selected EOR technology
5	Week 10	10%	**UG Presentation Summary**
6	Exams Period	50%	**Final Exam** Administered by UNSW exam unit

6. ASSESSMENT CRITERIA

6.1 Homework

Homework problems will be given every week. Each set of problems will cover the topics discussed during lecture/tutorial for that week. During Week 6, homework from Weeks 1 through 4 are due and should be uploaded to Moodle as a PDF. During Week 11, homework from Weeks 5 though 10 are due and should be uploaded to Moodle as a PDF.

Each marked homework will be worth 7.5% of your total marks.

All marked assignments must have an assessment coversheet or else they will not be graded.

6.2 Quizzes

One in-class quiz will be conducted during Week 6. The quiz will cover materials from Weeks 1-5.

6.3 Post-Graduate Presentations

Post-graduate students will form groups to research a given EOR technology. Each group will provide a 15-minute presentation during Weeks 7-9. The specific dates for each presentation will be released during Week 6. An additional guide providing the details of this assignment and the grading rubric will be posted on Moodle.

6.4 Under-Graduate Presentation Summary

All under-graduate students are expected to attend all of the post-graduate presentations. Each student will need to select a given presentation and provide a one-page summary. The summary is expected to outline the topic covered during the presentation and highlight how the given technology facilitates the recovery of additional hydrocarbon.

7. STUDYING A COURSE IN UNSW MINERALS AND ENERGY RESOURCES ENGINEERING

7.1. How We Contact You

At times, the School or your course conveners may need to contact you about your course or your enrolment. Your course conveners will use the email function within Moodle or we will contact you on your @student.unsw.edu.au email address.

We understand that you may have an existing email account and would prefer for your UNSW emails to be redirected to your preferred account. Please see these instructions on how to redirect your UNSW emails: https://www.it.unsw.edu.au/students/email/index.html

7.2. How You Can Contact Us

We are always ready to assist you with your inquiries. To ensure your question is directed to the correct person, please use the email address below for:

Enrolment or other admin questions regarding your program:
https://unswinsight.microsoftcrmportals.com/web-forms/

Course inquiries: these should be directed to the Course Convenor.

7.3. Computing Resources and Internet Access Requirements

UNSW Minerals and Energy Resources Engineering provides blended learning using the on-line Moodle LMS (Learning Management System).

It is essential that you have access to a PC or notebook computer. Mobile devices such as smart phones and tablets may compliment learning, but access to a PC or notebook computer is also required. Note that some specialist engineering software is not available for Mac computers.

Mining Engineering Students: OMB G48/49
Petroleum Engineering Students: TETB

It is recommended that you have regular internet access to participate in forum discussion and group work. To run Moodle most effectively, you should have:

- broadband connection (256 kbit/sec or faster)
- ability to view streaming video (high or low definition UNSW TV options)

More information about system requirements is available at www.student.unsw.edu.au/moodle-system-requirements

7.4. Accessing Course Materials Through Moodle

Course outlines, support materials are uploaded to Moodle, the university standard Learning Management System (**LMS**). In addition, on-line assignment submissions are made using the assignment dropbox facility provided in Moodle. All enrolled students are automatically included in Moodle for each course. To access these documents and other course resources, please visit:
www.moodle.telt.unsw.edu.au

7.5. Assignment Submissions

The School has developed a guideline to help you when submitting a course assignment.

We encourage you to retain a copy of every assignment submitted for assessment for your own record either in hardcopy or electronic form.

All assessments must have an assessment cover sheet attached.

7.6. Late Submission of an Assignment

Full marks for an assignment are only possible when an assignment is received by the due date.

Late assignments will not be accepted expect in rare cases of significant misadventures.

7.7. Special Consideration

You can apply for special consideration through UNSW Student Central when illness or other circumstances interfere with your assessment performance. Sickness, misadventure or other circumstances beyond your control may:

- Prevent you from completing a course requirement,
- Keep you from attending an assessable activity,
- Stop you submitting assessable work for a course,
- Significantly affect your performance in assessable work, be it a formal end-of-semester examination, a class test, a laboratory test, a seminar presentation or any other form of assessment.

We ask that you please contact the Course Convener immediately once you have completed the special consideration application, no later than one week from submission.

More details on special consideration can be found at: www.student.unsw.edu.au/special-consideration

7.8. Course Results

For details on UNSW assessment policy, please visit: www.student.unsw.edu.au/assessment

In some instances, your final course result may be withheld and not released on the UNSW planned date. This is indicated by a course grade result of either:

- WD – which usually indicates you have not completed one or more items of assessment or there is an issue with one or more assignment; or
- WC – which indicates you have applied for Special Consideration due to illness or misadventure and the course results have not been finalized.

In either event it would be your responsibility to contact the Course Convener as soon as practicable but no later than five (5) days after release of the course result. If you don't contact the convener on time, you may be required to re-submit an assignment or re-sit the final exam and may result in you failing the course. You would also have a NC (course not completed) mark on your transcript and would need to re-enroll in the course.

7.9. Students Needing Additional Support

The Student Equity and Disabilities Unit (SEADU) aims to provide all students with support and professional advice when circumstances may prevent students from achieving a successful university education. Take a look at their webpage: www.studentequity.unsw.edu.au/

7.10. Academic Honesty and Plagiarism

Your lecturer and the University will expect your submitted assignments are truly your own work. UNSW has very clear guidelines on what plagiarism is and how to avoid it. Plagiarism is using the words or ideas of others and presenting them as your own. Plagiarism is a type of intellectual theft. It can take many forms, from deliberate cheating to accidentally copying from a source without acknowledgement. The University has adopted an educative approach to plagiarism and has developed a range of resources to support students. All the details on plagiarism, including some useful resources, can be found at www.student.unsw.edu.au/plagiarism.

All Mining Engineering students are required to complete a student declaration for academic integrity which is outlined in the assignment cover sheets. By signing this declaration, you agree that your work is your own original work.

If you need some additional support with your writing skills, please contact the Learning Centre or view some of the resources on their website: www.lc.unsw.edu.au/. The Learning Centre is designed to help you improve your academic writing and communication skills. Some students use the Centre services because they are finding their assignments a challenge, others because they want to improve an already successful academic performance.

7.11. Continual Course Improvement

At the end of each course, all students will have the opportunity to complete a course evaluation form. These anonymous surveys help us understand your views of the course, your lecturers and the course materials. We are continuously improving our courses based on student feedback, and your perspective is valuable.

Feedback is given via https://student.unsw.edu.au/myexperience and you will be notified when this is available for you to complete.

We also encourage all students to share any feedback they have any time during the course – if you have a concern, please contact us immediately.

8. SCHOOL ASSESSMENT COVER SHEET

School of Minerals and Energy Resources Engineering

Assessment Cover Sheet

Course Convenor: _____

Course Code: _____ Course Title: _____

Assignment: _____

Due Date: _____

Student Name: _____ Student ID: _____

ACADEMIC REQUIREMENTS

Before submitting this assignment, the student is advised to review:

- the assessment requirements contained in the briefing document for the assignment;
- the various matters related to assessment in the relevant Course Outline; and
- the *Plagiarism and Academic Integrity* website at < http:/www.lc.unsw.edu.au/plagiarism/pintro.html > to ensure they are familiar with the requirements to provide appropriate acknowledgement of source materials.

If after reviewing this material there is any doubt about assessment requirements, then in the first instance the student should consult with the Course Convenor and then if necessary with the Director – Undergraduate Studies.

While students are generally encouraged to work with other students to enhance learning, all assignments submitted for assessment must be their entire own work and duly acknowledge the use of other person's work or material. The student may be required to explain any or all parts of the assignment to the Course Convenor or other authorised persons. *Plagiarism* is using the work of others in whole or part without appropriate acknowledgement within the assignment in the required form. *Collusion* is where another person(s) assists in the preparation of a student's assignment without the consent or knowledge of the Course Convenor.

Plagiarism and *Collusion* are considered as Academic Misconduct and will be dealt with according to University Policy.

STUDENT DECLARATION OF ACADEMIC INTEGRITY

I declare that:

- This assessment item is entirely my own original work, except where I have acknowledged use of source material [such as books, journal articles, other published material, the Internet, and the work of other student/s or any other person/s].
- This assessment item has not been submitted for assessment for academic credit in this, or any other course, at UNSW or elsewhere.

I understand that:

- The assessor of this assessment item may, for the purpose of assessing this item, reproduce this assessment item and provide a copy to another member of the University.
- The assessor may communicate a copy of this assessment item to a plagiarism checking service (which may then retain a copy of the assessment item on its database for the purpose of future plagiarism checking).

Student Signature: Date:

Students are advised to retain a copy of this assessment for their records and submission should be made in accordance to the assessment details available on the course Moodle site.