PET E 377 Modelling in Petroleum Engineering

Winter 2026 - January 05 to April 10

Class time: Monday, Wednesday, Friday 12:00-12:50 Location: NREF 2-127

Instructor:

Tamer Moussa, PhD, P.Eng (he/him)
tmoussa@ualberta.ca
NREF 4-150
Office Hours: Office Hours Scheduler

TA Information:

Karthik Sivaraman (he/him)
karthik2@ualberta.ca
NREF 1-110

Course Description:

*3 (fi 8) (either term, 3-0-0) Basics of numerical reservoir simulation and numerical solution of partial differential equations. Simulation methods as applied to specific problems in petroleum reservoir behavior. Applications on primary, secondary and tertiary recovery phases of petroleum production using commercial simulation packages.

1. **Theory**
   - Learn the basics of numerical reservoir simulation
   - Understand the numerical solution of partial differential equations
2. **Applications**
   - Apply simulation methods to primary, secondary, and tertiary (EOR) recovery phases.
   - Use commercial simulation software to model and optimize reservoir performance

Prerequisites: PET E 295 and BSc Engineering in all Petroleum
Corequisite: CH E 374
PET E 377 cannot be taken for credit if credit has already been obtained in PET E 477

Course Objectives & General Content:

Course Objectives:

1. Understand concepts and techniques for **modeling** oil and gas recovery processes.
2. Prepare and input data into a reservoir simulator to perform **history matching** of production data.
3. Gain the **engineering background** needed for reservoir analysis using numerical simulation.

It is important to prepare yourself for this course through a review of the prerequisite material. Students who do not have the required prerequisites at the time of taking this course should not expect supplementary tutoring from the instructor.

Course Delivery:

Class notes, tutorials, videos, assignments, announcements, and other relevant materials will be posted on eClass / Canvas.

Learning Outcomes:

By the end of this course, students should be able to:

1. **Model Fluid Flow**
   Derive equations for single- and two-phase flow in porous media with proper boundary and initial conditions.
2. **Numerical Approximations**
   Formulate finite-difference and finite-volume methods to solve partial differential equations.
3. **Compare Solutions**
   Compare results from numerical and analytical methods.
4. **Use Simulation Software**
   Gain practical knowledge of commercial reservoir simulation tools.
5. **Select Input Parameters**
   Choose appropriate input data for simulations.
6. **Build Simulation Models**
   Create models that represent geological and flow data, including uncertainties.
7. **Design Field Development Plans**
   Work in teams to design optimal field development plans for improved oil recovery using simulation tools.

Marking Scheme:

Activity	(A)Synchronous	Due/Scheduled	Weight
Homework (count the best 2)			10%
Team Project			35%
Midterm Exam			25%
Final Exam			30%

Term Work

All term work solutions will be posted no later than the last day of classes. All term work will be returned to students by the final day of classes, with the exception of major term work due in the last week of classes. The latter will be returned by the day of the final examination or the last day of the examination period if there is no final examination in the course as per university policy; instructors will make accommodations to return these term work. It is the responsibility of the student to pick up all their term work at the specified time and place. Any unreturned term work shall be retained and then shredded six months after the deadline for reappraisal and grade appeals. Final examinations will be kept for one year as required by university guidelines and the Government of Alberta's Freedom of Information and Protection of Privacy Act.

Additional Notes

The midterm and final exams will be open book and notes.

Calculator Policy

Approved programmable or approved non-programmable calculators are permitted in examinations. Any calculator taken into an examination must have a sticker identifying it as an acceptable programmable calculator (green sticker) or non-programmable calculator (gold sticker). Students can purchase calculators at the University Bookstore with the stickers already affixed. Calculators purchased elsewhere can be brought to the Student Services where the appropriate sticker will be affixed to the calculator.

Text and References (Recommended):

1. Aziz, K. and Settari, A. (1979) Petroleum Reservoir Simulation, Elsevier.
2. Ertekin, T., Abou-Kassem, J.H. and King, G.R. (2001) Basic Applied Reservoir Simulation. Society of Petroleum Engineers.
3. Mattax, C.C. and Dalton, R.L. (1990) Reservoir Simulation. Henry L. Doherty Memorial Fund of AIME, Society of Petroleum Engineers.

Website:

eClass / Canvas

Previous Examples of Evaluative Materials:

Practice problems will be posted on eClass / Canvas.

Did you know that the University of Alberta has various low-to-no-cost services to help students succeed? Visit http://www.deanofstudents.ualberta.ca/ for information about the academic, wellness, and various other support services available to U of A students. It's never too early or too late to seek help!

Topics

1. **Reservoir modelling – theory**
    - Analytical Models
    - Theory of numerical flow simulation
    - Solving PDEs for basis finite difference techniques
    - Discretization/ Gridding /IMPES (Implicit Pressure Explicit Saturation).
    - Jacobian / Simulator Architecture
    - Examples

2. **Introduction to simulation**
    - Modeling concepts
    - Reservoir Simulation Overview
    - Essentials of reservoir simulation
    - Applications of reservoir simulation
    - Types of Reservoir Simulation Models
    - Steps in a Reservoir Simulation Study
    - Data Needed

3. **From geology to dynamic reservoir model**
    - Grid Systems & Grid types
        - Cartesian grid, corner point grid, hybrid grids
    - Types of models:
        - 1D-2D-3D and radial grid concepts
    - Layering concepts

4. **Modelling standard PVT experiments (PVT data)**
    - Fluid properties & Initial distribution
    - Black oil simulation (PVT data set)

5. **Petrophysics for Simulation**
    - End Points Definitions (Relative Permeability)
    - Use of Capillary Pressure in the Simulator
    - Three-Phase Relative Permeabilities

6. **Production and well data configuration**
    - Historical production rates
    - Static Pressure & Bottom Hole Flowing Pressure (BHFP)
    - Well tests data (PI, skin)
    - Well type and well constraints
    - Perforated and productive layers

Course Schedule

1	05-Jan	Mon	Lecture 1	Introduction
2	07-Jan	Wed	Lecture 2	Reservoir Gridding
3	09-Jan	Fri	Lecture 3	Finite Difference
4	12-Jan	Mon	Lecture 4	Pressure Diffusion Equation
5	14-Jan	Wed	Lecture 5	Explicit Formulation
6	16-Jan	Fri	Lecture 6	Explicit Formulation - Numerical Example
7	19-Jan	Mon	Tutorial 1	• Introduction to CMG • Cartesian Gridding – 2D/3D • Regular Patterns, reservoir model generation
8	21-Jan	Wed	Tutorial 2	• Orthogonal (Corner Point) & Radial Gridding • Layering & Reservoir Property Specification
9	23-Jan	Fri	Lecture 7	Finite Difference - Implicit Formulation
10	26-Jan	Mon	Tutorial 3	• Non-orthogonal Gridding • Relative perm & Capillary pressure for reservoir simulation
11	28-Jan	Wed	Lecture 8	Finite Difference - Implicit Formulation
12	30-Jan	Fri	Lecture 9	Implicit Formulation - Numerical Example
13	02-Feb	Mon	Lecture 10	Transmissibility in 1D - Explicit Scheme
14	04-Feb	Wed	Lecture 11	Transmissibility Example using Explicit Scheme
15	06-Feb	Fri	Lecture 12	Transmissibility in 1D - Implicit Scheme
16	09-Feb	Mon	Lecture 13	Transmissibility Example using Implicit Scheme
17	11-Feb	Wed	Lecture 14	Hetrogeneity and Transmissibility for 2D flow
18	13-Feb	Fri	Lecture 15	Transmissibility and Boundary Conditions for 2D flow
Reading Week				
19	23-Feb	Mon	Design 1	Design Concept / Project Discussion
20	25-Feb	Wed	Tutorial 4	Black Oil Model - Water Flooding
21	27-Feb	Fri	Lecture 16	Review Class
12:00 - 1:00 PM - Students' Union Election Forum in the Myer Horowitz Theatre (SUB)				
22	**04-Mar**	**Wed**	**Exam**	**Mid-Term Exam**
23	06-Mar	Fri	Design 2	Design Example
24	09-Mar	Mon	Tutorial 5	• Reservoir Gridding – Use of Field Maps • Use of Logs for Modelling
25	11-Mar	Wed	Tutorial 6	Porosity, Permeability Realizations
26	13-Mar	Fri	Design 3	Design Project Update – 3-minute presentation
27	16-Mar	Mon	Tutorial 7	• Well Constraints (Operational Limits) • History Matching
28	18-Mar	Wed	Lecture 17	Hetrogeneity Modelling and 2D Hetrogeneous Example
29	20-Mar	Fri	Lecture 18	Two-Phase Flow
30	23-Mar	Mon	Lecture 19	Two-Phase Flow
31	25-Mar	Wed	Tutorial 8	• Optimization and Sensitivity Analysis • CMOST case study
32	27-Mar	Fri	Design 4	Project Consultation
33	30-Mar	Mon	Design 5	Presentation Group
34	01-Apr	Wed	Design 6	Presentation Group
Good Friday - Easter Break				
35	08-Apr	Wed	Design 7	Presentation Group
36	10-Apr	Fri	Lecture 20	Review Class - Class Picture
37	**22-Apr**	**Wed**	**Exam**	**Final Exam (1:00 PM to 4:00 PM)**

* Schedule is subjected to change; students will be informed about the changes by email.

Classroom: **NREF 2-127**

Computer Lab: **NREF 2-118**

Homework and Team Project

Unless stated otherwise, all homework and team projects must be electronically submitted to eClass / Canvas by 11:59 pm on the due date.

Late submissions will have 20% of the total marks deducted for each day or partial day (including weekend days) beyond the due time. There will be no make-up assignments or homework.

Discussion of the general approach to a difficult problem with fellow students is permitted; all work turned in must be your individual work.

Midterm and Final Exam

All tests and exams will be open-book and open-notes. They will be administered in person.

There will be a 50-minute midterm, and it will take place during one of the regular lecture meeting times. If a test is missed due to a valid reason (e.g., severe illness), its weight will be shifted to that of the final exam.

The final exam will be comprehensive and take place as scheduled by The Office of the Registrar. A student who misses the final exam should apply to the Faculty of Engineering for a deferred exam.

General Expectations

Disputed grades must be discussed with the instructor/TA within five (5) business days of their return to students.

Emails should include PET E 377 in the subject line. Emails will be responded to within one (1) business day. Please use your ualberta email address to avoid being filtered as spam. You are expected to check your ualberta email account and course website (on eClass / Canvas) regularly, at least once daily.

Although asynchronous materials (e.g., slides and notes) will be posted, participation in all lectures is strongly encouraged. These are excellent opportunities to interact with your classmates and engage in group discussions.

Both SI and imperial systems will be used in this course.

UNIVERSITY AND FACULTY POLICIES

COURSE OUTLINE POLICY

The policy about course outlines can be found in Course Requirements, Evaluation Procedures and Grading of the University Calendar, see https://calendar.ualberta.ca/

RESPECT AND PROFESSIONALISM

The Faculty of Engineering is committed to fostering and protecting an equitable, inclusive, and respectful work and study environment in line with University of Alberta policies and professional engineering industry standards. University is an opportunity for students to explore areas of interest and to potentially pursue a career in a specific field. The Faculty of Engineering prepares students to uphold industry standards to become a Professional Engineer (P. Eng). Respect, professionalism, and accountability must be upheld within the Faculty of Engineering.

Harassment and discrimination are serious issues that have a negative effect on culture and therefore the Student Code of Behaviour states that no student shall discriminate against or harass any person or group of persons. The Faculty expects an environment free of harassment, discrimination, and bullying. Please refer to the University's Discrimination, Harassment, and Duty to Accommodate Policy for definitions.

SAFETY DURING LEARNING ACTIVITIES

In all Faculty of Engineering courses, labs, seminars or other learning activities, safety is of paramount importance. In some cases, laboratory work in a program requires high standards for risk management to keep potential hazards safely under control. Anyone found to be unable to function safely, due to intoxication, harassment or discriminatory behaviour, or other reasons, in the class, lab, seminar or other learning activity may be asked to leave or be removed for their and the safety of other participants and instructors in alignment with the Student Code of Behaviour. As members, or prospective members, of the engineering profession, it is your responsibility to identify and inform the proper authorities of an unsafe work/learning environment.

AUDIO/VIDEO RECORDING

Audio or video recording, digital or otherwise, of lectures, labs, seminars or any other teaching environment by students is allowed only with the prior written consent of the instructor or as a part of an approved accommodation plan. Student or instructor content, digital or otherwise, created and/or used within the context of the course is to be used solely for personal study, and is not to be used or distributed for any other purpose without prior written consent from the content author(s).

Only those items specifically authorized by the instructor may be brought into the exam facility. The use of unauthorized personal listening, communication, recording, photographic and/or computational devices is strictly prohibited. Students should refrain from bringing any unauthorized electronic device into an examination room, including cell phones, high tech watches, high tech glasses or other such devices.

Engineering at Alberta

ACADEMIC INTEGRITY

Students at the University of Alberta must read and follow, in its entirety, the

Code of Student Behaviour

Failure to know the code is not an acceptable excuse for breaking the code.

The University of Alberta is committed to the highest standards of academic integrity and honesty. Students are expected to be familiar with these standards regarding academic honesty and to uphold the policies of the University in this respect. Students are particularly urged to familiarize themselves with the provisions of the Code of Student Behaviour (on the University Governance website) and avoid any behaviour which could potentially result in suspicions of cheating, plagiarism, misrepresentation of facts and/or participation in an offence. Academic dishonesty is a serious offence and can result in suspension or expulsion from the University.

Engineering students studying in the province of Alberta should also follow the

Code of Ethics

by The Association of Professional Engineers and Geoscientists of Alberta (APEGA).

The Code of Student Behaviour should not be too hard to follow. Listen to your instructor, be a good person, and do your own work, as this will lead you toward a path to success. Failure to follow the code can result in a grade of ‘F’ for the course, a transcript remark, suspension, and even expulsion from the university.

"Integrity is doing the right thing, even when no one is watching"
C. S. Lewis

Engineering at Alberta

NEED HELP?

There are a lot of services available to students on campus and in Edmonton, and sometimes it's hard to know where to go. While this isn't a comprehensive list, the services shown here should at least give you some ideas about where to start. If you're still not sure, check out the services just beneath this box—they'll give you the guidance you're looking for.

DON'T KNOW WHERE TO GO?

Student Service Centre

The U of A's central hub to find the right help for your needs.
uab.ca/ask

24/7 HELP

Empower Me (international)

1-833-628-5589

Edmonton Distress Line

780-482-4357 (HELP)

WELLNESS

Counselling and Clinical Services

Free, short-term, appointment-based counselling and psychiatric services. Also offers drop-in workshops. Book an initial consultation.
P: 780-492-5205
M, R, F, 8:00am-4:00pm; T, W, 8:00am-7:00pm

Interfaith Chaplains' Association

Get guidance, care, and support, whether or not you identify with a particular faith. Make an appointment.
P: 780-492-0339 | E: interfaithchaplains@ualberta.ca

The Landing

Offers drop-in support on matters of gender and sexual diversity.
P: 780-492-4949 | E: thelanding@su.ualberta.ca
M-R, hours vary

Peer Support Centre

Anonymous, confidential help from trained students. By appointment only.
P:780-492-4268 | E: psc@su.ualberta.ca
M-F, 9:00am-8:00pm

Sexual Assault Centre

Free, anonymous, and confidential drop-in counselling.
P: 780-492-9771 | E: sexualassaultcentre@ualberta.ca
M-F, 9:00am-8:00pm

University Health Centre

An on-campus health clinic that provides medical services to staff, students, and their spouses and children.
P: 780-492-2612 | E: hws@ualberta.ca
M-F, 8:30am-4:00pm

ACADEMIC

Engineering Student Services
Drop-in, first-come, first-served advising.
E: enggadvising@ualberta.ca

Engineering Student Success Centre
Drop-in tutoring for first-year courses.
E: dessc@ualberta.ca

Academic Success Centre
Many services to maximize your academic success.
E: success@ualberta.ca
M-F, 8:30am-4:30pm

Academic Accommodations
Connects students with disabilities to accommodations.
E: arrec@ualberta.ca
M-F, 8:30am-4:30pm

Office of the Student Ombuds
Call for complex problems and conflict mediation.
P: 780-492-4689 | E: ombuds@ualberta.ca

FINANCIAL

Student Service Centre
For awards and other funding supports.
uab.ca/ask

Campus Food Bank
Many food support options available.
E: info@campusfoodbank.com

SOCIAL

Unitea
Arrange a time to socialize with a peer.
E: unitea@ualberta.ca

BearsDen
U of A webpage. Find student groups, local events, and volunteer opportunities.

WORRIED ABOUT SOMEONE?

Helping Individuals at Risk (HIAR)
If you're worried about someone because of the things they've been saying or doing, or there's a noticeable change in their behaviour (often in multiple ways), contact HIAR, who will protect your confidentiality and help decide how best to support the person.

780-492-4372
hiarua@ualberta.ca

CONFIDENTIAL SUPPORT

Office of Safe Disclosure and Human Rights

The OSDHR advises confidentially on sensitive issues you may not feel comfortable solving on your own. Contact the OSDHR if you want to get help or to make a report while keeping your privacy.

780-492-7357
osdhr@ualberta.ca