Kolej Pengajian Kejuruteraan
UNIVERSITI TEKNOLOGI MARA

MINI PROJECT: CGE443

Semester: March – August 2025 (20252)

Lecturer	TENGKU AMRAN TENGKU MOHD		
Programme	EH243	: BACHELOR OF ENGINEERING (HONS.) OIL AND GAS	
Course	CGE443	: COMPUTER APPLICATIONS IN OIL AND GAS ENGINEERING	
Credit Hours	3.0	: 2 hours Lecture and 2 hours Laboratory	
Evaluation	Group work	: Mini Project	30%

1.0 INTRODUCTION

This Mini Project involves three (3) sections, which include simulating the base case model and formulate simulation models of different cases using ECLIPSE. This project requires the students to demonstrate their capability in using ECLIPSE software to solve oil and gas engineering problem and evaluate the performance of each simulated models with relevant justification.

2.0 COURSE AND PROGRAMME OUTCOMES WITH COMPLEX ENGINEERING PROBLEMS & KNOWLEDGE PROFILE

This project addresses two (2) course outcomes (COs) and two (2) programme outcomes (POs), whereby CO3 and PO2 are mapped to complex engineering problem characteristics (WP) and the required knowledge profiles (WK) as shown in Table 1.

Table 1: Mapping of Course Outcomes-Programme Outcome-Complex Engineering Problems (WP) & Knowledge Profile (WKs)

Course Outcomes	Programme Outcome	Complex Engineering Problems (WP)	Knowledge Profile (WKs)
CO3 - Develop formulation and evaluate the numerical technique outlined to oil and gas engineering applications. **(20%)**	**PO2**: Identify, formulate, research literature and analyse complex chemical/oil and gas engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.	**WP1 (Knowledge)** – in depth engineering knowledge at the level of one or more of WK3, WK4, WK5, WK6 or WK8 which allows a fundamental based, first principles analytical approach. **WP2 (Conflicting requirements)** – wide-ranging or conflicting technical, engineering and other issues. **WP3 (Analysis)** - no obvious solution and require abstract thinking, originality in analysis to formulate reservoir simulation model and evaluate its performance.	**WK4:(Engineering Specialist):** Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline, much is at the forefront of the discipline. **WK6: (Engineering Practice):** Knowledge of engineering practice (technology) in the practice areas in the engineering discipline. **WK8: (Research Literature)** Engagement with selected knowledge in the research literature of the discipline (sources related to the issues/problems/ solutions)

CO1 - Demonstrate capability in using computer applications for solving oil and gas engineering problem. **(10%)**	**PO4 -** Create, select and apply appropriate techniques, resources, modern engineering and IT tools, and including prediction and modelling to solve complex chemical/oil and gas engineering problems with an understanding of the limitations.	**Non-CPS**	**Non-CPS**

3.0 LEARNING OUTCOMES FOR THE MINI PROJECT

At the end of this assignment, the students should be able to:
1. Formulate basic reservoir simulation model using ECLIPSE.
2. Analyze the cases given and propose relevant input data files for simulating the performance of two-phase (water/oil) reservoir models.
3. Evaluate the performance of each simulated model from the simulation results with relevant justification based on literature.

4.0 DESCRIPTION

1. SIMULATING THE BASE CASE MODEL

Prepare an input data file (BASECASE.DATA) for simulating the performance of a two-phase (water/oil) three-dimensional reservoir of size 2500' x 2500' x 150', dividing it into three layers of equal thickness. The number of cells in the x and y directions are 5 and 5 respectively. Other relevant data are given below, using field units throughout:

Depth of reservoir top : 8000 ft
Initial pressure at 8075' : 4500 psia
Porosity : 0.20

Permeability in x direction : 200 mD for 1st and 3rd layers and 1000 mD for 2nd layer.
Permeability in y direction : 150 mD for 1st and 3rd layers and 800 mD for 2nd layer.
Permeability in z direction : 20 mD for 1st and 3rd layers and 100 mD for 2nd layer.

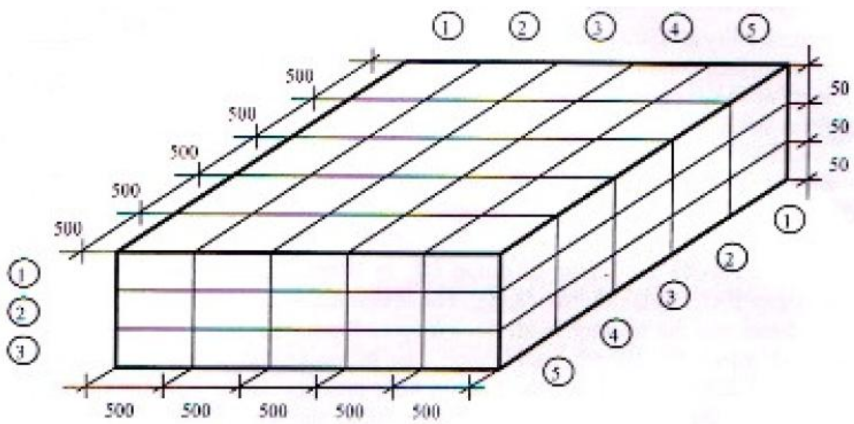

Figure 1: Schematic of model

Water and Oil Relative Permeability and Capillary Pressure Functions

Water Saturation	krw	kro	Pcow (psi)
0.25	0.0	0.9	4.0
0.5	0.20	0.3	0.8
0.7	0.40	0.1	0.2
0.8	0.55	0.0	0.1

Water PVT Data at Reservoir Pressure and Temperature

Pressure (psia)	Bw (rb/stb)	cw (psi-1)	µw (cp)	Viscosibility (psi-1)
4500	1.02	3.0E-06	0.8	0.0

Oil PVT Data, Bubble Point Pressure (Pb) = 300 psia

Pressure (psia)	Bo (rb/stb)	Viscosity (cp)
300	1.25	1.0
800	1.20	1.1
6000	1.15	2.0

Rock compressibility at 4500 psia	: 4E-06 psi-1
Oil density at surface conditions	: 49 Ibs/cf
Water density at surface conditions	: 63 Ibs/cf
Gas density at surface conditions	: 0.01 Ibs/cf

The oil-water contact is below the reservoir (8200 ft), with zero capillary pressure at the contact.

Drill a producer PROD, belonging to group G1, in Block No. (1,1) and an injector INJ, belonging to group G2, in Block No. (5,5). The insider diameter of the wells is 8”. Perforate both the producer and the injector in all three layers. Produce at the gross rate of 10,000 stb liquid/day and inject 11,000 stb water/day. The producer has a minimum bottom hole pressure limit of 2,000 psia, while the bottom hole pressure in the injector cannot exceed 20,000 psia. Start the simulation on 1st January 2008, and use 10 time steps of 200 days each.

In the SUMMARY section, ask the program to output the following parameters:

Field Average Pressure (FPR)	Bottom Hole Pressure for both wells (WBHP)
Field Oil Production Rate (FOPR)	Field Water Production Rate (FWPR)
Total Field Oil Production (FOPT)	Total Field Water Production (FWPT)
Well Water Cut for PROD (WWCT)	CPU usage (TCPU)

2. CASE 1: VARYING THE PROPERTIES

Copy file BASECASE.DATA to CASE1.DATA in the same folder. The above base case simulates a reservoir model that has uniform porosity and NTG. For some modification, the data file should be adapted to include the following features:

- Porosities varying according to layer (PORO in the GRID section)
- NTG varying according to layer (NTG in the GRID section)
- Water saturations that can go up to Sw=1 should there be an oil-water contact introduced into the model

To implement these, assuming the same number of cells and dimension in the x, y and z directions, the GRID section should be modified according to these additional information:

Keyword	Layer 1	Layer 2	Layer 3
PERMX	200	1000	200
PERMY	150	800	150
PERMZ	20	100	20
PORO	0.19	0.20	0.19
NTG	0.95	0.99	0.95

The following table will help you to define the above input data according to layer.

Keyword	value	X1	X2	Y1	Y2	Z1	Z2
DX							
DY							
DZ							

Next, the old SWOF table should be replaced for two different permeabilities with repective set of properties as follows:

	Sw	Krw	Kro	Pc
SWOF				
Table 1 for 1000mD				
	0.15	0.0	0.9	4.0
	0.45	0.2	0.3	0.8
	0.68	0.4	0.1	0.2
	0.8	0.55	0.0	0.1
	1.0	1.0	0.0	0.0

Table 2 for 200mD				
	0.25	0.0	0.9	9.0
	0.5	0.2	0.3	1.8
	0.7	0.4	0.1	0.45
	0.8	0.55	0.0	0.22
	1.0	1.0	0.0	0.0

3. CASE 2: SIMPLE LAYER SWEEP EFFICIENCY: VISCOUS, GRAVITY AND CAPILLARY FORCES

A) Two-Dimensional Model with High Perm in The Middle Layer

Create a CASE 2 folder, make a copy file CASE1.DATA, and rename it as CASE2A.DATA. The objective of this case is to make a more detailed cross-section model between the injector and producer.

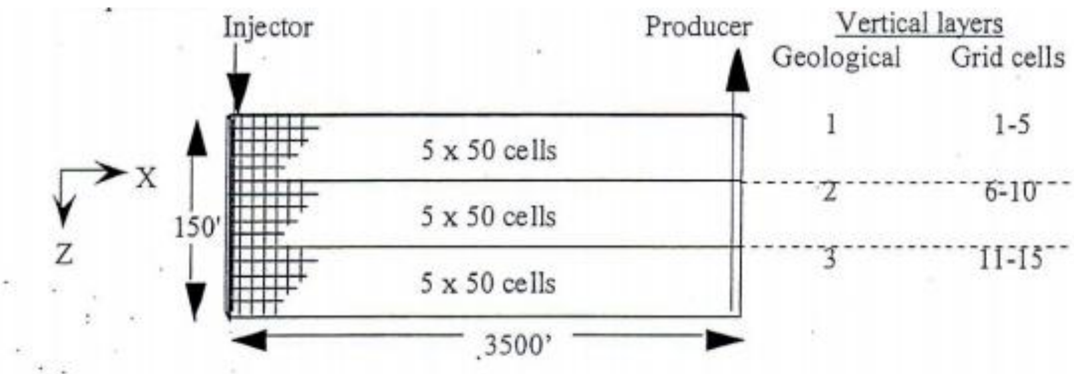

Figure 2: Schematic of model in three geological layers

Each layer has 5 x 50 cells to limit numerical dispersion. The input data file should be modified as follows:

(a) Set number of cells in x, y and z directions to be 50, 1 and 15, respectively and the grid dimensions are 70 x 1800 x 10 for all cells.

(b) The reservoir model is distributed over 3 geological layers as illustrated in Figure 2. Define TOPS for only the first layer of grid cells, but all poro/perm properties should be assigned per geological layer. Maintain the same PERMX, PERMZ, PORO and NTG values in each geological layer as in CASE 1. Delete PERMY and associated data.

(c) In the REGIONS section change number of cells in each layer accordingly when allocating relative permeability tables to cells in SATNUM keyword.

(d) In the SUMMARY section remove WWCT (PROD), and replace with FWCT, the field water cut. Add FWIT (Field Water Injection Total) and FOE (Field Oil Recovery Efficiency) to the list of output variables.

(e) Place injector at (1,1) and producer at (50,1) and complete both over all vertical cells. Set the injector to a rate control of 11,000 stb water/day with a maximum bottom hole pressure limit of 10,000 psia, and the producer to a liquid production rate of 10,000 stb/day, with a minimum bottom hole pressure limit (BHP) of 2,000 psia.

(f) Water injection at this rate will result in the displacement of one pore volume of after 2850 days, so set the time steps to give ten tenths of a pore volume.

B) High Perm in Bottom Layer

Copy CASE2A.DATA to CASE2B.DATA. Edit the new file to place the high permeability layer in the bottom instead of the middle. Alter the PERMZ, PORO, NTG and SATNUM keywords to reflect the layer changes also.

C) High Perm in Top Layer

Copy CASE2B.DATA to CASE2C.DATA. Edit the new file to place the high permeability layer on top

D) Slower Frontal Advance Rate

Copy CASE2C.DATA to CASE2D.DATA. Edit the new file so that only 1,100 stb water/day are injected, and only 1,000 stbl/day are produced, and the timesteps are increased from 285 to 2850 days each.

5.0 YOUR TASK

1. From **Base Case Model**, use **ECLIPSE Office** to analyze the performance of the simulated model in terms of
   (a) BHP of both wells (WBHP) vs. time and the field average pressure (FPR) vs. time.
   (b) water cut (WWCT) of the well PROD and the field oil production rate (FOPR) vs. time

2. From **Case 1**, use **ECLIPSE Office** to evaluate the performance of the simulated model from varying parameters compared to previous base case model for the following. Discuss and justify based on related literature (include in-text citation).
   (a) BHP of both wells (WBHP) vs. time and the field average pressure (FPR) vs. time.
   (b) Water cut (WWCT) of the well PROD and the field oil production rate (FOPR) vs. time.
   (c) BHP values for the first 10 days in the range 3,500 psia to 5,500 psia.

3. From **Case 2**, use the **EXCEL (.RSM)** to plot and compare the development of simulated models based on following:
   (a) Field Oil Recovery Efficiency (Y-axis) vs Field Cumulative Water Injection (X-axis) for parts A-D.
   (b) Field Water Cut vs Field Cumulative Water Injection for the four models (parts A – D).
   (c) Discuss and analyse the main differences in production behaviour between the four models with relevant justification based on literature. Evaluate the profiles in D compared with the other cases if plotted against time instead of volume of water injected.

6.0 SUBMISSION OF MINI PROJECT

Date	**:**	**12th June 2025**
Time released	**:**	**9:00 am**
Submission Due Date	**:**	**11th July 2025**
Submission Due Time	**:**	**11:59 pm**

REPORT

The report should include the followings:
- ✓ Front Cover
- ✓ Table of Contents
- ✓ Introduction (Background, problem statement, objectives)
- ✓ Results and Discussion – relevant justification and related citations
- ✓ Conclusion
- ✓ References
- ✓ Appendices (Input Data File Information for all cases. For Case 1 and Case 2, include only the sections that have been modified)

Format of the report:

- ✓ Font type: Arial, Font size: 11
- ✓ Margin (1” RIGHT, 1” LEFT, 1” TOP, 1” BOTTOM)
- ✓ Line spacing: 1.5
- ✓ Number of pages: 8-15 (The content only, excluding figures, references and appendices)
- ✓ Correct spelling and grammar
- ✓ **Plagiarism** (including irresponsible AI usage) will be penalized accordingly. The report will be checked using **Turnitin** similarity checking.
- ✓ Convert the file to pdf before submission

7.0 EVALUATION SCHEME

This mini project is evaluated according to separate rubrics for CPS elements (PO2, CO3) and non-CPS elements (PO4, CO1), which carry marks of 20% and 10%, respectively. The detailed rubric of each area is given in the Appendix.

Prepared by:	Vetted by:	Moderated by;
Dr Tengku Amran Tengku Mohd Senior Lecturer School of Chemical Engineering, UiTM Shah Alam	**Dr Munawar Zaman Shahruddin** Field Coordinator	**Dr Arina Sauki** OBE Committee
Date: 9/06/2025	Date: 10/06/2025	Date: 10/06/2025

Appendix

Rubric for CPS (CO3, PO2)

WP	Performance Criteria	Descriptors for Rubric Design	1 Needs work F,E (0 - 39.9)	2 Developing D, D+, C- (40.0 - 49.9)	3 Satisfactory C, C+ (50.0-59.9)	4 Competent B-, B, B+ (60.0 - 74.9)	5 Excellent A-, A, A+ (75.0 - 100.0)
1	Depth of knowledge required (8 marks)	Analyze the following: (1) Background of the problems and data given (WK4) (2) Simulated base case model (WK6) (WK4, WK6)	Use 1 WK but do not elaborate	Use 1 WK with brief elaboration	Use 2 WKs with brief elaboration	Use 2 WKs with acceptable elaboration	Use 2 WKs with extensive elaboration
		Evaluate the following simulation results and provide justification for the performance of the simulated model: WBHP, FPR, WWCT, FOPR (WK8)	Evaluate 2 parameters only	Evaluate 3 parameters with brief justification	Evaluate 3 parameters with acceptable justification	Evaluate 4 parameters with acceptable justification	Evaluate 4 parameters with extensive justification
3	Depth of analysis = no obvious solution, abstract thinking, originality (4 marks)	Develop new model of varying parameters (porosity, NTG, Sw) and justify the performance in terms of the following: (1) WBHP and FPR profiles against time (2) WWCT and FOPR profiles against time	Justify the performance by varying only one (1) parameter	Justify the performance by varying one (1) parameter with acceptable elaboration of the model	Justify the performance by varying two (2) parameters with acceptable elaboration of the model	Justify the performance by varying three (3) parameters with acceptable elaboration of the model	Justify the performance by varying three (3) parameters with extensive elaboration of the model
2	Range of Conflicting requirement = wide & conflicting technical, engr & other issues (8 marks)	Compare the following profiles of the simulated models developed and justify the performance of each simulated model based on literature (1) FOE vs FWIT for (A-D) models (2) FWCT vs FWIT for (A-D) models (3) FOE vs time for (A-D) models (4) FWCT vs time for (A-D) models	Provide only 1 simulated model	Compare 2 simulated models with acceptable discussion	Compare 3 simulated models with acceptable discussion	Compare 4 simulated models with acceptable discussion	Compare 4 simulated models with extensive discussion

Rubric for Non-CPS (CO1, PO4)

No	Topic	1 Needs work F,E (0 - 39.9)	2 Developing D, D+, C- (40.0 - 49.9)	3 Satisfactory C, C+ (50.0-59.9)	4 Competent B-, B, B+ (60.0 - 74.9)	5 Excellent A-, A, A+ (75.0 - 100.0)
1(a)	Ability to solve Base Case using ECLIPSE software (1 mark)	Demonstrate poor capability of using ECLIPSE software and its features	Demonstrate satisfactory capability of using ECLIPSE software and its features	Demonstrate average capability of using ECLIPSE software and its features	Demonstrate good capability of using ECLIPSE software and its features	Demonstrate excellent capability of using ECLIPSE software and its features
1(b)	Ability to solve Case 1 using ECLIPSE software (2 marks)	Poor capability to simulate the model using ECLIPSE and its features	Satisfactory capability to simulate the model using ECLIPSE and its features	Average capability to simulate the model using ECLIPSE and its features	Good capability to simulate the model using ECLIPSE and its features	Excellent capability to simulate the model using ECLIPSE and its features
1(c)	Ability to solve Case 2 using ECLIPSE software (2 marks)	Poor capability to simulate the model using ECLIPSE and its features	Satisfactory capability to simulate the model using ECLIPSE and its features	Average capability to simulate the model using ECLIPSE and its features	Good capability to simulate the model using ECLIPSE and its features	Excellent capability to simulate the model using ECLIPSE and its features
2	Ability to prepare the Input data file with reliable simulation output based on the cases given (3 marks)	major errors in the input data and simulation cannot be run	Missing several information on input data. The simulation can still be run	Minor error on the input data under specific header keywords. The simulation can be run and no significant impact on the simulation results	No error on input data. Information are arranged under correct header keywords. The simulation can be run. Input data provide reliable results on simulation	No error on input data. All information are defined correctly under specific header keywords. Simulation can be completely run. Input data are well-organized, accurate and provide reliable simulation results
3	Ability to display the specified outputs from simulation as instructed for all cases (2 marks)	Many figures are missing and not displayed, incomplete labelling, most parameters are incorrectly plotted	A few figures are missing, some figures are incorrectly plotted with incomplete labelling, some parameters are incorrectly plotted	Figures displayed of each case are correctly plotted using Eclipse Office and MS Excel but with incomplete labelling, correct parameters are plotted as instructed, but wrong simulated output	All figures of each case are displayed and correctly plotted using Eclipse Office and MS Excel but with incomplete labelling, correct parameters are plotted as instructed	All figures of each case are displayed and correctly plotted using Eclipse Office and MS Excel with complete labelling, correct parameters are plotted as instructed