FLOW OF POROUS MEDIA

MSc in Petroleum Engineering **MFKOT730035**

COURSE DESCRIPTION

University of Miskolc
Faculty of Earth Science and Engineering
Petroleum and Natural Gas Institute
September 2022

Course Data Sheet

Course Title: Flow in Porous Media **Instructor:** Dr. Zoltán TURZÓ associate professor	**Code:** MFKOT730035 **Responsible department/institute:** DPE/IPNG (OMTSZ/KFGI) **Course Element: Compulsory**
Position in curriculum* **(which semester)**: 3 (2)	**Pre-requisites (if any):** Reservoir Engineering Fundamentals (MFKOT720024)
No. of contact hours per week (lecture + seminar): 0+3	**Type of Assessment (examination / practical mark / other):** practical mark
Credits: 3	**Course:** full time

Course Description:

1. Equation of single phase filtration.
2. Solution of the equation of single phase filtration.
3. Piston-like displacement.
4. Characteristics of various flow regimes, steady-state flow, unsteady-state flow, pseudo steady-state slow
5. The radial-diffusivity equation, solutions to the radial-diffusivity, equation bounded cylindrical reservoir, infinite cylindrical reservoir with line source, well pseudo steady-state flow, choosing the best pressure functions
6. Principle of superposition accounting for the effects of more than one well, accounting for rate change effects, accounting for pressure change effects simulating boundary effects.
7. The equation of two phase filtration, vertical two-phase filtration of incompressible fluids, the fractional flow equation, frontal displacement determination of the frontal saturation by material balance method.
8. Water coning, fingering and cresting in vertical and horizontal wells, critical rate calculation.
9. Steady state and pseudo-steady state filtration around horizontal well.
10. Water and gas coning in horizontal wells
11. Well Tests: flow tests
12. Well Tests: Pressure Build-up Tests (PBUPT)
13. Well Tests: Interpretations of PBUPT
14. Well Tests: Interpretations of PBUPT

Competencies to evolve

Knowledge:

Knows the economic processes related to the hydrocarbon industry.

Knows the properties of the fluids found in petroleum, natural gas and geothermal reservoirs, as well as the storage rocks; characteristics of flow in such reservoirs.

Knows the production mechanisms of underground reservoirs and the primary or enhanced extraction mechanisms that ensure optimal production.

Knows the basics of numerical simulation of underground storages.

Knows the methods and tools of computerized design and analysis in the hydrocarbon industry.

Ability:

Able to interpret the economic processes related to the hydrocarbon industry and to give adequate answers to them.

Capable of predicting the behavior of fluids in petroleum, natural gas, and geothermal reservoirs, the properties of reservoir rocks, and the characteristics of flow in such reservoirs.

Able to recognize the production mechanisms of underground reservoirs and select the primary or enhanced extraction mechanisms that provide optimal production.

Capable of numerical simulation of underground storages.

Capable of hydrocarbon industrial computer design and analysis.

Attitude:

Autonomy and responsibility:

Able to independently manage hydrocarbon industrial complex planning works and perform project management tasks, or participate in them.

Capable of independently choosing the appropriate mechanisms for the production of underground reservoirs; to implement the most favorable "reservoir management".
Able to autonomously plan the use of energy carriers produced from renewable natural resources and residual materials in the energy supply system, and manage the operation of the established system.
Takes responsibility for his/her professional decisions and the work processes carried out by him/her or under his/her control.

Assessment and grading:

Students will be assessed with using the following elements.

Attendance:	5 %
Midterm exam	40 %
Final exam	55 %
Total	100%

Grading scale:

% value	Grade
90 -100%	5 (excellent)
80 – 89%	4 (good)
70 - 79%	3 (satisfactory)
60 - 69%	2 (pass)
0 - 59%	1 (failed)

Compulsory or recommended literature resources:

- Craft and Hawkins: Applied Petroleum Reservoir Engineering, Prentice Hall, 1991, ISBN 0-13-039884-5
- Towler: Fundamental Principles of Reservoir Engineering, SPE Textbook Series, Vol.8., 2002, ISBN 1-55563-092-8
- T. Ahmed: Advanced Reservoir Engineering, Gulf Publishing Co. 2005, ISBN-13: 978-0-7506-7733-2
- T. Ahmed: Reservoir Engineering Handbook, Gulf Publishing Co., 2001, ISBN 0-88415-770-9
- L. P. Dake: Fundamentals of Reservoir Engineering, Elsevier, 1978, ISBN 0-444-41830-X

Course Schedule for 2022/23 school year, fall term

Date	Topic
9/7/2022	Equation of single phase filtration.
9/14/2022	Solution of the equation of single phase filtration.
9/28/2022	Piston-like displacement.
9/28/2022	Characteristics of various flow regimes, steady-state flow, unsteady-state flow, pseudo steady-state slow
10/5/2022	The radial-diffusivity equation, solutions to the radial-diffusivity, equation bounded cylindrical reservoir, infinite cylindrical reservoir with line source, well pseudo steady-state flow, choosing the best pressure functions
10/12/2022	Principle of superposition accounting for the effects of more than one well, accounting for rate change effects, accounting for pressure change effects simulating boundary effects.
10/19/2022	Test writing.
10/26/2022	The equation of two phase filtration, vertical two-phase filtration of incompressible fluids, the fractional flow equation, frontal displacement determination of the frontal saturation by material balance method.
11/9/2022	Water coning, fingering and cresting in vertical and horizontal wells, critical rate calculation.
11/9/2022	Steady state and pseudo-steady state filtration around horizontal well.
11/16/2022	Water and gas coning in horizontal wells
11/23/2022	Well Tests: flow tests
11/30/2022	Well Tests: Pressure Build-up Tests (PBUPT), Well Tests: Interpretations of PBUPT
12/7/2022	Test writing.

Test Example

CLOSED BOOK
(15 minutes)

NAME of STUDENT: __________________________ ID No.:________________

1. Mark the correctness of the following statements.

	TRUE	FALSE
The constitutive equation (relationship between the fluxes and driving forces) at single phase filtration is the Darcy's law		
The Continuity Equation expresses the conservation of the energy		
$\frac{d\rho}{dp} = 0$ is the State Equation of slightly compressible fluid		
The compressibility of real gas can be calculated with the following equation $c_g = \frac{1}{p} - \frac{1}{z(p)}\frac{\partial z}{\partial p}$		
At the derivation of the special filtration equation of slightly compressible fluid we shoul assume that the reservoir is isotropic, homogeneous, and viscosity is constant and the porous media is incompressible.		

2. Write up the definition of the pszeudo-pressure introduced by Al Hussany

3. Give the name of the parameter of the equation bellow

$$\Delta m(p) = \frac{\phi c_g \mu}{k}\frac{\partial m(p)}{\partial t}$$

m(p)…………………………………

ϕ…………………………………….

c_g……………………………………

μ……………………………………

k…………………………………….

4. Can be use of the above equation in case of real gas flow

Mark the correct answer

TRUE	FALSE

“I pledge that I have neither given nor received any unauthorized assistance on this quiz.”

Student’s Signature: ________________________

Examination review questions

Final Exam

OPEN BOOK

May 16, 2013
(50 minutes)

Student Name:…………………………………..

Student ID No.:…………………………………..

Question No.	Marks	Score
1	11	
2	13	
3	12	
Total	**36**	

"I pledge that I have neither given nor received any unauthorized assistance on this exam."

Student's Signature: ________________________

Question No. 1

The following data of a oil bearing layer are known:

- Permeability: $k = 1.50\ 10^{-14}$ m^2
- Porosity: $\phi = 0.25$
- Thickness: $h = 8.00$ m
- Well radius: $r_w = 0.12$ m
- Oil viscosity: $\mu = 1.0\ 10^{-3}$ Pas
- Oil compressibility: $c = 1.0\ 10^{-9}$ 1/Pa
- Production rate: $q = -20.00$ m^3/day
- Initial pressure $p_i = 10.00$ MPa

$$p_i - p(r,t) = \frac{\mu q}{4\pi hk} Ei\left(-\frac{r^2}{4Kt}\right)$$

a)

$$p_i - p(r,t) = -\frac{\mu q}{4\pi hk}\left(0{,}80907 + \ln\frac{Kt}{r^2}\right)$$

b)

Determine the flowing bottomhole pressure in the well and 100 m distance from the well after 30 days!

Which formula can be used to determine the pressure 100 m distant after one day?

Summarize the results here.

Flowing bottomhole pressure after 30 days, bar		
Can the formulae b) use to calculate the flowing bottomhole pressure	Yes	No
Pressure at 100 from the well after 30 days, bar		
Can the formulae b) use to calculate the pressure at 100 from the well after 30 days	Yes	No
Which formula can be used to determine the pressure 100 m distant after one day	a)	b)

Question No. 2

Calculate the dimensionless variables after 35 days for the well which data given bellow

t =	35.00	day
r =	410.00	ft
p =	1397.00	psi
B_o =	1	

- Permeability:	k =	1.75E+01	mD
- Porosity:	ϕ =	0.05	
- Thickness:	h =	49.21	ft
- Well radius:	r_w =	0.328	ft
- Oil viscosity:	μ =	8.00E-01	cP
- Oil compressibility:	c =	1.03E-05	1/psi
- Production rate:	q =	-283.00	bbl/day
- Initial pressure	p_i =	2030.53	psi

Summarize the results here.

Dimensionless time t_D=	
Dimensionless radius r_D=	
Dimensionless pressure p_D=	

Question No. 3

There are two well placed centrally in two cylindrical drainage areas. The radius of both drainage area is **r_e = 3000 m**. **Well 1** is located (**0.9 r_e**) distance from the origin of the drainage area. The **Well 2** is located (**0.45 r_e**) distance from the origin of the drainage area. Both well wellbore radius is **r_w = 0.1 m**, which well production (**Well 1 q_{f1}, Well 2 q_{f2}**) is grater if the potential functions (φ_e, φ_w) are same in both cases:

Summarize the results here.

q_{f1}/q_{f1}=		
Which is greater	q_{f1}	q_{f2}

$$q_f = \frac{2\pi(\varphi_e - \varphi_w)}{\ln\left[\frac{r_e^m}{m r_1^{m-1} r_w}\left(1 - \left[\frac{r_1}{r_e}\right]^{2m}\right)\right]}$$

$$q_f = \frac{2\pi(\varphi_e - \varphi_w)}{\ln\left[\frac{r_e}{r_w}\left(1 - \frac{\delta^2}{r_e^2}\right)\right]}$$

$$q_f = \frac{2\pi(\varphi_e - \varphi_w)}{\ln\left[\frac{\rho_e}{\rho_e \frac{\pi}{d} r_w e^{-\frac{\pi L}{d}}}\left(1 - \frac{\rho_e^2 e^{-\frac{2\pi L}{d}}}{\rho_e^2}\right)\right]} = \frac{2\pi(\varphi_e - \varphi_w)}{\ln\left[\frac{2d}{\pi r_w} \operatorname{sh}\frac{\pi L}{d}\right]}$$

$$q_f = \frac{2\pi(\varphi_e - \varphi_w)}{\ln\frac{2a}{r_w}}$$