



UNIVERSITY OF MINES AND TECHNOLOGY, TARKWA
FIRST SEMESTER EXAMINATIONS, NOV. – DEC. 2018

COURSE NO: PE 377

COURSE NAME: RESERVOIR ENGINEERING II

CLASS: PE III

TIME: 3 HRS

Name: _____ Index Number: _____

SECTION A

(Answer this section on the question paper)

1. In waterflooding, the injection pressure is inversely proportional to the water injection rate. **(True/ False)**
2. Formation zones referred to as “Thief zones” are of sufficiently low permeability. **(True/ False)**
3. Areal continuity of the pay zone is important for a successful waterflooding process. **(True/ False)**
4. The direct line drive flooding pattern has the lines of injection and production opposite to each other. **(True/ False)**
5. The volumetric sweep efficiency is simply the product of the displacement efficiency and the vertical sweep efficiency. **(True/ False)**
6. Give 4 reservoir lithology and rock properties that affect flooding ability and success.
 - i) _____
 - ii) _____
 - iii) _____
 - iv) _____
7. What is the oil recovery range of the following drive mechanisms?
 - i) Rock and liquid expansion: _____
 - ii) Solution gas: _____
 - iii) Water drive: _____
 - iv) Combination drive: _____
8. There are many procedures for determining the optimum time to waterflood. How do you know which one to select? **(2 Marks)**
9. Core analysis test carried out on UMaT reservoir #1 showed that the initial and residual oil saturations are 70 and 35% respectively. Calculate the displacement efficiency when the oil saturation is reduced to 67% and 57%. **(2 Marks)**

SECTION B

(Answer ALL the questions in this section in the answer booklet)

QUESTION 1

- a) What is Darcy law? **(2 Marks)**
- b) With the aid of a diagram show the effects of positive and negative skin on the pressure profile near wellbore of UMaT well #1. **(3 Marks)**
- c) With the aid of diagrams, show the difference between the normal nine-spot and inverted nine-spot injection patterns in waterflooding. **(4 Marks)**
- d) **Figure 1** shows an oil reservoir which has undergone waterflooding. Core analysis tests indicate that the initial and residual oil saturations are 70 and 25%, respectively. Given that $L = 2000$ ft, $H = 400$ ft, $W = 300$ ft, $x_f = 1100$ ft and $x_g = 210$ ft. Calculate the recovery factor. **(4 Marks)**

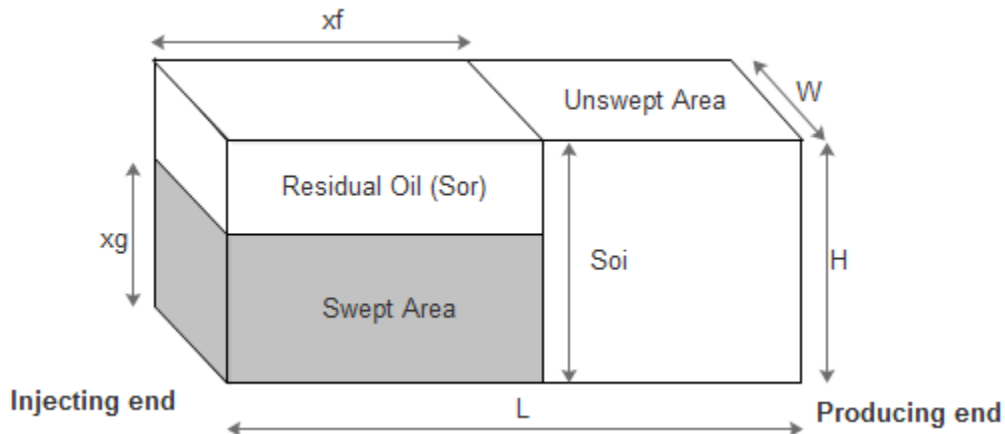


Figure 1

QUESTION 2

- a) An incompressible fluid flows in a linear porous medium (See **Figure 2**) with the following properties: $k = 100$ md, $\phi = 12\%$, and $\mu = 2$ cp.

Calculate:

- i) Flow rate in bbl/day
- ii) Apparent fluid velocity in ft/day
- iii) Actual fluid velocity in ft/day

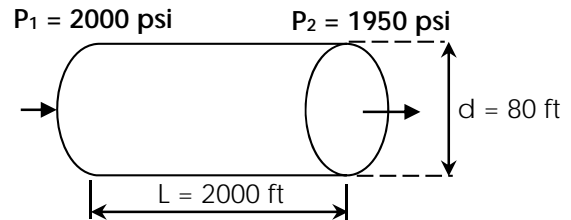


Figure 2

(5 Marks)

b) UMaT well #1 of radius of 0.25 ft is producing at a stabilized rate of 500 STB/day at a stabilized bottom-hole flowing pressure of 1850 psi. The pay zone is known to have a uniform thickness and permeability of 25 ft and 110 md respectively. The well drains in an area of approximately 35 acres. If the oil viscosity and formation volume factor are 2.5 cp and 1.25 bbl/STB, Calculate:

- i) the pressure distribution and pressure drop across 2 ft intervals from r_w to 2.25 ft, 4 to 6 ft, 18 to 20 ft, 98 to 100 ft and 744 to 746 ft.
- ii) plot the pressure profile around the wellbore. **(10 Marks)**

SECTION C

(Answer ONLY ONE question from this section in the answer booklet)

QUESTION 3

The following data present the cumulative water influx and the rate of water influx into Chambers reservoir calculated over a period of time.

Time (days)	Pressure (psi)	W_e (M bbl)	e_w (bbl/day)
0	3793	0	0
80	3774	23	352
198	3724	165	986
356	3640	456	1892
654	3551	967	2650
920	3478	1598	3255
1256	3380	2378	4015

Assuming that the boundary pressure would drop to 3250 psi after 1398 days of production, calculate the cumulative water influx at that time. **(15 Marks)**

QUESTION 4

a) The following data are available on a well in the Chambers Field:

$$\begin{array}{llll}
 p_e = 3016 \text{ psi} & p_{wf} = 2100 & r_e = 745' & r_w = 0.25' \\
 B_o = 1.25 & \mu_o = 3.0 & k = 0.12 \text{ Darcy} & h = 20' \\
 c_o = 25 \times 10^{-6} \text{ psi}^{-1} & & &
 \end{array}$$

Assuming a slightly compressible fluid, calculate the oil flow rate. Compare the result with that of incompressible fluid. **(5 Marks)**

b) **Figure 3** shows the rate history of a well that is producing under transient flow condition for 16 hours. Given the following data:

$$p_i = 5000 \text{ psi}$$

$$h = 20'$$

$$B_o = 1.1 \text{ bbl/STB}$$

$$\phi = 15\%$$

$$\mu_o = 2.5 \text{ cp}$$

$$r_w = 0.3'$$

$$c_t = 20 \times 10^{-6} \text{ psi}^{-1}$$

$$s = 0$$

$$k = 40 \text{ md}$$

Calculate the sand face pressure after 16 hours.

(10 Marks)

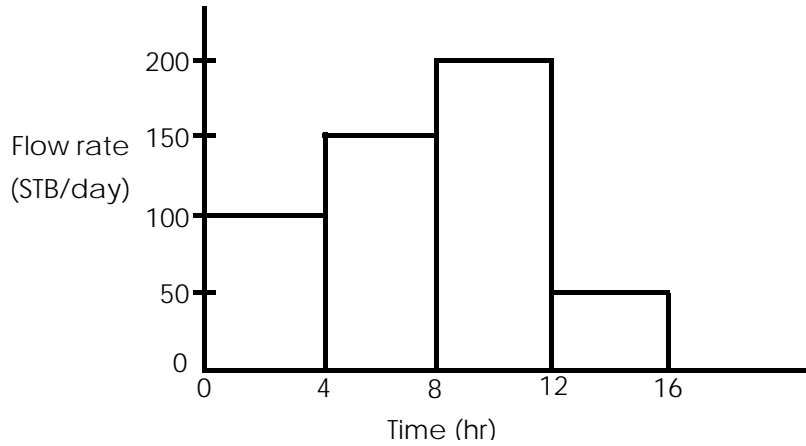


Figure 3: Rate history

EQUATIONS

$$Q = \frac{0.00708kh(p_e - p_{wf})}{\mu B \ln\left(\frac{r_e}{r_w}\right)}$$

$$Q_{sc} = \frac{0.111924Ak(p_1^2 - p_2^2)}{TLz\mu_g}$$

$$q = \frac{0.001127kA(p_1 - p_2)}{\mu L}$$

$$Q_o = \left[\frac{0.00708kh}{\mu_o B_o c_o \ln\left(\frac{r_e}{r_w}\right)} \right] \ln[1 + c_o(p_e - p_{wf})]$$

$$W_e = (c_w + c_f) W_i (p_i - p)$$

$$W_e = C \int_0^t \left[\frac{p_i - p}{\ln(at)} \right] dt$$

$$W_e = C \sum_0^t \left[\frac{\Delta p}{\ln(at)} \right] \Delta t$$

$$W_i = \left[\frac{\pi(r_a^2 - r_e^2)h\phi}{5.615} \right]$$

$$\frac{p_i - p}{e_w} = \left(\frac{1}{C}\right) \ln(a) + \left(\frac{1}{C}\right) \ln(t) \quad W_e = C \sum_0^t (\Delta p) \Delta t \quad W_e = C \left[\int_0^t (p_i - p) dt \right]$$

$$E_D = \frac{V_p (S_{oi} - S_{or})}{V_p S_{oi}} = \frac{S_{oi} - S_{or}}{S_{oi}}$$

$$(\Delta p)_{Q_1 - 0} = \left[\frac{162.6(Q_1 - 0)\mu B}{kh} \right] \times \left[\log \left(\frac{kt_4}{\phi \mu c_t r_w^2} \right) - 3.23 + 0.87s \right]$$

$$(\Delta p)_{Q_2 - Q_1} = \left[\frac{162.6(Q_2 - Q_1)\mu B}{kh} \right] \times \left[\log \left(\frac{k(t_4 - t_1)}{\phi \mu c_t r_w^2} \right) - 3.23 + 0.87s \right] \text{ and so on.}$$

GOOD LUCK

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