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KENYATTA UNIVERSITY
EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE

IN PETROLEUM ENGINEERING

EPL 504: WELL & RESERVOIR SIMULATION

3RD TRIMESTER 2022/2023 **TIME: 2 Hours**

INSTRUCTIONS:

The examination consists of **TWO** sections (**A** and **B**). Answer SECTION **A** (**COMPULSORY**) and **ANY TWO QUESTIONS** from **SECTION B**.

Section A- Compulsory (30marks)

QUESTION 1

There are three (3) basic engineering principles/concepts or equations used in the derivation of a flow equation in reservoir simulation.

Explain these concepts using applicable equations or diagrams.

Section B –Answer any Two Questions (Each question 20 marks)

QUESTION 2

a. Explain the principles of gridding system. (7 marks). (7 marks)

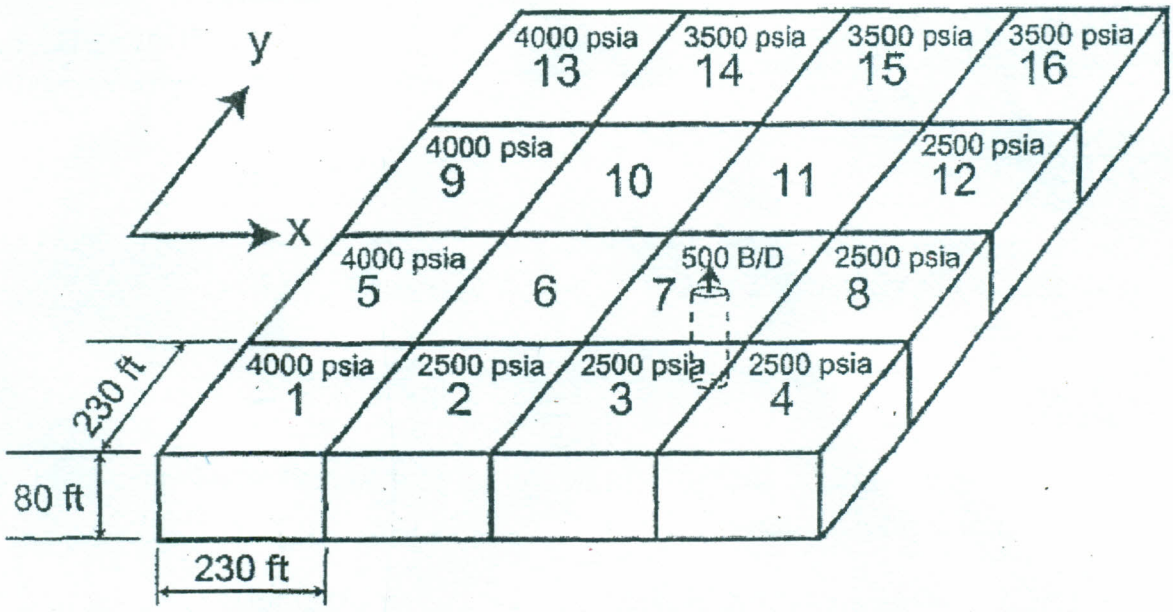
b. How can the grid system be used to estimate unknown parameters in grid blocks. (7 marks) (7 marks)

c. Why is fining done near the wellbore? (6 marks) (6 marks)

QUESTION 3

Consider single-phase flow of water in a 2D horizontal reservoir. The reservoir is discretized using 4x4 equal blocks as shown in the figure below. Block 7 hosts a well that produces 500 B/D of water. All blocks have $A_x = A_y = 230$ ft, h = 80 ft, and $k_x = k_y = 65$ mD. The water FVF and viscosity are 1.0 rB/STB and 0.5 cp, respectively. The pressure of reservoir boundary blocks is specified as $P_2 = P_3 = P_4 = P_8 = P_{12} = 2500$ psia, $P_1 = P_5 = P_9 = P_{13} = 4000$ psia, and $P_{14} = P_{15} = P_{16} = 3500$ psia.

Assuming that the reservoir water and rock are incompressible, calculate the pressure of the grid block with the well.



QUESTION 4

a. Explain the stages of reservoir modelling. (10 marks)

b. Briefly explain 4 types of reservoir simulations. (10 marks)

QUESTION 5

Material balance analysis is a method of reservoir simulation. For a reservoir above bubble point pressure and with a closed boundary, explain how the simulation equation changes with production.

$$N_p[B_o + B_g(R_p - R_s)] + W_p B_w - W_{inj} B_{winj} - G_{inj} B_{ginj}$$
$$= N\left\{[B_o - B_{oi} + B_g(R_{si} - R_s)] + \frac{B_{oi}}{B_{gi}} m(B_g - B_{gi})\right.$$
$$\left. + B_{oi}(1+m)\left(\frac{c_f + c_w S_w}{1 - S_w}\Delta p\right)\right\} + W_e B_w$$

EPL 504 – Formula Sheet

$a = -\ln(1-d)$	$a_i = \frac{1}{b}[(1-d_i)^{-b} - 1]$	$a_i = \frac{d_i}{1-d_i}$
$d = 1 - e^{-a}$	$d_i = 1 - (1+ba_i)^{-\frac{1}{b}}$	$d_i = \frac{a_i}{1+a_i}$
$a = a_i$	$a = a_i(1+ba_i\Delta t)^{-1}$	$a = a_i(1+a_i\Delta t)^{-1}$
$q = q_i\, e^{(-a\Delta t)}$	$q = \frac{q_i}{(1+b\,a_i\,\Delta t)^{(\frac{1}{b})}}$	$q = \frac{q_i}{(1+a_i\,\Delta t)}$
$Q = \frac{q_i - q}{a}$ $q = q_i - Q\,a$	$Q = \frac{{q_i}^b}{a_i(1-b)}\left({q_i}^{(1-b)} - q^{(1-b)}\right)$ $q^{(1-b)} = {q_i}^{(1-b)} - \frac{Q\,a_i(1-b)}{{q_i}^b}$	$Q = \frac{q_i}{a_i}\ln\left(\frac{q_i}{q}\right)$ $q = q_i\, e^{\left(\frac{-Q\,a_i}{q_i}\right)}$

$$u_x\big|_{x_{i-1/2}} = \beta_c \frac{k_x\big|_{x_{i-1/2}}}{\mu\big|_{x_{i-1/2}}}\left[\frac{(\Phi_{i-1} - \Phi_i)}{\Delta x_{i-1/2}}\right]$$

$$T^m_{z_{i,j,k-1/2}}[(p^m_{i,j,k-1} - p^m_{i,j,k}) - \gamma^m_{i,j,k-1/2}(Z_{i,j,k-1} - Z_{i,j,k})]$$
$$+T^m_{y_{i,j-1/2,k}}[(p^m_{i,j-1,k} - p^m_{i,j,k}) - \gamma^m_{i,j-1/2,k}(Z_{i,j-1,k} - Z_{i,j,k})]$$
$$+T^m_{x_{i-1/2,j,k}}[(p^m_{i-1,j,k} - p^m_{i,j,k}) - \gamma^m_{i-1/2,j,k}(Z_{i-1,j,k} - Z_{i,j,k})]$$
$$+T^m_{x_{i+1/2,j,k}}[(p^m_{i+1,j,k} - p^m_{i,j,k}) - \gamma^m_{i+1/2,j,k}(Z_{i+1,j,k} - Z_{i,j,k})]$$
$$+T^m_{y_{i,j+1/2,k}}[(p^m_{i,j+1,k} - p^m_{i,j,k}) - \gamma^m_{i,j+1/2,k}(Z_{i,j+1,k} - Z_{i,j,k})]$$
$$+T^m_{z_{i,j,k+1/2}}[(p^m_{i,j,k+1} - p^m_{i,j,k}) - \gamma^m_{i,j,k+1/2}(Z_{i,j,k+1} - Z_{i,j,k})]$$
$$+q^m_{sc_{i,j,k}} = \frac{V_{b_{i,j,k}}}{\alpha_c \Delta t}\left[\left(\frac{\phi}{B}\right)^{n+1}_{i,j,k} - \left(\frac{\phi}{B}\right)^{n}_{i,j,k}\right],$$