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FEDERAL UNIVERSITY OF TECHNOLOGY, OWERRI
SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY
DEPARTMENT OF PETROLEUM ENGINEERING
2018/2019 HARMATTAN SEMESTER EXAMINATION

Course Title: **Reservoir Modelling And Simulation**
Course Code: **PET 505**
Instructions: **Answer Only 5 Questions.**
Question 1 to 4 are Compulsory you can answer either Question 5 or 6

Date: **21st June, 2019**
Time: **3 Hours**
Units: **3**

QUESTION 1

Question 1 a

i. What do you mean by the term history matching?
ii. Name the parameters which can be varied either singly or collectively for history matching optimization.
iii. With a flow chart only, state the reservoir simulation study process.

Question 1 b

i. List the history matching parameters
ii. Why do we have increase in energy during the history matching of Ihiagwa reservoirs?
iii. Differentiate between simultaneous solution method and **IMPES** solution of a reservoir simulator

IMPES

Question 1 c

collection of data

Name the area where **BOAST** is not recommended and why?

QUESTION 2

a. Show the flow chart of solving the simulation equation using **IMPES**
b. State the partial differential equations for both oil phase and water phase using a fully implicit formulation
c. Differentiate between a one dimensional model and a three dimensional model.
d. List the groups of data generally required in making a simulation run.
e. State the data sources and their parameters as required by the engineer.

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QUESTION 3

a. List three advantages of reservoir simulation and three abuses of reservoir simulation.
b. Identify the following grid types in the following format:

Figure	Grid type/name	Imax	Jmax	Kmax	Applications
Figure 1					i. ii
Figure 2					i. ii
Figure 3					i. ii.

$\phi = \hat{o}\, C_t + C_o (P - P_o)$

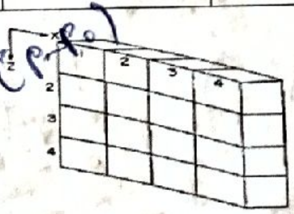
Figure 1

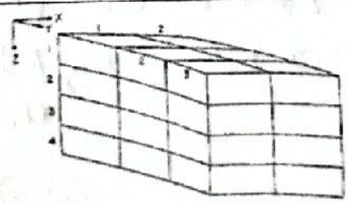
Figure 2

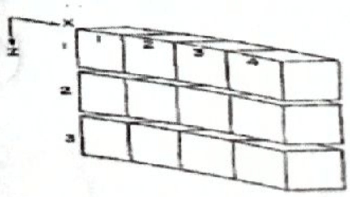
Figure 3

c. Given the basic single phase flow equation as equation 1 below:

$$\frac{\partial}{\partial x}\left(\beta_c \frac{A_x K_x}{\mu B}\frac{\partial \Phi}{\partial x}\right)\Delta x + \frac{\partial}{\partial y}\left(\beta_c \frac{A_y K_y}{\mu B}\frac{\partial \Phi}{\partial y}\right)\Delta y + \frac{\partial}{\partial z}\left(\beta_c \frac{A_z K_z}{\mu B}\frac{\partial \Phi}{\partial z}\right)\Delta z + q_{sc} = \frac{V_b}{\alpha_c}\frac{\partial}{\partial t}\frac{\emptyset}{B} \quad \text{........1}$$

Derive the simplest form of PDE that governs the flow of an incompressible fluid in a 3D homogenous and isotropic formation with no depth gradient. Assume that there is no well in the reservoir.

QUESTION 4

a. A 2D slightly compressible fluid transport equation is given as equation

$$\frac{\partial}{\partial x}\left(\beta_C \frac{A_x K_x}{\mu_l B_l}\frac{\partial p}{\partial x}\right)\Delta x + \frac{\partial}{\partial y}\left(\beta_C \frac{A_y K_y}{\mu_l B_l}\frac{\partial p}{\partial y}\right)\Delta y + q_{lsc} = \frac{V_b \phi C_l}{\alpha_c B_l}\frac{\partial p}{\partial t} \quad (2)$$

I. Write the explicit finite-difference approximation to this equation

II. Write the implicit finite-difference approximation to this equation

b. For a 1D Single phase flow of slightly compressible oil, we can show that the flow equation for an explicit formulation in block is:

$$T^n_{lxi+1/2}(P^n_{i+1} - P^n_i) - T^n_{lxi-1/2}(P^n_i - P^n_{i-1}) + q_{lsci} = \left(\frac{v_b \phi c_l}{\alpha_c B^o_l \Delta t}\right)_i (P^{n+1}_i - P^n_i) \ldots\ldots\ldots\ldots 3$$

Where the interblock transmissibility is $T^n_{lxi\pm 1/2} = \left(B_c \frac{A_x K_x}{\mu_l B_l \Delta x}\right)_{i\pm 1/2}$; $a_c = 5.615$ and $B_c = 1.127$

At the time of discovery of the reservoir illustrated in figure 4; the fluids were in hydrodynamic equilibrium and the pressure of grid block 2 was 3000 psia. All grid blocks have $\Delta x = 400\ ft.$; $\Delta y = 200 ft; h = 80\ ft; k = 222 md$ and $\phi = 0.20$. The well in gridblock 2 is produced at a rate of 200 STB/D and fluid properties are $\mu_o = 2cp, B_o = B^o_o = 1\ RB/STB;\ C_o = 5 \times 10^{-5} Psi^{-1}$. Using single phase simulator shown in equation 3 and a time step of 10 days, report the pressure distribution in the reservoir at 2 time steps.

Problem

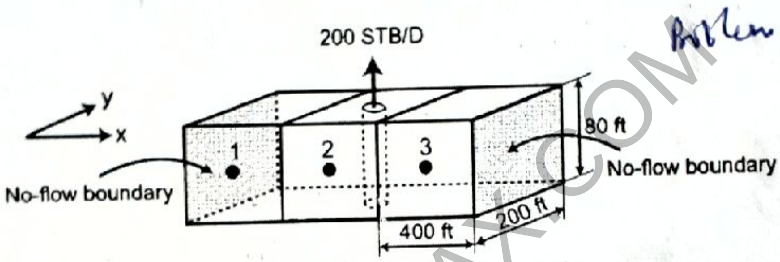

Figure 4: Discretized 1D Reservoir

222×10^{-3}

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QUESTION 5

a. Find the derivative of $f(x) = \frac{X^3 \, SinX}{e^{3x}}$ with respect to X

b. The single phase transmissibility of a porous medium to gas is given by

$$T_{gx}(P) = \frac{\beta_c \alpha_c A_x K_x}{\mu_g \Delta X}\frac{T_{sc}}{P_{sc}}\frac{P}{ZT}$$

Where $\beta_c, \alpha_c, A_x, K_x, T_{sc}, P_{sc}$ and T are constants while μ_g, P and Z are functions of pressure. Obtain a derivative of the transmissibility with respect to pressure

c. Evaluate the following

i. $\Delta^2 f(X_{i+1})$

ii. $\nabla^2 f(X_{i-1})$

iii. $\delta^2 f(X_i)$

(1) $\Delta x = \Delta y \Delta z = ft^2$ $\quad$ m $\times 10^{-3}$

(2) $T_{lxi+1/2} = \left(B_c \frac{A_x K_x}{\mu_l B_l \Delta x}\right)_{i+1/2}$ = stb - D/cp-rb

QUESTION 6

a. Find the partial derivative of oil in place with respect to pressure and saturation for a reservoir undergoing simultaneous pressure and saturation changes.

b. Develop the tri-diagonal matrix of the following incompressible flow equation $\frac{\partial}{\partial x}\left(\beta_c A_x K_x \frac{\partial P}{\partial X}\right)\Delta X + \mu q_{sc} = 0$ for N = 6 cells given that a well is located in cell 4 flowing at a rate of q_{sc} and that the reservoir is completely sealed

c. Solve the following system of equations using Gaussian Elimination method

$$\begin{bmatrix} 2 & 3 & -1 \\ 5 & 1 & 8 \\ 4 & -5 & 3 \end{bmatrix}\begin{bmatrix} P_1 \\ P_2 \\ P_3 \end{bmatrix} = \begin{bmatrix} 9 \\ 45 \\ 5 \end{bmatrix}$$

(8) $\frac{\alpha C B_l \Delta t}{V_b \phi C_l}$