Final Exam
Time 2:30 hours
Date: 22/01/2014

University of Misratah

Dept. Of petroleum Engineering
Driling Engineering

Question 1:

The following drilling information were obtained from an exploratory well in Al-Faregh oil field

Depth (ft)	R (ft/hr)	
500	119	
1000	98	
1500	80	$R = Ke^{(-2.303aD)}$
3000	45	Average bit life =20hr
4500	25	Rig type is duplex rig
6000	14	
8500	5	
10000	3	

The plane was to drill a new developmentary well in the same field to the drilling target of 8000ft.

Determine:

a) The general drilling rate equation of the field. (6 points)

b) Number of bits required to drill the well to depth 4500 ft. (4 points)

c) Rotating time to drill the well to 4500 ft. (4 points)

Question 2:

The following data of shear rate and shear stress were obtained from mud laboratory experiments:

Shear stress $lbf/100ft^2$	Shear rate $(\sec^{-1})$
5	10
10	20
15	30
18	35
22	40

Determine:

a) The drilling fluid behaviour equation. (5 points)

b) Shear stress at shear rate 50 $\sec^{-1}$. (4 points)

Question 3:

a) Calculate the mud flow rate for Newtonian fluid inside a 3 inch drill pipe and in the annulus opposite to drill pipe required to produce a maximum shear rate of 70 sec^{-1} at the wall of pipe. Hole diameter is 9.625 in and O.D pipe is 3.5 in. (4 points)

b) For the same case, calculate the friction pressure losses in inside drill pipe and in annulus. Viscosity of fluid is 20cp. (4 points)

Question 4:

The geologist has noticed a decrease in the rock cutting accumulation at the shale shaker. The drilling engineer has decided to investigate the problem by suggesting different drilling parameters and determining friction pressure losses gradient is 0.0475 psi/ft in the drilling circulation system excluding bit. Given:

Well depth	=10000ft
Nozzle size (3 nozzles)	= ½ in
Nozzle coefficient of discharge	= 90%
Mud density	= 9 Ibm/gal
Mud flow rate	= 500 gal/min
Drill collar inside diameter	= 2.75 in
Pump pressure	= 1600 psi
Pump suction pressure	= 50 psi

Calculate:

a) The pressure at the bottom of the well inside the drill string. (5 points)

b) The pressure drop across bit nozzles. (4 points)

c) The bottom hole circulating pressure. (4 points)

Question 5:

In order to have an optimum wellbore cleaning capacity, the drilling engineer decided to design a water drilling fluid making pressure drop across bit nozzle of 800 psi.

Nozzle size (3 nozzles)	= ¼ in
Nozzle coefficient of discharge	= 0.9
Mud density	= 8.46 Ibm/gal

Calculate:

a) The velocity of the drilling fluid through bit nozzle. (4 points)

b) The drilling fluid flow rate. (4 points)

Question 6:

9 ppg mud is being circulated through the drilling system. The pressure increase developed by the pump is 3,500 psi. The velocity of drilling fluid through 3 in inside diameter of drill string is 9 ft/sec.

a) Determine the hydraulic horse power being developed by the pump and find out the power consumed for 1,100 psi friction pressure loss in the drill string. (4 points)

b) What is the hydraulic impact force if pressure drop across the bit is 1,200 psi, while the discharge coefficient is 0.9 (4 points)

$$\frac{dD}{dt} = Ke^{-2.303aD}$$

$$Di = \frac{1}{2.303a}\ln\left(2.303aKT_b + e^{2.303aD_{i-1}}\right)$$

$$Tr = \frac{1}{2.303aK}\left(e^{2.303aD} - 1\right)$$

$$\tau = \mu * \gamma$$

$$V^{-} = \frac{q}{2.448d^2}$$

$$V^{-} = \frac{q}{2.448(d_2^{\,2} - d_1^{\,2})}$$

$$P_1 + 0.052\rho(D_2 - D_1) - 8.074 * 10^{-4}\rho\left(V_2^{\,2} - V_1^{\,2}\right) + \Delta P_{pump} - \Delta P_{friction}$$

$$\Delta P_{bit} = \frac{8.311 * 10^{-5} * \rho * q^2}{C_d^{\,2} * At^2}$$

$$BHCP = BHHP + \Delta P_{friction}$$

$$BHHP = 0.052 * \rho * D + P_{surface}$$

$$V_n = C_d\sqrt{\frac{\Delta P_{bit}}{8.074 * 10^{-4} * \rho}}$$

$$V_n = \frac{q}{3.117At}$$

$$Fj = 0.01823 * C_d * q * \sqrt{\rho * \Delta P_{bit}}$$

$$PH = \frac{\Delta P_{pump} * q}{1714}$$

	Frictional Pressure Loss	Shear Rate At Pipe Wall
Newtonian	Pipe $\frac{dp_f}{dL} = \frac{\mu v}{1,500\, d^2}$	Pipe $\dot{\gamma}_w = \frac{96\, v}{d}$
	Annulus $\frac{dp_f}{dL} = \frac{\mu v}{1,000\, (d_2 - d_1)^2}$	Annulus $\dot{\gamma}_w = \frac{144\, v}{(d_2 - d_1)}$
Bingham Plastic	Pipe $\frac{dp_f}{dL} = \frac{\mu_p v}{1,500\, d^2} + \frac{\tau_y}{225\, d}$	Pipe $\dot{\gamma}_w = \frac{96\, v}{d} + 159.7 \frac{\tau_y}{\mu_p}$
	Annulus $\frac{dp_f}{dL} = \frac{\mu_p v}{1,000\, (d_2 - d_1)^2} + \frac{\tau_y}{200(d_2 - d_1)}$	Annulus $\dot{\gamma}_w = \frac{144\, v}{(d_2 - d_1)} + 239.5 \frac{\tau_y}{\mu_p}$
Power-Law	Pipe $\frac{dp_f}{dL} = \frac{K v^n}{144,000\, d^{1+n}} \left(\frac{3 + 1/n}{0.0416} \right)^n$	Pipe $\dot{\gamma}_w = \frac{24 v}{d} (3 + 1/n)$
	Annulus $\frac{dp_f}{dL} = \frac{K v^n}{144,000\, (d_2 - d_1)^{1+n}} \left(\frac{2 + 1/n}{0.0208} \right)^n$	Annulus $\dot{\gamma}_w = \frac{48 v}{d_2 - d_1} (2 + 1/n)$