Exam B

March 9, 2005

50 minutes, closed book except for 2 cheat sheets, calculator, and straight edge.

Turn in you cheat sheets with your exam.

Show your work. Include the units. Use symbols instead of values when necessary.

1. (20 points) A well has the following data:

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$p_i = 5{,}199$ psia	$\mu = 2.1$ cp	$h = 125$ ft
$q_{oi} = 123$ stb/d	$\phi = 0.17$	$r_w = 0.25$ ft
$B_o = 1.12$ rb/stb	$c_t = 12 \times 10^{-6}$ psi^{-1}	$S_w = 0.20$

Suppose the well produces at 123 stb/d for 150 days, then produces at 175 stb/d for 300 days. The well has a productivity index of 0.22 stb/d/psi and a drainage area of $A = 1.62 \times 10^6$ ft^2.

(a) Calculate the pore volume and original oil-in-place (OOIP).

(b) Calculate the average reservoir pressure at 450 days (use the tank model approach).

(c) Calculate p_{wf} at 450 days, assuming that the well is in pseudo-steady state.

a.) $\text{Pore Vol.} = Ah\phi = (1.62\times10^6)(125)(.17)\left(\frac{1\text{ rb}}{5.615\text{ ft}^3}\right) = \boxed{6.13\times10^6 \text{ rb}}$ ✓

$\text{OOIP} = \text{Pore Vol}\,\frac{(1-S_w)}{B_o} = 6.13\times10^6\text{ rb}\,\frac{(1-.2)}{1.12\ \frac{\text{rb}}{\text{stb}}} = \boxed{4.38\times10^6 \text{ stb}}$ ✓

b.) $\frac{\Delta p}{\Delta t} = \frac{-qB}{V_p c_t} \Rightarrow \Delta p = \frac{q_1 B\,\Delta t_1}{V_p c_t} + \frac{q_2 B\,\Delta t_2}{V_p c_t}$

$= \frac{(123)(1.12)(150)}{(6.13\times10^6)(12\times10^{-6})} + \frac{175(1.12)(300)}{(6.13\times10^6)(12\times10^{-6})} = \boxed{1080.3 \text{ psi}}$ ✓

$\bar{p} = 5199 - 1080.3 = \boxed{4118.7 \text{ psi}}$ ✓

c.) $J = \frac{q}{\bar{p} - p_{wf}} \Rightarrow p_{wf} = \bar{p} - \frac{q}{J}$

$= 4118.7 - \frac{175}{.22} = \boxed{3323 \text{ psi}}$ ✓

2. (20 points) Suppose you *did not know the productivity index* in problem 1, but can use all the other data. Use the Dietz shape factor tables. You estimate that the well is in the center of a 4 x 1 rectangle and that k = 12 md and s = 5.1.

(a) Calculate the productivity index (stb/d/psi).

(b) When is the end of the SLSL?

(c) When does pseudo-steady state begin?

$C_A = 5.379$

$K = 12$

$S = 5.1$

a.) $$J = \frac{.00708\ Kh}{B\mu\left[\frac{1}{2}\ln\left(\frac{10.06A}{C_A r_w^2}\right) - \frac{3}{4} + s\right]} = \frac{.00708\,(12)(125)}{(1.12)(2.1)\left[\frac{1}{2}\ln\left(\frac{10.06\,(1.62\times10^6)}{5.379\,(.25)^2}\right) - \frac{3}{4} + 5.1\right]} = \boxed{.342\ \frac{stb/d}{psi}}$$

b.) $$t = \frac{\phi \mu c_t A t_{DA}}{.000264\ K} = \frac{(.17)(2.1)(12\times10^{-6})(1.62\times10^6)(.01)}{.000264\ K} = \boxed{21.91\ hr.}$$ ← from chart

c.) $$t = \frac{\phi \mu c_t A t_{DA}}{.000264 K} = \frac{(.17)(2.1)(12\times10^{-6})(1.62\times10^6)(.8)}{.000264\ (12)} = \boxed{1752.6\ hr}$$

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3. (20 points) Suppose wells A and B are in an *infinite homogeneous reservoir* a distance of 880 ft apart. Well B has a skin factor of 9.0 and begins producing at 170 stb/d at t = 0. Well A has a skin factor of 5.9 and begins producing 300 hours later at 210 stb/d.

(a) Calculate the effect of well B on well A at t = 1,100 hours.

(b) Calculate the effect of well A on well A at t = 1,100 hours.

(c) Caculate the total effect of A and B to give p_{wf} in well A at t = 1,600 hours. **[Use necessary data from Problem no. 1 and use k = 6.5 md.**

$$t_{Dr} = \frac{0.000264k}{\phi \mu c_t}\frac{t}{r^2} = \frac{0.000264(6.5)}{(.17)(2.1)(12\times10^{-6})}\frac{t}{r^2} = 400.56\frac{t}{r^2}$$

$$t_{Dr_B} = \frac{400.56\,(1100)}{880^2} = 0.569$$

$$P_D = 0.32$$

$$\Delta P_{B/A} = \frac{141.2\,qB\mu}{kh}P_D = \frac{141.2\,(170)(1.12)(2.1)(0.32)}{(6.5)(125)} = 22.2\,psi$$

$$t_{Dr_A} = \frac{400.56\,(800)}{.25^2} = 5.13\times10^6$$

$$P_D = 8 + 5.9 = 13.9$$

$$\Delta P_{A/A} = \frac{141.2\,qB\mu P_D}{kh} = \frac{141.2\,(210)(1.12)(2.1)(13.9)}{6.5\,(125)} = 1193.1\,psi$$

1600 hr

$t_{Dr_B} = 0.828$ $\quad P_D = 0.41$ $\quad \Delta P_{B/A} = 28.5$ psi

$t_{Dr_A} = 8.33\times10^6$ $\quad P_D = 8.1 + 5.9 = 14$

$\Delta P_{A/A} = 1201.7$ psi

$$P_{wf}(1600\,hr) = 5199 - (28.5 + 1201.7) = 3{,}968.9\,psia$$

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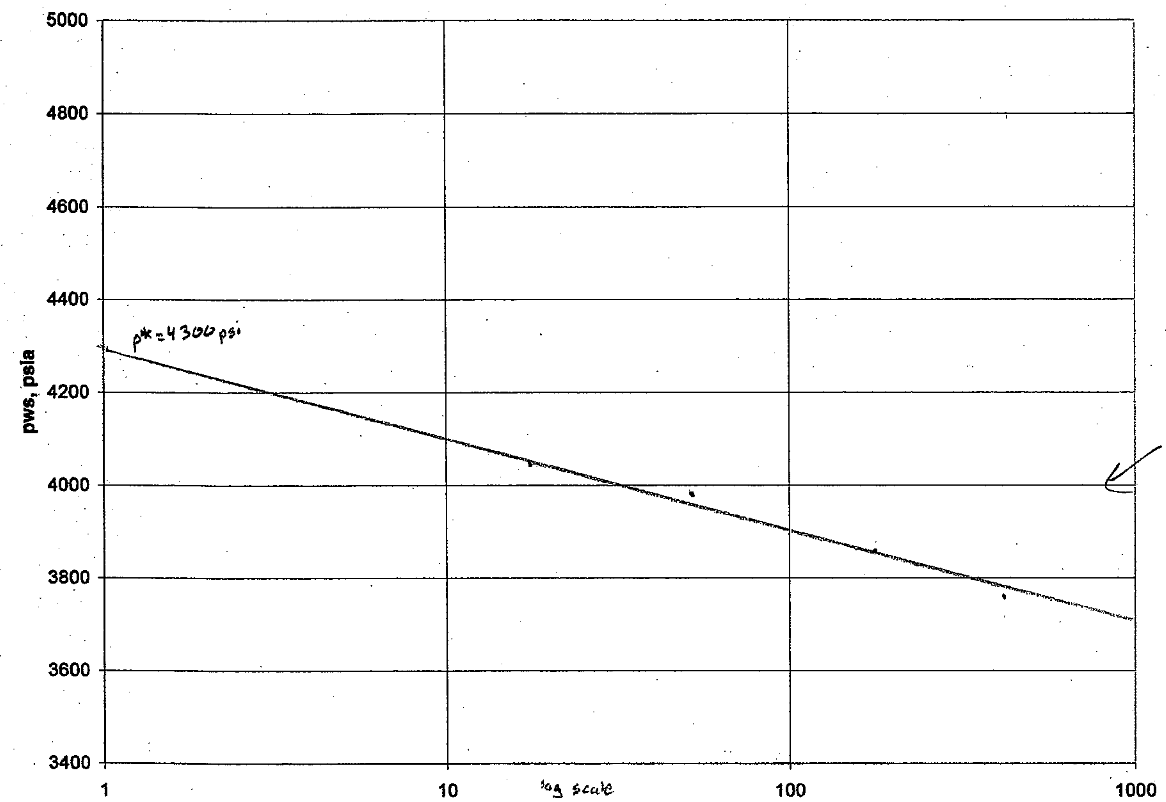
4. (20 points) We have a well producing for a closed square reservoir. We want to evaluate the well, so we produce it at constant rate of 123 stb/d for 1,000 hours and then shut it in. Below is the shut-in time and pressure data. **Use necessary data from Problem no. 1.**

Shut-in time, hours	Shut-in pressure, psia	$\frac{t_p+\Delta t}{\Delta t}$
2	3753	501
5	3886	201
15	3949	67.7
43	4020	24.3

Analyze this as a build-up test.
(a) Calculate the plotting variables,
(b) Make a Horner plot
(c) Determine the permeability
(d) Determine the average reservoir pressure



Some error in plotting points

$$\frac{t_p+\Delta t}{\Delta t}$$

c.) $m = \dfrac{3753-4020}{\log(501)-\log(24.3)} = -203 \ \dfrac{\text{psi}}{\text{cycle}}$

$K = 162.6 \dfrac{qB\mu}{mh} = 162.6 \dfrac{(123)(1.12)(2.1)}{203(125)} = \boxed{1.85 \text{ md}}$

d.) $t_{pDA} = \dfrac{.000264 K t_p}{\phi \mu c_t A} = \dfrac{.000264(1.85)(1000)}{(.17)(2.1)(12\times10^{-6})(1.62\times10^{6})} = .070$

From chart ⇒ $P_{DMBH} \approx \sim .88 \Rightarrow \bar{p} = p^* - \dfrac{m}{2.303} \cdot P_{DMBH}$

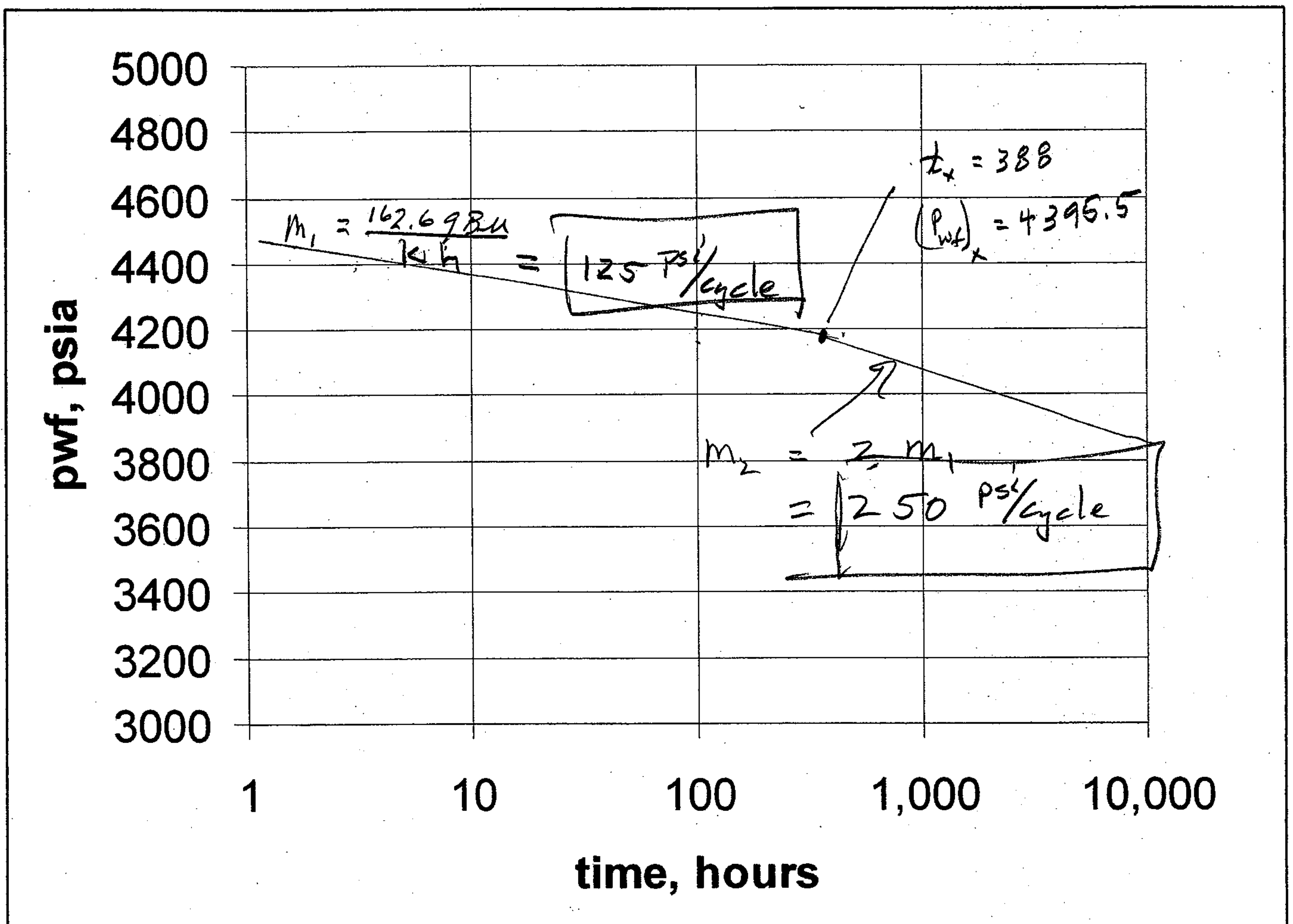
$= 4300 - \dfrac{203}{2.303} \cdot .88 = \boxed{4222 \text{ psi}}$

5. **(20 points)** We expect that a well is close to a fault. We are going to perform a drawdown test on the well and want to anticipate the results. We estimate that $k = 3$ md, $s = 0$, and the distance to the fault is 200 ft. We know that the drawdown curve will look like two SLSL lines intersecting a t_x. **[Use any other necessary data from problem no. 1].**

(a) Calculate the time and p_{wf} of the intersection of SLSL's.

(b) Draw the SLSL before the intersection.

(c) **Draw** the SLSL after the intersection.



(a) $L = \sqrt{\frac{0.000148\, k t_x}{\phi \mu c_t}}$ $\quad t_x = \frac{(200)^2 (0.17)(2.1)(12\times10^{-6})}{0.000148\,(3)} = \boxed{386 \text{ hrs.}}$

SLSL: $p_D = \frac{1}{2}\ln t_D + 0.4045 + S$

$$\frac{kh(P_i - P_{wf})}{141.2\, qB\mu} = \frac{1}{2}\ln \frac{0.000264\, k\, t_x}{\phi \mu c_t r_w^2} + 0.4045$$

$$(P_i - P_{wf}) = \frac{141.2\,(123)(1.12)(2.1)}{(3)(125)}\left[\frac{1}{2}\ln\frac{0.000264\,(3)(386)}{(0.17)(2.1)(12\times10^{-6})(0.25)^2} + 0.4045\right]$$

$$= 108.9\left[\frac{1}{2}\ln(1.142\times10^{6}) + 0.4045\right] = 803.5$$

$$(P_{wf})_x = P_i - \Delta P = 5199 - 803.5 = \boxed{4{,}395.5 \text{ psia}}$$