

February 13, 2006

Key

50 minutes, closed book except for 1 cheat sheet, calculator, and straight edge. Turn in you cheat sheet with your exam. Show your work. Include the units. Use symbols instead of values when necessary.

1. (20 points) Use the data below to calculate the values left blank in the other two tables. Indicate the units of each of your calculated variables. Show your work.

$c_f = 5.1 \times 10^{-6} \text{ psi}^{-1}$	$\mu = 0.90 \text{ cp}$	$h = 110 \text{ ft}$	$S_w = 0.24$
$q = 321 \text{ stb/d}$	$\phi = 0.21$	$r_w = 0.28 \text{ ft}$	$c_w = 3.4 \times 10^{-6} \text{ psi}^{-1}$
$B = 1.35 \text{ rb/stb}$	$c_o = 14.3 \times 10^{-6} \text{ psi}^{-1}$	$k = 10 \text{ md}$	$S_g = 0$

t_D	t
13,000	0.0572 days
230,000	0.92 days
6,300,000	25.2 days

s	$(\Delta p)_{skin}$
5.1	255 psi
10.4	520 psi
19.6	981 psi

$$c_t = c_f + s_o c_o + s_w c_w + s_g c_g$$

$$= [5.1 + (0.76)(14.3) + (0.24)(3.4)] \times 10^{-6}$$

$$= [5.1 + 10.87 + 0.82] \times 10^{-6} = 16.8 \times 10^{-6} \text{ psi}^{-1}$$

$$t_D = \frac{0.00633 k t_{days}}{\alpha \mu c_t r_w^2} \rightarrow t_{const} = \frac{0.00633(10)}{(0.21)(0.9)(16.8 \times 10^{-6})(0.28)^2} = 2.5 \times 10^5 \text{ days}$$

$$s = \frac{k h (\Delta p)_{skin}}{141.2 q B \mu} \rightarrow s_{const} = \frac{(10)(110)}{141.2(321)(1.35)(0.9)} = 0.020$$

2. (15 points) Attached is the PVT data for the SPE1 test case. Calculate c_o at 2,515 psi, assuming that

(a) the oil is saturated.

(b) the oil is undersaturated.

$$c_o = -\frac{1}{B_o} \frac{\Delta B_o}{\Delta p} + \frac{B_g}{B_o} \frac{\Delta R_s}{\Delta p}$$

$$\begin{aligned} \text{(a)} \quad c_o &= -\frac{1}{1.500} \frac{(1.565-1.500)}{500} + \frac{0.001294}{1.500} \frac{(930-775)}{500} \\ &= -86.67 \times 10^{-6} + 267.43 \times 10^{-6} \\ &= \boxed{180.76 \times 10^{-6} \text{ psi}^{-1}} \end{aligned}$$

$$\text{(b)} \quad \frac{\Delta R_s}{\Delta p} = 0$$

$$c_o = -\frac{1}{1.500} \frac{1.579-1.695}{5000} = \boxed{15.5 \times 10^{-6} \text{ psi}^{-1}}$$

6. (20 points) An input data sheet from Gassim is attached (this is not the data used for HW problem no. 3).

[Note that $c_o = 0$ when CNST is used].

(a) Calculate the rate of wellbore pressure change (psi/day) during the PSS period

(b) Calculate the skin factor, s .

$$(a) \quad V_p = \frac{\pi r_e^2 h \phi}{1} = \pi (950)^2 (130) (0.21)$$
$$= \boxed{7.74 \times 10^7 \text{ ft}^3}$$

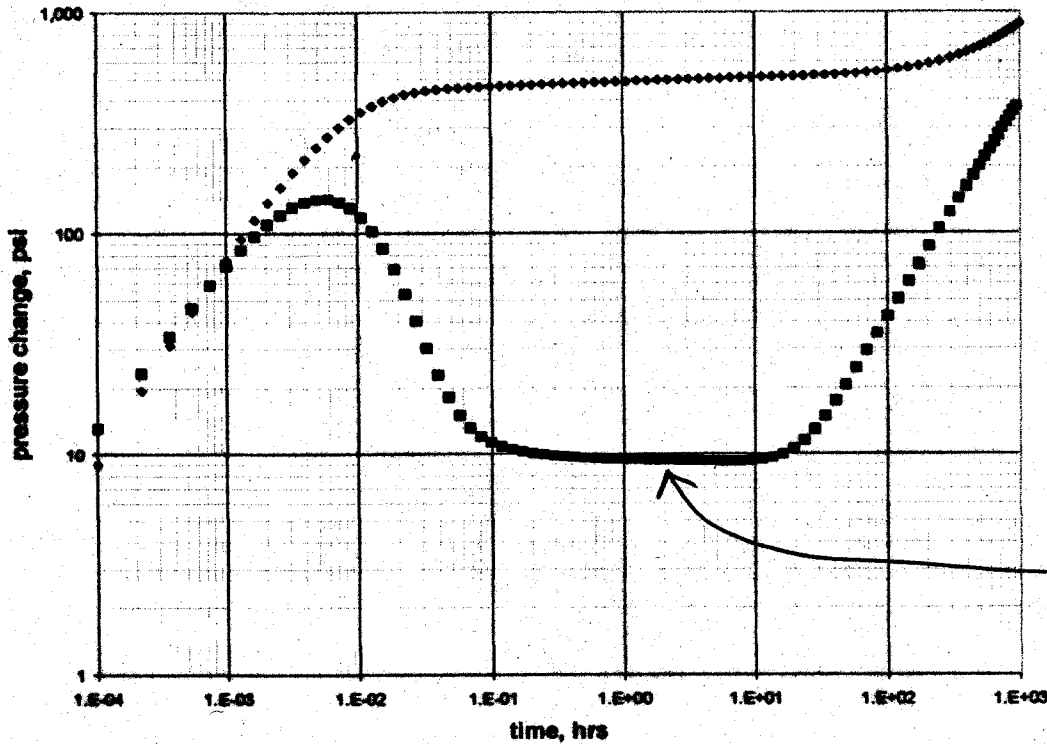
$$\frac{dc_o}{dt} = c_f + s_w c_w \quad (c_o = 0)$$
$$= [15 + (0.25)(4)] \times 10^{-6} = \boxed{16.0 \times 10^{-6} \text{ psi}^{-1}}$$

$$\frac{dp}{dt} = \frac{-qB}{V_p c_t} = \frac{-(720)(1.2)}{(16.0 \times 10^{-6})(7.74 \times 10^7)} = \boxed{0.698 \text{ psi/day}}$$

$$(b) \quad s = \left(\frac{k}{k_s} - 1 \right) \ln \frac{r_s}{r_w}$$
$$= \left(\frac{12}{0.15} - 1 \right) \ln \frac{6.8301}{0.25} = \boxed{94.8}$$

5. (15 points) Suppose you have the following log-log plot of field data. Calculate permeability, given the following other data:

$p_i = 4061$ psia	$\mu = 0.70$ cp	$h = 160$ ft
$q = 386$ stb/d	$\phi = 0.21$	$r_w = 0.28$ ft
$B = 1.35$ rb/stb	$c_t = 23.3 \times 10^{-6}$ psi ⁻¹	$S_w = 0.18$



SLSL when derivative = 0.5

$$0.5 = \frac{k h \Delta p}{141.2 q B \mu} = \frac{k(160)(10)}{141.2(386)(1.35)(0.7)}$$

$$k = 16.1 \text{ md.}$$

4. (15 points) The following data is a portion of the p_w vs. t data for a well test. We want to make a so-called "derivative" plot for the log-log type curve. Calculate the value of the "derivative" at $t = 424.78$ hours.

t, hours	p_w , psia
294.83	3731.6
353.90	3729.7
<u>424.78</u>	<u>3727.7</u>
509.84	3725.8

$$\left(\frac{dp}{d \ln t}\right) \text{ or } \left(t \frac{dp}{dt}\right)$$

Forward diff.

$$\text{Deriv.} = \frac{3725.8 - 3727.7}{\ln\left(\frac{509.84}{424.78}\right)} = 10.4 \text{ psi}$$

Backward diff.

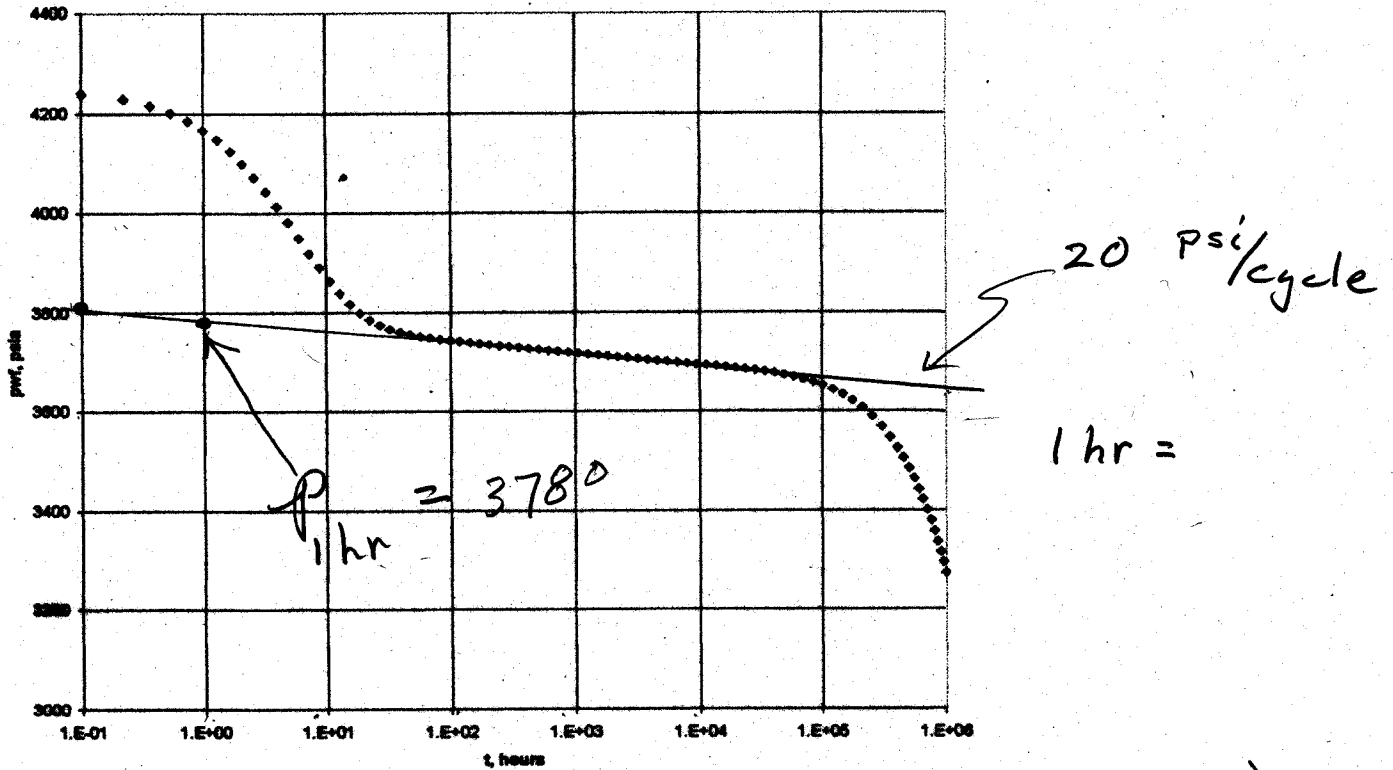
$$\text{Deriv.} = \frac{3727.7 - 3729.7}{\ln\left(\frac{424.78}{353.90}\right)} = 10.9 \text{ psi}$$

Central diff.

$$\text{Deriv.} = \frac{3725.8 - 3729.7}{\ln\left(\frac{509.84}{353.90}\right)} = 10.68 \text{ psi}$$

3. (15 points) A "drawdown" flow test is conducted with a well flowing at constant rate. The plot of p_{wf} vs. $\log(t)$ is attached. Calculate k and s from this plot, given the following data:

$p_i = 4,251$ psia	$\mu = 0.80$ cp	$h = 110$ ft
$q = 241$ stb/d	$\phi = 0.23$	$r_w = 0.28$ ft
$B = 1.25$ rb/stb	$c_t = 21.3 \times 10^{-6}$ psi ⁻¹	$S_w = 0.23$



$$k = \frac{162.6 q B \mu}{m h} = \frac{162.6 (241) (1.25) (0.80)}{(20) (110)}$$

$$= \boxed{17.8 \text{ md}}$$

$$s = 1.1515 \left[\frac{(4251) - (3780)}{(20)} - \log \frac{(17.8)}{(0.23)(0.8)(21.3 \times 10^{-6})(0.28)^2} + 3.23 \right]$$

$$= 1.1515 [23.55 - 7.761 + 3.23]$$

$$= \boxed{19.0}$$

CASE EXAM A
 CMNT Homogeneous Cylindrical Reservoir
 CMNT Radial Flow, Constant-rate production, Infinite-acting
 CMNT Slightly Compressible Fluid
 CMNT Wellbore is modeled by the first cell to show
 CMNT Single Value Input Data

IMAX 27
 JMAX 1
 RWEL 0.001
 CROC 0.000015
 SWAT 0.25
 CWAT 0.000004
 PREF 3000
 NEWT 1
 BETA 0

$15 \times 10^{-6} \text{ psi}^{-1}$
 4×10^{-6}

$B = 1.2$

CMNT Bo, ref/scf viscosity cp
 CNST 1.2 0.82 $\mu_w = 0.25$

$r_s = 0.8301$

CMNT Grid Input Data Geometrically spaced grid system
 CMNT b = 1.49
 CMNT The actual value of rw is assigned to the

RR -1 1.491895506

0.2500	0.3729	0.5564	0.8301	1.2384	1.8477	2.7565	4.1125	6.1354	13.65601
20.5733	30.394	45.346	67.651	100.92	150.57	224.64	335.14	550	600
650	700	750	800	850	900	950			

DELT 130
 KX 12
 KY 12

$h = 130$

$r_e = 950$

PHI 0.21
 POI 3000

$\phi = 0.21$

WIND 1 1 1 1
 PHIS 12.4
 KX 1000000
 KY 1000000
 WIND 2 1 1
 KX 0.15
 KY 0.15
 END

CMNT Schedule Data
 CMNT Well No. i - location j - location skin
 NAME 1 1 1 0
 CMNT Well No. scf/D

QG 1 720.0

$q = 720.$

ALPH 1.2
 DELT 0.0001
 DTMX 50
 WELL 1
 PMAP 2
 TIME 1000
 END