PETE 693—WELL STIMULATION, Spring 2014
Instructor: Dr. Dare Awoleke

Midterm, Thursday, 10th April, 2014

Duration: 8:15—10:45am

Instructions

- Open book. Open notes. Use all you can except your neighbour.
- Write your answers in this booklet. You might want to use a pencil just in case of erasures.
- You need writing material and a simple calculator.

Relax, take a deep breath, read through all the questions once and start when you are told to!

Fundamentals and formation damage (20 points)

1. Answer the following questions
    a. **(10 points)** In well stimulation, high viscosity fluids can be pumped into the formation to increase the flow resistance in higher-permeability regions due to the presence of viscous fluid. Show using the Hawkins reasoning and **Figure 1** below that:

$$s_{vis} = \left(\frac{\mu_{gel}}{\mu} - 1 \right) \ln \left(\frac{r_{gel}}{r_w} \right)$$

b. **(5 points)** Fill in the blanks using the options in the brackets. The IPR curve in **Figure 2** is for a _____(oil,gas,2-phase) reservoir producing under _____(steady-state, PSS, transient)conditions. Why is this so?

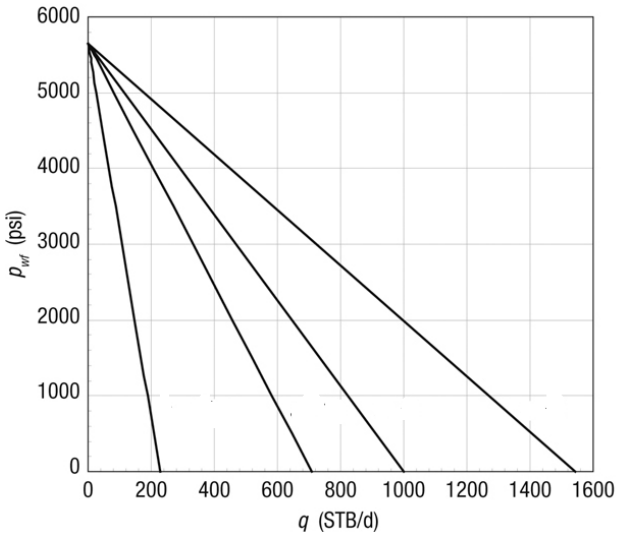

Figure 2

c. **(2points)** Also using **Figure 2**, label the IPR line with the smallest and largest skin factors.

d. **(3 points)** In Pang and Sharma's work on well injectivity decline in injections wells, what primary modes of well impairment did they model?

Fracturing Geometry (30 points)

2. Answer the following questions
    a. **(2points)** In a couple of sentences, what was Griffith's contribution to work regarding the development of fracture geometry models?

    b. **(2points)** In a couple of sentences, what was Sneddon's contribution to the same discussion?

    c. **(4points)** What are the assumptions on which the following models are based on:
        i. PKN model

        ii. KGD model

        iii. Pseudo-3D models

        iv. Full-3D models

d. **(2points)**What are the main factors that affect the development of the width in a fracture?

e. **(2points)**What are the primary factors that the net pressure required for height migration) based on Simonson's and Newberry et al.'s work?

f. **(2points)**A hydraulic fracture propagates in the direction_____to the _____principal stress.

g. **(1 point)**What is net pressure?

h. **(1 point)**In the PKN model, what can you say about the relationship between the net pressure and fracture length?

i. **(1 point)**In the KGD model, what can you say about the relationship between the net pressure and fracture length?

j. **(4 points)**Nolte did some work regarding the interpretation of fracturing pressures.
   i. What variables did he plot?

   ii. How many modes did he identify? Explain the significance of the diferent modes to the best of your ability (in a couple of sentences).

   iii. Which one of the modes is consistent with the assumptions of the PKN model?

   iv. Which one of the modes is the most desirable?

k. **(2 points)**What information do we get from a step-up test?

l. **(2 points)**What information do we get from a step down test?

m. **(2 points)**What is the function of the pad in hydraulic fracturing?

n. **(2 points)**What is the most important parameter we can get from a minifrac?

o. **(1 point)**For which one of the following cases do the concepts ofequivalent skin and effective wellbore radius apply?

Basic Geomechanics (15 points)

3. Assume a formation is 5000ft deep. What percent overpressure (above pore pressure) is necessary to result in a horizontal fracture? The formation density, fluid density and Poisson's ratio are 165 lb/ft3, 40 lb/ft3 and 0.25, respectively.

Design of hydraulic fracturing treatments (35 points)

4. Design a hydraulic fracture using the 2D PKN model using the following data:

$q_i = 40bpm; x_f = 700\,ft; h_f = 100\,ft; v = 0.25; E = 5\times10^6\,psi; n' = 0.6; K' = 0.03; C_L = 5\times10^4\,ft/\min^{1/2};$

$r_p = 0.7; h = 70\,ft; V_{frac\_fluid\_pumped} = 60{,}000gal$

$\text{Pr}oppant: \rho_p = 165lb/\,ft^3; \phi_p = 0.4; c_f = 3ppg; k_f = 5darcy$

$\text{Re}servoir: \phi = 0.1; k = 0.1md, r_e = 2980\,ft; r_w = 0.25\,ft; c_t = 1\times10^5\,psi^{-1}$

$w_{\max} = C_1 x_f^{\frac{1}{2n'+2}}, w_{\max}\ in\ inches\ and\ x_f\ in\ ft$

$C_1 = 5\times10^{-2}$

Calculate the following:

a. **(5 points)** Average fracture width at the end of pumping in inches

b. **(5 points)** Fracture efficiency

c. **(5 points)** Volume of pad in gals

d. **(5 points)**Proppant mass in lbs

e. **(5 points)**Propped fracture width in inches

f. **(5 points)**Fracture conductivity in md-ft

g. **(5 points)**Dimensionless fracture conductivity