Exam#3: April 16, 2009

1. For 3-component, water-oil system, arrange the FD equations in the following form. This form is one of the most efficient forms.

(a) Complete the incident matrix of the accumulation form.

	δx_2	δp_o	δS_o	δS_g	δx_1	δy_1	δy_2
C_1							
C_2							
C_3							
W							
G_1							
G_2							
G_3							

(b) To create a lower diagonal matrix, do the following:
   1. Start with row 5 and column 5 entry. Use this entry to create zeros in row 6, column 5 and row 7, column 5.
   2. Now start with row 6, column 6 entry and create zeros in row 7 and column 6.
   3. Now use row 7, column 7 entry to create zeros in column 7, rows 6, 5, 4, 3, 2, 1.
   4. Finally use row 6, column 6 entry and create zeros in column 6, rows 6, 5, 4, 3, 2, 1.
   5. Complete this procedure to end up with a lower triangular matrix.

(c) Can you explain why the above ordering and procedure is probably a most optimal ordering?

2. To simulate a black oil or a gas-condensate system, we use C_1 and C_2 as the light and the heavy components. Thus, the gas phase will consist of both C_1 and C_2 and the oil phase will consist of both C_1 and C_2.

   (a) Develop the FD equations: for a water-oil-gas system containing two components C_1 and C_2 where C_1 is methane and C_2 is normal-decane. Use the following optimal ordering:

	δp_o	δS_o	δS_g	δx_1	δy_1
C_1					
C_2					
W					
G_1					
G_2					

   Use $K_1(p) = y_1/x_1$ and $K_2(p) = y_2/x_2$ for the thermodynamic constraints.

   (b) Show the entries in the accumulation term matrix as $\beta_{11}, \beta_{12}, \ldots$

   (c) Show what the reduced lower triangular matrix would look after creating zeros in the upper triangular part of the matrix.

3. Assume you are injecting steam in a water-containing formation. Therefore, you will only have water phase and steam (vapor) phase at best.

   (a) Write down the equations for the mass and energy balance for this two-phase, one-component system for a 1-D problem.

   (b) Define all terms and give units.

   (c) Write the incident matrix for the expansion of the accumulation term.