THE PENNSYLVANIA STATE UNIVERSITY
DEPARTMENT OF ENERGY AND GEO-ENVIRONMENTAL ENGINEERING
GEOEE 408 CHARACTERIZATION OF GROUNDWATER SYSTEMS

Mid-term Examination - Tuesday February 29th, 2000 - 75 minutes
Answer all three questions.

For water: $\sigma = 7.3 \times 10^{-2}\ N/m;\ \ \mu = 1.12 \times 10^{-3}\ N.s/m^2$

Name: ________________________________

SN: ________________________________

Question	Points	Score
1	100	
2	100	
3	100	
Total	300	

Include extra sheets, as needed, and return entire packet.

Question 1

Define the following terms, and identify the units [MLT] of the quantity, where relevant. Be as specific and as exhaustive in your definitions as possible.

1. Effective saturation, S_e.

2. Darcy's law, written in terms of pressure gradients.

3. Diffusion coefficient, D^*.

4. Advection-dispersion equation, $\frac{\partial c}{\partial t} = D_L \frac{\partial^2 c}{\partial x^2} - v_x^a \frac{\partial c}{\partial x}$.

5. Brooks-Corey relations, $S_e = [\frac{p_c}{p_b}]^{-\lambda}$

6. Conservative tracer.

7. Free-product.

8. Irreducible non-wetting saturation, S_{nw_0}.

9. Mechanical dispersion, processes of.

10. Fracture permeability, $k = \frac{b^3}{12s}$.

Question 2

At the scale of a few meters the bulk fracture permeability of rocks at Yucca Mountain is of the order $k = 10^{-14}\ m^2$. Matrix permeabilities are so low ($k = 10^{-18} m^2$) that they can be ignored.

1. Evaluate the height of fluid that may be held in vertical fractures of uniform spacing of $0.2\,m$. Vertical fracture sets strike both E-W and N-S, at the same spacing.

2. What is the corresponding magnitude of van Genuchten's α parameter? Define the units.

3. If the relative permeability of the wetting fluid, $k_{r_w} = 0.8$, at 70% water saturation of the vertical fractures, what is the volumetric flow rate in the vertical direction per unit plan area of $1\ m^2$. The vertical gradient is $\partial h/\partial z = 1$.

4. How does this flux compare with the net infiltration at the site, equivalent to rainfall of $5\,mm/yr$.

Question 3

For the figure, showing the plume resulting from pulse injection of chloride tracer in well graded sands at the Borden aquifer, determine the following. (Use the shape of the plume after 647 days.)

Note: $M = c_0 V$; $c = \frac{M}{8(\pi t)^{3/2}\sqrt{D_x D_y D_z}} \exp[-\frac{X^2}{4D_x t} - \frac{Y^2}{4D_y t} - \frac{Z^2}{4D_z t}]$.

1. The longitudinal dispersivity, D_L.
2. The coefficient of longitudinal hydrodynamic dispersion, α_L.
3. The transverse dispersivity, D_T.
4. How far downgradient from the source will the center of mass of the plume be 10 years after injection?
5. What will be the peak concentration of the plume after 10 years if the peak concentration after 647 days is 30 ppm?
6. What is the *approximate* volume of fluid comprising the plume, if the porosity of the aquifer is 0.3? Use the area of a rectangle to approximate the area of an ellipse.
7. What is the mass of chloride comprising the plume?