GLY-4822

Assignment 3

1. (5 points) Write the porosity n in terms of the total volume V_{total} and the pore volume *Vpores*.

2. (5 points) What is the pore volume in terms of the total volume and the solids volume *Vsolids*?

3. (5 points) Use the results of 1 and 2 to show that

$$n = 1 - \frac{V_{solids}}{V_{total}} \tag{1}$$

4. (10 points) The solid density $\rho_s = M_{solids}/V_{solids}$ and the bulk density $\rho_b = M_{solids}/V_{total}$. Use these to show that

$$n = 1 - \frac{\rho_b}{\rho_s} \tag{2}$$

5. (10 points) What are the pressures in Pascals (relative to atmospheric pressure taken as 0 at the water surface) 1 and 2 meters down in a swimming pool? What are the pressure heads (in meters of water) at those depths?

6. (10 points) If the water surface is taken as the elevation datum, what are the elevation heads 1 and 2 meters down in the pool?

7. (15 points) What are the total heads 1 and 2 meters below the surface of the pool?

8. (20 points) The following table contains actual data collected by your predecessors in GLY-4822. The data were obtained from a 30-cm long, 2.54 cm diameter column of glass beads of approximate diameter 3 mm. The 0, 0 point at the top of the table can be added because the flow under zero gradient must be zero.

Use the data to compute the hydraulic conductivity *K*. Plot *dh/dx* vs. *Q*. Fit a trend line through the points and set the intercept to 0. The equation of the trend line is $Q = KA\ dh/dx$, and its slope is *KA*. Divide the trend line slope by the cross-sectional area of the flow to get *K*.

Use that measured *K* to predict the flow *Q* at each of the gradients used in the measurements. Plot dh/dx vs both the observed and predicted *Q*s on the same graph. Comment on the predictive ability of Darcy's Law and the estimated K in this case.

dh/dx	Q (ml s^{-1})
0	0
0.15	0.79
1.11	3.87
0.67	2.67
0.97	2.63
1.12	3.86

9. (20 points) Use the approximate Kozeny-Carman equation

$$k = \frac{n^3}{(1-n)^2} \frac{d_m^2}{180} \tag{3}$$

to estimate the intrinsic permeability of the bead pack. d_m is the mean grain diameter and n is the porosity. Assume n is 0.2 in this case. The intrinsic permeability depends only on the geometry of the porous medium and not on gravity (what planet you're on) and viscosity (what fluid you are working with). Then convert the intrinsic permeability to hydraulic conductivity (i.e., water on Earth) using the following equation:

$$K = k \frac{g}{\nu} . \tag{4}$$

The ν is the kinematic viscosity of water (10^{-6} m^2 s^{-1}). Be careful to use consistent units. Compare this Kozeny-Carman estimate of the hydraulic conductivity with the estimate obtained by direct measurement in Question 8.