The following equations and information may or may not be needed to work some of the problems. They are here for your reference if you need them.

The capillary rise equation has 2 different forms, depending on whether you're measuring pressure directly, or looking at height of rise. Use whichever form of the equation is most convenient for the application at hand.

$$\Delta P = \frac{2\sigma}{R} \quad \text{or} \quad \rho_w gh = \frac{2\sigma}{R}$$

Assume contact angle = 0°

$$\sigma = surface\ tension = 72.7\ \frac{dyn}{cm} = 72.7\ \frac{g}{\sec^2}$$ (Use the appropriate units for the equation you use.)

$$1 \text{ bar pressure} = 10^6\ \frac{\text{dyn}}{\text{cm}^2}$$

h = height of rise above free surface
R = radius of tube
ΔP = pressure difference across interface
g = grav. accel. = 9.8 m/sec^2
ρ_w = density water = 1 g/cm^3
remember 1 μm = 10^{-6} m

Darcy's Law

$$J_w = -K\frac{\Delta H}{\Delta L} \quad \text{or} \quad Q = -KA\frac{\Delta H}{\Delta L}$$

Poiseuille's Law

$$Q = -\frac{\pi R^4 \rho g \Delta H}{8nL}$$

Assume $n = 1x10^{-2}\ \frac{g}{cm \sec}$

ρ = 1.0 g/cm^3
g = 9.8 m/sec^2

$$K_{EFFECTIVE} = \frac{L_{TOTAL}}{\left(\frac{L_1}{K_1} + \frac{L_2}{K_2}\right)}$$

Name ________________________

Agry 560 Exam
November 7, 2002
(135 points) (10 pages)

(4) 1. In the auger-hole method for measuring saturated hydraulic conductivity below a water table, what is actually measured?

a) infiltration into dry soil
b) vertical conductivity
c) horizontal conductivity
d) some combination of horizontal and vertical conductivity

(4) 2. Tensiometers measure what in the soil? (circle all true statements)

a) volumetric water content
b) gravimetric water content
c) matric potential
d) osmotic potential

(4) 3. The ceramic cups on tensiometers must remain saturated in order to function properly. At what tension will the pores in the cup desaturate?

a) 15 bar
b) 1 bar
c) 0.33 bar
d) 0.1 bar

(4) 4. What is the force that causes water to flow out of the soil samples and the soil to equilibrate at the desired matric potential in the pressure plate method?

a) the weight of the soil samples
b) the higher pressure inside the pressure pot
c) the attraction of the ceramic plate for the water
d) the column of water from under the plate to the outlet tube

(4) 5. If the pH of a soil changes from pH = 7 to pH = 5, how will neutron probe readings at a constant soil water content be affected?

a) readings will be higher
b) readings will stay the same
c) readings will be lower

(9) 6. Draw a sketch of a soil water retention curve (desorption), for a sand and a silt loam (include both curves on the same graph). Explain the reasons for the differences in the shapes of the two curves. (Be sure to label the axes!)

(6) 7. Write out Richards' equation. Discuss how Richards' equation is an "extension" of Darcy's Law.

(8) 8. The total soil water potential (Ψ_T) is made up of 3 major components. Name those 3 components, and briefly describe the forces responsible for each of those components of water potential.

(10) 9. Draw a sketch of a sand table and label all the parts. Explain the theory and operation of the sand table for water retention measurements. Also explain the range of matric potentials where it is used, and why it can be used only in that range.

(12) 10. Describe (equipment, procedures, theory, etc.) both the double-ring infiltrometer method and the sprinkling infiltrometer method, for measuring infiltration rates in the field. Be sure to include the major advantages and disadvantages of each method (use sketches to help your discussion).

(12) 11. Sketch a figure of soil water content vs. depth, in a soil profile at two points in time during an infiltration event. (put both times on the same graph)

a) Describe the features of the graph, the different zones of the soil that have been identified, etc.

b) Why do infiltration rates decline with time? Use your graph to illustrate the most important reason, and then briefly mention at least 2 other reasons why the rates decline

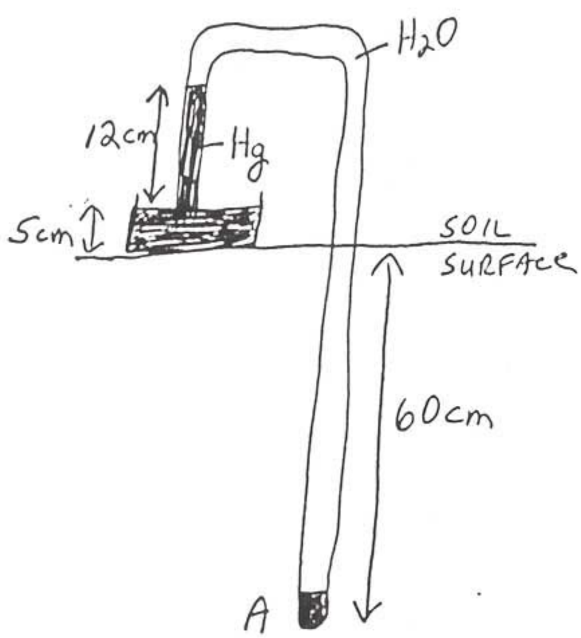
c) The Green and Ampt infiltration equations have 3 main assumptions. Use your graph to illustrate 2 of these assumptions, and discuss the conditions where the assumptions are most reasonable.

(16) 12. a) Discuss the main advantages and disadvantages of each of the following methods for measuring soil water content: 1) soil sampling and drying, 2) neutron probe, 3) TDR, and 4) electrical resistance.

b) If you want to be able to know the precise times that the wetting front reaches certain depths, which technique(s) might be suitable? Why?

(8) 13. You are studying an organism that lives in pores with diameters between 30 and 50 µm. The organism is only active and mobile in the soil when those pores are water filled. What is the range of matric potentials in which the organism is active?

(8) 14. A mercury tensiometer is installed in the soil as shown. Calculate the pressure head, gravitational head, and total hydraulic head of the soil at point A, using the soil surface as the reference elevation. **SHOW ALL WORK AND UNITS!**



Assume

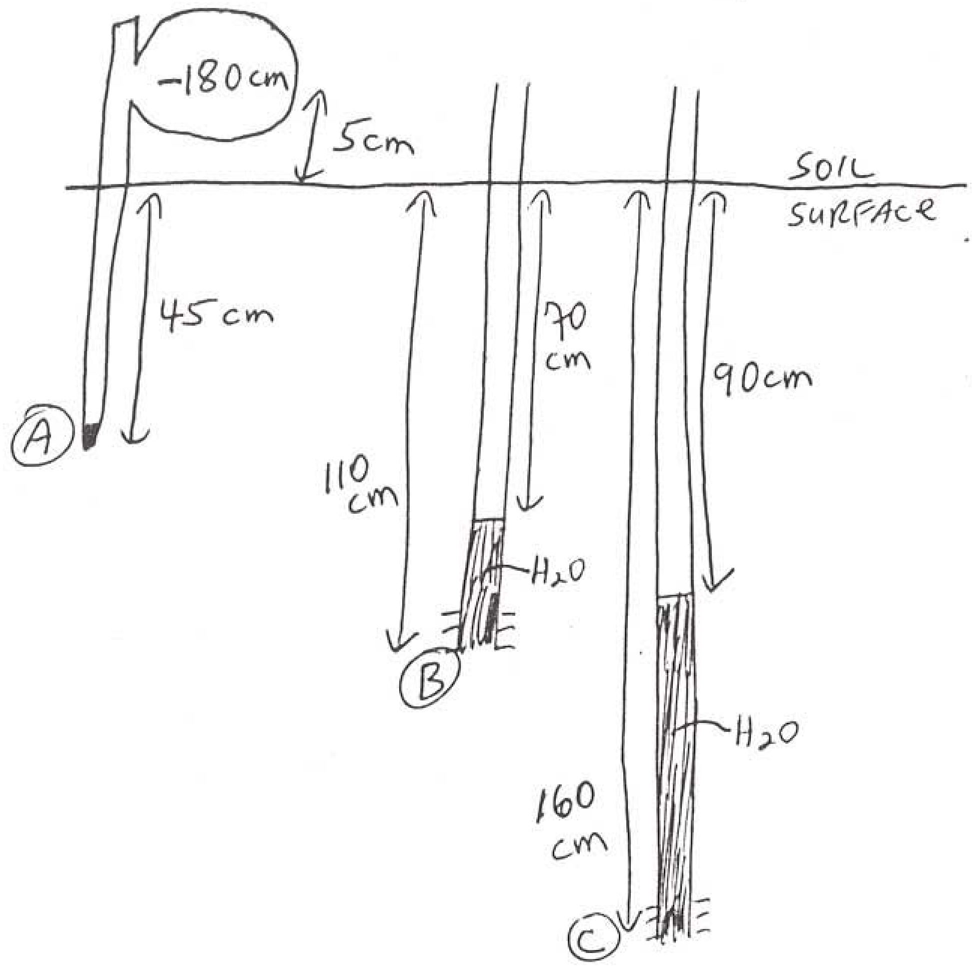
$\rho_{H_2O} = 1.0\ g/cm^3$

$\rho_{Hg} = 13.65\ g/cm^3$

(10) 15. A nest of piezometers and a guage tensiometer are installed as shown.

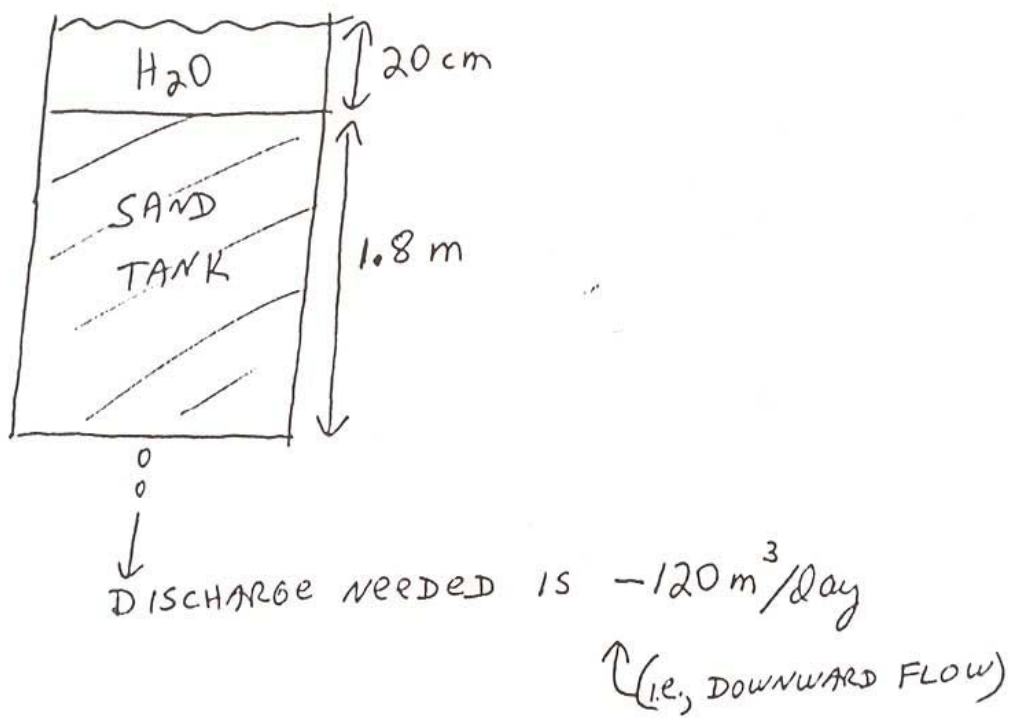
a) Calculate the pressure head, gravitational head, and total hydraulic head of the soil at points A, B, and C, using the soil surface as the reference elevation.

b) What is the best estimate of the water table depth in this profile, given the data?



(8) 16. A water purification facility is using large sand columns for water filtration. They pond water on top of very large sand tanks and allow it to flow under saturated conditions to the bottom of the columns. They need to produce a total of 120 m^3/day of purified water. What total cross-sectional area (m^2) of sand tanks do they need, in order to filter this much water? **SHOW ALL WORK AND UNITS!** Partial credit will be given when I can follow your work and thought process. (you may have been given more information than you need to solve the problem)

Saturated hydraulic conductivity = 75 cm/day
Saturated volumetric water content = 0.45
Sand content = 95%



(8) 17. We are monitoring water flow through a soil profile in the field. The soil consists of 75 cm of silt loam overlying 25 cm of clay. Tile drains are located at the 100 cm depth. We have installed tensiometers right at the border between the silt loam and clay, so that we can monitor pressure head. We now want to calculate the saturated conductivity of the silt loam, without taking soil cores and doing lab measurements. We pond 6 cm of water on top of the soil, and we measure how much water flow comes out through the tile drains. We continue until we are sure we have reached steady-state saturated flow. The measured steady-state flow rate through the column is -9 cm/day, and the measured pressure head at the interface between silt loam and clay is +30 cm. **Calculate the saturated conductivity of the silt loam material**. SHOW ALL WORK AND UNITS! (Partial credit will be given when I can follow your work and thought process.)