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°

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

1 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 $\quad J_w = -K\frac{\Delta H}{\Delta L} \quad$ 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 18, 2004
(145 points) (11 pages)

(4) 1. Tensiometers measure what in the soil? (circle all true statements)
a) hydrogen concentration
b) gravimetric water content
c) volumetric water content
d) matric potential
e) osmotic potential

(4) 2. Neutron probes should be calibrated for your soil. What are the purposes of calibration? (circle all true statements)

a) to adjust readings for application of fertilizer salts such as potassium nitrate (KNO_3)
b) to adjust readings for soil pH
c) to adjust readings for hydrogen present in clays and soil organic matter
d) to adjust readings for hysteresis in the soil water retention curve
e) to adjust readings for slow neutron absorbers such as boron, chloride and cadmium (B, Cl, Cd)

(3) 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) 0.1 bar
b) 0.33 bar
c) 1 bar
d) 15 bar

(3) 4. TDR (time domain reflectometry) as used to determine soil water, measures the dielectric constant which is directly related to:

a) Hydrogen concentration
b) Matric potential
c) Gravimetric water content
d) Volumetric water content

(3) 5. We normally define soil available water storage capacity as
a) θ at Saturation - θ at air dry
b) θ at wilting point - θ at field capacity
c) θ at field capacity - θ at air dry
d) θ at field capacity - θ at wilting point

(3) 6. When a field tile is working and draining water from the soil, the zone immediately around
the tile will have a ψ of
a) 0.0 bar
b) -0.1 bar
c) -0.3 bar
d) -15 bar

(3) 7. The sand table was used to create a tension of 50 cm of water (-0.05bar). That helps us determine the
a) saturation point
b) aeration porosity
c) field capacity
d) wilting point

(4) 8. In the aggregate size distribution lab, if the moist samples had been broken to pass through a 12 mm screen rather than the usual 8 mm screen, and then wet-sieved with the usual nest of sieves of 4.76 mm, 2mm, 1mm, and 0.21 mm, what would the maximum possible value of MWD be?
a) 12 mm
b) 4.76 mm
c) 8.38 mm
d) 6.38 mm

(6) 9. You want to measure soil water content over 2-inch increments down to 12 inches (i.e. you want 0-2", 2-4, 4-6, 6-8, 8-10, and 10-12" water contents). Which of the following methods <u>could be suitable</u> for this application? (some may be more time consuming than others, but are they inherently suitable?) <u>CIRCLE all correct answers</u>! For all 4 methods, state <u>why</u> the method is suitable or <u>why</u> it is <u>not</u> suitable.

a) electrical resistance blocks
Why or why not?

b) neutron probe
Why or why not?

c) TDR
Why or why not?

d) sampling with soil probe and oven drying
Why or why not?

(10) 10. 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) 11. Write out Richards' equation. Discuss how Richards' equation is an "extension" of Darcy's Law.

(6) 12. 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.

(8)13. We discussed several methods for measuring unsaturated hydraulic conductivity or diffusivity in soil, including the "instantaneous profile" method, the crust test method, steady sprinkling with a sprinkling infiltrometer in the field, and an evaporation method from a shallow water table.
Describe either the "instantaneous profile" method or the crust test method (ie I will only read one method from you). Describe the general methodology, and state whether the method is a steady-state method or a transient method.

(6) 14. Rank the following 3 soils (1 = highest, 3 = lowest) for each of the soil physical properties listed in the table.

	water content -0.1 bar	saturated hydraulic conductivity	water content -15 bar	plant available water
sand				
clay				
silt loam				

(10) 15. Draw a sketch of a pressure plate system. Explain the theory and operation of the pressure plate for water retention measurements. Also explain the range of matric potentials where it is used, and why we use different types of plates at different pressure ranges.

(12) 16. 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.

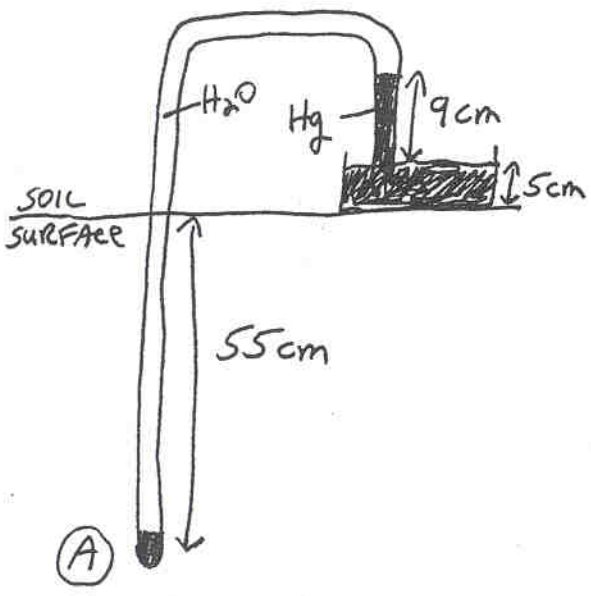
b) Why do infiltration rates decline with time? Use your graph to illustrate the most important reason, and then briefly mention at least 2 other reasons why the rates decline

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.

(12) 17. Discuss the concept of "field capacity". Include some discussion of at least the following points: a) what important characteristic of the soil, are people really wanting to know, when they talk about "field capacity", b) what is the simplified definition or understanding of field capacity, c) why is the concept in (b) somewhat erroneous, and d) what is a more complete definition of field capacity that better reflects the complex reality? Use graph(s) to help illustrate your points, as needed.

(8) 18. You have measured a "capillary fringe" (i.e. capillary rise) above the water table of 8cm at your field site. What is the soil pore size that is causing this rise above the water table?

(8) 19. 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:

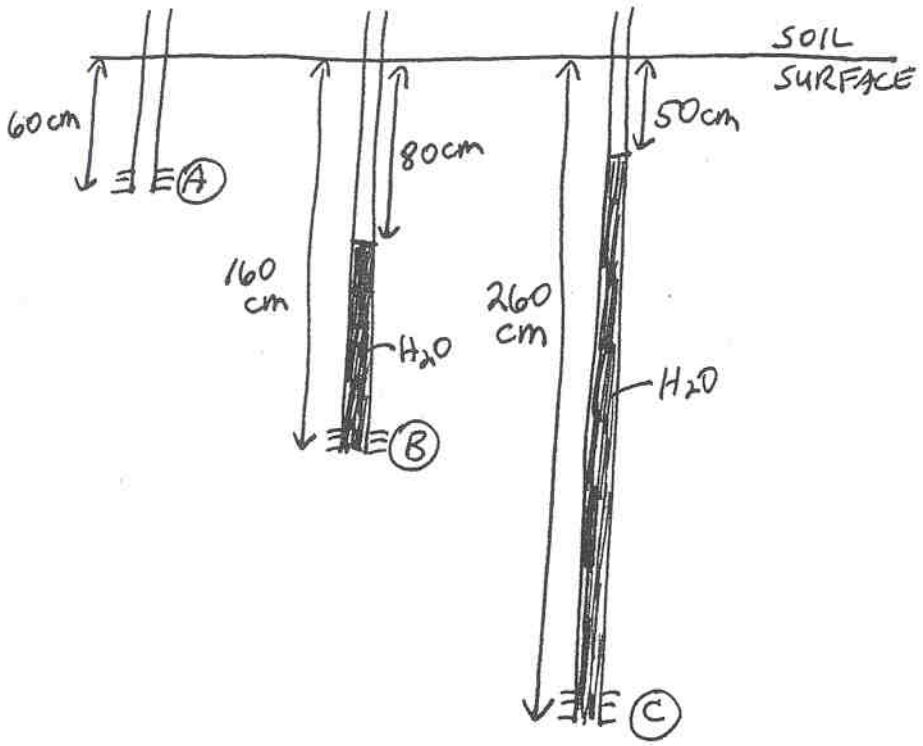
$\rho_{H_2O} = 1.0\ g/cm^3$

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

(8) 20. A nest of piezometers is installed as shown.

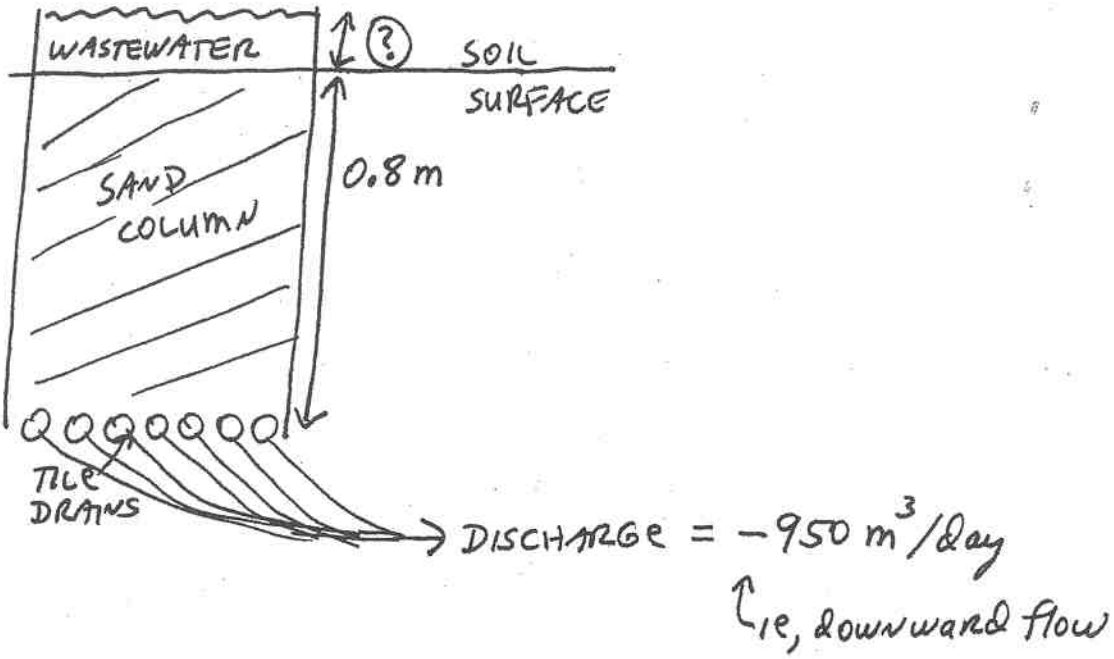
a) Calculate the pressure head, gravitational head, and total hydraulic head of the soil at points B and C, relative to the soil surface.

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



(8) 21. A food processing plant is using soil filtration as the final step in treating the wastewater before discharge into the river. It ponds the water in large basins (total area of basins is 600 m^2), where it flows under saturated conditions through the soil to tile drains at a depth of 0.8 m. They must dispose of 950 m^3 per day. What ponding depth do they need in the basins, in order to dispose of this volume of wastewater? SHOW ALL WORK AND UNITS! (you may have been given more information than you need to solve the problem)

Pressure head at tile drains = 0 cm
Saturated hydraulic conductivity = 1.2 m/day
Saturated volumetric water content = 0.40
Sand content = 95%
Area of basins = 600 m^2



(10) 22. A gauge tensiometer is installed in the soil as shown. We know from other observations that the water table is located at 130 ycm depth in this soil. If we assume that the unsaturated soil is in hydraulic equilibrium with the water table, then:

(a) what is the pressure head (hp) at the tensiometer cup?

(b) what is the pressure head (hp) at the guage?

SHOW ALL WORK AND UNITS! Partial credit will be given when I can follow your work and thought process.