**Exam 2, Soil Physics (Agron 577), Spring 2003**

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Name

**Part 1: Building Blocks:** (36 pts total)

**1:** In the following table, each line (row) concerns a single equation. Fill in the missing entries (2 pts, each). If the equation doesn't have a name, state what it describes (e.g., Coulomb's envelope).

| **Name** | **Equation** | **Physical situation described** |
|---|---|---|
| Richards equation | | |
| | $h = \dfrac{2\gamma \cos(\alpha)}{(\rho_w - \rho_a)gR}$ | |
| | | Total potential of water in soil |
| Advection-dispersion equation | | |
| | | Steady-state, saturated flow through soil |
| | $C(\theta) = \dfrac{\partial \theta}{\partial \psi}$ | |
| Equation of continuity | | |

**2:** Give units for the following (1 pt. each). Use base SI units where you can.

| | |
|---|---|
| Concentration (e.g., of a solute): | Dielectric constant: |
| $\theta$ | Hydraulic conductivity: |
| Dispersion coefficient: | Diffusion coefficient: |
| Flux density: | Flux: |

**<u>Part 2: Comprehension:</u>** (5 pts each; 30 pts total)

**3)** Explain the inkbottle effect.

**4)** Describe one situation in the lab, and one in the field, where you would encounter pneumatic potential.

**5)** How does a neutron probe measure water content?

**6)** What is "soil water potential"?

**7)** Why is the <u>scaling</u> of a dispersion model important?

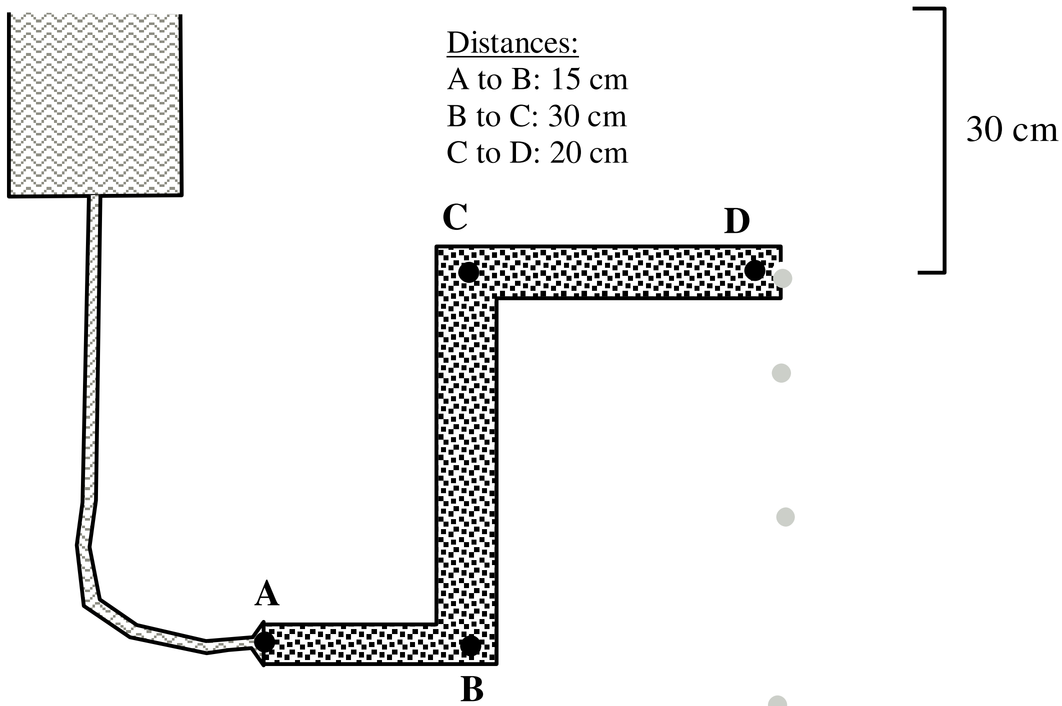
**8)** Why is short-time cumulative infiltration proportional to square root of time, while long-term infiltration is proportional to time?

**Part 3: Application:** (15 pts each; 45 pts. total)

For all the calculations, assume that the following values apply:

Water viscosity: $1.25 \times 10^{-2}$ kg m$^{-1}$ s$^{-1}$
Particle density: 2650 kg m$^{-3}$
Gravitational acceleration = 9.81 m s$^{-2}$
Interfacial tension: $7.3 \times 10^{-2}$ kg s$^{-2}$
Water density: 1000 kg m$^{-3}$
Wetting angle = 0°

**9)** Water is moving out of a 25 cm tall reservoir through a large tube, into a soil column, then out through a hole at the end.

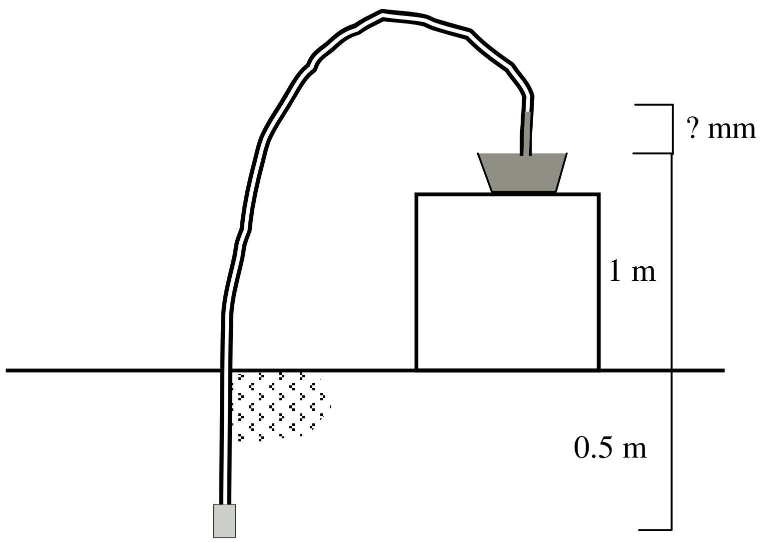



Fill in the table. Use **A** as the gravitational reference.

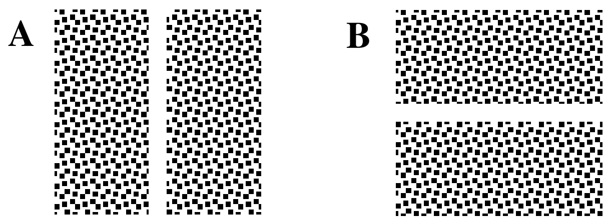
| Location | $\psi_T$ | $\psi_g$ | $\psi_m$ |
|---|---|---|---|
| A | | 0 | |
| B | | | |
| C | | | |
| D | | | |

What is the ratio of the flux density when the water level is at the top of the reservoir, to the flux density when the water level is at the bottom of the reservoir? Assume K = 0.2 mm/hr.

**10)** You have a mercury tensiometer buried at 0.5 m below the ground surface, as shown in the (oddly familiar) diagram below. You know that the water table is 3 m below the ground surface. If the system is at equilibrium, what is $\psi_m$ at the tensiometer? What is the height of rise of the mercury, currently given as "? mm"? Recall that $\rho_{Hg}$ = 13,600 kg $m^{-3}$.

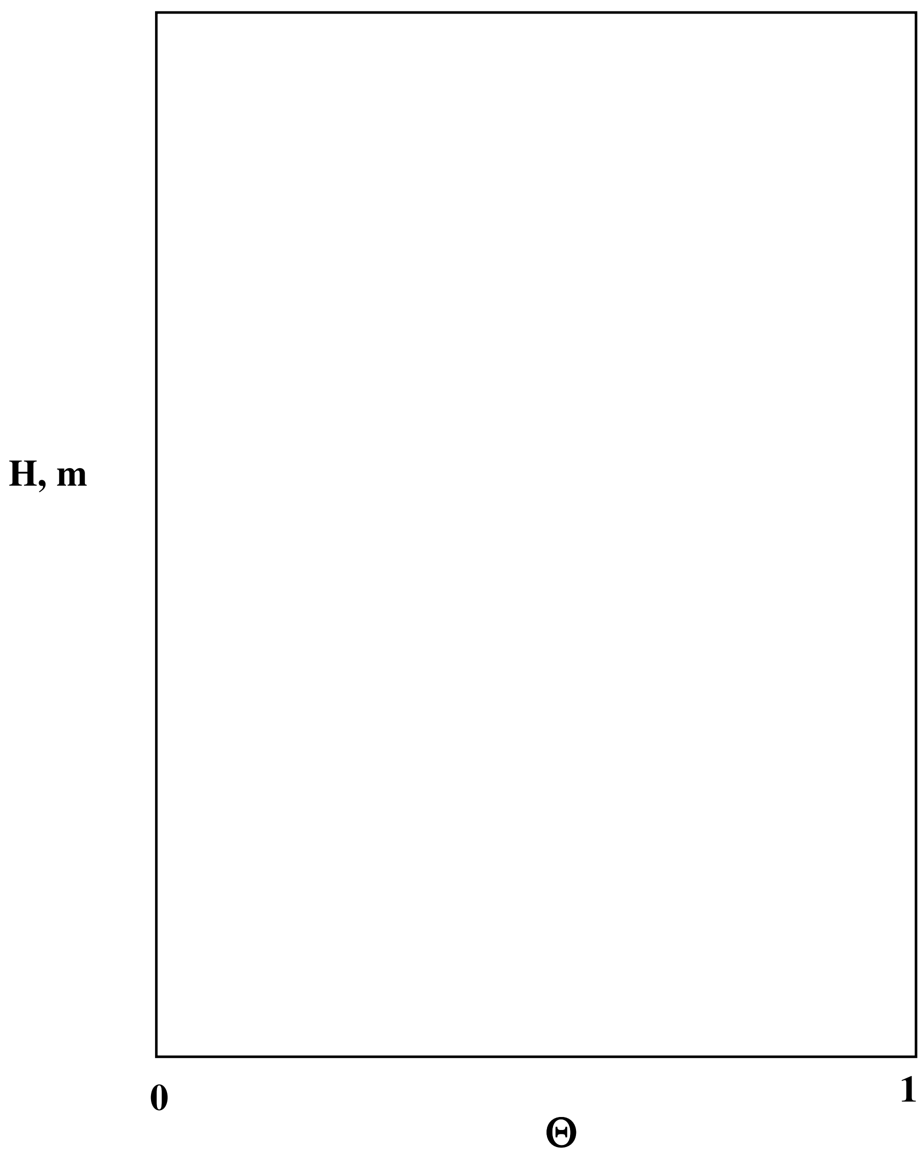


**11)** We saw in the homework how the continuity of large pores affects the saturated hydraulic conductivity. Does it also affect water retention? Consider the following two <u>two-dimensional</u> soils:




Suupose that the matrix porosity is 0.5, pores in the matrix are 1.0mm in radius, the "macropore" is 1.0 cm in radius, and the sample is 5 cm tall. On this page, sketch the <u>primary drainage curve</u> for the two soils and label them **A** and **B**; on the next page, do the same for the <u>primary wetting curve</u>. ***Don't worry about exact values*** for the potential axis: I'm more interested in the shapes of the curves.

## Primary Drainage Curve:



**Primary Wetting Curve:**