Name ________________________

Agry 465 Exam
October 18, 2006
(100 points) (9 pages)

(4) 1. In each of the following pairs of soils, indicate which one would have the <u>greatest</u> volumetric heat capacity, and which would have the <u>greatest</u> thermal conductivity. (It is possible that the same soil could have both the highest heat capacity and the highest thermal conductivity.)

		heat capacity (a or b?)	thermal conductivity (a or b?)
a) dry soil at BD=1.3 g/cm^3	b) wet soil at BD = 1.3 g/cm^3	_______	_______
a) compact soil at saturation	b) loose soil at saturation	_______	_______

(6) 2. For each of the following surface soil treatments listed below, 1) state whether the average soil temperature in the top 5 cm will probably increase or decrease, compared with a bare, flat, smooth soil surface, and 2) briefly explain the reasons for the increase or decrease. (Assume it is in the spring of the year, when the soil is starting to warm up.)

a) straw mulch added to the surface

b) clear plastic

(4) 3. Thermocouples are used to measure soil temperature. The basic principle of their operation is:

a) Two different metals that expand differently with temperature changes. The difference is expansion/contraction is measured.
b) Two junctions of two different metals. A voltage is generated proportional to the temperature difference between the two junctions.
c) Metal wire junction attached to a mercury thermometer with digital readout meter.
d) None of the above.

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

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

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

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

(4) 6. 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) 7. TDR (time domain reflectometry) as used to determine soil water, measures the dielectric constant which is directly related to:

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

(2) 8. When calculating water potentials in a system at equilibrium, the H_{TOT} (or Ψ_{TOT}) is ___________________________________ throughout the system.

(2) 9. When calculating water potential in a system at equilibrium when the reference elevation is set at the **water table**, then the H_{TOT} is exactly ___________________________ throughout the system.

(6)10. 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 could be suitable for this application? (some may be more time consuming than others, but are they inherently suitable?) CIRCLE all correct answers! For all 4 methods, state why the method is suitable or why it is not 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?

(8) 11. Sketch soil water retention curves (desorption) for two soils, a sand and a silt loam (include both curves on the same graph). Explain the reasons for the differences in the two curves. Label your curves and axes.

(4) 12. Circle the letter(s) in front of all true statements below:

a) Electrical resistance blocks are no longer used and are an obsolete technology.
b) Electrical resistance blocks are very accurate devices for obtaining precise water content values.
c) Electrical resistance blocks must be calibrated for your soil, in order to relate the readings to actual soil water content.
d) Electrical resistance block readings can be automated and are useful for automating irrigation systems

(3) 13. Total soil water potential (Ψ_{TOT}) is made up of 3 components: matric, gravitational, and osmotic (solute) potentials. Explain the main forces that make up each of these potentials.

matric (Ψ_m)

gravitational (Ψ_Z)

solute (Ψ_S)

<u>These relationships may or may not be useful in the problems that follow.</u>

Pressure change across a water surface $\Delta P = 2\gamma/R$

Capillary rise equation $\rho_w gh = \frac{2\gamma}{R}$

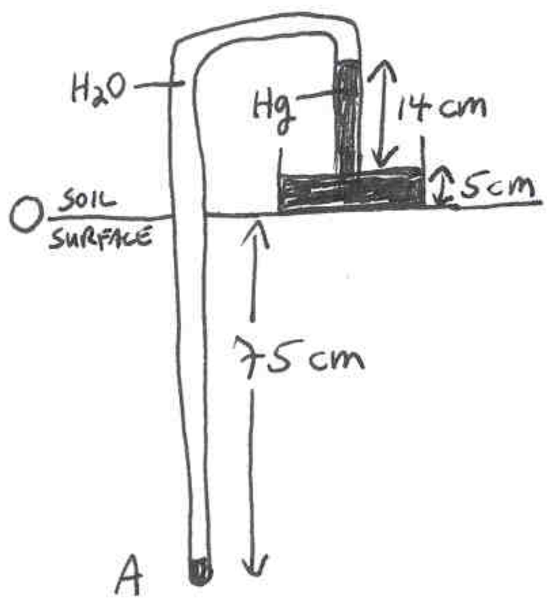
1 bar pressure = 10^6dyn/cm^2
1 bar pressure = 1000 cm H_2O

Surface tension of water = γ = 72.7 dynes/cm = 72.7g /sec^2

Gravity = g = 980cm/sec^2 ρ_{water} = 1.0 g/cm^3 ρ_{Hg} = 13.65 g/cm^3

(5) 14. If pore size were uniform and 0.006cm in diameter, what would be the capillary rise above a water table?

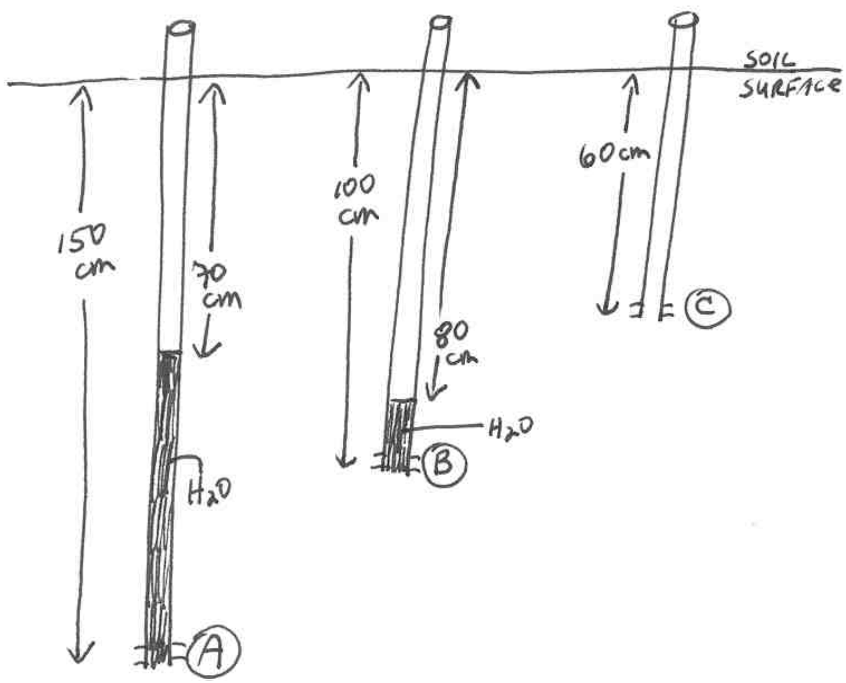
(10) 15. A mercury tensiometer is installed in the soil as shown. Calculate the pressure head, gravitational head, and total hydraulic head of the soil at point A, using the soil surface as the reference elevation. **SHOW ALL WORK AND UNITS!**



(10) 16. A nest of piezometers is installed as shown.

a) List the pressure head, gravitational head, and total hydraulic head of the soil at points A, 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?

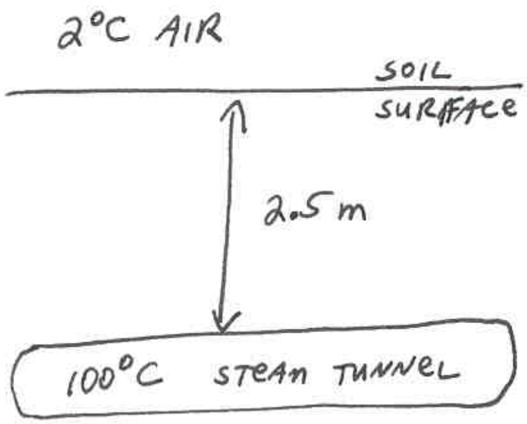


(10) 17. Steam tunnels conduct heat from a power plant to numerous classroom buildings on a renowned university campus. (Location of steam tunnels are noticeable as strips of melted snow across the lawns.) As a first estimate of the amount of heat lost from the top of these buried tunnels up through soil to the air above, let's assume steady-state 1-dimensional flow of heat through the soil and no movement of water or vapor. Calculate the heat loss per m^2 of tunnel roof area, assuming a constant air temperature of 2ºC, constant tunnel roof temperature of 100ºC, tunnel roof depth of 2.5 m, and soil thermal conductivity of $4x10^{-3}$ cal/cm secºC. SHOW ALL WORK AND UNITS! **Your final answer should be expressed in units of** $\frac{\text{cal}}{\text{m}^2\text{day}}$ **and be expressed in scientific notation!**

INFORMATION YOU MAY OR MAY NOT NEED:

Heat flow equation $q_H = -K \frac{\Delta T}{\Delta Z}$

Soil thermal conductivity = $4x10^{-3}$ cal/cm secºC
Soil organic matter content = 2.5%
Soil bulk density = 1.25 g/cm^3



(10) 18. Mean annual temperature at the soil surface in east central Indiana is about 10°C. Soil temperature variation at the surface (z = 0) during the year is predicted by this equation:

$T_o = T_{ave} + A_o \sin(\omega t) = 10^oC + 14^o C \sin(\omega t)$

Plot the predicted temperature wave for a year <u>at the surface</u> and at a <u>depth of 150 cm</u>. Equations and information that may be useful follow. **<u>Show all calculations on this sheet. Plot both curves on the graph paper on next page</u>**.

Thermal diffusivity = $D_H = 1.095 \times 10^5$ cm^2/yr

d = damping depth = $\sqrt{\frac{D_H \tau}{\pi}}$

τ is time period, in this case 1 year

$A_z = A_o e^{-z/d}$

$\omega = 2\pi/\tau$

timelag = $\Delta t = z/\omega d$

z is soil depth of interest