KEY

Name:_____ Lab Section:_____

**EXAM 3, CRSS/FORS 3060, Fall Semester 2011**

**I. Multiple Choice**. Circle the *best* answer. 2 pts. each. ~~84~~ 83 pts.

1. Soil water flows
   A. from higher elevation to lower elevation
   B. toward roots
   C. from higher head to lower head
   D. from higher pressure to lower pressure
   E. toward streams

2. In unsaturated soils, pressure head is:
   A. positive
   B. negative
   C. zero
   D. undefined
   E. any of the above

3. Which of the following is NOT one of the reasons that plants transpire?
   A. Water is lost when stoma are opened to obtain carbon dioxide.
   B. Evaporative cooling keeps plants cool.
   C. Transpiration is necessary to move nutrients from the roots.
   D. Water is needed for photosynthetic processes.
   E. Plants transpire to eliminate waste products from the leaves.

Any Answer Essentially a 2 point Bonus for everyone

→ O2 is a waste product!

5. Which two of the following forms of energy are considered in soil water movement?:
   A. Kinetic
   B. Pressure
   C. Gravitational
   D. Thermal
   E. Nuclear

6. Which of the following information would be most useful for estimating PET?
   A. Solar radiation
   B. Air temperature
   C. Vapor pressure deficit and wind speed
   D. Date and time
   E. Soil moisture

7. Convectional storms, or thunderstorms,
   A. generally cause low-intensity, long duration rainfall
   B. occur more often in the winter in Georgia
   C. tend to have high raindrop energies
   D. are common in polar regions
   E. none of the above

**II. True or False** (1 point each)

6. T Annual AET must be less than annual PET.
7. F The moisture content of the root zone cannot fall below the wilting point.

16

3

8. F Soil water cannot flow vertically upward
9. T PET is easy to measure, but AET is difficult to measure.
10. T Soil tension and negative pressure head are different ways of saying the same thing..

**III. Fill-in**. Write a word, phrase, etc. in the blank that best fits the description; (1 pt. each)

10

11. interception rainfall caught on leaves and limbs and evaporated before reaching the ground.
12. porosity ratio of void space to total soil volume.
13. Plants can no longer draw water from the soil, the soil is at the wilting point.
14. Leaf Area Index ratio of leaf surface area to land area. LAI
15. stoma holes in the bottom of leaves through which air is exchanged.
16. Dew point temperature at which a parcel of air becomes saturated.
17. pan evaporation / PET measured with a US Weather Bureau Type A pan.
18. vapor pressure deficit difference between saturated vapor pressure and current vapor pressure ($e_s$-e).
19. capillary rise is inversely related to soil pore diameter.
20. Darcy French hydraulic engineer who developed the equation for groundwater flow. His name is also the name of the equation for groundwater flow.

**IV. Short Answer**

21. Explain the basic processes by which rainfall occurs (ignore lake effect precipitation). (3 pts)

3

1 Air rises
1 Adiabatic cooling
1 Reaches dewpoint (saturation)

22. Briefly explain how clearcutting a small watershed (while leaving the soil litter layer intact) affects streamflows (5 pts)

5

LAI ↓
Interception ↓
Transpiration ↓
Water — water tables rise
More Flow

23. What physical properties of soil and water allow soil to serve as an important water reservoir? (5 pts)

5

2 polar water molecules
2 negatively charged particle surfaces
1 Adhesion and cohesion
Small pores

**V. Calculations**. SHOW YOUR WORK, INCLUDING EQUATIONS

**24**. A soil sample is taken in a ring with radius = 4cm and height = 6cm. The oven-dry mass of the soil is 361.7 grams. a) What is the bulk density? (3 pts)

$Vol = \pi r^2 h$

$= \pi\ 16(6)$

$= 301.44$ (1)

$BD = \frac{\text{dry soil mass}}{\text{volume}} = \frac{361.7\ g}{301.44\ cm^3}$ (1)

$= 1.2\ g/cm^3$ (1)

3

b) What is the porosity? (2 pts)

$PS = 1 - \frac{BD}{PD} = 1 - \frac{1.2}{2.65} = 0.55$

2

**25**. An A horizon is 30 cm thick. The bulk density of the soil is 1.25. A sample was adjusted to varying tensions, and weighed.

A. Calculate water contents in the table below. (9 pts)

1 ea

| Tension | 0 bars | 0.1 bars | 15 bars | 10,000 bars |
|---|---|---|---|---|
| sample mass(g) | 1424 | 1320 | 1100 | 1000 |
| mass of water (g) | 424 | 320 | 100 | 0 |
| $H_2O$ content (wt:$\theta_G$) | 0.42 | 0.32 | 0.10 | 0 |
| $H_2O$ content (vol:$\theta_V$) | 0.53 | 0.40 | 0.13 | 0 |

9

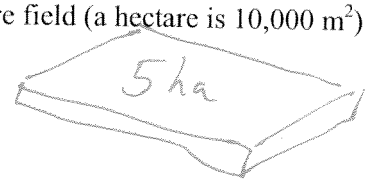
B. Calculate plant available water (in centimeters) at field capacity in the horizon. (2 pts)

$= \text{Soil Depth}\ (\theta_{V\,FC} - \theta_{V\,WP})$

$= 30\ cm\ (0.40 - 0.13) = 8.1\ cm$

2

C. Assume this horizon has dried to the wilting point; how many liters of irrigation water must be added to a 5-hectare field (a hectare is 10,000 $m^2$) to bring it back to field capacity (liter = 1000$cm^3$)? (3 pts)




2 pts

$Vol = depth \times Area$ (1)

$Vol = 8.1\ cm \times 5 \times 10{,}000\ m^2 \times \frac{100\ cm}{m} \times \frac{100\ cm}{m} \times \frac{L}{1000\ cm^3}$

$= 4{,}050{,}000\ Liters$ (1)

2

**26**. The depth of available water at field capacity for the soil below is 10.0 cm. Crop factor = 1.0

A. Complete the field water budget below. (7 points) AET = $K_c K_s PET$

NOTE: RE-READ THE FIRST SENTENCE OF THIS QUESTION BEFORE STARTING!

| | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 |
|---|---|---|---|---|---|
| F | 7.0 | 5.6 | 4.59 | 3.67 | 7.80 |
| Ks | 0.7 | 0.56 | 0.46 | 0.37 | 0.78 |
| PET | 2.0 | 1.8 | 2.0 | 0.2 | 0.2 |
| AET | 1.4 | 1.01 | 0.92 | 0.07 | 0.16 |
| F' | 5.6 | 4.59 | 3.67 | 3.60 | 7.64 |
| P | 0.0 | 0.0 | 0.0 | 4.2 | 4.2 |
| F'' | 5.6 | 4.59 | 3.67 | 7.80 | 11.84 |
| Q | 0 | 0 | 0 | 0 | 1.84 |
| F''' | 5.6 | 4.59 | 3.67 | 7.80 | 10.0 |

7

12

B. What fraction of precipitation became runoff on day 4? Why is this fraction so low? (2 pts)

2 — 0% Soil was dry. Rain did not bring it to FC

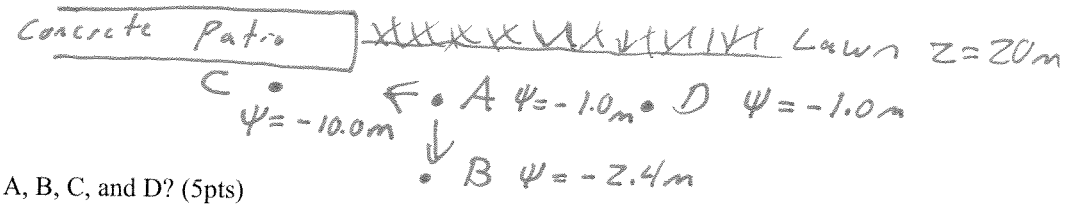
C. What fraction of precipitation became runoff on day 5? Why is this fraction so high? (2 pts)

2 — 1.84/4.2 = 0.44 Soil was wet. Infiltration exceeded FC

D. Prior to rainfall, should the soil have been irrigated any time during days 1 -3? Why or why not? (1 pt)

1 — No, never reached 0.25 × 5

**27.** It has been raining on the lawn shown below, adjacent to a concrete patio. The elevation of the ground surface is 20 meters. Point A is 0.10 m below the surface, and point B is 0.30 m below the surface. Points C and D are 0.4 meters from Point A in opposite directions, and they are at the same elevation as Point A.




A. What are the hydraulic heads at A, B, C, and D? (5pts)

5 — A = 19.9 - 1 = 18.9

B = 19.7 - 2.4 = 17.3

C = 19.9 - 10 = 9.9

D = 19.9 - 1 = 18.9

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3 — B. Use arrows to show all directions water is flowing from point A (3 pts) towards C and B

C. What are the hydraulic gradients between A and B, A and C, and A and D? (4 pts)

4 — $\frac{\Delta H}{L}$

A→B $\frac{18.9 - 17.3}{.2} = \frac{1.6}{.2} = 8$ (1)

A→C $\frac{18.9 - 9.9}{.4} = \frac{9.0}{0.4} = 22.5$ (1)

24

A→D → 0 (1)