Utah State University
Department of Civil and Environmental Engineering
CEE 6400 Physical Hydrology

Final exam. Date: 12/12/2012
D.G. Tarboton Time: 110 min
[100 points total]

Open Book. Answer all questions. **Please answer on separate sheets of paper**. You may refer to the textbook, notes, solutions to homework and any other written, printed or online reference material.

Calculator/Computer use. You may use a programmable calculator or computer. You should limit the use of the calculating device to the performance of calculations or examination of reference material. You may use spreadsheet or other appropriate programs for calculations, but should write your answers down on paper to hand in. For full or partial credit show your work. I need to see how you got your answer as well as the answer. You may not send messages using the computer or communicate in any way with anyone other than the instructor. Email and messaging programs (Facebook, instant messaging etc.) should be turned off for the duration of the exam. If one of these programs is open during the exam it may be grounds for disqualification.

1. **Evaporation.** At a weather station near a lake the following measurements are available.

   - Air pressure 85 kPa
   - Air Temperature 22 ^{o}C
   - Specific humidity 0.009 kg/kg
   - Net radiation 90 W/m^2
   - Wind speed 2.5 m/s at a height of 2.0 m
   - Surface roughness length $z_o = 3 \times 10^{-4}$ m.

   a) Indicate which of the following methods you have sufficient information to use to calculate lake evaporation
      A. Priestley Taylor
      B. Mass Transfer/Aerodynamic
      C. Combination/Penman
      D. Energy balance/Bowen Ratio [10]

   b) Calculate the evaporation in mm/day using all the methods for which there is sufficient information. [30]

[40 points]

2. **Infiltration.** Consider a soil with the following properties

   Porosity n = 0.4

   Saturated hydraulic conductivity, K_{sat} = 1.5 cm/h

   Air entry head $|\psi_a|$ = 29 cm

   Pore size distribution index b = 7

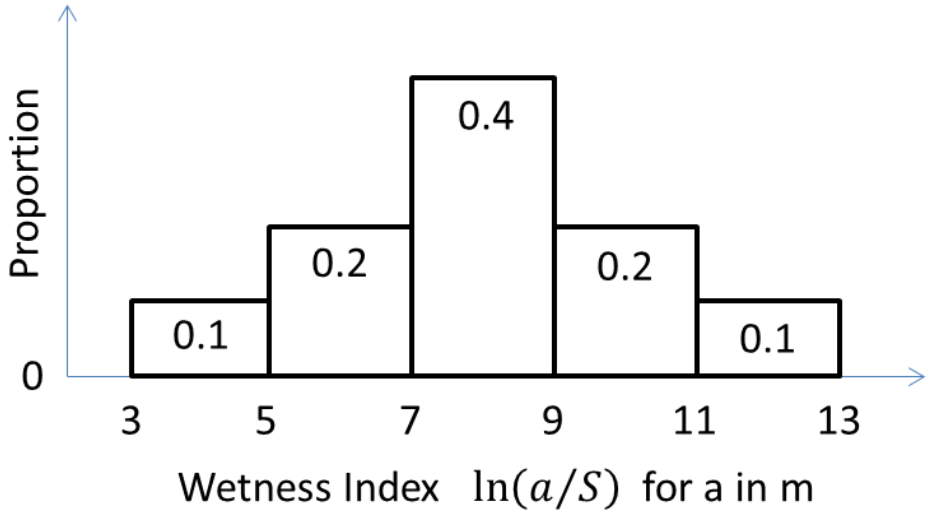
   The water table is 1.2 m below the surface and conditions are hydrostatic.

   a) What is the position of the top of the capillary fringe? [5]
   b) Plot the moisture content versus depth through the soil. Indicate numerical values for the moisture content at the water table, top of capillary fringe, and surface. [7]
   c) Calculate the soil moisture deficit (cm). [8]
   d) Explain the difference between infiltration excess and saturation excess runoff generation and the role played by this soil moisture deficit in these mechanisms. [5]
   e) Suppose that in a different location with the same soil the depth to the water table is 0.25 m. Calculate the soil moisture deficit in this location. [5]

   [30 points]

3. **TOPMODEL.** Consider a watershed with the following TOPMODEL parameters and wetness index distribution shown below

Surface Hydraulic Conductivity K_o = 12 m/hr
Transmissivity T_o = 3.84 m^2/hr
Parameter m = 0.08 m
Parameter f = 3.125 m^{-1}
Area A = 400 km^2
Effective porosity θ_e = 0.25



a) Determine the TOPMODEL parameter $\bar{\lambda}$ for this watershed. [4]
b) Plot a graph of hydraulic conductivity with depth showing the hydraulic conductivity at depths of 0.5, 1 and 2 m. [4]

Sampling at multiple locations in this watershed has determined that the mean depth to the water table is 1.3 m.

c) Determine the average soil moisture deficit $\bar{D}$ in m. [3]
d) Determine the baseflow in m^3/s. [4]
e) Determine the threshold wetness index above which the watershed is saturated. [4]
f) Determine the fraction of area that is saturated. [3]

Assume a storm in which 5 cm of precipitation falls and there is no infiltration excess runoff.

g) Determine the saturated area at the end of the storm. [4]
h) Determine the volume of runoff due to saturation excess rainfall on saturated and variably saturated areas (in m^3) from this storm. [4]

[30 points]