53:078 Principles of Hydrology
Exam 1
Spring 2003 Name: ______________________

Equations and constants you may (or may not) find useful:

$$\Delta S = \bar{I} - \overline{Q} \qquad Z = \frac{1}{V}\sum_{i=1} D_i^6 \qquad Z = \alpha R^{\beta}$$

$$CD = 1 - \frac{P_{gage}}{P_{true}} \qquad P_x = \sum_{i=1}^{n} w_i P_i \qquad w_i = \frac{(1/x_i)^2}{\sum_{i=1}^{n}(1/x_i)^2}$$

$$w_i = \frac{1}{n}\frac{N_x}{N_i} \qquad P_A = \sum_{i=1}^{n} w_i P_i \qquad \beta = \frac{H_s}{Q_e}$$

$$R_n = H_s + Q_e \qquad Q_e = \frac{R_n}{1+\beta} \qquad E = \frac{1}{l_v \rho_v}\frac{R_n}{1+\beta}$$

$$E = KE_p \qquad \theta = \frac{V_w}{V} \qquad F_p = it_p$$

$$f^*(t) = \frac{1}{2}St^{-1/2} + K \qquad F^*(t) = St^{1/2} + Kt$$

$$t_p = \frac{S^2(i - K/2)}{2i(i-K)^2} \qquad t_0 = t_p - \frac{1}{4K^2}\left(\sqrt{S^2 + 4KF_p} - S\right)^2$$

$$f^*(t) = f_c + (f_0 - f_c)e^{-kt} \qquad F^*(t) = f_c t + \frac{(f_0 - f_c)}{k}(1 - e^{-kt})$$

$$t_p = \frac{1}{ik}\left[f_0 - i + f_c \ln\left(\frac{f_0 - f_c}{i - f_c}\right)\right] \qquad t_0 = t_p - \frac{1}{k}\ln\left(\frac{f_0 - f_c}{i - f_c}\right)$$

1 day = 86400 s 1 mi^2 = 640 ac 1 acre = 43560 ft^2

g = 9.8065 m s^{-2} l_v = 2.5 x 10^6 J kg^{-1} ρ_v = 1000 kg m^{-3}

1 W = 1 J s^{-1} 1 mb = 100 Pa = 100 N m^{-2}

(25) 1. Miscellaneous

a) Weather radars do not measure rainrate. What do radars measure? How is it related to rainfall? Provide your answer in two or three sentences (**no** equations allowed):

b) The two main factors affecting evaporation from an open water surface are:

____

____

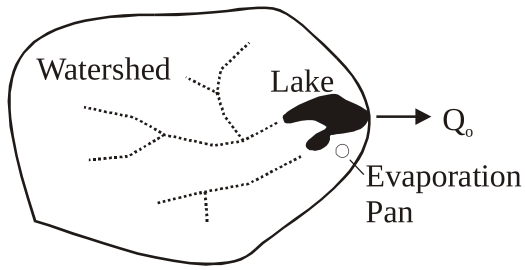
c) At a meteorological station, the evaporative heat flux is 200 W/m^2 and the sensible heat flux is 100 W/m^2. The evaporation rate is ___________ mm/day and the Bowen's ratio is __________ .

d) A streamflow hydrograph can be partitioned into two components. The _____________________ component is water that travels quickly to the stream channel during a storm event. The _____________________ component is water that reaches the water table and moves slowly to the stream.

Runoff Generation Mechanism	Definition
e) ______________________________	Water infiltrates and moves rapidly downslope through the unsaturated zone to the stream.
f) ______________________________	Runoff is generated when the water table reaches the ground surface. Runoff consists of return flow and precipitation on saturated areas.
g) ______________________________	Runoff is generated when the rainrate exceeds the infiltration capacity.

(25) 2. Water Budget

Over a 30-day period, the areal average precipitation (P) over the region (*including* both the lake and the watershed) is 2.0 inches and the pan evaporation (E_p) is 7.0 inches. During this period, the lake outflow (Q_o) is a constant 1.5 cfs. Groundwater flows into and out of the lake and the watershed are negligible. Perform a water budget to determine the change in *lake storage* for the month.



Some hydrologic parameters for the lake and watershed:

Pan coefficient (K):	0.60
Runoff coefficient (C):	0.20 (discharge as a fraction of precipitation)
Bowen's Ratio:	0.40
Watershed drainage area:	1920 acres (excluding the lake area)
Lake area:	18 acres (constant)

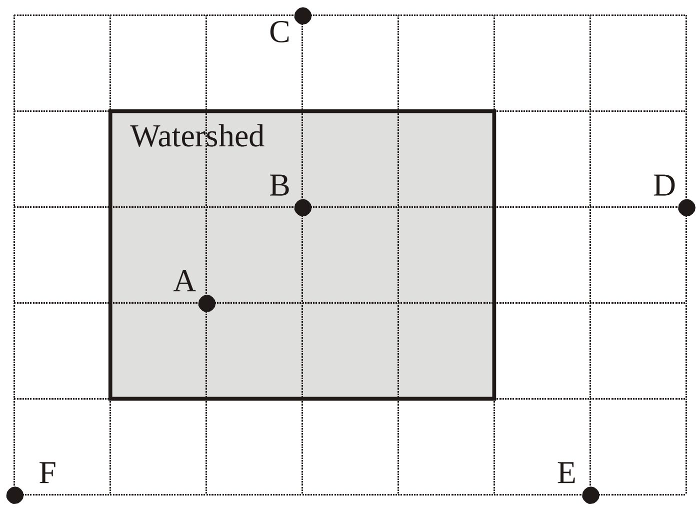
a) Derive the lake water budget equation. Define any symbols use (if they are not defined above). For you final answer, include only those terms that are relevant for the 30-day period. To receive full credit, CLEARLY MARK YOUR FINAL ANSWER.

b) The lake evaporation is _________________ acre-feet.

c) The change in lake storage is _________________ acre-feet.

(25) 3. Storm Analysis During a Flood Event

A prolonged period (1 week) of extreme rainfall produced flooding for a watershed (see sketch). Use the gage information listed below to estimate the rainfall for this storm. If needed, fill in missing gage measurements using the *three nearest gages* with precipitation observations.



Gage	Normal Weekly Precip (mm)	Storm Measured Precip (mm)
A	24	120
B	25	?
C	22	100
D	20	80
E	24	140
F	28	?

a) The storm precipitation at B is _____________ mm based on the Normal Ratio method.

b) The areal average precipitation for the watershed is _____________ mm using the Thiessen Polygon method.

(25) 4. Infiltration During a Storm

The properties of a soil in an infiltration basin are:

Soil:	Sand	f_0:	30 cm/hr
η:	0.42	f_c:	3 cm/hr
θ_i:	0.20	k:	2 hr^{-1}

For the design event, water flows into the infiltration basin at a constant rate of 10 cm/hr for a 4-hour period.

Answer the following:

a) The cumulative infiltration F is 8 cm at a time of __________ hr. The infiltration rate f at this time is ___________ cm/hr.

b) The infiltration rate f is 4 cm/hr at a time of __________ hr.

c) The soil water content θ at the surface at the end of the design event is ____________.