

**FALL 2015 2<sup>nd</sup> MID-TERM EXAM**

Wednesday, November 11<sup>th</sup> 2015, 13:00-14:30

Closed book exam (formula sheet allowed)

80 min

**COMPREHENSION QUESTIONS (20 pts)**

Briefly (three lines at most) answer the following questions:

***A-Multiple choice questions***

- a) How do we estimate flood potential using the hypsometric curve?
  - a. by looking at the area behind the curve
  - b. by looking at the maximum deviation  $D_m$
  - c. by looking at the slope of the curve close to point (1,0)
  - d. using the profile factor  $F_p$
- b) The latent heat of evaporation is
  - a. the amount of heat required to convert a unit mass of ice to vapor without a change of temperature
  - b. the summation of latent heat of fusion and latent heat of condensation
  - c. amount of heat required to convert a unit mass of water into vapor without a change of temperature
  - d. amount of heat required to convert a unit mass of water into vapor by 1 °C
- c) In which season is interception storage more important ?
  - a. Fall
  - b. Winter
  - c. Spring
  - d. Summer
- d) If the  $\log_{10}$  of the mean and  $\log_{10}$  of standard deviation are 3.21 and 0.45, respectively, and the population of peak discharges,  $Q$ , is assumed to be a log-normal distribution, the 2-yr peak discharge is a) 3.21; b)  $\exp(3.21)$ ; c)  $\log_{10}(3.21)$ ; d)  $10^{3.21}$ . (Tip: if  $Q$  is lognormal distributed, then  $\log(Q)$  has a normal distribution)
- e) When an amount of heat is applied to a water body, how do we split it into sensible heat flux and latent heat flux? a) using the Penman equation; b) using the dry bulb wet bulb equation; c) using the energy balance equation; d) using the Bowen ratio

***Solution:*** question a, answer=a; question b, answer=a; question c, answer=b; question d, answer=d; question e, answer=d;

***B-short answers (three lines at most):***

1. Explain the difference between sensible heat flux and latent heat flux.
  - o The sensible heat flux is the fraction of heat flux that raises or lowers the water body temperature; the latent heat flux is the fraction of heat flux that leads to a change of phase (evaporation, sublimation, melting, condensation, etc.) in the water body.
2. Explain how the energy balance equation can be used to calculate evaporation.

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- The energy balance is used to calculate the heat flux in the water body; The Bowen ratio is used to find the latent heat flux; finally, the latent heat flux is converted to evaporation using the latent heat of vaporisation.
- 3. Cite 3 factors affecting evaporation and explain how they affect it.
  - Atmospheric pressure: more evaporation at low pressure
  - Relative humidity: less evaporation at high levels of relative humidity
  - Wind speed: more evaporation at high wind speed
- 4. What the difference between potential evapotranspiration and evapotranspiration?
  - Potential evapotranspiration occurs when there is no limit in water availability (i.e it is the maximum possible amount of evaporation given climatic conditions); Actual evaporation is the amount of evaporation that actually happen, and is usuallu less than potential evapotranspiration except in very rare cases)
- 5. List 5 components of the water balance equation as applied to a watershed.
  - Precipitation
  - Streamflow
  - Evaporation
  - Infiltration
  - Base flow

**PROBLEM 1 (30 PTS)**

Consider a reservoir, initially dry, whose surface area is  $1\text{km}^2$ . It receives, from the beginning, a uniform flow of  $40\text{cm/h}$  for  $5\text{h}$ . The outflow from the reservoir is observed as  $0$  at the beginning as well as  $10\text{h}$  later. When time equals  $5\text{h}$ , the outflow equals inflows (i.e  $40\text{ cm/h}$ ). For simplicity, assume that outflow is linear during its rise as during its recession.

- a. Calculate the inflow and outflow in  $\text{m}^3/\text{s}$  at times  $0, 2.5\text{h}, 5\text{h}, 7.5\text{h}, 10\text{h}, 12.5\text{h}, 15\text{h}$
- b. Compute the storage in the reservoir and graph it against time.
- c. At what time the storage achieves its peak?

**SOLUTION**

Delta t	Inflow (cm/h)	Inflow (m <sup>3</sup> /s)	Outflow (cm/h)	Delta h= (I-O)*3600/1000000	H (m)
0	40	111.1111111	0	0.4	0
2.5	40	111.1111111	55.55555556	0.2	0.4
5	40	111.1111111	111.1111111	0	0.6

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7.5	0	0	55.55555556	-0.2	0.6
10	0	0	0	0	0.4
12.5	0	0	0	0	0.4
15	0	0	0	0	0.4
17.5	0	0	0	0	0.4
20	0	0	0	0	0.4
22.5	0	0	0	0	0.4
25	0	0	0	0	0.4

The peak storage is achieved at  $t=7.5h$

**PROBLEM 2 (20 PT)**

The probability that a roadway will be flooded  $i$  times in any one year is given by the following mass function:

$$P(i) = \begin{cases} k & \text{for } i = 0 \\ k/i & \text{for } i = 1, 2, \dots, 5. \\ 0 & \text{otherwise} \end{cases}$$

Find the value of  $k$  that makes this a legitimate probability-mass function. Plot the mass and cumulative functions and find the following probabilities: (a)  $P(2 \text{ floods})$ , (b)  $P(i \leq 3)$ , (c)  $P(i > 1)$ , and (d)  $P(2 \leq i < 4)$ .

**SOLUTION**

The value of  $k$  is legitimate if the sum of probabilities=1

$$k + \sum_{i=1}^5 k/i = 1$$

$$\text{if } k \left( 1 + 1 + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \frac{1}{5} \right) = 1$$

$$3.2833333k = 1$$

$$k = \frac{1}{3.2833333} = 0.3045$$

i	P(i)	F(i)
0	0.304568528	0.304568528
1	0.304568528	0.609137056
2	0.152284264	0.76142132
3	0.101522843	0.862944163
4	0.076142132	0.939086295
5	0.060913706	1

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- $P(2 \text{ floods})=0.1522$
- $P(i \leq 3)=P(0)+P(1)+P(2)+P(3)=0.8629$
- $P(i > 1)=P(2)+P(3)+\dots+P(6)=0.39$
- $P(2 \leq i < 4)=P(2)+P(3)=0.2538$

**PROBLEM 3 (25 pts)**

Assuming a lognormal distribution, make a frequency analysis of the January rainfall,  $P$ , of Pigeon Lake for the period 1954-1971. Plot the data using the Weibull plotting-position formula. Based on the frequency curve, estimate

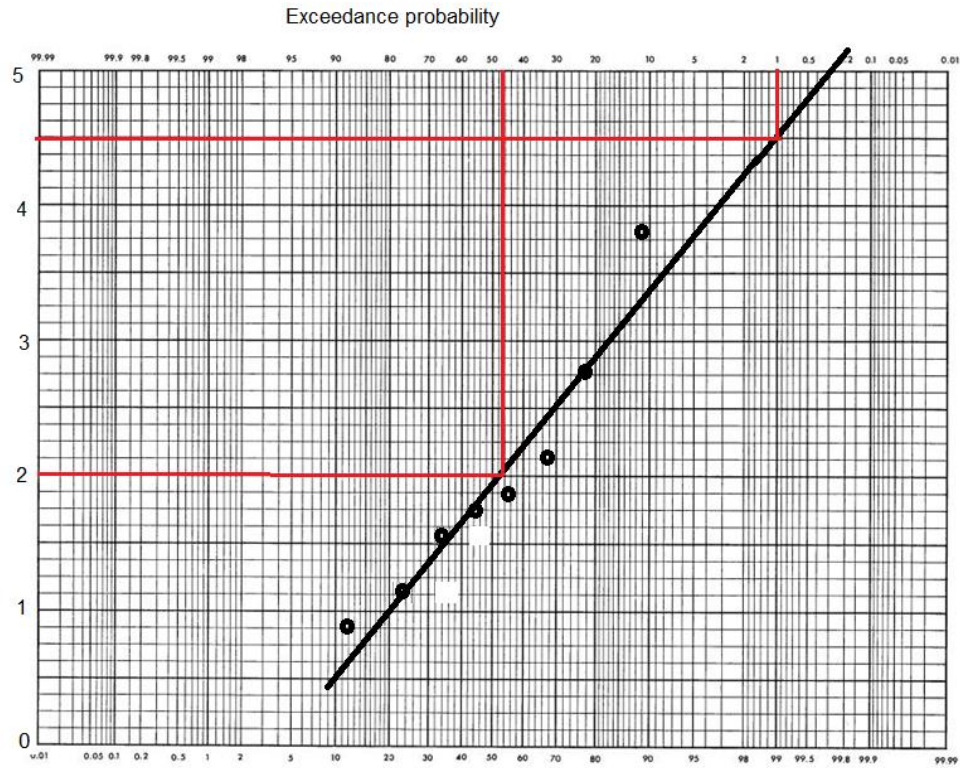
- a) The 100-yr January rainfall
- b) The probability that the January rainfall in any one year will exceed 100 in.

Year	P (in)	Year	P (in)
<b>1954</b>	620	<b>1958</b>	36
<b>1955</b>	150	<b>1959</b>	54
<b>1956</b>	8	<b>1960</b>	5541
<b>1957</b>	89	<b>1961</b>	13

**SOLUTION**

Rank i	Year	P (in)	Log(P)	Weibul
1	1960	5541	3.74358815	0.11111111
2	1954	620	2.79239169	0.22222222
3	1955	150	2.17609126	0.33333333
4	1957	89	1.94939001	0.44444444
5	1959	54	1.73239376	0.55555556
6	1958	36	1.5563025	0.66666667
7	1961	13	1.11394335	0.77777778
8	1956	8	0.90308999	0.88888889

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- 100 year precipitation : exceedance probability=1%; from the graph,  
 $\log_{10}(P_{100})=4.5$ ;  $P_{100}=10^{4.5}=31622\text{in}$
- More than 100 in:  $\log_{10}(100)=2$ ; exceedance probability=0.48 (from graph)