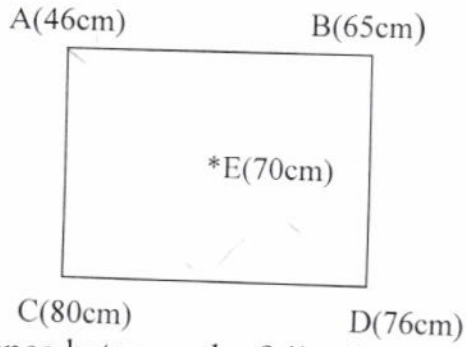
University Of Technology
Building and Construction Eng. Dept.
Final Exam – 2013/2014

Subject : Engineering Hydrology — Class : 3 rd year
Branch :Water & Dams Eng. — Time : 3 hours.
Examiner : Dr. Ibtisam R. Kareem — Date : 3 /6 /2012

***Note: Answer four questions only(question 4 must be included)***

**Q1)a-**The area shown in figure bellow is composed of a square plot of side 10 km. The annual precipitations at the rain-gauge stations located at the four corners and the center of the square plot are indicated in figure. Find the mean precipitation over the area by Thiessen polygon method, and compare with the arithmetic mean, *(13 Marks).*




**b-** Show the difference between the following: *(12 Marks)*

1- Base flow & Direct runoff.
2- Tipping bucket rain gauge & Weighing type rain gauge.
3- Φ-index & W-index
4- Stream density & Drainage density.

**Q2) a-** Choose the correct statement in the following: *(10 Marks)*

1-A double mass analysis is made
(*a*) to find the missing rainfall at a station in a particular area
(*b*) to adjust the record at a station to the changed environment
(*c*) for all the above purposes

2- Isohyetal method gives accurate mean areal depth of rainfall
(*a*) in a plain country
(*b*) in a gently sloping basin
(*c*) in a basin consisting of plains and hills.

3- Interception loss is
(*a*) more towards the end of a storm
(*b*) more at the beginning of a storm
(*c*) uniform throughout the storm.

4- A synthetic unit hydrograph is developed
(*a*) for a basin whose stream is gauged.
(*b*) for a basin over which no raingauge and stream gauge are established.
(*c*) for a basin having a raingauge network but with no stream gauging station.

5- Given a hdyrograph of inflow into the reservoir, flood routing is the process of
(*a*) determining reservoir pool elevation
(*b*) determining discharge over the spillway and through sluice ways
(*c*) determining exclusion of silt-charge from the reservoir

**b-** A 20-cm well penetrates 30 m below static water level (GWT). After a long period of pumping at a rate of 1800 lpm, the drawdowns in the observation wells at 12 m and 36 m from the pumped well are 1.2 m and 0.5 m, respectively. Determine: (i) the transmissibility of the aquifer.(ii) the drawdown in the pumped well assuming R = 300 m. *(15 Marks)*

**Q3)a-**The total observed runoff volume during a storm of 6-hr duration with a uniform intensity of 18 mm/hr is 23 $mm^3$. If the area of the basin is 250 $km^2$, find the average infiltration rate and the runoff coefficient for the basin. *(13 Marks)*

**b-** State the following: *(12 Marks)*

1- Types of the precipitation.
2- Water losses.
3- Factors affecting Evapotranspiration.

**Q4) a-** Given below are flows from a storm of 1- hr duration on a stream with a drainage area of 1000$km^2$. Assume constant base flow = 800$m^3$/sec, drive:

a) 1-hr U.H
b) 2-hr U.H *(17 Marks)*.

| Time(hr) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Flow($m^3$/sec) | 800 | 900 | 1000 | 2000 | 1800 | 1600 | 1300 | 1000 | 800 |

**b-** Show the relationship between the fallowing: *(8 Marks)*

1- Annual precipitation and Annual runoff.
2- Actual evaporation and Pan evaporation.

**Q5) a-** Perform the flood routing for a reach of river given: X = 0.2 and K=2days. The inflow hydrograph with $\Delta t$=1day is given in table below, assume equal inflow and outflow rates in day 1 : *(17 Marks)*

Use the fallowing equations:

$C_1=(\Delta t- 2KX)/(\Delta t+2K-2KX)$, $C_2=(\Delta t+ 2KX)/(\Delta t+2K-2KX)$

$C_3= (2K-2KX-\Delta t)/(\Delta t+2K-2KX)$

| Time Days | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Inflow cfs | 4260 | 7646 | 11167 | 16730 | 21590 | 20950 | 26570 | 46000 | 59960 | 57740 | 47890 | 34460 | 21660 |
| Time Days | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | |
| Inflow cfs | 34680 | 45180 | 49140 | 41290 | 33830 | 20510 | 14720 | 11436 | 9294 | 7831 | 6228 | 6083 | |

**b-** For certain flood data. The fallowing are found: *(8 Marks)*

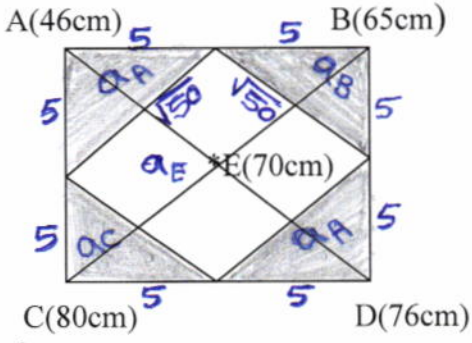
$\overline{q}$ = 1500 $m^3$/sec and $\sigma_q$ = 150. Find the 10-yrs and 100-yrs return period floods using Gumbel distribution. Use the following table:

| K- Values | |
|---|---|
| Return period(yr) | K |
| 10 | 1.30 |
| 100 | 3.14 |
| 400 | 4.23 |

GOOD LUCK

# Typical solutions of Engineering Hydrology Final Exam 2014

**Q1)a-**




By Thiessen method

aA = aB = aC = aD = 1/2(5*5) 12.5 $km^2$ & aE = $\sqrt{50} * \sqrt{50} = 50$ $km^2$

p = (aA*pA + aB*pB + aC*pC + aD*pD + aE*pE ) / AT

P = (12.5*46 +12.5*65 +12.5*76 +12.5*80 + 50*70) / 10*10 =68.375cm

By arthmatic method

P = (46 + 65 + 76 + 80 + 70) / 5 =67.4cm

**b-**

**1-Base flow**: The amount of water coming from groundwater and soil contribution even there is no rainfall

**Direct runoff**: Discharge from rainfall excess after losses have been subtracted.

**2-Tipping bucket rain gauge** :This consists of a cylindrical receiver 30 cm diameter with a funnel inside. Just below the funnel a pair of tipping buckets is pivoted such that when one of the bucket receives a rainfall of 0.25 mm it tips and empties into a tank below, while the other bucket takes its position and the process is repeated.

**Weighing type rain gauge**: when a certain weight of rainfall is collected in a tank, which rests on a spring-lever balance, it makes a pen to move on a chart wrapped round a clock driven drum. The rotation of the drum sets the time scale while the vertical motion of the pen records the cumulative precipitation.

3- **Φ-index**: is defined as that rate of rainfall above which the rainfall volume equals the runoff volume. The φ-index is relatively simple and all losses due to infiltration, interception and depression storage

**W-index** : is the average infiltration rate during the time rainfall intensity exceeds the infiltration capacity rate

**4-Stream density** of a drainage basin is expressed as the number of streams per square kilometre. stream density, $Ds = N_s/A_s$

**Drainage density** is expressed as the total length of all stream channels (perennial and intermittent) per unit area of the basin and serves as an index of the areal channel development of the basin Drainage density, $D_d = L_s/A$

**5-Aquifer**:A water bearing geologic formation or stratum capable of transmitting water through its pores at a rate sufficient for economic extraction by wells.

**Aquifuge:** A geologic formation with no interconnected pores and hence can neither absorb nor transmit water.

**Q2) a-** Choose the correct statement in the following:

1- (*b*) to adjust the record at a station to the changed environment

**2-** (*c*) in a basin consisting of plains and hills.

3- (*b*) more at the beginning of a storm

4- (*c*) for a basin having a raingauge network but with no stream gauging station.

5- (a)reservoir pool elevation.

b-

Dupuit's Eq. (7.7): $Q = \dfrac{\pi K(h_2^2 - h_1^2)}{2.303 \log_{10} r_2/r_1}$

$h_2 = H - s_2 = 30 - 0.5 = 29.5$ m; $h_1 = H - s_1 = 30 - 1.2 = 28.8$ m

$$\frac{1.800}{60} = \frac{\pi K(29.5^2 - 28.8^2)}{2.303 \log_{10} 36/12}$$

$K = 2.62 \times 10^{-4}$ m/sec or **22.7 m/day**

Transmissibility $T = KH = (2.62 \times 10^{-4})\ 30 = 78.6 \times 10^{-4}$ m$^2$/sec,

$= 22.7 \times 30 = \mathbf{681\ m^2/day}$

Eq. (7.8): $Q = \dfrac{2.72\ T\ (H - h_w)}{\log_{10} R/r_w}$

$$\frac{1.800}{60} = \frac{2.72(78.6 \times 10^{-4})\ S_w}{\log_{10} 300/0.10}$$

drawdown in the well, $S_w = \mathbf{4.88\ m}$

**Q3)a-**

**Solution** (*a*) Infiltration loss *Fp* = Rainfall (P) – Runoff (R)

$= 18 \times 6 - (23^* 10^6\ m^3/250^* 10^6\ m^2) \times 1000$

$= 108 - 92 = 16$ mm

fave = Fp/t = 16 mm/6 hr = 2.666 mm/hr

(*b*) Yield = C A P

$23 \times 10^6\ m^3 = C(250 \times 10^6\ m^2)^*108/1000 \rightarrow C = 0.85$

**b-** State the following:

1- Types of the precipitation.

a-Thermal convection (convectional precipitation)—

b-Conflict between two air masses (frontal precipitation

c-Orographic lifting (orographic precipitation

d-Cyclonic (cyclonic precipitation.

**2-** Water losses

(*i*) Interception loss-due to surface vegetation, *i.e.,* held by plant leaves.

(*ii*) Evaporation:

(*iii*) Transpiration—from plant leaves.

(*iv*) Evapotranspiration for consumptive use from irrigated land.

(*v*) Infiltration—into the soil at the ground surface.

(*vi*) Watershed leakage ground water movement from one basin to another or into the sea..

3- Factors Affecting Evapotranspiration

(*i*) Climatological factors like percentage sunshine hours, wind speed, mean monthly temperature and humidity.

(*ii*) Crop factors like the type of crop and the percentage growing season.

(*iii*) The moisture level in the soil.

**Q4) a-**

| Time(hr) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Flow($m^3$/sec) | 800 | 900 | 1000 | 2000 | 1800 | 1600 | 1300 | 1000 | 800 |

| DRH ($m^3$/sec) | 1hr-UH (($m^3$/sec) | S-curve ($m^3$/sec) | Lagged ($m^3$/sec) | 2hr-UH ($m^3$/sec) |
|---|---|---|---|---|
| 0 | 0 | 0 | - | 0 |
| 100 | 69.5 | 69.5 | 0 | 34.75 |
| 200 | 138.9 | 208.4 | 69.5 | 69.45 |
| 1200 | 833.4 | 1041.8 | 208.4 | 416.7 |
| 1000 | 694.5 | 1736.3 | 1041.8 | 347.25 |
| 800 | 555.5 | 2291.8 | 1736.3 | 277.75 |
| 500 | 347.2 | 2639 | 2291.8 | 173.6 |
| 200 | 138.9 | 2777.9 | 2639 | 69.45 |
| 0 | 0 | 2777.9 | 2777.9 | 0 |

$d=\sum DRH*\Delta t / A= 4000*1*3600/1000*10^6 = 1.44cm.$

b- Show the relationship between the fallowing: *(8 Marks)*

1- Annual precipitation and Annual runoff. $R = K * P$

2- Actual evaporation and Pan evaporation. $E = E_p * C$

**Q5) a-**

$$\underset{2k.x \le \Delta t \le k}{C_0 = \frac{-k.x + 0.50 * \Delta t}{k(1-x) + 0.50\Delta t}} = \underset{2*2*0.2 \le 1 \le 2}{\frac{-2*0.20 + 0.5*1}{2(1-0.20) + 0.50*1}} = \underset{\text{o.k}}{\frac{0.10}{2.10}} = 0.04762$$

$$C_1 = \frac{k.x + 0.50 * \Delta t}{k(1-x) + 0.50 * \Delta t} = \frac{0.90}{2.10} = 0.42857$$

$$C_2 = \frac{k(1-x) - 0.50 * \Delta t}{k(1-x) + 0.50 * \Delta t} = \frac{1.10}{2.10} = 0.52381$$

$$\sum_{i=0}^{2} C_i = 0.04762 + 0.42857 + 0.52381 = 1.0$$

| Time Days | Inflow cfs | $C_0 * I_2$ | $C_1 * I_1$ | $C_2 * O_1$ | Outflow cfs |
|---|---|---|---|---|---|
| 1 | 4260 | | | | 4260 |
| 2 | 7646 | 364 | 1826 | 2231 | 4421 |
| 3 | 11167 | 532 | 3277 | 2316 | 6125 |
| 4 | 16730 | 797 | 4786 | 3208 | 8791 |
| 5 | 21590 | 1028 | 7170 | 4605 | 12803 |
| 6 | 20950 | 998 | 9253 | 6706 | 16957 |
| 7 | 26570 | 1265 | 8979 | 8882 | 19126 |
| 8 | 46000 | 2190 | 11387 | 10018 | 23596 |
| 9 | 59960 | 2855 | 19714 | 12360 | 34929 |
| 10 | 57740 | 2750 | 25697 | 18296 | 46743 |
| 11 | 47890 | 2280 | 24746 | 24484 | 51511 |
| 12 | 34460 | 1641 | 20524 | 26982 | 49147 |
| 13 | 21660 | 1031 | 14769 | 25744 | 41544 |
| 14 | 34680 | 1651 | 9283 | 21761 | 32695 |
| 15 | 45180 | 2151 | 14863 | 17126 | 34140 |
| 16 | 49140 | 2340 | 19363 | 17883 | 39586 |
| 17 | 41290 | 1966 | 21060 | 20735 | 43762 |
| 18 | 33830 | 1611 | 17696 | 22923 | 42229 |
| 19 | 20510 | 977 | 14499 | 22120 | 37595 |
| 20 | 14720 | 701 | 8790 | 19693 | 29184 |
| 21 | 11436 | 545 | 6309 | 15287 | 22140 |
| 22 | 9294 | 443 | 4901 | 11597 | 16941 |
| 23 | 7831 | 373 | 3983 | 8874 | 13230 |
| 24 | 6228 | 297 | 3356 | 6930 | 10583 |
| 25 | 6083 | 290 | 2669 | 5543 | 8502 |

**b-**

$q_x = q + K \sigma_x =$

$q_{10} = 1500 + 1.3*150 = 1695 m^3/sec$

$q_{100}$ $1500 + 3.14 * 150 = 1971 m^3/sec$