UTHM
Universiti Tun Hussein Onn Malaysia

# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION
## SEMESTER I
## SESSION 2022/2023

| | | |
|---|---|---|
| COURSE NAME | : | HYDROLOGICAL DESIGN & ANALYSIS |
| COURSE CODE | : | BFW 40203 |
| PROGRAMME CODE | : | BFF |
| EXAMINATION DATE | : | FEBRUARY 2023 |
| DURATION | : | 3 HOURS |
| INSTRUCTION | : | 1. ANSWER **ALL** QUESTIONS<br>2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK**<br>3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK |

THIS QUESTION PAPER CONSISTS OF **NINE (9)** PAGES

**Q1** (a) (i) With the aid of diagram, explain the typical differences between hydrological cycle parameters in natural and urban areas.

(3 marks)

(ii) Explain the importance of a catchment area in urban area.

(2 marks)

(iii) Based on **FIGURE Q1(a)**, draw the potential boundary of a sub-catchment in Hutan Lipur Jeram Toi, Jelebu, Negeri Sembilan.

(2 marks)

(iv) By choosing **ONE (1)** simple method, measure the catchment area in **Question Q1(a)(iii)** with scale of 1 cm : 1 km. Show your calculation on **FIGURE Q1(a).**

(4 marks)

(b) An urban catchment with 87 hectares of residential area in Kemuning Permai, Shah Alam, Selangor is shown in **FIGURE Q1(b)**. By using MSMA 2nd edition, calculate the intensity using empirical method and plot the temporal pattern of design rainfall for 30 minutes for this catchment with return period of 1-year ARI. Refer **TABLE Q1(b)(i), Q1(b)(ii)** and **Q1(b)(iii)**.

(6 marks)

(c) Using time-area method, predict the peak discharge of the hydrograph if the design rainfall event calculated from **Q1(b)** occurs in this catchment (**TABLE Q1(c)**). Assume continuous loss is constant at 0.25 mm/10 min. Plot the hydrograph.

(8 marks)

**Q2** (a) (i) Define hydrograph. Describe **THREE (3)** typical characters of hydrographs.

(4 marks)

(ii) With the aid of hydrograph, highlight and explain at least **TWO (2)** hydrological parameters that affected by the urban development.

(4 marks)

(b) (i) Explain the purpose of using unit hydrograph (UH) and synthetic unit hydrograph.

(4 marks)

(ii) **TABLE Q2(b)** shows the ordinates of a storm hydrograph of a river draining a catchment area of 423 $km^2$ due to a 6-hr isolated storm. By using any method for the baseflow separation, derive the ordinates of a 6-h unit hydrograph for the catchment.

(7 marks)

(c) Develop a 50-minutes of SCS triangular unit hydrograph for an urban area 750 ha with time concentration of 30 minutes.

(6 marks)

**Q3** (a) From the Kluang annual rainfall record of 15 years (1974-1998) shown in **TABLE Q3(a)**:

(i) Plot a return period log graph (on a given log paper) and formulate an equation from the log trendline.

(5 marks)

(ii) Estimate the annual rainfall with 20 and 50 years of return period.

(3 marks)

(iii) Estimate any **TWO (2)** dependable rainfalls that larger than 65%.

(2 marks)

(iv) Predict the probability of an annual rainfall of magnitude equal to or exceeding 90 cm.

(2 marks)

(b) (i) Discuss the importance of frequency analysis in civil engineering.

(2 marks)

(ii) **TABLE Q3(b)** shows annual maximum series for Johor River in Kota Tinggi for sample of 10 years. Predict 50- and 150-year return period flood data (in $m^3/s$) of this river using Log Pearson Type III Method.

(11 marks)

**Q4** (a) (i) Describe **TWO (2)** effects of uncontrolled erosion on small sites.

(2 marks)

(ii) List **THREE (3)** of each control facilities of erosion and sediment.

(3 marks)

(b) (i) With the aid of diagram, describe

a. sediment basin,
b. check dam.

(6 marks)

(ii) Discuss the difference between dry and wet sediment basin sizing criteria.

(6 marks)

(c) Briefly discuss your opinion on **FOUR (4)** actions on Erosion and Sediment Control (ESC) principles to handle any related problems according to site conditions.

(8 marks)

**-END OF QUESTIONS-**

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**FIGURE Q1(a)**: Hutan Lipur Jeram Toi, Jelebu contour map

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## FIGURES

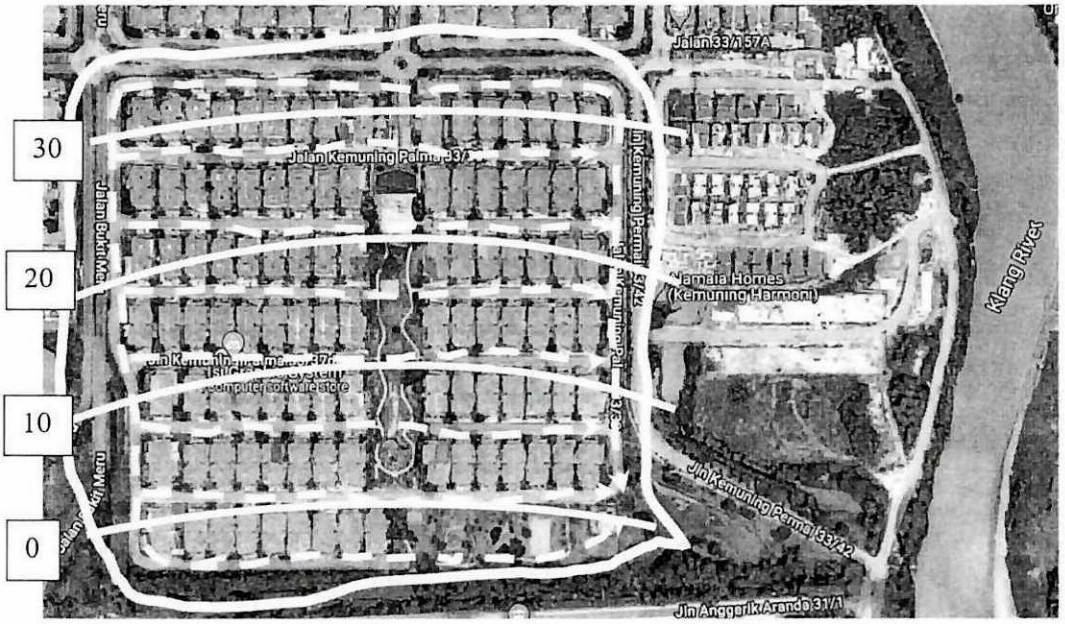


**FIGURE Q1(b)**: Catchment area and the isochrones for Kemuning Permai, Shah Alam

## EQUATIONS

Intensity, $i = \frac{\lambda T^{\kappa}}{(d+\theta)^{\eta}}$ ; Intensity, $i = \frac{rainfall\ depth,\ P}{t}$

$q_j = I_j.A_1 + I_{j-1}.A_2 + \cdots + I_1.A_j$ ; Probability, P = 1/T ; Probability, P = m/(N+1)

$y_T = \bar{y} + K_T s_y$ ; $x_T = Q_T = 10^{Y_T}$ ; $s_y = \sqrt{\sum(y-\bar{y})^2/(n-1)}$

$c_s = \frac{n\sum_{i=1}^{n}(x_i-\bar{x})^3}{(n-1)(n-2)s_y{}^3}$ ; $\bar{x} = \bar{y}$ ; $s^3 = s_y{}^3$ ; $y = \log(Q)$ OR

$logx = \overline{logx} + K\sigma_{logx}$ ; $\overline{logx} = \frac{\sum(logx_i)}{n}$ ; $\frac{\sum_i^n(logQ-avg(logQ)^2}{n-1}$

$\sigma_{logx} = \sqrt{\frac{\sum(\log x-\overline{logx})^2}{n-1}}$ or $\sigma logQ = \sqrt{variance}$ ; $c_s = \frac{n\sum(logx-\overline{logx})^3}{(n-1)(n-2)(\sigma_{logx})^3}$

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## TABLES

**TABLE Q1(b)(i)**: Fitting constants for the IDF empirical equation for the different locations in Malaysia for low ARIs between 0.5 and 12 month and storm duration from 5 minutes to 72 hours

| State | No | Station ID | Station Name | Constant | | | |
|---|---|---|---|---|---|---|---|
| | | | | λ | κ | θ | η |
| Selangor | 1 | 2815001 | JPS Sungai Manggis | 57.3495 | 0.2758 | 0.1693 | 0.8671 |
| | 2 | 2913001 | Pusat Kwln JPS Teluk Gong | 65.3556 | 0.3279 | 0.3451 | 0.8634 |
| | 3 | 2917001 | Setor JPS Kajang | 62.9564 | 0.3293 | 0.1298 | 0.8273 |
| | 4 | 3117070 | JPS Ampang | 69.1727 | 0.2488 | 0.1918 | 0.8374 |

**TABLE Q1(b)(ii)**: Recommended Intervals for Design Rainfall Temporal Pattern

| Storm Duration (minutes) | Time Interval (minutes) |
|---|---|
| **Less than 60** | 5 |
| 60 – 120 | 10 |
| 121 – 360 | 15 |
| Greater than 360 | 30 |

**TABLE Q1(b)(iii)**: Region 2: Johor, Negeri Sembilan, Melaka, Selangor dan Pahang

| No. of Block | Storm Duration | | | |
|---|---|---|---|---|
| | 15-min | 30-min | 60-min | 180-min |
| 1 | 0.255 | 0.124 | 0.053 | 0.053 |
| 2 | 0.376 | 0.130 | 0.059 | 0.061 |
| 3 | 0.370 | 0.365 | 0.063 | 0.063 |
| 4 | | 0.152 | 0.087 | 0.080 |
| 5 | | 0.126 | 0.103 | 0.128 |
| 6 | | 0.103 | 0.153 | 0.151 |
| 7 | | | 0.110 | 0.129 |
| 8 | | | 0.088 | 0.097 |
| 9 | | | 0.069 | 0.079 |
| 10 | | | 0.060 | 0.062 |
| 11 | | | 0.057 | 0.054 |
| 12 | | | 0.046 | 0.042 |

**TABLE Q1(c)**: Areas between the isochrones

| ID | Isochrones | Area (ha) |
|---|---|---|
| $A_1$ | 0 – 10 | 10 |
| $A_2$ | 10 – 20 | 22 |
| $A_3$ | 20 > | 22 |

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## TABLES

**TABLE Q2(b)**: The ordinates of a storm hydrograph of a river

| **Time from start of storm (h)** | 0 | 6 | 12 | 18 | 24 | 30 | 36 | 42 | 48 | 54 | 60 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Discharge ($m^3/s$)** | 9 | 25 | 43 | 67 | 88 | 54 | 39 | 25 | 17 | 10 | 10 |

**TABLE Q3(a)**: Kluang annual rainfall record of 15 years (1974 – 1988)

| **Year** | **Annual Rainfall (cm)** |
|---|---|
| 1974 | 141.2 |
| 1975 | 156.0 |
| 1976 | 158.9 |
| 1977 | 149.1 |
| 1978 | 139.3 |
| 1979 | 136.5 |
| 1980 | 152.7 |
| 1981 | 140.7 |
| 1982 | 161.7 |
| 1983 | 132.0 |
| 1984 | 134.6 |
| 1985 | 143.6 |
| 1986 | 111.9 |
| 1987 | 158.9 |
| 1988 | 195.3 |

**TABLE Q3(b)**: Annual maximum series of Johor River

| **Year** | **Streamflow, Q (cfs)** |
|---|---|
| 2003 | 57800 |
| 2004 | 42000 |
| 2005 | 57100 |
| 2006 | 34600 |
| 2007 | 80000 |
| 2008 | 49200 |
| 2009 | 68200 |
| 2010 | 32600 |
| 2011 | 46400 |
| 2012 | 65000 |

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**TABLE Q2(b)**: Frequency factors K for Gamma and log-Pearson Type III Distribution

| | Recurrence Interval In Years | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1.0101 | 2 | 5 | 10 | 25 | 50 | 100 | 200 |
| SKEW COEFFICIENT | Percent Chance (>=) = 1-F | | | | | | | |
| Cs | 99 | 50 | 20 | 10 | 4 | 2 | 1 | 0.5 |
| 3 | -0.667 | -0.396 | 0.420 | 1.180 | 2.278 | 3.152 | 4.051 | 4.970 |
| 2.9 | -0.690 | -0.390 | 0.440 | 1.195 | 2.277 | 3.134 | 4.013 | 4.904 |
| 2.8 | -0.714 | -0.384 | 0.460 | 1.210 | 2.275 | 3.114 | 3.973 | 4.847 |
| 2.7 | -0.740 | -0.376 | 0.479 | 1.224 | 2.272 | 3.093 | 3.932 | 4.783 |
| 2.6 | -0.769 | -0.368 | 0.499 | 1.238 | 2.267 | 3.071 | 3.889 | 4.718 |
| 2.5 | -0.799 | -0.360 | 0.518 | 1.250 | 2.262 | 3.048 | 3.845 | 4.652 |
| 2.4 | -0.832 | -0.351 | 0.537 | 1.262 | 2.256 | 3.023 | 3.800 | 4.584 |
| 2.3 | -0.867 | -0.341 | 0.555 | 1.274 | 2.248 | 2.997 | 3.753 | 4.515 |
| 2.2 | -0.905 | -0.330 | 0.574 | 1.284 | 2.240 | 2.970 | 3.705 | 4.444 |
| 2.1 | -0.946 | -0.319 | 0.592 | 1.294 | 2.230 | 2.942 | 3.656 | 4.372 |
| 2 | -0.990 | -0.307 | 0.609 | 1.302 | 2.219 | 2.912 | 3.605 | 4.298 |
| 1.9 | -1.037 | -0.294 | 0.627 | 1.310 | 2.207 | 2.881 | 3.553 | 4.223 |
| 1.8 | -1.087 | -0.282 | 0.643 | 1.318 | 2.193 | 2.848 | 3.499 | 4.147 |
| 1.7 | -1.140 | -0.268 | 0.660 | 1.324 | 2.179 | 2.815 | 3.444 | 4.069 |
| 1.6 | -1.197 | -0.254 | 0.675 | 1.329 | 2.163 | 2.780 | 3.388 | 3.990 |
| 1.5 | -1.256 | -0.240 | 0.690 | 1.333 | 2.146 | 2.743 | 3.330 | 3.910 |
| 1.4 | -1.318 | -0.225 | 0.705 | 1.337 | 2.128 | 2.706 | 3.271 | 3.828 |
| 1.3 | -1.383 | -0.210 | 0.719 | 1.339 | 2.108 | 2.666 | 3.211 | 3.745 |
| 1.2 | -1.449 | -0.195 | 0.732 | 1.340 | 2.087 | 2.626 | 3.149 | 3.661 |
| 1.1 | -1.518 | -0.180 | 0.745 | 1.341 | 2.066 | 2.585 | 3.087 | 3.575 |
| 1 | -1.588 | -0.164 | 0.758 | 1.340 | 2.043 | 2.542 | 3.022 | 3.489 |
| 0.9 | -1.660 | -0.148 | 0.769 | 1.339 | 2.018 | 2.498 | 2.957 | 3.401 |
| 0.8 | -1.733 | -0.132 | 0.780 | 1.336 | 1.993 | 2.453 | 2.891 | 3.312 |
| 0.7 | -1.806 | -0.116 | 0.790 | 1.333 | 1.967 | 2.407 | 2.824 | 3.223 |
| 0.6 | -1.880 | -0.099 | 0.800 | 1.328 | 1.939 | 2.359 | 2.755 | 3.132 |
| 0.5 | -1.955 | -0.083 | 0.808 | 1.323 | 1.910 | 2.311 | 2.686 | 3.041 |
| 0.4 | -2.029 | -0.066 | 0.816 | 1.317 | 1.880 | 2.261 | 2.615 | 2.949 |
| 0.3 | -2.104 | -0.050 | 0.824 | 1.309 | 1.849 | 2.211 | 2.544 | 2.856 |
| 0.2 | -2.178 | -0.033 | 0.830 | 1.301 | 1.818 | 2.159 | 2.472 | 2.763 |
| 0.1 | -2.252 | -0.017 | 0.836 | 1.292 | 1.785 | 2.107 | 2.400 | 2.67 |
| 0 | -2.326 | 0.000 | 0.842 | 1.282 | 1.751 | 2.054 | 2.326 | 2.576 |

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## TABLES

**TABLE Q2(b)**: Frequency factors K for Gamma and log-Pearson Type III Distribution (Continued)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 0 | -2.326 | 0.000 | 0.842 | 1.282 | 1.751 | 2.054 | 2.326 | 2.576 |
| -0.1 | -2.4 | 0.017 | 0.846 | 1.27 | 1.716 | 2.000 | 2.252 | 2.482 |
| -0.2 | -2.472 | 0.033 | 0.850 | 1.258 | 1.680 | 1.945 | 2.178 | 2.388 |
| -0.3 | -2.544 | 0.050 | 0.853 | 1.245 | 1.643 | 1.890 | 2.104 | 2.294 |
| -0.4 | -2.615 | 0.066 | 0.855 | 1.231 | 1.606 | 1.834 | 2.029 | 2.201 |
| -0.5 | -2.686 | 0.083 | 0.856 | 1.216 | 1.567 | 1.777 | 1.955 | 2.108 |
| -0.6 | -2.755 | 0.099 | 0.857 | 1.200 | 1.528 | 1.720 | 1.880 | 2.016 |
| -0.7 | -2.824 | 0.116 | 0.857 | 1.183 | 1.488 | 1.663 | 1.806 | 1.926 |
| -0.8 | -2.891 | 0.132 | 0.856 | 1.166 | 1.448 | 1.606 | 1.733 | 1.837 |
| -0.9 | -2.957 | 0.148 | 0.854 | 1.147 | 1.407 | 1.549 | 1.660 | 1.749 |
| -1 | -3.022 | 0.164 | 0.852 | 1.128 | 1.366 | 1.492 | 1.588 | 1.664 |
| -1.1 | -3.087 | 0.180 | 0.848 | 1.107 | 1.324 | 1.435 | 1.518 | 1.581 |
| -1.2 | -3.149 | 0.195 | 0.844 | 1.086 | 1.282 | 1.379 | 1.449 | 1.501 |
| -1.3 | -3.211 | 0.210 | 0.838 | 1.064 | 1.240 | 1.324 | 1.383 | 1.424 |
| -1.4 | -3.271 | 0.225 | 0.832 | 1.041 | 1.198 | 1.270 | 1.318 | 1.351 |
| -1.5 | -3.33 | 0.240 | 0.825 | 1.018 | 1.157 | 1.217 | 1.256 | 1.282 |
| -1.6 | -3.880 | 0.254 | 0.817 | 0.994 | 1.116 | 1.166 | 1.197 | 1.216 |
| -1.7 | -3.444 | 0.268 | 0.808 | 0.970 | 1.075 | 1.116 | 1.140 | 1.155 |
| -1.8 | -3.499 | 0.282 | 0.799 | 0.945 | 1.035 | 1.069 | 1.087 | 1.097 |
| -1.9 | -3.553 | 0.294 | 0.788 | 0.920 | 0.996 | 1.023 | 1.037 | 1.044 |
| -2 | -3.605 | 0.307 | 0.777 | 0.895 | 0.959 | 0.980 | 0.990 | 0.995 |
| -2.1 | -3.656 | 0.319 | 0.765 | 0.869 | 0.923 | 0.939 | 0.946 | 0.949 |
| -2.2 | -3.705 | 0.330 | 0.752 | 0.844 | 0.888 | 0.900 | 0.905 | 0.907 |
| -2.3 | -3.753 | 0.341 | 0.739 | 0.819 | 0.855 | 0.864 | 0.867 | 0.869 |
| -2.4 | -3.800 | 0.351 | 0.725 | 0.795 | 0.823 | 0.830 | 0.832 | 0.833 |
| -2.5 | -3.845 | 0.360 | 0.711 | 0.711 | 0.793 | 0.798 | 0.799 | 0.800 |
| -2.6 | -3.899 | 0.368 | 0.696 | 0.747 | 0.764 | 0.768 | 0.769 | 0.769 |
| -2.7 | -3.932 | 0.376 | 0.681 | 0.724 | 0.738 | 0.740 | 0.740 | 0.741 |
| -2.8 | -3.973 | 0.384 | 0.666 | 0.702 | 0.712 | 0.714 | 0.714 | 0.714 |
| -2.9 | -4.013 | 0.390 | 0.651 | 0.681 | 0.683 | 0.689 | 0.690 | 0.690 |
| -3 | -4.051 | 0.396 | 0.636 | 0.660 | 0.666 | 0.666 | 0.667 | 0.667 |