UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACCALAUREUS INGENERIAE *CIVIL ENGINEERING*
SUBJECT	:	**Hydraulic Engineering 3B**
CODE	:	**HMG3B21**
DATE	:	SUMMER EXAMINATION 12 NOVEMBER 2019
DURATION	:	3 HRS (SESSION 2) 12:30 – 15:30
WEIGHT	:	50 : 50
TOTAL MARKS	:	100

ASSESSOR	:	PROF. M.O. DINKA	
MODERATOR	:	DR S Nyande Biyakika	FILE NO: HMG3B 2019
NUMBER OF PAGES	:	3 PAGES AND 2 ANNEXURES	

INSTRUCTIONS	:	QUESTION PAPERS MUST BE HANDED IN
REQUIREMENTS	:	2 ANSWER BOOKLETS

INSTRUCTIONS TO STUDENTS

- PLEASE ANSWER ALL QUESTIONS
- PROVIDE SHORT AND PRECISE ANSWERS FOR THE THEORETICAL PART
- SHOW ALL THE STEPS FOR CALCULATIONS CLEARLY
- YOU WILL NOT PASS IF YOU FAIL ELO QUESTIONS

PART I: FLOOD HYDROLOGY [50]

QUESTION 1 [20 Marks]

1.1. Discuss the main components and characteristics of a hydrologic cycle. Also briefly discuss the effects of human activity and climate change on hydrologic cycle in recent time. (8)

1.2. Distinguish between stochastic and deterministic methods for the determination of flood peaks. Give an example for each. (4)

1.3. Define the following terms in hydrology: (4)

a) Bathometry
b) Tornedo

1.4. Determine the specific map ID for the indicated coordinates (1:10 000 scales): (4)

a) 26°15'04'' S, 29°25'10''E
b) 24°30'35'' S, 28°44'06''E

QUESTION 2 [18 Marks]

The folowing information (Table 1) is available for a proposed new dam site in Waterval Catchment.

Table 2

Contours (masl)	Area (m^2)	Storage ($m^3 * 10^6$)	Outflow discharge (m^3/s)
430.4	700	3.2	5
432	1800	4.4	20
434	4800	5.6	45
436	9000	5.9	85
438	17000	6.4	140
440	26000	7.2	180
444	40000	7.8	220

When the reservoir level was at 530.5 m, the following storm hydrograph (Table 2) was measured at the entrance to the dam, whose drainage area is 280 km^2.

Table 2

Time (h)	0	4	8	16	20	24	32
Discharge (m^3/s)	5	16	40	80	42	25	15

2.1 (a) Determine the bathymetric constants a and b. (4)
(b) how much water stored between 434 m and 440 m contours (4)

2.2. For the hydrograph given above, determine: *(Hint: Use constant base flow)*

a) Volume of direct runoff (m^3/s) (4)
b) Effective rainfall depth (cm) (2)
c) Unit hydrograph for a duration of 12 hrs (4)

QUESTION 3 [12 Marks]

For the new dam catchment site under Question 2, the following information are provided:

- Length of the longest watercourse = 10.8 km
- Slope of the longest watercourse = 1.4%
- M = 70 mm, R = 20 days, MAP = 550 mm
- C2 = 10% and C100 = 50%
- Franco-Rodier region 5.2.

Value of Q/Q_p		
	A_e (Km^2)	
T (yrs)	100	1000
50	0.380	0.447
100	0.494	0.556

Calculate the intensity and flood peaks corresponding to a return periods of 20 and 70 years return periods using the following methods:

(a) Standard Design Flood (5)
(b) Frankou-Rodier Method (5)
(c) Discuss the difference between (a) and (b) (2)

PART II: OPEN CHANNEL FLOW [50]

QUESTION 4 [20 Marks]

4.1.Define the term open channel flow. Explain it in terms of the flow condition, energy applied and its analysis. (5)
4.2.Discuss the two types of steady state non-uniform flow conditions. (4)
4.2.Briefly discuss about waves and surges in open channels. (4)
4.3. Derive Manning's Equation for uniform flow from basic principles (7)

QUESTION 5 [18 Marks]

A rectangular channel carries a discharge of 70 m^3/s. The median particle diameter of the suspended load is 2.5 mm. The channel conveyance factor is 700. Use $\upsilon = 1.14*10^{-6}$.
Determine the following:

(a) Chezy's Coefficient and D-W friction factor (2)
(b) Bed slope required to be provided (2)
(c) Normal flow width, depth and mean velocity (4)
(d) Critical flows: depth, velocity, slope and specific energy (4)
(e) Reynolds number and Froude number and state their status (2)
(f) Normal depth of flow at a discharge of 50 m^3/s (3)
(g) Comment on the applicability of Manning's Equation (1)

QUESTION 6 [12 Marks]

A trapezoidal channel (n = 0.016, m =1.5) carries a discharge of 50 m^3/s has a bottom width of 6m and bed slope of 1 in 500. The upstream end of the profile is assumed at a depth equal to 1% greater than the normal depth. Compute the water surface profile created by a dam that backs up the water to a depth of 3.6 m immediately behind the dam. Also identify the type of water surface profile.

FORMULA SHEET **HYDROLOGY**

$p = 1 - \left(1 - \frac{1}{T}\right)^N$	$G_2 = \left(\frac{I_1 + I_2}{2}\right) + G_1 - O_1$	$Q_2 = C_1.I_2 + C_2.I_1 + C_3.Q_1$	
i = regional factor × MAP factor × frequency factor		$C_1 = \frac{0.5\Delta t - KX}{K(1-X) + 0.5\Delta t}$	$Q = xA_e^y$
regional factor (coastal) = $\frac{122.8}{(1 + 4.779 \times t)^{0.7372}}$		$C_2 = \frac{0.5\Delta t + KX}{K(1-X) + 0.5\Delta t}$	$T = \frac{a \times N + b}{c \times m + d}$
regional factor (inland) = $\frac{217.8}{(1 + 4.164 \times t)^{0.8832}}$		$C_3 = \frac{K(1-X) - 0.5\Delta t}{K(1-X) + 0.5\Delta t}$	$C_1 + C_2 + C_3 = 1$
MAP factor = $\frac{18.79 + 0.17 \times \text{MAP}}{100}$		$\frac{\Delta t}{2(1-X)} \le K \le \frac{\Delta t}{2X}$	$S = \frac{a}{b+1} \times h^{b+1}$
ARF = $(90\,000 - 12\,800 \ln A + 9\,830 \ln t)^{0.4}$		$S_{\text{temporary}} = \frac{a}{b+1} \times \left[(h_{\text{FSL}} + h_{\text{overflow}})^{b+1} - h_{\text{FSL}}^{\ b+1}\right]$	
$Q = C \times i \times A$	$t_c = \left(\frac{0.87 \times L^2}{1\,000 \times S}\right)^{0.385}$	$Q_P = K_u \times \frac{A}{T_L}$	$Q = 10^6 \times \left(\frac{A}{10^8}\right)^{1-0.1K}$
$T_L = C_t\left(\frac{L \times L_c}{\sqrt{S}}\right)^{0.36}$	$\frac{V_t}{V_{50}} = 0.376 \ln\left(\frac{t}{3.5}\right)$	$Q = K \times h_{\text{overflow}}^{\frac{3}{2}}$	$K = \frac{2}{1+x}$
$P_{t,T} = 1.13(0.41 + 0.64 \ln T)(-0.11 + 0.27 \ln t)(0.79M^{0.69}R^{0.2})$		$A = a^{\frac{1}{b+1}} \times (b+1)^{\frac{b}{b+1}} \times S^{\frac{b}{b+1}}$	
$C_T = \frac{C_2}{100} + \left(\frac{Y_T}{2.33}\right)\left(\frac{C_{100}}{100} - \frac{C_2}{100}\right)$	$p = 1/T$	$G = \frac{\text{outflow}}{2} + \frac{\text{temporary storage}}{\Delta t}$	
$e = 611\exp\left[\frac{17.27 * T_d}{237.3 + T_d}\right]$	$e_s = 611\exp\left[\frac{17.27 * T}{237.3 + T}\right]$	$q_v = 0.622\frac{e}{P}$	$\rho_a = \frac{P}{R_a T}$
$Runoff\ Depth = \frac{V_{DRH}}{A}$	$RH = \frac{e}{e_s} * 100$	$p = \frac{1}{T}$	$T = \frac{N+1}{m}$

Table 2.1 Frequency factors for different return periods

Return period (T) (yrs)	2	5	10	20	50	100
Frequency (f) factor	0.47	0.64	0.81	1	1.3	1.6

Table 5.1 Values of return period factors (Y_T)

T (yrs)	2	5	10	20	50	100	200
Y_T (-)	0	0.85	1.28	1.64	2.05	2.33	2.58

FORMULA SHEET — OPEN CHANNEL FLOW

$\tau_o = \rho g R S_o$	$V = C\sqrt{RS_o}$	$V = \frac{K_u}{n} R^{2/3} S^{1/2}$	$n = \frac{d_m^{1/6}}{25}$	$R_h = \frac{A}{P_w}$
$K = \frac{AR^{2/3}}{n} = \frac{1}{n}\frac{A^{5/3}}{P^{2/3}} = K_u\left(\frac{Q}{\sqrt{S_o}}\right)$		$h_f = \left(\frac{fL}{D}\right)\frac{V^2}{2g}$	$q = \frac{Q}{b}$	$F_g = \gamma A L S_o$
$R_e = \frac{\rho V R}{\mu}$	$F_r = \frac{V}{\sqrt{gy}}$	$E_s = z + \frac{\alpha V^2}{2g}$	$M = \rho Q V$	$Q = V.A$
$C = \frac{R^{1/6}}{n}$	$q_{\max} = \sqrt{g y_c^3}$	$y_c = \left(\frac{q^2}{g}\right)^{(1/3)}$	$S_c = \frac{g\,n^2}{y_c^{1/3}}$	$P = \rho g h$

$$A = \frac{1}{8}(\phi - \sin\phi)D^2$$

$$P = \frac{1}{2}\phi D$$

$$B = \left(\sin\frac{\phi}{2}\right)D$$

Channel	n
River: earth, straight	0.02-0.025
River: earth, meandering	0.03-0.05
Unlined canal: earth, straight	0.018-0.025
Unlined canal: rock, straight	0.025-0.045
Concrete	0.012-0.017

$$Q = C_d C_v \frac{2}{3}\sqrt{\frac{2g}{3}}\, b h^{\frac{3}{2}}$$

$$V = \frac{1}{n} R^{\frac{2}{3}} S_0^{\frac{1}{2}}$$

$$K = \frac{A^{\frac{5}{3}}}{nP^{\frac{2}{3}}}$$

$$y_1 = \frac{y_2}{2}\left(\sqrt{1 + 8Fr_2^2} - 1\right)$$

$$y_2 = \frac{y_1}{2}\left(\sqrt{1 + 8Fr_1^2} - 1\right)$$

$$\frac{dE_s}{dx} = S_0 - S_f$$

$$\Delta E = \frac{(y_2 - y_1)^3}{4 y_1 y_2}$$