UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACCALAUREUS INGENERIAE *CIVIL ENGINEERING*
SUBJECT	:	**Hydraulic Engineering 3B**
CODE	:	**HMG3B21**
DATE	:	SSA EXAMINATION 07 JANUARY 2020
DURATION	:	3 HRS (SESSION 2) 12:30 – 15:30
WEIGHT	:	50 : 50
TOTAL MARKS	:	100

ASSESSOR	:	PROF M.O. DINKA	
MODERATOR	:	DR S NYENDE-BYAKIKA	FILE NO: HMG3B 2019
NUMBER OF PAGES	:	3 PAGES AND 3 ANNEXURES	

INSTRUCTIONS	:	QUESTION PAPERS MUST BE HANDED IN
REQUIREMENTS	:	2 SHEETS OF PAPER

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 about flood hydrology. Also discuss why hydrologists and engineers are interested to study flood hydrology. (6)

1.2. Briefly discuss about Empirical and deterministic methods for the determination of flood peaks. Give an example (s) for each. (5)

1.3. What are the precipitation types common in South Africa? Write the lifting mechanisms and conditions (stepwise) to be satisfied for the formation of precipitation. Discuss the formation of orographic precipitation in South Africa. Also briefly discuss why the windward side received more rain than the leeward side in orographic precipitation. (9)

QUESTION 2 [12 Marks]

Given below are a stream flow hydrograph at the inlet to the new dam catchment proposed under question 2.

Time (h)	0	2	4	6	10	24	20	24	32	36	40	44
Q ordinates (m^3/s)	42	40	80	130	150	130	90	48	27	15	5	0

Calculate the following:

(a) Ordinates of direct runoff (5)
(b) Depth of effective rainfall (3)
(c) Ordinates of unit 6 hr unit hydrograph (4)

Hint: *use a straight line method* for base flow separation

QUESTION 2 [18 Marks]

The storm hydrograph given bellow was measured at a point in a river at 2-hr intervals from an isolated storm of 2-hr duration for a stream with a drainage area of 350 km^2. The river is characterized by an X value of 0.30 and has an average flood wave velocity of 1.4 m/s for a typical flood.

Time (hr)	0	2	4	6	8	10	14	18	22	26	30
Discharge(m^3/s)	30	38	120	270	200	180	120	80	70	50	20

2.1. Evaluate the effect of flood at a point 12 km downstream of the measuring point. Define the meaning of X and K and then determine the time required for the flood wave to travel from upstream to downstream. Also determine the flood attenuation and lag time. Assume the initial outflow as 5 m^3/s. (12)

PART II: OPEN CHANNEL FLOW [50]

QUESTION 4 [16 Marks]

4.1. Discuss the importance of control points and its location in open channel flow. (5)

4.2. Define wave celerity and briefly discuss about surges in open channels. (5)

4.2. Prove the critical flow equation for constant discharge: $\frac{\alpha Q_{max}^2 B}{gA^3} = 1$ (6)

QUESTION 5 [18 Marks]

Water flows at a rate of 40 m^3 /s in a trapezoidal channel (**Fig. Q5**) with bottom width of 5m and side slope of 1:2 (V:H). The initial flow depth is 0.6 m. Both channels are infinitely long and has similar properties with the conveyance factor 600 and median particle size of 2.5 mm. Assume no head loss due to friction.

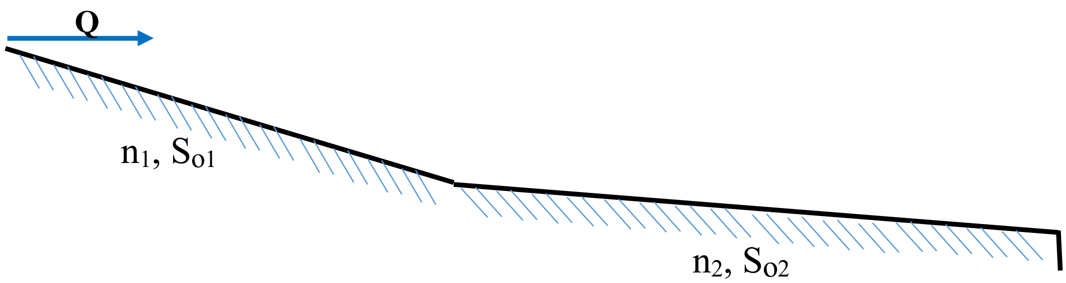

Fig. Q5

Calculate:

a) Normal depth and velocity (2)
b) Critical flow: depth and velocity (2)
c) Normal and critical bed slopes (2)
d) Specific energy and sequent depth (2)
e) Reynold and Froude numbers and state their status (2)
f) Calculate the following if hydraulic jump will occur. (5)
   i. Downstream flow depth
   ii. Energy loss in the channel
   iii. Velocity downstream of the hydraulic jump
   iv. Location, the height and the length of jump
g) Determine and sketch the type of the water surface profile in these channels for a flow depth of 0.3 m. Indicate the position of control points and hydraulic jump. (5)

QUESTION 6 [14 Marks]

A trapezoidal channel (n=0.018, m =1.5) with a bottom width of 4m carries a discharge of 40 m^3/s at a bed slope of 0.002. The water depth is 4.0 m immediately behind the dam. The upstream end of the profile is assumed at a depth equal to 1% greater than the normal depth. Compute the water depth at a distance of 500m and 800 m upstream the dam site (*Use a Standard Step Method).* Also identify the type of water surface profile.

FORMULA SHEET

HYDROLOGY

[redacted]

$$Q_2 = C_1.I_2 + C_2.I_1 + C_3.Q_1$$

HY

$$C_1 = \frac{0.5\Delta t - KX}{K(1-X)+0.5\Delta t}$$

$$C_2 = \frac{0.5\Delta t + KX}{K(1-X)+0.5\Delta t}$$

$$C_3 = \frac{K(1-X) - 0.5\Delta t}{K(1-X)+0.5\Delta t}$$

$p =$ … $\bar{I}_2 = \left(\frac{I_1 + I_2}{2}\right) + G_1$

$i = 1$ … [AP factor × frequ… factor

$$\text{regional factor (coastal)} = \frac{122.8}{(1 + 4.779 \times t}$$

$$\text{regional factor (inland)} = \frac{217.8}{(1 + 4.164 \times t)}$$

$$\text{MAP factor} = \frac{18.79 + 0.17 \times \text{MAP}}{100}$$

$e = 611\exp\left[\frac{17.27*T_d}{237.3+T_d}\right]$	$e_s = 611\exp\left[\frac{17.27*T}{237.3+T}\right]$	$q_v = 0.622\frac{e}{P}$	$\rho_a = \frac{P}{R_a T}$
$Runoff\ Depth = \frac{V_{DRH}}{A}$	$RH = \frac{e}{e_s}*100$	$p = \frac{1}{T}$	$T = \frac{N+1}{m}$

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**

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