UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACCALAUREUS INGENERIAE *CIVIL ENGINEERING*
SUBJECT	:	**Hydraulic Engineering 3B**
CODE	:	**HMG3B21**
DATE	:	SSA EXAMINATION 2 DECEMBER 2014
DURATION	:	3 HRS (SESSION 2) 11:30 – 14:30
WEIGHT	:	50:50
TOTAL MARKS	:	100

ASSESSOR	:	DR MO DINKA	
MODERATOR	:	DR MS MAGOMBEYI	File Number: HMG3B 2014
NUMBER OF PAGES	:	3 PAGES AND 2 ANNEXURES	

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

INSTRUCTIONS TO STUDENTS:

- PLEASE ANSWER ALL THE QUESTIONS.
- PROVIDE SHORT AND PRECISE ANSWERS FOR THE THEORETICAL PART
- SHOW ALL THE STEPS FOR CALCULATIONS CLEARLY

PART I: FLOOD HYDROLOGY [50]

QUESTION 1: THEORY [20 Marks]

a) As an engineer, why would you need Depth-Duration-Frequency curves? *(3)*
b) Distinguish between stochastic and deterministic methods for the determination of flood peaks. Give an example for each. *(6)*
c) Discuss the formation of convective precipitation in South Africa. Write the conditions (stepwise) to be satisfied for the formation of convective precipitation. *(4)*
d) Why is Area Reduction Factor (ARF) applied to adjust rainfall in an area? (3)
e) Define the following terms briefly: *(4)*
   (i) Coalescence (ii) Dew point temperature

QUESTION 2 [15 Marks]

Given a stream with the following records of monthly mean runoff:

Time (month)	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Runoff ($*10^6$ m^3/s)	94	122	45	5	5	2	0	2	16	7	72	92	21	55	53

Use the Sequent Peak and Ripple Methods to find the storage required to maintain a constant yield of 23 Mm^3/s per month from that stream.

QUESTION 3 [15 Marks]

The air temperature measured at sea level is 18 °C, the specific humidity is 0.005 kg H_2O/kg air and air pressure is measured as 130 KPa. The air is now lifted orographically through a height of 1650 m above sea level. Take Ra = 287 J/Kg/K
Determine the:

(a) Saturated and actual vapour pressures (mb) *(4)*
(b) Dew point temperature (°C) *(3)*
(c) Relative humidity (%) *(2)*
(d) Air density (kg/m^3) *(3)*
(e) Is it likely that it will rain? (3)

PART II: OPEN CHANNEL [50]

QUESTION 4. THEORY [20 Marks]

Answer the following questions in short and precise.

(a) Derive the relation between Chezy C and Darcey-Weisbatch f. *(6)*
(b) Define the occurrence of hydraulic jump and explain its advantage and disadvantages. *(6)*

(c) Derive equation of energy loss due to hydraulic jump from basic principle. *(8)*

QUESTION 5 [30 Marks]

Water flows at a rate of 120 m^3 /s in a rectangular channel with bottom width of 8m and side slope of 1:2 (V:H). The water flows out freely at the end of the channel. The long section of the channel is shown in the figure Q5 bellow. Manning's n is 0.014.

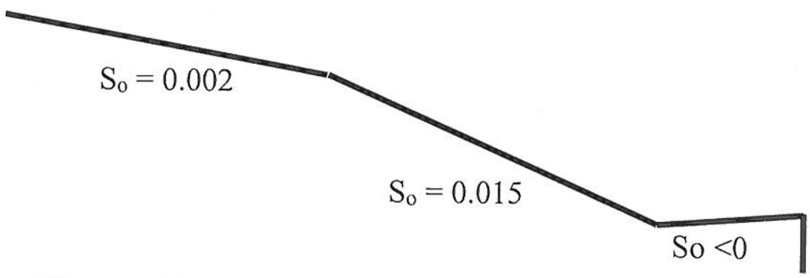

Figure Q5

a) Calculate the normal flow depth and velocity *(4)*
b) Calculate critical flow: depth, velocity and slope *(4)*
c) Determine the flow depth upstream and downstream of the hydraulic jump *(4)*
d) Identify all control points in the channel and determine the flow depths at all the control points *(6)*
e) Draw and identify the flow profiles for a flow depth of 0.8 m *(4)*
f) Calculate the following if hydraulic jump occurs. *(8)*
   (i) Downstream flow depth
   (ii) Energy loss in the channel
   (iii) Velocity downstream of the hydraulic jump
   (iv) Height of the jump
   (v) Length of the jump

FORMULA SHEET

Flood Hydrology

$p = 1 - \left(1 - \frac{1}{T}\right)^{N}$	$G_2 = \left(\frac{I_1 + I_2}{2}\right) + G_1 - O_1$	$Q_2 = C_2 I_1 + C_1 I_2 + C_3 Q_1$

i = regional factor × MAP factor × frequency factor	$C_1 = \frac{K \times X + 0.5 \times \Delta t}{K - K \times X + 0.5 \times \Delta t}$	$Q = xA_e^{y}$
regional factor (coastal) $= \frac{122.8}{(1 + 4.779 \times t)^{0.7372}}$	$C_2 = \frac{-K \times X + 0.5 \times \Delta t}{K - K \times X + 0.5 \times \Delta t}$	$T = \frac{a \times N + b}{c \times m + d}$
regional factor (inland) $= \frac{217.8}{(1 + 4.164 \times t)^{0.8832}}$	$C_3 = \frac{K - K \times X - 0.5 \times \Delta t}{K - K \times X + 0.5 \times \Delta t}$	$C_1 + C_2 + C_3 = 1$
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 $= (90\,000 - 12\,800 \ln A + 9\,830 \ln r)^{0.4}$	$S_{\text{temporary}} = \frac{a}{b+1} \times \left[(h_{\text{FSL}} + h_{\text{overflow}})^{b+1} - h_{\text{FSL}}^{\ b+1}\right]$	

$Q = C \times i \times A$	$t_c = \left(\frac{0.87 \times L^2}{1\,000 \times S}\right)^{0.385}$	$Q_P = K_u \times \frac{A}{T_L}$	$Q = 10^5 \times \left(\frac{A}{10^5}\right)^{1-0.1K}$
$T_L = C_t\left(\frac{L \times L_c}{\sqrt{S}}\right)^{0.36}$	$\frac{V_T}{V_{50}} = 0.376 \ln\left(\frac{T}{3.5}\right)$	$Q = K \times h_{\text{overflow}}^{\frac{3}{2}}$	$K = \frac{2}{1+x}$

$P_{t,T} = 1.13(0.41 + 0.64 \ln T)(-0.11 + 0.27 \ln t)(0.79M^{0.69}R^{0.2})$	$A = a^{\frac{1}{b+1}} \times (b+1)^{\frac{b}{b+1}} \times S^{\frac{b}{b+1}}$

$C_T = \frac{C_2}{100} + \left(\frac{Y_T}{2.33}\right)\left(\frac{C_{100}}{100} - \frac{C_2}{100}\right)$	$p = 1/T$	$G = \frac{\text{outflow}}{2} + \frac{\text{temporary storage}}{\Delta t}$

$e = 611\exp\left[\frac{17.27 * T_d}{237.3 + T_d}\right]$	$e_s = 611\exp\left[\frac{17.27 * T}{237.3 + T}\right]$	$q_v = 0.622\frac{e}{P}$	$RH = \frac{e}{e_s}$	$\rho_a = \frac{P}{R_a T}$
$Runoff\ Depth = \frac{V_{DRH}}{A}$	$K > \Delta t > 2KX$			

$\frac{\Delta t}{2(1-X)} \le K \le \frac{\Delta t}{2X}$	$K = \frac{\Delta L}{c}$	$K_t = R_t - Q_t + K_{t-1}\ if\ R_t - Q_t + K_{t-1} \ge 0$ $K_t = K_{t-1}\ R_t - Q_t + K_{t-1} < 0$

FORMULA SHEET

Open Channel Flow

$v = \frac{K_u}{n} R^{2/3} S^{1/2}$	$h_f = \frac{f.L}{D} \frac{V^2}{2g}$	$R_e = \frac{\rho v L}{\mu}$	$h_f = S_o L$
$\tau_o = \rho g R S_o$	$F_r = \frac{v}{\sqrt{gh}}$	$S_o = S_w = S_f$	$Q = A_1 v_1 = A_2 v_2$
$Q = \sum_{i=1}^{n} V_i A_i$	$V_i = \frac{K_u}{n_i} \left(\frac{A_i}{P_i} \right)^{2/3} S^{1/2}$	$K = \frac{K_u}{n} A R^{2/3}$	$n = 0.13 \frac{d^{1/6}}{g^{0.5}}$
$H_j = (y_2 - y_1)$	$H = Z + y + \frac{\alpha v^2}{2g}$	$E_1 = E_2 + \Delta z$	$\Delta E = \frac{(y_2 - y_1)^3}{4 y_1 y_2}$
$y_c = \left(\frac{q^2}{g} \right)^{1/3}$	$E_s = y + \frac{\alpha v^2}{2g}$	$v = C \sqrt{R\,S}$	$c = \sqrt{g y_1}$
$\alpha = \frac{\int u^3 dA}{\bar{V}^3 A} = \frac{V_1^3 A_1 + V_2^3 A_2 + V_3^3 A_3}{\bar{V}^3 (A_1 + A_2 + A_3)}$		$v_w = \sqrt{\frac{g y_2}{2 y_1} [(y_2 + y_1)]} + v_1$	$h = \left(\frac{fL}{D} \right) \frac{V^2}{2g}$
$\frac{y_2}{y_1} = \frac{1}{2} \left[\sqrt{1 + 8 F_1^2} - 1 \right]$		$H_j = 5 \quad to\, 7 * (y_2 - y_1)$	$v_w = \sqrt{\frac{g y_2}{2 y_1} [(y_2 + y_1)]} + v_1$
$H_j = 5 \quad to\, 7 * (y_2 - y_1)$		$\bar{V} = \frac{Q}{A} = \frac{V_1 A_1 + V_2 A_2 + V_3 A_3}{A_1 + A_2 + A_3}$	