UNIVERSITY OF JOHANNESBURG

PROGRAM : BACCALAUREUS INGENERIAE
CIVIL ENGINEERING

SUBJECT : **Hydraulic Engineering 3B**

CODE : **HMG3B21**

DATE : SUMMER EXAMINATION
11 NOVEMBER 2014

DURATION : 3 HRS (SESSION 2) 12:30 - 15:30

WEIGHT : 50:50

TOTAL MARKS : 100

ASSESSOR : DR MO DINKA 02/11/2014

MODERATOR : DR MS MAGOMBEYI 2/11/2014 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 THEORETICAL PART
- SHOW All THE STEPS FOR CALCULATIONS CLEARLY

PART I: FLOOD HYDROLOGY [50]

QUESTION 1: THEORY [20]

a) As a hydrologist, you are sent to Lake Sibaya in KwaZulu-Natal region to study its characteristics. What parameters (at least five) would you select and use to characterize the lake and its catchment. Define the parameters and explain the useful information you can obtain out of it. *(7 pts)* Marks (use marks for all)

b) Discuss the formation of orographic precipitation in South Africa. Write the conditions (stepwise) to be satisfied for the formation of orographic precipitation. ~~What are the lifting mechanisms responsible for the formation~~? *(6 pts)*

c) Why is Area Reduction Factor (ARF) ~~is~~ applied to adjust rainfall in an area? (3 pts)

d) Define the following terms briefly: **(2 pts each)**

(i) ~~a)~~ Cloud seeding (ii) ~~b)~~ Flood routing

QUESTION 2 [15]

The hydrograph given bel~~l~~ow was measured at a point in a river. The river is characterized by an X value of 0.30 in the Muskingum equation and has an average flood wave velocity (celerity) of 1.1 m/s for a typical flood.

t (h)	0	2	4	6	8	10	14	18	22	26	30
Q (m^3/s)	0	40	80	250	200	180	120	80	60	20	0

leave as it is

i. Evaluate the effect of flood at a point 8.5 km downstream of the measuring point. (7 pts)

ii. Determine the time required for the flood wave to travel from upstream to downstream. (4 pts)

iii. Determine flood attenuation and lag time. (4 pts)

Assume reservoir was empty initially.

QUESTION 3 [15]

At a certain climatic station, air pressure is measured as 120 KPa. The air temperature at saturated vapor pressure is 21 °C and the specific humidity is 0.006 kg H_2O/kg air. The air is now lifted orographically through a height of 1760 m above sea level. Take $R_a = 287$ 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/m³) (3)

~~(d) Will it be likely that it will rain?~~

(e) Is it likely that it will rain? (3)

PART II: OPEN CHANNEL [50]

QUESTION 4. THEORY [20]

Answer the following questions ~~in short and~~ precise

(a) Write Bernoulli's equation and state the assumptions. (4 pts)

(b) Write equation of a dimensionless parameter used to classify fluids flow into laminar or turbulent. Also give the ranges of the dimensionless parameter for laminar and turbulent flow for open channel. (4 pts)

(c) Define the occurrence of hydraulic jump and explain its advantage and disadvantages. (5 pts)

(d) Discuss the concept of control point. (4 pts)

QUESTION 5 [14]

(a) Derive equation of energy loss due to hydraulic jump from basic principles. (7 pts)

(b) Derive Chezy Equation for uniform flow from basic principles (7 pts)

QUESTION 6 [23]

Water flows at a rate of 20 m^3 /s in a trapezoidal channel with bottom width of 5m and side slope of 1:[illegible] (V:H). The initial flow depth is 0.3m and the slope changes from steep to flat ~~as shown in Figure.~~ The conveyance factor of the channel is 400 and Manning's n is 0.025. Assume no head loss due to friction.

Calculate:

a) Normal depth and velocity
b) Critical flow depth and velocity
c) Normal and critical bed slopes
d) Specific energy and sequent depth
e) Reynold and Froude numbers and state their status
f) Type of flow for a flow depth of 0.3 m
g) Calculate the following if hydraulic jump will occur
   a. Downstream flow depth
   b. Energy loss in the channel
   c. Velocity downstream of the hydraulic jump
   d. Height of jump
   e. Length of 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 $= \frac{18.79 + 0.17 \times MAP}{100}$		$\frac{\Delta t}{2(1-X)} \le K \le \frac{\Delta t}{2X}$	$S = \frac{a}{b+1} \times h^{b+1}$
$ARF = (90\,000 - 12\,800 \ln A + 9\,830 \ln r)^{0.4}$		$S_{temporary} = \frac{a}{b+1} \times \left[(h_{FSL} + h_{overflow})^{b+1} - h_{FSL}^{\ b+1}\right]$	
$Q = C \times i \times A$	$t_c = \left(\frac{0.87 \times L^2}{1\,000 \times S}\right)^{0.385}$	$Q_T = K_u \times \frac{A}{T_L}$	$Q = 10^6 \times \left(\frac{A}{10^8}\right)^{1-0.1K}$
$T_L = C_t \left(\frac{L \times L_c}{\sqrt{S}}\right)^{0.36}$	$\frac{V_t}{V_{50}} = 0.376 \ln\left(\frac{t}{3.5}\right)$	$Q = K \times h_{overflow}^{\frac{3}{2}}$	$K = \frac{2}{1+x}$
$P_{t,T} = 1.13(0.41 + 0.64 \ln T)(-0.11 + 0.27 \ln t)(0.79 M^{0.69} R^{0.2})$		$A = a^{\frac{1}{b+1}} \times (b+1)^{\frac{b}{b+1}} \times S^{\frac{b}{b+1}}$	
$C_T = \frac{C_2}{100} + \left(\frac{Y_T}{2.33}\right)\left(\frac{C_{100}}{100} - \frac{C_2}{100}\right)$	$p = 1/T$	$G = \frac{\text{outflow}}{2} + \frac{\text{temporary storage}}{\Delta t}$	

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

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

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