UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME	:	HYDRAULICS
COURSE CODE	:	BFC 21103
PROGRAMME	:	BFF
EXAMINATION DATE	:	DECEMBER 2019/JANUARY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS IN **PART A**, AND **TWO (2)** QUESTIONS IN **PART B**

THIS QUESTION PAPER CONSISTS OF **TEN (10)** PAGES

PART A: ANSWER **ALL** QUESTIONS

Q1 (a) A 6 m diameter semicircle channel conveys 12 m^3/s of flow at depth of 2.5 m. Determine the state of flow based on Froude number.

(4 marks)

(b) A 98.43-inch wide rectangular channel conveys flow at 4500 L/s on a slope which drops 1 m per 250000 cm length, with Manning roughness of 0.016. Determine the state of flow based on Reynolds number, where $\nu = 1.004 \times 10^{-6}$ m^2/s.

(7 marks)

(c) A channel shown in **FIGURE Q1(c)** carries flow at a rate of 0.85 m^3/s on longitudinal slope 0.003 and Chezy coefficient 55.7. Calculate the depth of uniform flow.

(5 marks)

(d) Based on **QUESTION Q1(c)**, if inclined length L of the channel is 50 m, estimate the cost to construct this channel. Excavation cost is RM 4.20 per m^3 and lining cost is RM 6.00 per m^2.

(4 marks)

Q2 (a) **TABLE Q2(a)** shows variation in values of roughness coefficient. Using example, explain why these values differ with each other.

(4 marks)

(b) A trapezoidal channel with 3 m bottom width and 3(H) : 2(V) side slope carries a discharge of 22000 L/s on longitudinal slope of 0.002 and roughness n = 0.013. Calculate the critical depth.

(5 marks)

(c) A trapezoidal channel is to carry 22 m^3/s of flow on a bed slope of 1/2000. Given that Manning's n is 0.026 and the sides of channel are inclined 52.5° to the vertical, determine the bottom width, depth and velocity for the best hydraulic section.

(7 marks)

(d) A channel is required to convey 20 m^3/s of water at mean velocity of 3 m/s. Evaluate depth of flow for most effective parabola and semicircle sections.

(4 marks)

Q3 (a) With a sketch of specific energy curve, briefly explain alternate depths.

(4 marks)

(b) Depth of critical flow in a channel shown in **Figure Q3(b)** is $y_c = b/3$. Determine b as a function of flow discharge Q.

(5 marks)

(c) A 6 m wide rectangular channel discharges flow at 0.85 $m^3/s/m$. A section of the channel is to be constricted. Analyse limit of the channel's width that can be constricted so that the upstream uniform flow depth is maintained at 0.90 m.

(7 marks)

(d) A control section 'controls' the upstream or downstream flow. Justify the similarities and the differences between Case 1, Case 2 and Case 3 for flow over broad-crested weir.

(4 marks)

PART B: ANSWER **ANY TWO (2)** QUESTIONS

Q4 (a) Briefly explain phenomenon of hydraulic jump with the aid of diagram.

(3 marks)

(b) A spillway is discharging flow with velocity of 35 m/s and depth of 1.5 m. Hydraulic jump occured downstream resulted in power due to energy loss P_L of 304 MW. Find

(i) Conjugate depth y_2

(2 marks)

(ii) Height of jump

(1 mark)

(iii) Width of spillway

(3 marks)

(c) Water flows at 2.0 m^3/s in a 4 m wide rectangular channel with bottom slope of 1/1250. Gradually-varied flow (GVF) is formed in the channel and the flow depth at a section is 0.2 m. Categorize the GVF profile based on **TABLE Q4(c)** if Manning coefficient n is 0.016. Briefly explain where this type of GVF will occur.

(7 marks)

(d) **FIGURE Q4(d)** illustrates schematic sketch of GVF. Using information provided in the figure, recommend equation for

(i) Total energy H

(ii) Specific energy E

(4 marks)

Q5 (a) Briefly explain **ONE (1)** purpose each for placing (i) chute blocks; and (ii) baffle blocks at the bottom of stilling basin.

(4 marks)

(b) Flow in a small stream is measured using a 90° V-notch weir. Invert elevation of the V-notch is set at 2.00 m above datum. A gauge staff reads level of impounded water behind the weir at 2.40 m. Assuming coefficient of discharge of 0.62, determine rate of flow of the stream.

(3 marks)

(c) A 2.7 m wide rectangular channel conveys flow at uniform depth of 1.2 m. A sluice gate with coefficient of discharge 0.61 is built within the channel. At an opening of 20 cm, hydraulic jump is formed downstream. If depth of flow immediately after the gate and before hydraulic jump is 0.125 m, analyse

(i) Conjugate depth of hydraulic jump, and

(5 marks)

(ii) Discharge through spillway.

(2 marks)

(d) A weir is built upstream of a spillway discharging flow with velocity V_1 and Froude number Fr_1 of 33.57 m/s and 21.52, respectively. Rate of flow is 100 m^3/s and width of spillway is 12 m. Recommend size and quantity of Blocks A and C for stilling basin USBR Type III downstream of spillway.

(6 marks)

Q6 (a) Classify Pelton and Francis turbines in terms of
(i) Head of water H
(ii) Specific speed N_s

(4 marks)

(b) A centrifugal pump with 30 cm diameter impeller is discharging 0.20 m^3/s of water at 1200 rpm and 15 m head of water. If another similar pump is required to deliver 2.0 m^3/s at 1000 rpm, calculate diameter of the impeller and head that could be developed by this pump.

(5 marks)

(c) An 82.5% efficient turbine is supplied with 25 m^3/s of water with 15 m head. Determine
(i) Fluid power

(1 mark)

(ii) Shaft power of the turbine, and

(1 mark)

(iii) Shaft power of a 1 : 6 model under a head of 1.5 m.

(5 marks)

(d) Predict with an aid of diagram, what would happen to discharge Q and pressure head H of flow if two similar pumps are installed in parallel and in series within a piping system.

 (4 marks)

- END OF QUESTIONS -

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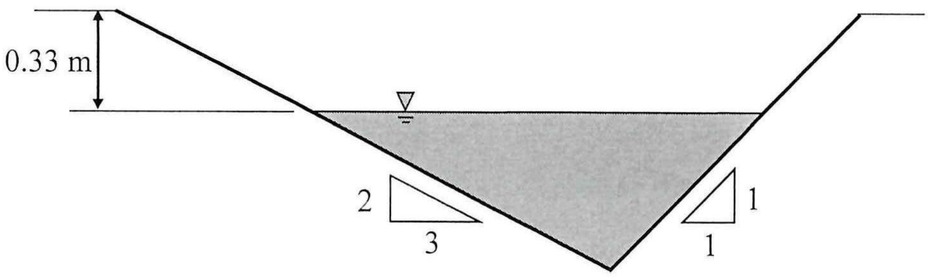

FIGURE Q1(c)

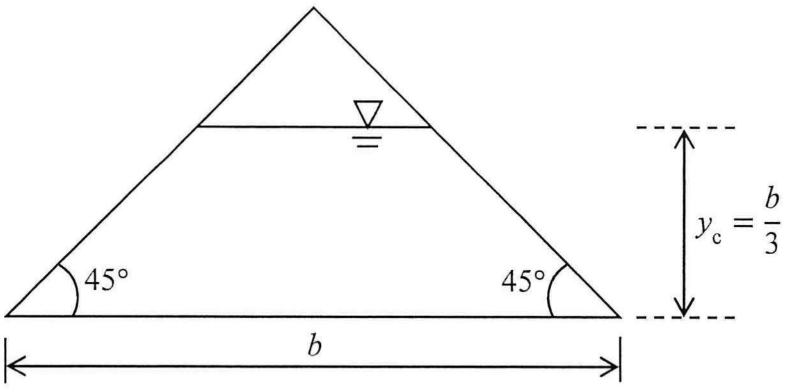

FIGURE Q3(b)

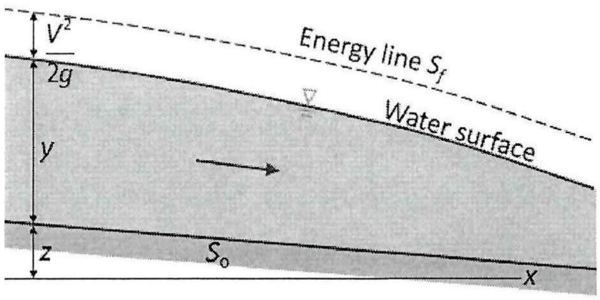

FIGURE Q4(d)

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TABLE Q2(a): Manning roughness coefficient

Channel type	**Manning's *n***
Natural channel	
i. Clean and Straight	0.030
ii. Vegetation	0.100
iii. Mountain River	0.040 – 0.050
Artificial Channel	
i. Earth ground (clean)	0.022
ii. Earth ground (vegetation)	0.027 – 0.035
iii. Cement (plane/ smooth)	0.011
iv. Cement (mortar)	0.013
v. Concrete	0.017
vi. Asphalt (smooth)	0.013
vii. Asphalt (rough)	0.016
viii. Steel	0.012

TABLE Q4(c): Mild slope characteristics

Channel	**Region**	**Condition**	**Type**
Mild slope	1	$y > y_o > y_c$	M_1
	2	$y_o > y > y_c$	M_2
	3	$y_o > y_c > y$	M_3

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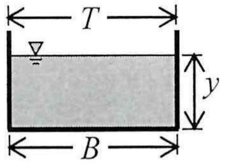
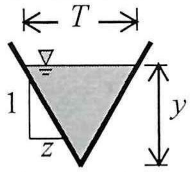
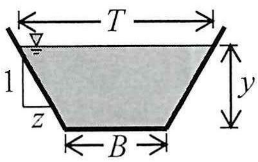
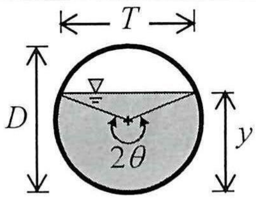
Open channel flow section geometries

Section	Area A	Top width T	Wetted perimeter P
 Rectangular	By	B	$B+2y$
 Triangular	zy^2	$2zy$	$2y\sqrt{1+z^2}$
 Trapezoidal	$By+zy^2$	$B+2zy$	$B+2y\sqrt{1+z^2}$
 Circular	$\frac{D^2}{8}(2\theta-\sin 2\theta)$	$D\sin\theta$	θD

Sizing for USBR Type III stilling basin

Block A	Block B	Block C
$h_1 = y_1$	$h_3 = y_1(0.168\text{Fr}_1 + 0.63)$	$h_4 = y_1\left(\frac{\text{Fr}_1}{18}+1\right)$
$w_1 = y_1$	$w_3 = \frac{3}{4}h_3$	$t = \frac{h_3}{5}$
$s_1 = y_1$	$s_3 = \frac{3}{4}h_3$	$z_2 = 2.0$
	$t = \frac{h_3}{5}$	
	$z_1 = 1.0$	
	$L_1 = \frac{4}{5}y_2$	

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Best hydraulic/ most efficient section

Cross section	Area A	Wetted perimeter P	Hydraulic radius R	Top width T	Hydraulic depth D
Trapezoid	$\sqrt{3}y^2$	$2\sqrt{3}y$	$\frac{y}{2}$	$\frac{4\sqrt{3}}{3}y$	$\frac{3}{4}y$
Rectangle	$2y^2$	$4y$	$\frac{y}{2}$	$2y$	y
Triangle	y^2	$2\sqrt{2}y$	$\frac{\sqrt{2}}{4}y$	$2y$	$\frac{y}{2}$
Semicircle	$\frac{\pi}{2}y^2$	πy	$\frac{y}{2}$	$2y$	$\frac{\pi}{4}y$
Parabola	$\frac{4\sqrt{2}}{3}y^2$	$\frac{8\sqrt{2}}{3}y$	$\frac{y}{2}$	$2\sqrt{2}y$	$\frac{2}{3}y$

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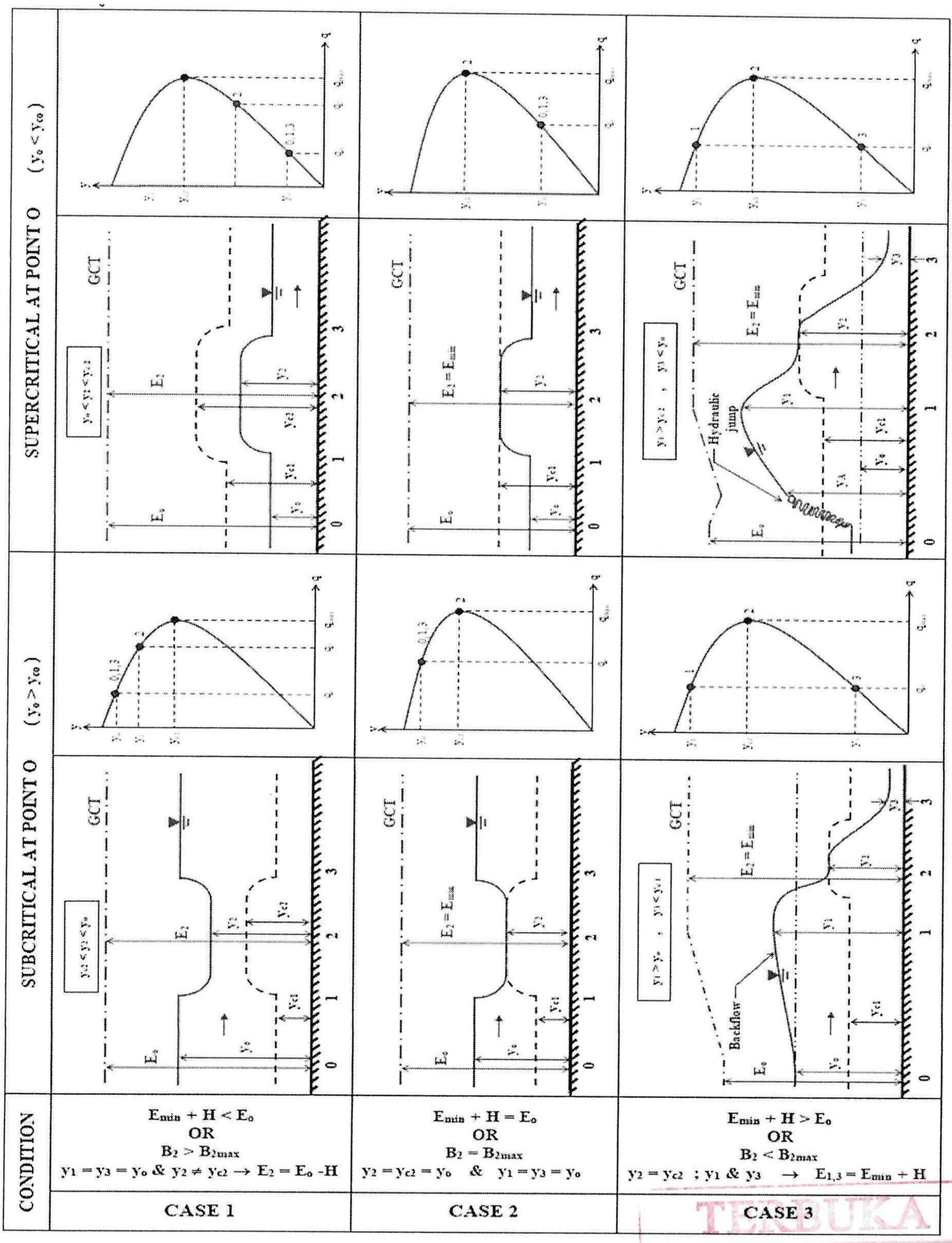
Characteristics of flow through constricted channel



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Equations sheet

$Q = AV$ $\quad q = yV$ $\quad Q = A\frac{1}{n}R^{\frac{2}{3}}S_o^{\frac{1}{2}}$ $\quad Q = ACR^{\frac{1}{2}}S_o^{\frac{1}{2}}$

$\mathrm{Fr} = \frac{V}{\sqrt{gD}}$ $\quad \mathrm{Fr}^2 = \frac{q^2}{gy^3}$ $\quad \mathrm{Fr} = \frac{q}{\sqrt{gy}}$ $\quad \mathrm{Re} = \frac{VR}{\nu}$

$\frac{A_c^3}{T_c} = \frac{Q^2}{g}$ $\quad \frac{V_c}{\sqrt{gD_c}} = 1$ $\quad y_c = \sqrt[3]{\frac{q^2}{g}}$ $\quad E_{\min} = \frac{3}{2}y_c$

$E = y + \frac{q^2}{2gy^2}$ $\quad E = y + \frac{V^2}{2g}$ $\quad E_L = \frac{(y_2 - y_1)^3}{4y_1y_2}$

$\frac{y_2}{y_1} = \frac{1}{2}\left(-1 + \sqrt{1 + 8\mathrm{Fr}_1^2}\right)$ $\quad V_1 = \sqrt{2g(y_o - y_1)}$

$Q = C_d ab\sqrt{2g(y_o - y_1)}$ if $(y_o - y_1) > y_2$

$Q = C_d ab\sqrt{2g(y_o - y_2)}$ if $(y_o - y_1) \le y_2$

$dx = \frac{dy}{S_o}\left[\frac{1 - \left(\frac{y_c}{y_{ave}}\right)^3}{1 - \left(\frac{K_o}{K_{ave}}\right)^2}\right]$ $\quad K = \frac{Q}{S_o^{\frac{1}{2}}} = \frac{1}{n}AR^{\frac{2}{3}}$ $\quad Q = \frac{8}{15}C_d\sqrt{2g}\,H_1^{\frac{5}{2}}\tan\left(\frac{\theta}{2}\right)$

$P = \gamma QH$ $\quad P = \eta_o\gamma QH$ $\quad P = \frac{2\pi N}{60}T$ $\quad P_L = \rho g Q E_L$

$\frac{ND}{\sqrt{H}}$ $\quad \frac{Q}{ND^3}$ $\quad \frac{P}{D^5N^3}$ $\quad N_s = \frac{N\sqrt{P}}{H^{\frac{5}{4}}}$

$\frac{H}{N^2D^2}$ $\quad Q_u = \frac{Q}{\sqrt{H}}$ $\quad N_u = \frac{N}{\sqrt{H}}$ $\quad P_u = \frac{P}{H^{\frac{3}{2}}}$