Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2018/2019

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

THIS QUESTION PAPER CONSISTS OF **NINE (9)** PAGES

PART A: ANSWER **ALL** QUESTIONS

Q1 (a) Define the following
(i) Depth of flow
(ii) Discharge
(iii) Non-prismatic channel
(iv) 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 at 0.016.

(i) Convert all measurements in SI units

(4 marks)

(ii) Determine the state of flow based on Reynolds number ($\nu = 1.004 \times 10^{-6}$ m^2/s).

(4 marks)

(c) A trapezoidal channel with 3 m width and side slope at 2(H):3(V) carries a discharge of 18000 L/s on longitudinal slope of 1:500 and roughness $n = 0.013$. Calculate

(i) Normal depth of flow, and

(4 marks)

(ii) Critical depth.

(4 marks)

Q2 (a) Define the following
(i) Section factor Z
(ii) Bazin roughness coefficient m.

(2 marks)

(b) Give **TWO (2)** assumptions in derivation of Chezy equation.

(3 marks)

(c) A compound channel in **Figure Q2(c)** has its bottom being rounded off by a circular curve, where the radius is equal to depth of flow y_o. The longitudinal slope is 1 in 2000 and Manning's roughness coefficient is 0.017. Calculate the depth of flow if discharge is 25 m^3/s.

(6 marks)

(d) A channel is required to convey 10 m^3/s of water at mean velocity of 1.25 m/s. Calculate:

(i) Dimensions of the effective section for rectangular, parabola and semicircle shapes,

(7 marks)

(ii) Evaluate which channel in **Q2(d)(i)** that has the least wetted perimeter.

(2 marks)

Q3 (a) Flow in an approximately rectangular channel has a velocity head equal to its depth. Is the flow sub-critical, critical, or super-critical? Explain your reasoning.

(2 marks)

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

(5 marks)

(c) A 3.05 m wide rectangular channel carries 3.4 m^3/s of flow at uniform depth 0.6 m. A 0.2 m high broad crested weir is placed across the channel.

(i) Does this weir cause a hydraulic jump upstream of the weir? Explain why.

(5 marks)

(ii) Calculate depth of flow above the weir, and just upstream of the weir. Classify the surface profile occur upstream of the weir. Sketch the resulting water-surface profile and energy line, showing the critical depth y_c and normal depth y_o.

(8 marks)

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

Q4 (a) Describe how gradually-varied flow is formed, using **ONE (1)** flow example.

(2 marks)

(b) Identify **THREE (3)** examples on why gradually-varied flow (GVF) profile analysis is important.

(3 marks)

(c) Flow from a concrete rectangular channel (Manning's $n = 0.017$) falls freely into a reservoir at rate of 7.8 m^3/s. The width and longitudinal slope of the channel is 5 m and 0.0006, respectively. At the inlet of the reservoir, the flow becomes critical. Using numerical integration method with 4 steps, analyse the type of profile and plot the water surface profile. The answers should be in four significant figures.

(15 marks)

Q5 (a) List **TWO (2)** examples of hydraulic structure.

(2 marks)

(b) With aid of sketch, briefly explain the function of spillway.

(3 marks)

(c) A rectangular channel conveys flow at uniform depth of 120 cm. A sluice gate is built within the channel. At certain height of gate opening, hydraulic jump is formed downstream. If the depth of flow immediately after the gate and before hydraulic jump is 0.125 m, analyse conjugate depth of the hydraulic jump.

(5 marks)

(d) A spillway has its height of water level, H_1 and height of water level to peak spillway, H_0 at 42 m and 5.5 m, respectively. The discharge of flow is given as 100 m^3/s and the width of the spillway is 12 m.

(i) Based on **Figure Q5(d)**, determine length of basin.

(6 marks)

(ii) Design a stilling basin involving with Block A and B at the downstream of spillway following the Stilling Basin Type III method.

(4 marks)

Q6 (a) Turbines can be classified into impulse and reaction turbines.

(i) Give **ONE (1)** example of each turbine.

(2 marks)

(ii) Briefly explain on how turbine derive its energy.

(3 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) A Francis turbine produces 7560 kW at 450 rpm under a net head of 26 m with an overall efficiency of 80%. Assuming same turbine works with a net head of 60 m under homologous conditions. Analyse the
(i) Revolution per-minute
(ii) Discharge
(iii) Brake power
(iv) Specific speed.

(10 marks)

END OF QUESTION

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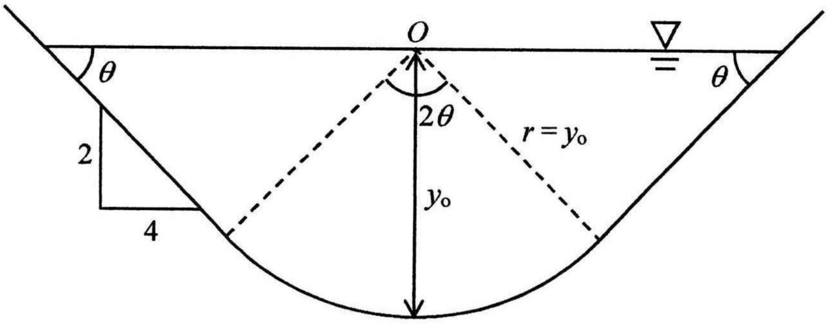

FIGURE Q2(c)

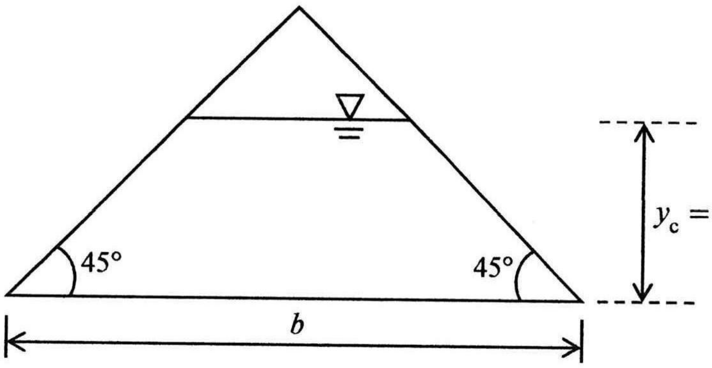

FIGURE Q3(b)

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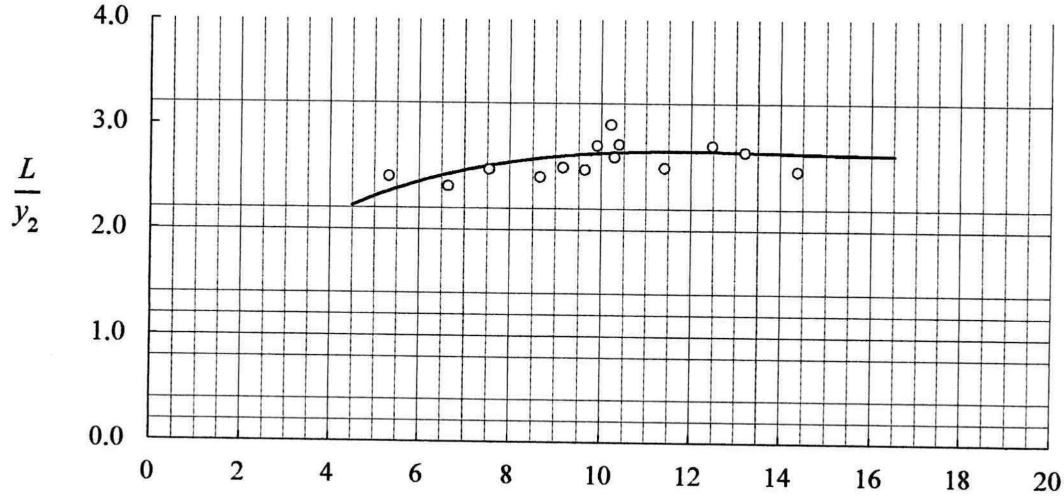


$$\mathrm{Fr}_1 = \frac{V_1}{\sqrt{g y_1}}$$

FIGURE Q5(d): Length of jump on horizontal floor

Table 1. Open channel flow section geometries

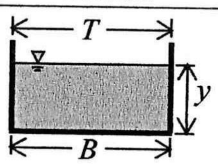
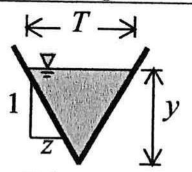
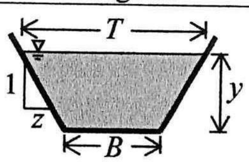
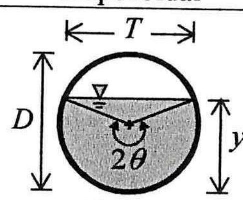
Section	Area A	Top width T	Wetted perimeter P
 Rectangular	By	B	$B+2y$
 Triangular	zy^2	$2zy$	$2y\sqrt{1+z^2}$
 Trapezoidal	$By+zy^2$	$B+2zy$	$B+2y\sqrt{1+z^2}$
 Circular	$\frac{D^2}{8}(2\theta-\sin 2\theta)$	$D\sin\theta$	θD

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Table 2. 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	$\frac{4\sqrt{2}}{3}y^2$	$\frac{8\sqrt{2}}{3}y$	$\frac{y}{2}$	$2\sqrt{2}y$	$\frac{2}{3}y$

Table 3. Sizing for USBR Type III stilling basin

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

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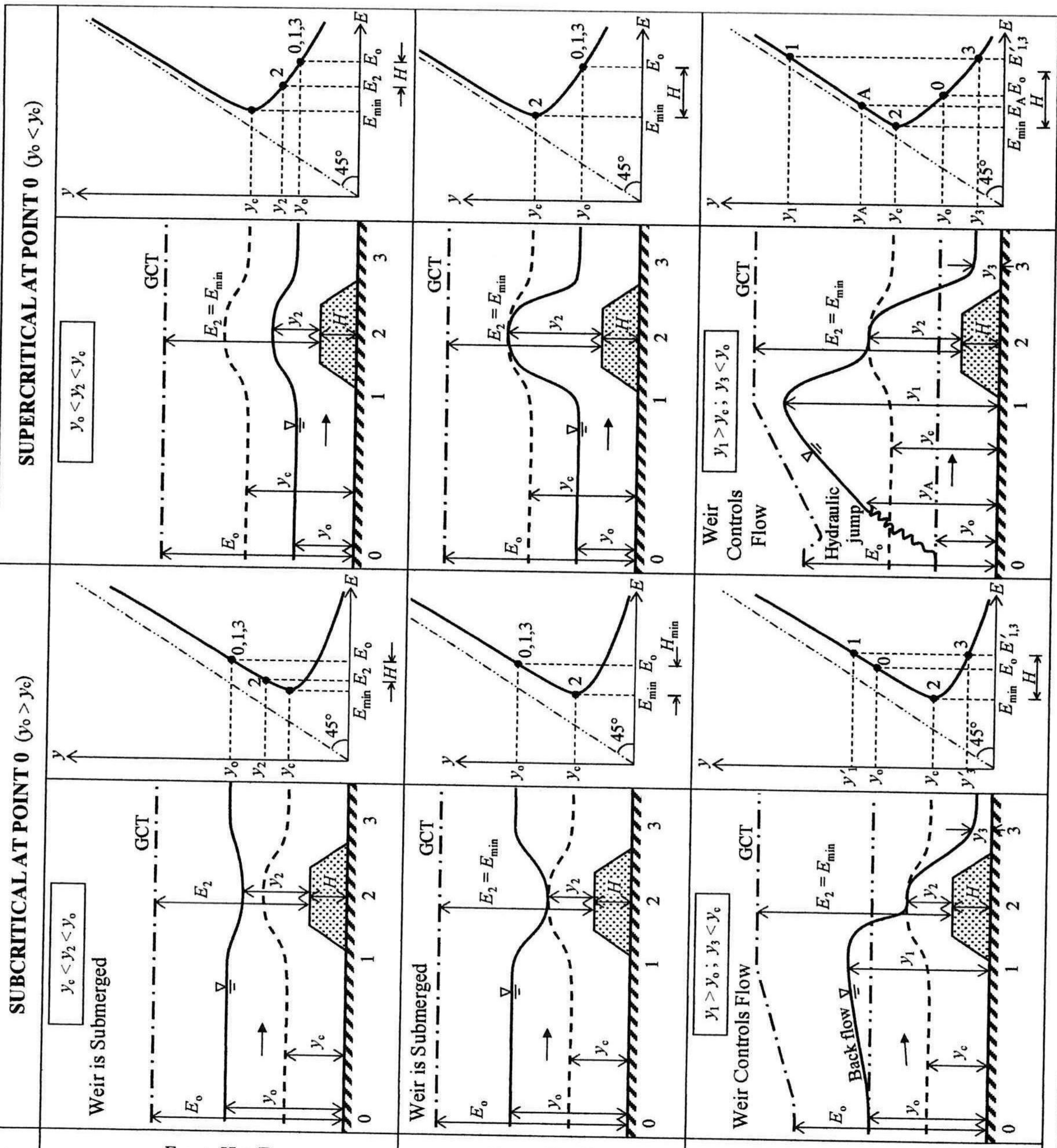
Table 4. Characteristics of flow over broad-crested weir



CONDITION	CASE
$E_{min} + H < E_o$ or $H < H_{min}$ $y_1 = y_3 = y_o$ & $y_2 \neq y_c \rightarrow E_2 = E_o - H$	CASE 1
$E_{min} + H = E_o$ or $H = H_{min}$ $y1 = y_3 = y_o$ & $y_2 = y_c$	CASE 2
$E_{min} + H < E_o$ or $H < H_{min}$ $y_1 = y_3 = y_o$ & $y_2 \neq y_c \rightarrow E_2 = E_o - H$	CASE 3

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Equations sheet

$$Q = AV \qquad q = yV$$

$$Q = A\frac{1}{n}R^{\frac{2}{3}}S_o^{\frac{1}{2}} \qquad Q = ACR^{\frac{1}{2}}S_o^{\frac{1}{2}}$$

$$\mathrm{Fr} = \frac{V}{\sqrt{gD}} \qquad \mathrm{Fr}^2 = \frac{q^2}{gy^3} \qquad \mathrm{Re} = \frac{VR}{\nu} \qquad \frac{A_c^3}{T_c} = \frac{Q^2}{g} \qquad \frac{V_c}{\sqrt{gD_c}} = 1$$

$$y_c = \sqrt[3]{\frac{q^2}{g}} \qquad E_{\min} = \frac{3}{2}y_c \qquad E = y + \frac{q^2}{2gy^2} \qquad E = y + \frac{V^2}{2g}$$

$$\frac{y_2}{y_1} = \frac{1}{2}\left(-1 + \sqrt{1 + 8\mathrm{Fr}_1^2}\right) \qquad V_1 = \sqrt{2g(y_o - y_1)} \qquad E_L = \frac{(y_2 - y_1)^3}{4y_1y_2}$$

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

$$P = \gamma QH \qquad P = \eta_o \gamma QH \qquad P = \frac{2\pi N}{60}T$$

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

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