Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2017/2018

COURSE NAME	:	HYDRAULICS
COURSE CODE	:	BFC 21103
PROGRAMME	:	BFF
EXAMINATION DATE	:	JUNE / JULY 2018
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER: (A) **ALL** QUESTIONS IN **SECTION A**, AND (B) **ANY TWO (2)** QUESTIONS IN **SECTION B**

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

SECTION A: ANSWER **ALL** QUESTIONS

Q1 (a) Give **TWO (2)** differences between flow in pipe and flow in open channel.

(4 marks)

(b) A compound channel shown in **FIGURE Q1(b)** 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.

(6 marks)

(c) A 1.5 m wide rectangular channel conveys flow at 3500 L/s on a longitudinal slope of 1/2000 and Manning roughness 0.016. Determine the state of flow based on

(i) Reynolds number ($\nu = 1.004 \times 10^{-6}$ m^2/s), and

(ii) Froude number.

(10 marks)

Q2 (a) Explain briefly the following

(i) Unsteady flow

(ii) Uniform flow.

(2 marks)

(b) A trowel-finish trapezoidal concrete channel carries 2.5 m^3/s of flow on a longitudinal slope of 0.0004. Analyse the proportions of the most efficient channel section having

(i) Side slope 2 horizontal : 1 vertical, and

(12 marks)

(ii) Most effective side slope.

(6 marks)

Q3 (a) 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 the limit of channel width that can be constricted when upstream depth of flow is not allowed to exceed 0.90 m.

(6 marks)

(b) A 7.5 m wide rectangular channel conveys flow at uniform depth of 2.5 m. The channel longitudinal slope is 1/2000 with Manning roughness n of 0.030. If a 0.25 m high broad-crested weir is to be built across the channel, analyse the depth of flow upstream, above, and downstream of the weir.

(14 marks)

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

Q4 (a) Explain briefly how hydraulic jump is formed.

(2 marks)

(b) A hydraulic jump occurs within a rectangular channel with energy loss of 3.5 m. If the supercritical upstream flow has Froude number of 9.0, determine the conjugate depths.

(5 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.

(13 marks)

Q5 (a) Explain briefly the application of the following hydraulic structures.

(i) Spillway
(ii) Sluice gate
(iii) Energy dissipator

(6 marks)

(b) A weir is installed within a 1.0 m wide rectangular channel. Flow discharges under a 36 cm head. Considering coefficient of discharge of 0.60, calculate the rate of flow if the following are used.

(i) Triangular weir with side slope 1(H) : 2(V)
(ii) 1.0 m wide rectangular weir
(iii) 0.3 m bottom-width trapezoidal weir with side slope 1(H) : 1(V).

(6 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 the depth of flow immediately after the gate and before hydraulic jump is 0.125 m, analyse

(i) Conjugate depth of the hydraulic jump, and

(6 marks)

(ii) Discharge through the spillway.

(2 marks)

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Q6 (a) Explain briefly the functions of following machines.
(i) Pump
(ii) Turbine

(4 marks)

(b) Pump is required to supply 22,000 L/s of water for a residential area under a head of 18 m. If two identical pumps installed in series are to be used, calculate

(i) Power delivered to the flow by each pump, and

(4 marks)

(ii) Shaft power and speed of each pump if its efficiency is 72% and the torque is 11 kNm.

(6 marks)

(c) An 82.5% efficient turbine is supplied with 25 m^3/s of water with 15 m head. Determine
(i) Fluid power
(ii) Shaft power of the turbine, and
(iii) Shaft power of a 1 : 6 model under a head of 1.5 m.

(6 marks)

- END OF QUESTION -

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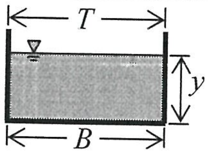
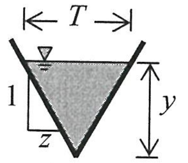
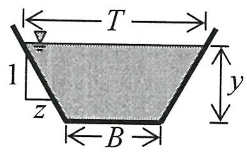
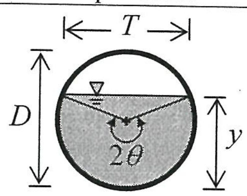
Table 1. Open channel flow section geometries

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

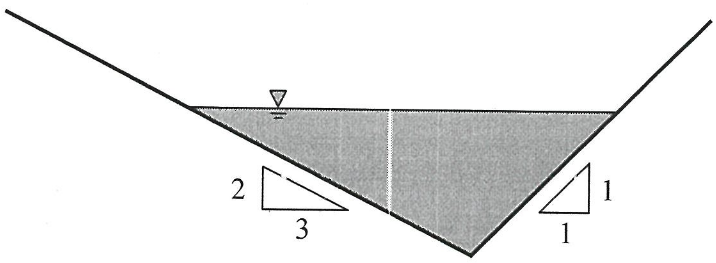


FIGURE Q1 (b)

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Table 2. Values of Manning roughness coefficient *n* for lined or built-up channels

Type of channel and description	Manning *n*
A. Metal	
a. Smooth steel surface	
1. Unpainted	0.012
2. Painted	0.013
b. Corrugated	0.025
B. Non-metal	
a. Cement	
1. Neat, surface	0.011
2. Mortar	0.013
b. Wood	
1. Planed, untreated	0.012
2. Planed, creosoted	0.012
3. Unplaned	0.013
4. Plank with battens	0.015
5. Lined with roofing paper	0.014
c. Concrete	
1. Trowel finish	0.013
2. Float finish	0.015
3. Finished, with gravel on bottom	0.017
4. Unfinished	0.017
5. Gunite, good section	0.019
6. Gunite, wavy section	0.022
7. On good excavated rock	0.020
8. On irregular excavated rock	0.027
d. Concrete bottom float finished with sides of	
1. Dressed stone in mortar	0.017
2. Random stone in mortar	0.020
3. Cement rubble masonry, plastered	0.020
4. Cement rubble masonry	0.025
5. Dry rubble or riprap	0.030
e. Gravel bottom with sides of	
1. Formed concrete	0.020
2. Random stone in mortar	0.023
3. Dry rubble or riprap	0.033
f. Brick	
1. Glazed	0.013
2. In cement mortar	0.015
g. Masonry	
1. Cemented rubble	0.025
2. Dry rubble	0.032
h. Dressed ashlar	0.015

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Table 3. Best hydraulic/ most efficient sections

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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Equations sheet

$Q = AV$ $q = yV$

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

$\mathrm{Fr} = \frac{V}{\sqrt{gD}}$ $\mathrm{Re} = \frac{VR}{\nu}$

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

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

$$\mathrm{d}x = \frac{\mathrm{d}y}{S_o}\left[\frac{1 - \left(\frac{y_c}{y_{\mathrm{ave}}}\right)^3}{1 - \left(\frac{K_o}{K_{\mathrm{ave}}}\right)^2}\right]$$

$$Q = \frac{8}{15}C_d\sqrt{2g}H_1^{\frac{5}{2}}\tan\left(\frac{\theta}{2}\right)$$

$Q = \frac{2}{3}C_d\sqrt{2g}LH_1^{\frac{3}{2}}$ $Q = \frac{2}{3}C_d\sqrt{2g}H_1^{\frac{3}{2}}\left(L + \frac{4}{5}H_1\tan\theta\right)$

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

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

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

$\frac{ND}{\sqrt{H}}$ $\frac{Q}{ND^3}$ $\frac{P}{D^5N^3}$

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Table 4. Characteristics of flow over broad-crested weir

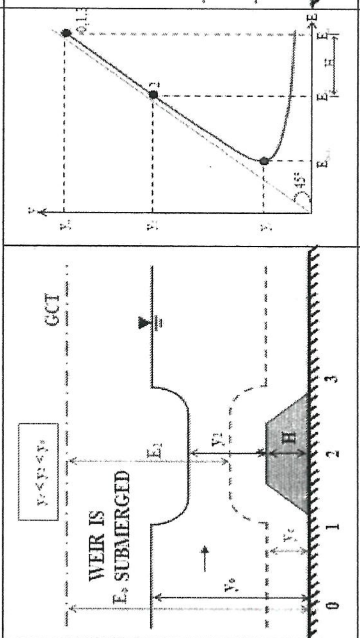
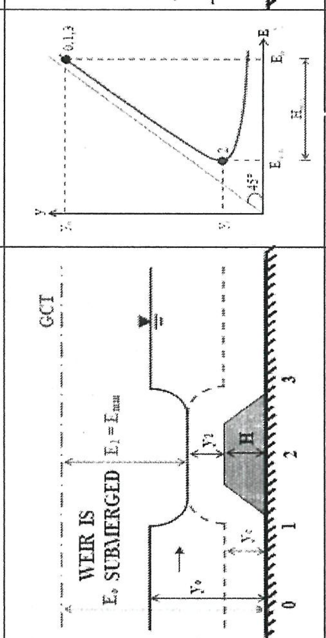
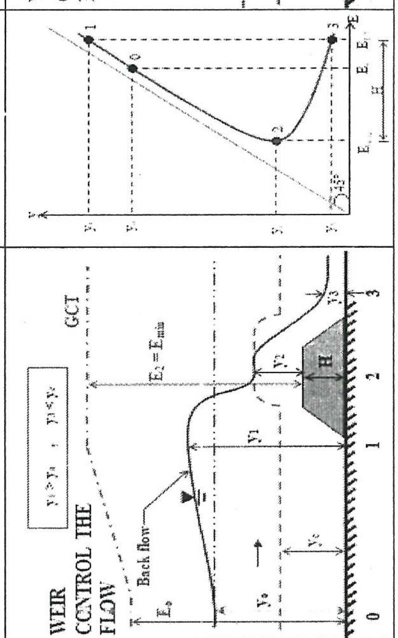
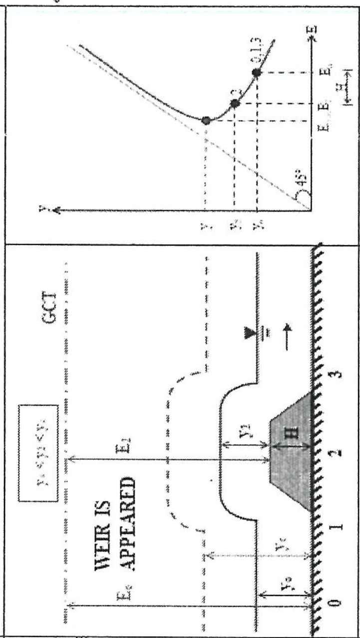
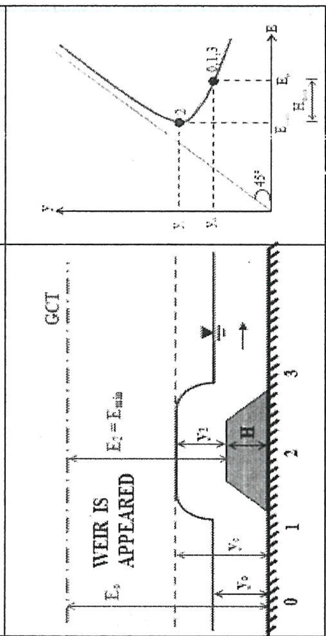
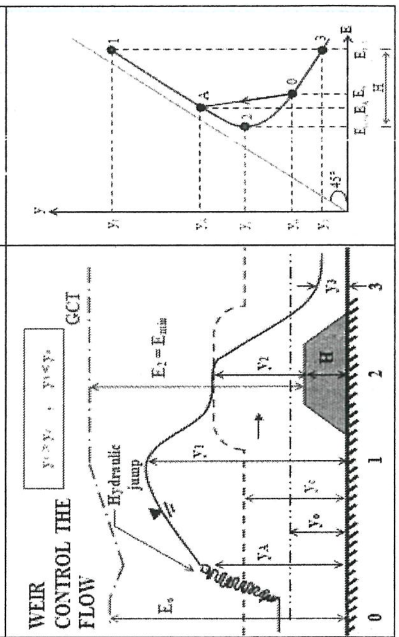
	CASE 1	CASE 2	CASE 3
CONDITION	$E_{min} + H < E_o$ OR $H < H_{min}$ $y_1 = y_3 = y_o$ & $y_2 \neq y_c \rightarrow E_2 = E_o - H$	$E_{min} + H = E_o$ OR $H = H_{min}$ $y_1 = y_3 = y_o$ & $y_2 = y_c$	$E_{min} + H > E_o$ OR $H > H_{min}$ $y_2 = y_c$; y_1 & $y_3 \rightarrow E_{1,3} = E_{min} + H$
SUBCRITICAL AT POINT O ($y_o > y_c$)			
SUPERCRITICAL AT POINT O ($y_o < y_c$)			

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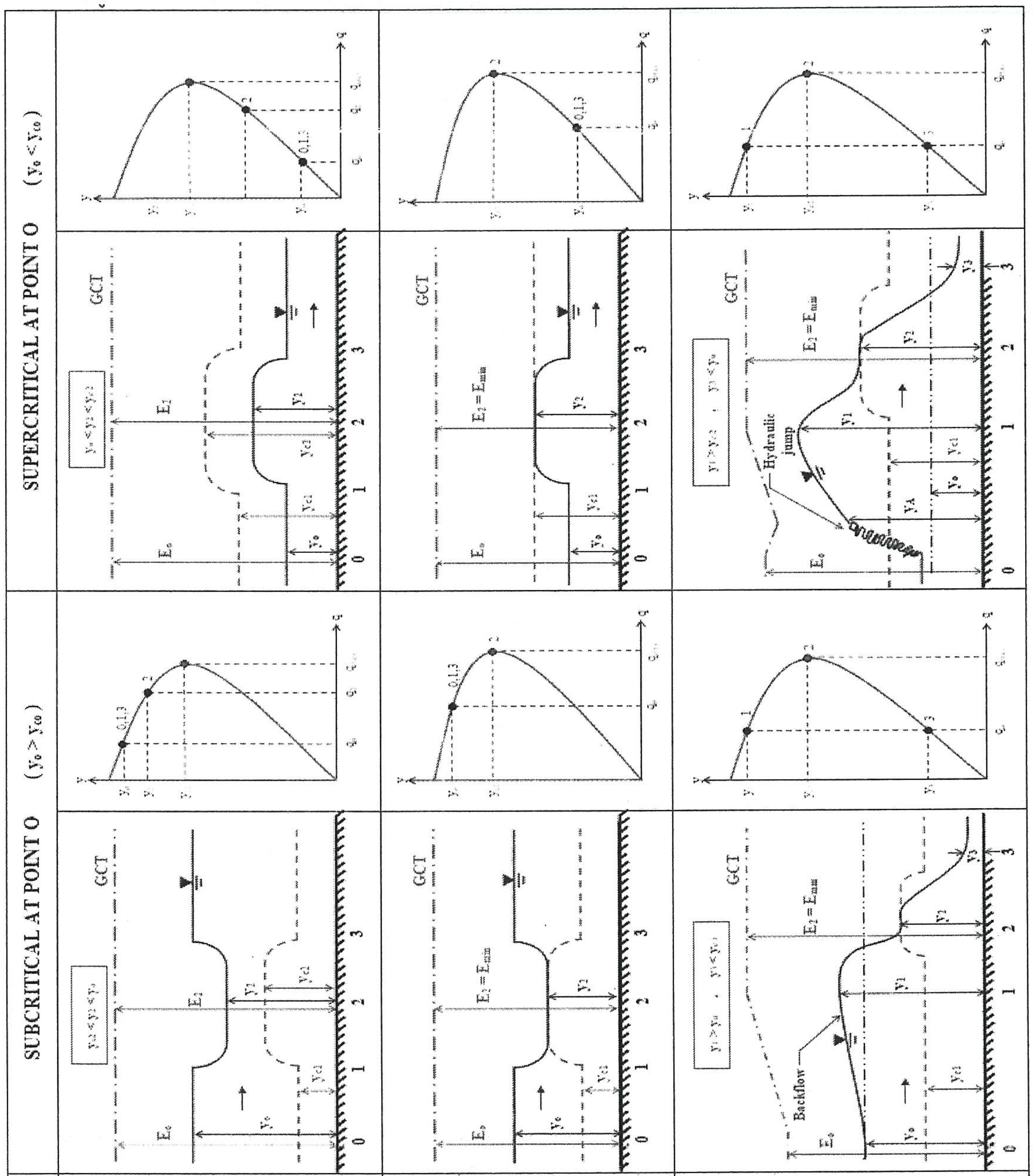
Table 5. Characteristics of flow through constricted channel



CONDITION	$E_{min} + H < E_o$ OR $B_2 > B_{2max}$ $y_1 = y_3 = y_o$ & $y_2 \neq y_{c2} \rightarrow E_2 = E_o - H$	$E_{min} + H = E_o$ OR $B_2 = B_{2max}$ $y_2 = y_{c2} = y_o$ & $y_1 = y_3 = y_o$	$E_{min} + H > E_o$ OR $B_2 < B_{2max}$ $y_2 = y_{c2}$; y_1 & y_3 $\rightarrow$ $E_{1,3} = E_{min} + H$
	CASE 1	**CASE 2**	**CASE 3**

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