UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2016/2017

COURSE NAME	:	HYDRAULICS
COURSE CODE	:	BFC21103
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JUNE 2017
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER (A) **ALL** QUESTIONS IN SECTION A, AND (B) ANY **TWO** (2) QUESTIONS IN SECTION B

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

SECTION A

Q1 (a) Define the following terms :

(i) Prismatic channel
(ii) Subcritical flow
(iii) Hydraulic depth
(iv) Froude number

(4 marks)

(b) **FIGURE Q1(b)** shows the water at the rate of 0.4 m^3/s flows through a 1 m diameter vitrified sewer, when the sewer pipe is half full. Determine the slope of the water, if Manning coefficient n is 0.013.

(4 marks)

(c) A compound channel shown in FIGURE Q1(c) is used to convey 8.94×10^{-1} m^3/s of flow. If the channel longitudinal slope and Chezy flow resistance coefficient are 1/2000 and 45, respectively, determine

(i) Normal depth of flow
(ii) State of flow based on Froude number

(12 marks)

Q2 (a) Discuss on the potential advantages of using the best hydraulic section channel.

(5 marks)

(b) A wood-lined trapezoidal channel has a side slope of 1.5(H): 2(V). Compute bottom width of the channel necessary to carry 123 m^3/s of discharge at a normal depth of 1.5 m and with a bottom slope of 0.00067.

(7 marks)

(c) Design the trapezoidal channel as best hydraulic cross-section with Q = 10 m^3/s, $n = 0.014$, $S_0 = 0.0004$, and $z = 3/2$ (**FIGURE Q2(c)**).

(8 marks)

Q3 (a) Briefly explain the function of control section in channel.

(2 marks)

(b) A 4.5-m wide rectangular channel is expected to discharge 50 m^3 in 10 second at water depth of 3.0 m. Analyse:

(i) Depth of flow upstream and downstream of constriction, if width has reduced to 3.5 m.

(9 marks)

(ii) Depth of flow at upstream, downstream and above the weir, if 3-m weir is to be proposed at the channel.

(9 marks)

SECTION B

Q4 (a) Explain briefly **TWO (2)** applications of hydraulic jump and **TWO (2)** applications of gradually varied flow analysis.

(4 marks)

(b) A bridge is to be built across a 11.5-m wide almost-rectangular river with bed slope of 1/850, perimeter roughness n = 0.06, and discharge of 27.3 m^3/s. The bridge piers will cause constriction to the flow since the width of the flow will be reduced to 6.2 m. Determine

(i) Type of flow at upstream of the constriction.

(6 marks)

(ii) Length of the gradually-varied flow profile should it occurs upstream of the constriction. At downstream, the depth of flow rises to 3.8 m, immediately before the constriction. Use numerical integration method with $N = 3$ steps.

(10 marks)

Q5 (a) A sluice gate is built in a 1.5 m wide rectangular channel having uniform depth of y_o = 0.3 m, coefficient of discharge C_d = 0.605, and gate opening of a = 0.127 m. Hydraulic jump occurs downstream. If the depth of flow before the hydraulic jump y_1 = 0.189 m, calculate

(i) Conjugate depth y_2 of the hydraulic jump.

(ii) Discharge through the spillway.

(5 marks)

(b) A rectangular weir with 3.3-m long and 1.6-m high is contracted at both ends (n = 2). If the weir is discharging water from a reservoir under a head of 0.7 m, estimate

(i) The coefficient of discharge, C_d using Bazin formula.

(2 marks)

(ii) The length of weir, L if a free-flowing discharge from the weir is 13.2 m^3/s.

(5 marks)

(c) A rectangular spillway with 21-m wide is discharging flood flow at a rate of 260 m^3/s at 1.3-m depth. Design an USBR Type III stilling basin at the toe of the spillway.

(8 marks)

Q6 (a) Explain briefly 'similarity' in model studies, and state **TWO (2)** advantages of similarity.

(4 marks)

(b) Two identical pumps installed in series are used to supply 23000 L/s of water under a head of 20 m. Given shaft power P and density of water ρ is 5000 kW and 1000 kg/m^3 respectively, calculate:

(i) Total power of water and overall efficiency of the pump.

(3 marks)

(ii) Power of water and pressure head for single pump.

(2 marks)

(iii) Total discharge if pumps connected in parallel.

(1 mark)

(c) Kaplan turbine is expected to produce 861 kW of power at 206 rpm with a 20 m head. A 1:5 model is designed to function under a head of 3 m. Assume overall efficiency is 80% for both model and prototype, estimate:

(i) Rotational speed, power and discharge of model.

(8 marks)

(ii) Specific speed for both model and prototype.

(2 marks)

-END OF QUESTIONS -

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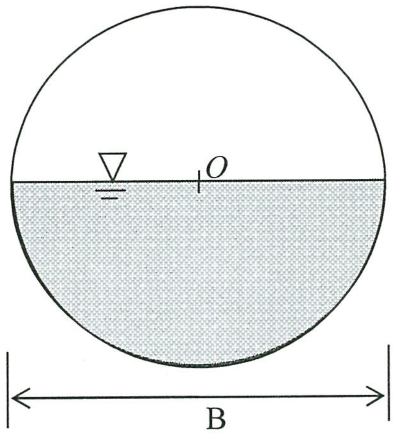
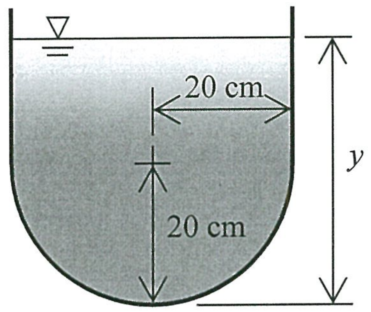


FIGURE Q1(b)



Note that $y > 20$ cm

Figure Q1(c)

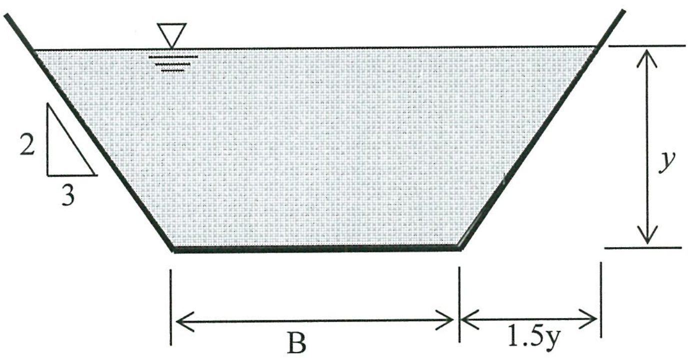


FIGURE Q2(c)

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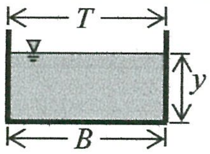
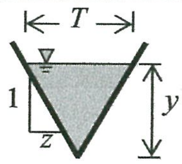
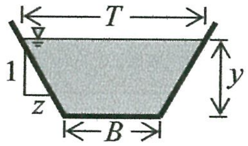
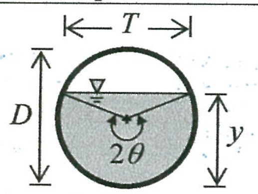
Table 1.0. Open channel flow section geometries

Section	Flow area A	Top width T	Wetted perimeter P
 Rectangular	By	B	$B+2y$
 Triangular	zy^2	$2zy$	
 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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Appendix III

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Table 2.0 Best hydraulic sections

Cross section	Flow area A	Wetted perimeter P	Hydraulic radius R	Top width T	Hydraulic depth D
Trapezoid	$\sqrt{3}y^2$	$2\sqrt{3}y$	$\frac{y}{2}$	$\frac{4\sqrt{3}}{3}y$	$\frac{3}{4}y$
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 3.0 Manning roughness coefficient n

Type of channel	Manning roughness coefficient n
Smooth steel	0.012
Corrugated metal	0.025
Wood	0.013
Concrete	0.017
Brick	0.015
Vegetal	0.03 – 0.5

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Table 4.0 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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Some useful equations:

$$Q = AV \qquad Q = A\frac{1}{n}R^{\frac{2}{3}}S_o^{\frac{1}{2}} \qquad Q = ACR^{\frac{1}{2}}S_o^{\frac{1}{2}} \qquad q = \frac{Q}{B} \qquad \mathrm{Re} = \frac{VR}{\nu}$$

$$\mathrm{Fr} = \frac{V}{\sqrt{gD}} \qquad \mathrm{Fr}^2 = \frac{q^2}{gy^3} \qquad \frac{A_c^3}{T_c} = \frac{Q^2}{g} \qquad y_c = \sqrt[3]{\frac{q^2}{g}} \qquad E_{\min} = \frac{3}{2}y_c$$

$$E = y + \frac{V^2}{2g} \qquad E = y + \frac{q^2}{2gy^2} \qquad K = \frac{Q}{S_o^{\frac{1}{2}}} = \frac{1}{n}AR^{\frac{2}{3}} \qquad \mathrm{dx} = \frac{\mathrm{dy}}{S_o}\left[\frac{1-\left(\frac{y_c}{y_{\mathrm{ave}}}\right)^3}{1-\left(\frac{K_o}{K_{\mathrm{ave}}}\right)^2}\right]$$

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

$$\mathrm{C_d} = 0.611 + 0.075\frac{\mathrm{H_1}}{\mathrm{P}} \qquad \mathrm{C_d} = \left(0.607 + \frac{0.00451}{\mathrm{H_1}}\right)\left[1+0.55\left(\frac{\mathrm{H_1}}{\mathrm{H_1+P}}\right)^2\right]$$

$$Q = \frac{2}{3}C_d\sqrt{2g}LH_1^{\frac{3}{2}} \qquad \mathrm{Q} = \frac{2}{3}\mathrm{C_d}\sqrt{2g}\mathrm{L_e}\mathrm{H_1^{\frac{3}{2}}} \qquad L_e = L - 0.1nH_1$$

$$V_1 = \sqrt{2g\left(H_1 - \frac{H_o}{2}\right)} \qquad y_1 = \frac{Q}{BV_1} \qquad \text{No. of block} = \frac{B}{(s+w)}$$

$$\frac{H}{N^2D^2} \qquad \frac{Q}{ND^3} \qquad \frac{P}{\rho N^3D^5} \qquad N_s = \frac{N\sqrt{Q}}{H^{\frac{3}{4}}}$$

$$H = H_d - H_s = \left[\frac{p_d}{\gamma} + z_d + \frac{V_d^2}{2g}\right] - \left[\frac{p_s}{\gamma} + z_s + \frac{V_s^2}{2g}\right] \qquad N_s = \frac{N\sqrt{P}}{H^{\frac{5}{4}}}$$

$$P_d = P_o = \gamma QH \qquad P_s = P_i = T\omega = \frac{2\pi N}{60}T \qquad \eta = \frac{P_o}{P_i}$$