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Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2015/2016

COURSE NAME	:	HYDRAULICS
COURSE CODE	:	BFC 21103
PROGRAMME	:	BACHELOR OF CIVIL ENGINEERING WITH HONOURS
EXAMINATION DATE	:	DECEMBER 2015/ JANUARY 2016
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER: (A) **ALL** QUESTIONS IN **PART A**, AND (B) **ANY TWO (2)** QUESTIONS IN **PART B**

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

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PART A: ANSWER **ALL** QUESTIONS

Q1 (a) With the aid of diagram, show the differences between open channel flow and pipe flow.

(2 marks)

(b) Define the following :

(i) open channel flow,
(ii) prismatic channel,
(iii) steady flow, and
(iv) gradually-varied flow.

(4 marks)

(c) A trapezoidal channel with bottom width 0.5 m and side slope 2(V) : 3(H) conveys a uniform flow at a depth of 0.75 m. Find

(i) hydraulic radius *R*, and

(2 marks)

(ii) hydraulic depth *D*.

(2 marks)

(d) **FIGURE Q1(d)** shows an open channel flow with discharge of 21 m^3/s. Given that the kinematic viscosity is 1.004×10^{-6} m^2/s, find the state of flow based on :

(i) Froude number Fr, and

(5 marks)

(ii) Reynolds number Re.

(5 marks)

Q2 (a) **TABLE Q2(a)** shows the variation in roughness coefficient of open channels. Give your opinion why these values differ between each other.

(2 marks)

(b) A trapezoidal channel with bottom width 4 m and side slope 5(H) : 3(V) carries a discharge of 32000 L/s on longitudinal slope of 0.004 and roughness n = 0.015. Calculate

(i) Normal depth of flow, and

(5 marks)

(ii) Critical depth

(5 marks)

(c) (i) Give **TWO (2)** advantages in using best hydraulic section.

(4 marks)

(ii) Prove that the depth of flow in a hydraulically-efficient rectangular section is equal to half the width of the channel.

(4 marks)

Q3 A bridge is constructed across a 9.5 m wide rectangular river that discharges 14.55 m^3/s of flow with roughness coefficient n = 0.05, and on a longitudinal slope of 1/2500. Due to the constriction by bridge piers, the channel width is now reduced to 1.5 m.

(a) Determine the depths of flow upstream, downstream, and at the constriction.
(12 marks)

(b) Propose a minimum allowable distance between each bridge abutment to be rebuilt so that the depth of flow upstream is not affected by the constriction in (a).
(2 marks)

(c) Sketch the E-y curves for flow when B = 9.5 m, $B_2 = B_{max}$ and B_2 = 1.5 m, providing the exact values of $E_{min\ o}$, y_{co}, y_o, E_o, E_{min2}, y_{c2}, y_{c2}', E_{min2}', y_1' and y_3'.
(6 marks)

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

Q4 (a) List **TWO (2)** applications of hydraulic jump.
(2 marks)

(b) Describe how hydraulic jump is formed.
(4 marks)

(c) Water flows into a very wide rectangular channel at a constant rate of 1.0 $m^3/s/m$. At one point, the bed slope changes from $S_{o1} = 6.87 \times 10^{-3}$ to $S_{o2} = 3.24 \times 10^{-4}$. Given roughness coefficient n = 0.018,
(i) Calculate the depths of uniform flow on both slopes, and
(ii) Determine the type of both slopes.
(4 marks)

(d) A 7 m wide rectangular channel with bottom slope of 0.001 and Manning roughness n = 0.02 conveys 30 m^3/s of flow. Using numerical integration method with N = 4 steps, estimate the length of gradually-varied flow produced by a weir that caused the depth of flow upstream of weir to increase to 3 m.
(10 marks)

Q5 (a) State the **THREE (3)** sets of blocks typically installed in USBR stilling basin type III.

(2 marks)

(b) Explain **TWO (2)** functions of each of the following hydraulic structures.

(i) Weir

(ii) Energy dissipator

(2 marks)

(c) A rectangular weir contracted at one side has an opening length of 2.0 m and height of 1.25 m. Calculate the discharge when water with head of 0.82 m flows through the weir.

(6 marks)

(d) A weir is built with H_l = 36 m and H_o = 8 m as shown in **FIGURE Q5(d)**. The weir discharges 90 m^3/s of flow through a 10 m wide spillway. Design an USBR stilling basin type III downstream.

(10 marks)

Q6 (a) Two similar pumps can be connected in series or in parallel. State the difference between pumps connected in series and parallel based on the head loss and flow rates.

(4 marks)

(b) A centrifugal pump with a 12 cm diameter impeller requires a power input of 60 kW when the flowrate is 3200 m^3/s against a 60 m head. The impeller is changed to one with a 10 cm diameter. Determine the expected flow rate, head, and input power if the pump speed remains the same.

(6 marks)

(c) Data measured during tests of a centrifugal pump at 3500 rpm are given in **TABLE S6(c)**. The density of fluid is 1000 kg/m^3 and flow rate is 11.5 m^3/hr. The torque applied to the pump shaft is 3.68 Nm. Compute the total heads at the pump inlet and outlet, the hydraulic power delivered to the fluid, and the pump efficiency.

(10 marks)

- END OF QUESTIONS -

Appendix I

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FIGURES

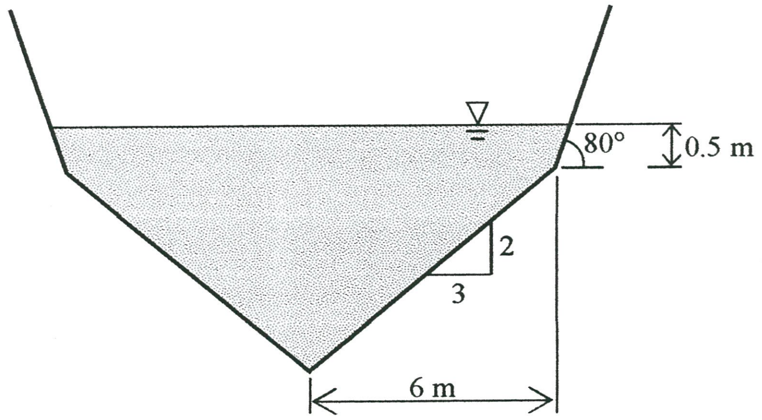

FIGURE Q1(d)

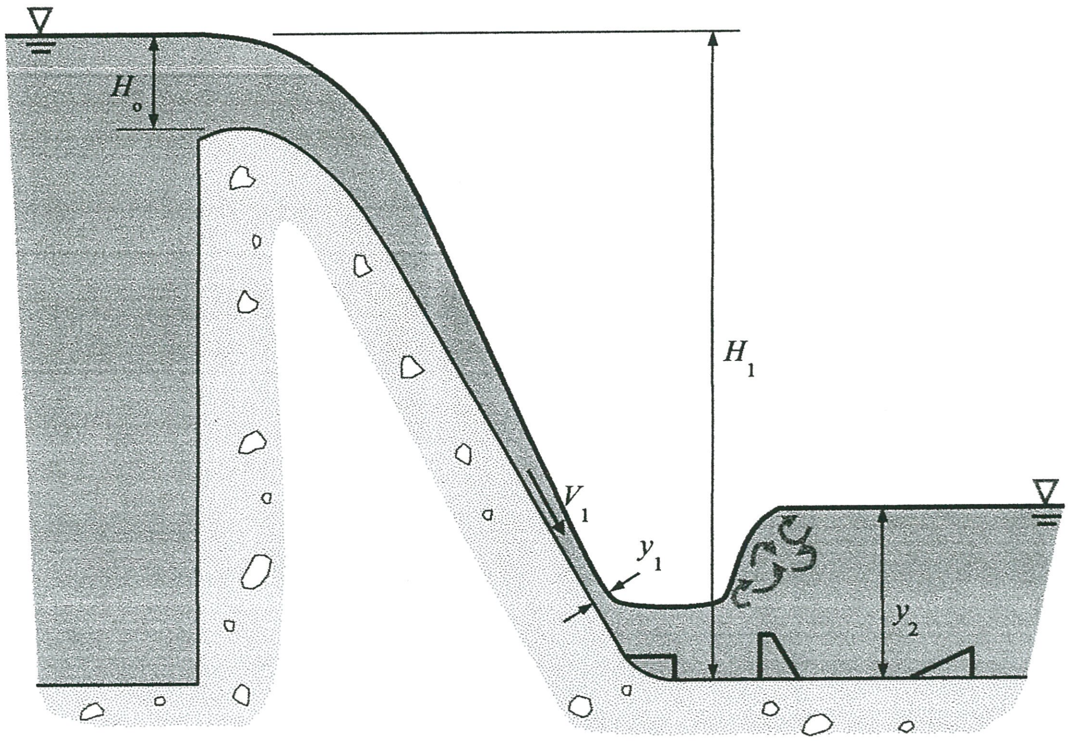

FIGURE Q5(d)

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TABLES

TABLE Q2(a)

Channel type	Manning *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 Q6(c)

Parameter	Inlet section	Outlet section
Gauge pressure p (kPa)	95.2	412
Elevation above datum z (m)	1.25	2.75
Velocity of flow V (m/s)	2.35	3.62

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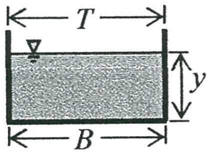
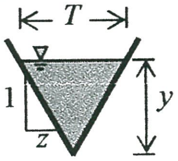
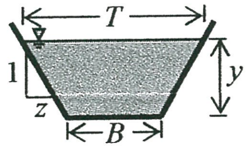
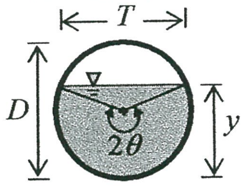
Table 1.0. Open channel flow section geometries

Section	Flow area A	Top width T	Wetted perimeter P
 Rectangular	By	B	$B + 2y$
 Triangular	zy^2	$2zy$	$2y\sqrt{1+z^2}$
 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

Appendix IV

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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	$\sqrt{3}y^2$	$2\sqrt{3}y$	$\frac{y}{2}$	$\frac{4\sqrt{3}}{3}y$	$\frac{3}{4}y$
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 3.0 Sizing for USBR Type III stilling basin

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

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Some useful equations:

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

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

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

$$Q = \frac{2}{3}C_d\sqrt{2g}L_eH_1^{\frac{3}{2}} \qquad C_d = \left(0.607 + \frac{0.00451}{H_1}\right)\left[1 + 0.55\left(\frac{H_1}{H_1 + P}\right)^2\right] \qquad L_e = L - 0.1nH_1$$

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

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

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

$$H = H_d - H_s = \left[\frac{p_d}{\gamma} + z_d + \frac{V_d^2}{2g}\right] - \left[\frac{p_s}{\gamma} + z_s + \frac{V_s^2}{2g}\right]$$

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