Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2023/2024

COURSE NAME	:	HYDRAULIC
COURSE CODE	:	BFC 21103
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JANUARY/FEBRUARY 2024
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER ALL QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ Closed book 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES.

Q1 (a) List **THREE (3)** states of flow by comparing normal depth (y_o) with critical depth (y_c).

(3 marks)

(b) Briefly explain the function of control section and give **TWO (2)** examples of control sections with the aid of diagram.

(5 marks)

(c) *The bridge is construct* over a 7.5 meter wide, almost rectangular river with a uniform flow depth of 2.5 meters, bed slope of 1/2000, and perimeter roughness of n = 0.030. Determine the flow depth upstream, above, and downstream of a 1.5 meter high broad-crested weir built to measure the rate of flow.

(7 marks)

(d) The system shown in **Figure Q1.1** has a specific discharge of 3 m^3/s. The depth, y_1, upstream of the sluice gate is 2 m. Analyse:

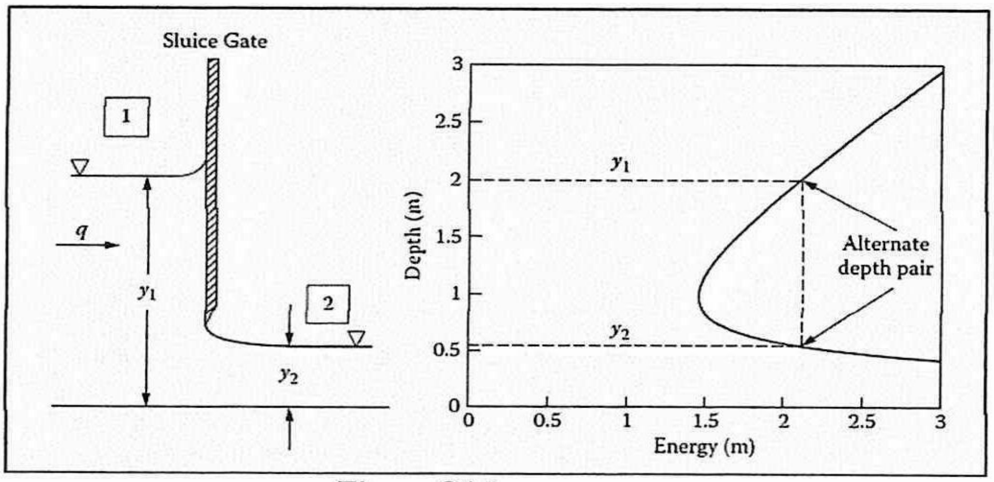


Figure Q1.1

(i) The upstream Froude number, Fr_1 and state the flow

(3 marks)

(ii) The specific energy upstream of the sluice gate, E_1.

(3 marks)

(iii) The downstream depth, y_2 and specific energy, E_2.

(4 marks)

Q2 (a) Draw a simple sketch illustrating the concept of the conjugate depth of a hydraulic jump and briefly explain of the conjugate depth based on the sketch.

(3 marks)

(b) Create a simple sketch to illustrate the flow profile through a horizontal slope. Provide a brief description of the characteristics of the flow profile in open channel hydraulics.

(5 marks)

(c) A constant hydraulic jump occurs in rectangular channel with the initial and sequent depths are 0.4 m and 1.2 m, respectively. Estimate:

(i) Velocity, V

(3 marks)

(ii) Discharge per unit width, q

(2 marks)

(iii) Energy loss, E_L

(2 marks)

(d) A very wide river in **Figure Q2.1** has uniform depth of 2.5 m and surface roughness, n = 0.035 laid on a longitudinal slope of 0.0004. The set-up weir at the downstream of the river causing backwater to occur, where water surface increases 2 m from normal depth at the back of weir.

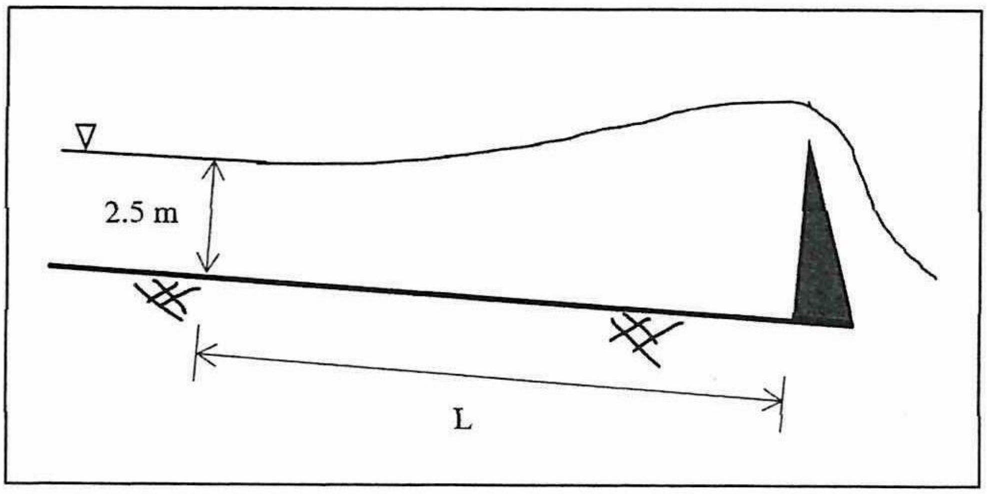


Figure Q2.1

(i) Analyse GVF water profile to estimate length, L using direct step in 2 steps.

(8 marks)

(ii) Justify the result in **Q2 (d)(i)** if 4 steps were used instead of 2 steps.

(2 marks)

Q3 (a) Briefly illustrate the sluice gate condition where the upstream control the flow and the best design of spillway in a reservoir.

(3 marks)

(b) Elaborate and illustrate on the concepts of suppressed and unsuppressed weirs in open channel hydraulics.

(5 marks)

(c) A trapezoidal notch weir was designed to cater the full supply of discharge at 2.0 m^3/s and head of 1.2 m. One laboratory experiment was carried out by using the same notch weir at head of 0.6 m and discharge of 0.6 m^3/s. Consider the coefficient of discharge as 0.65, calculate the base width (L), and side slopes angle (θ) of the trapezoidal notch weir.

(7 marks)

(d) A 6 m width spillway discharges 120 m^3/s of water from a reservoir. The head of water above the spillway crest is 5.0 m while the water depth in front of the dam is at 72 m. Movement of flow towards downstream of the spillway has produced a very high kinetic energy and to reduce this energy, an energy dissipator structure is proposed. (Please refer information in **Table Q3.1**, **Figure Q3.1** and **Figure Q3.2)**

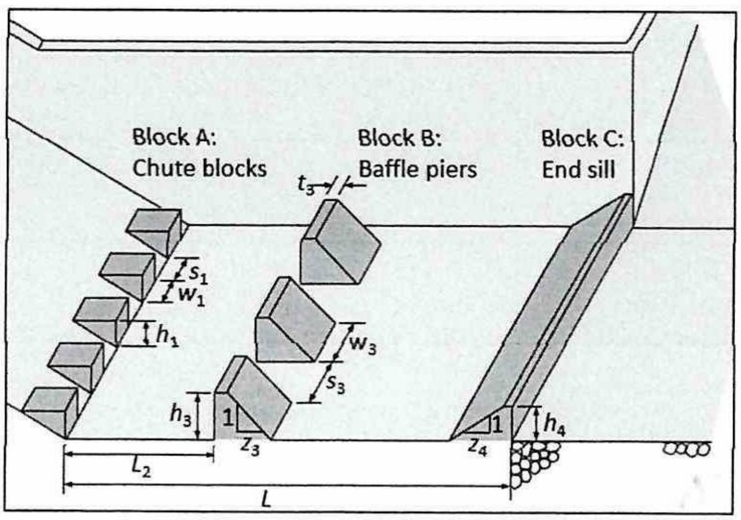


Figure Q3.1

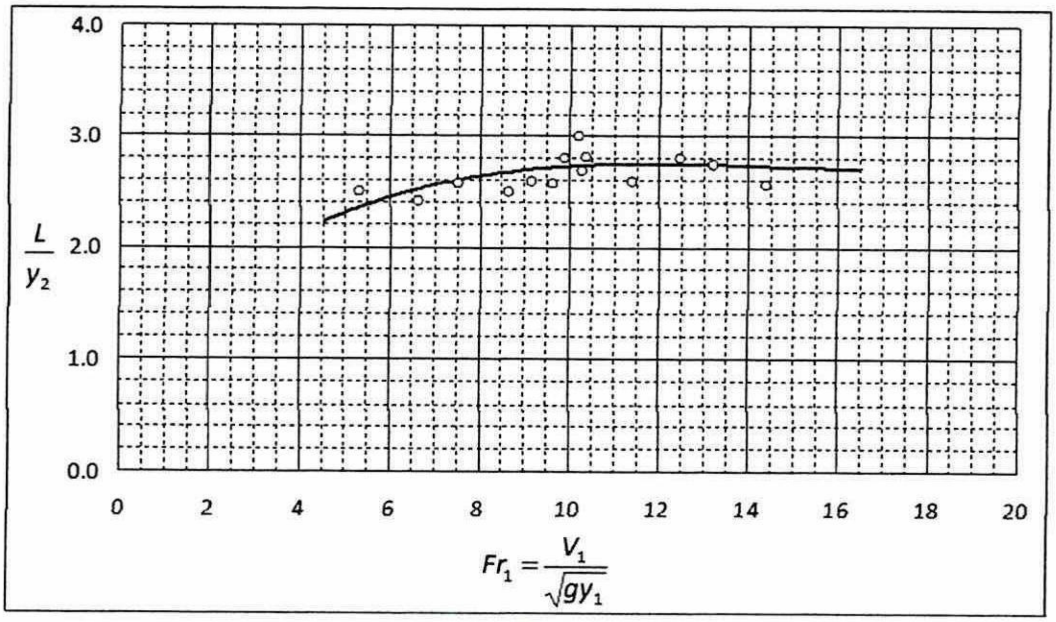


Figure Q3.2

(i) Design the Stilling Basin Type III structure.

(8 marks)

(ii) Propose graphically the dimensions of calculated values in **Q3(d) (i)**.

(2 marks)

Q4 (a) Define energy conversion through pumps and turbines.

(3 marks)

(b) Sketch a diagram to define the relationship between pump characteristics, system characteristics and operating (duty) point.

(5 marks)

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

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

(3 marks)

(ii) Power of water for single pump and total discharge if pumps connected in parallel.

(4 marks)

(d) A ¼ -scale model centrifugal pump is tested under a head of 7.5 m at a speed of 500 rpm. It was found that 7.5 kW was needed to drive the model. Assuming similar mechanical efficiencies, calculate:

(i) Speed and power required by the prototype when pumping against a head of 44 m.

(7 marks)

(ii) Ratio of the discharge in the model to that in the prototype.

(3 marks)

- END OF QUESTIONS -

APPENDIX A

Table Q1.1 General geometric element for calculation aid in Q1 to Q3

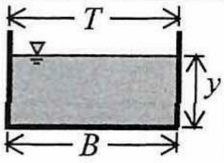
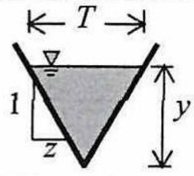
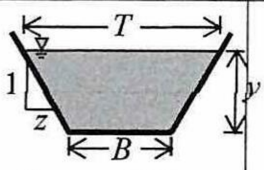
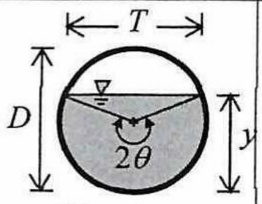
Section	Flow area A	Top width T	Wetted perimeter P
 Rectangular	By	B	$B+2y$
 Triangular	zy^2	$2zy$	$2y\sqrt{1+z^2}$
 Trapezoidal	$By+zy^2$	$B+2zy$	$B+2y\sqrt{1+z^2}$
 Circular	$\frac{D^2}{8}(2\theta-\sin 2\theta)$	$D\sin\theta$	θD

Table Q3.1

Block A	Block B	Block C
$h_1 = y_1$ $s_1 = y_1$ $w_1 = y_1$	$h_3 = (0.168\mathrm{Fr}_1 + 0.63)y_1$ $s_3 = 0.75h_3$ $w_3 = 0.75h_3$ $t_3 = 0.2h_3$ $z_3 = 1.0$	$h_4 = \left(\frac{\mathrm{Fr}_1}{18}+1\right)y_1$ $z_4 = 2.0$

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APPENDIX B

EQUATIONS SHEET

$$Q = Av \quad q = \frac{Q}{B} \quad q = yv \quad Q = \frac{1}{n}AR^{2/3}\sqrt{S_o} \quad R = \frac{A}{P} \quad D = \frac{A}{T}$$

$$y_c = \sqrt[3]{\frac{q^2}{g}} \quad R_e = \frac{VR}{\nu} \quad \frac{A_c^3}{T_c} = \frac{Q^2}{g}$$

$$F_r = \frac{v}{\sqrt{gD}} \quad E_{min} = \frac{3}{2}y_c \quad S_c = \frac{n^2 g A_c}{T_c {R_c}^{4/3}} \quad \frac{H_m}{{D_m}^2 {N_m}^2} = \frac{H_p}{{D_p}^2 {N_p}^2}$$

$$\frac{Q_m}{N_m {D_m}^3} = \frac{Q_p}{N_p {D_p}^3} \quad n_o = \frac{P_o}{P_i}$$

$$\frac{P_m}{\gamma_m {D_m}^5 {N_m}^3} = \frac{P_p}{\gamma_p {D_p}^5 {N_p}^3} \quad N_{sm} = N_{sp} = \left(\frac{N_m\sqrt{Q_m}}{{H_m}^{3/4}}\right) = \left(\frac{N_p\sqrt{Q_p}}{{H_p}^{3/4}}\right)$$

$$No.of\ blocks = \frac{B}{s+w} \quad L_2 = 0.8y_2 \quad Q = \frac{2}{3}C_d\sqrt{2g}L{H_1}^{3/2}$$

$$Q = \frac{8}{15}C_d\sqrt{2g}\,.tan\theta.{H_1}^{5/2} \quad Q = \frac{2}{3}C_d B\sqrt{2g}L_e{H_1}^{3/2} \quad L_e = L - (0.1nH_1)$$

$$\frac{{A_c}^3}{T_c} = \frac{Q^2}{g} \quad H_{min} = E_o - E_{min} \quad {Fr_1}^2 = \frac{q^2}{g{y_1}^3} \quad \frac{y_2}{y_1} = \frac{1}{2}\left[-1 + \sqrt{1 + 8{Fr_1}^2}\right]$$

$$E = y + \frac{q^2}{2gy^3} \quad E = y + \frac{v^2}{2g} \quad E_L = \frac{(y_2 - y_1)^3}{4y_1y_2} \quad dx = \frac{dE}{S_o - \overline{S_f}}$$

$$S_f = \frac{n^2V^2}{R^{\frac{4}{3}}} \quad P_L = \rho g Q E_L \quad \Delta y = \frac{y_{initial} - y_{end}}{Number\ of\ steps}$$