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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	HYDRAULICS
COURSE CODE	:	BFC 21103
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JULY 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

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Q1 (a) Explain the possible depths in the specific energy curve with a diagram.
(3 marks)

(b) Discuss and illustrate with a diagram the occurrence of control section points for flow passing on the broad crested weir and constricted width of a channel.
(4 marks)

(c) A triangular channel with an apex angle of 50° flowed the discharge at 16 m^3/s. Determine the critical depth using a graph method. You may use the attached graph paper to show your solution.
(6 marks)

(d) A broad crested weir with 0.6 m height is constructed inside a rectangular channel of 3 m width. Water flows inside the channel at a discharge of 10.5 m^3/s and the normal depth is 0.6 m. Compute :-

(i) The critical depth,
(2 marks)

(ii) The depth before, above, and after the weir,
(6 marks)

(iii) Sketch the specific energy curve for the weir and label all flow depth values calculated from Q1(d)(i to ii) including the normal depth,
(2 marks)

(iv) Label all specific energy values for flow which is associated at normal depth, depths on, before and after the weir as well as the weir height.
(2 marks)

(Note : Please refer to Table **APPENDIX A.1** and **APPENDIX A.2**)

Q2 (a) Briefly explain the types of hydraulic jump based on the Froude number.
(4 marks)

(b) Provide **TWO (2)** diagrams and a description of the Gradually Varied Flow profile for positive and negative slopes.
(5 marks)

(c) A 2 m wide sluice gate in a rectangular spillway discharges 30 m^3 /s of flow at a depth of 0.6 m. The hydraulic jump occurs downstream. Determine :

(i) Type of jump
(2 marks)

(ii) Height of jump
(4 marks)

(iii) Energy loss
(2 marks)

(d) Flow from a very wide channel at 3 m depth and longitudinal slope of 0.0006 decreased gradually and falls freely at a rate of 9.37 m^3/s.m. At the inlet of the reservoir, the flow becomes critical. Using the numerical integration method with 4 steps and consider Chezy's coefficient as 73.6 $m^{0.5}$/s, analyse the length of gradually varied flow that caused water to decrease to critical depth and sketch the flow profile.

(8 marks)

Q3 (a) With the aid of a diagram, state **ONE** function of the spillway.

(4 marks)

(b) Briefly discuss the concept of the energy dissipator structure in civil engineering.

(5 marks)

(c) A sluice gate is built in a rectangular channel with a bottom width b of 2.5 m. The flow and gate characteristics are depth of flow at the upstream $y_o = 2$ m, depth correction factor $\psi = 0.63$, coefficient of discharge $C_d = 0.59$, and height of gate opening $a = 0.5$ m. Calculate the discharge under the sluice gate when the depth of flow at the downstream y_2 is 1.6 m.

(6 marks)

(d) A compound weir (**Figure Q3.1**) is installed at a 10 m-wide rectangular channel section. Considering the coefficient of discharge of 0.60.

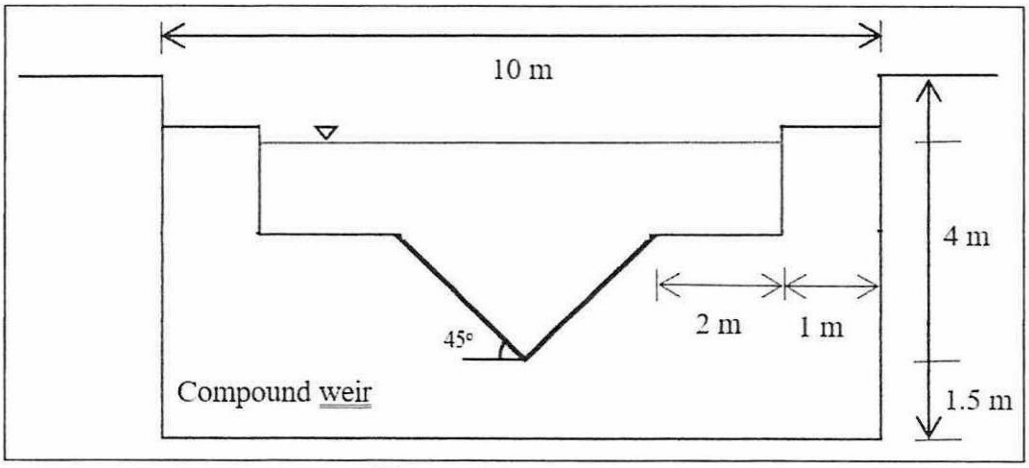

Figure Q3.1

(i) Determine the flowrate equation for compound weir

(4 marks)

(ii) Analyze the flow rate in L/s

(6 marks)

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Q4 (a) Briefly discuss classification of turbine based on the head of water.

(3 marks)

(b) Explain the characteristics curve of a centrifugal pump as illustrated in **Figure Q4.1**.

(6 marks)

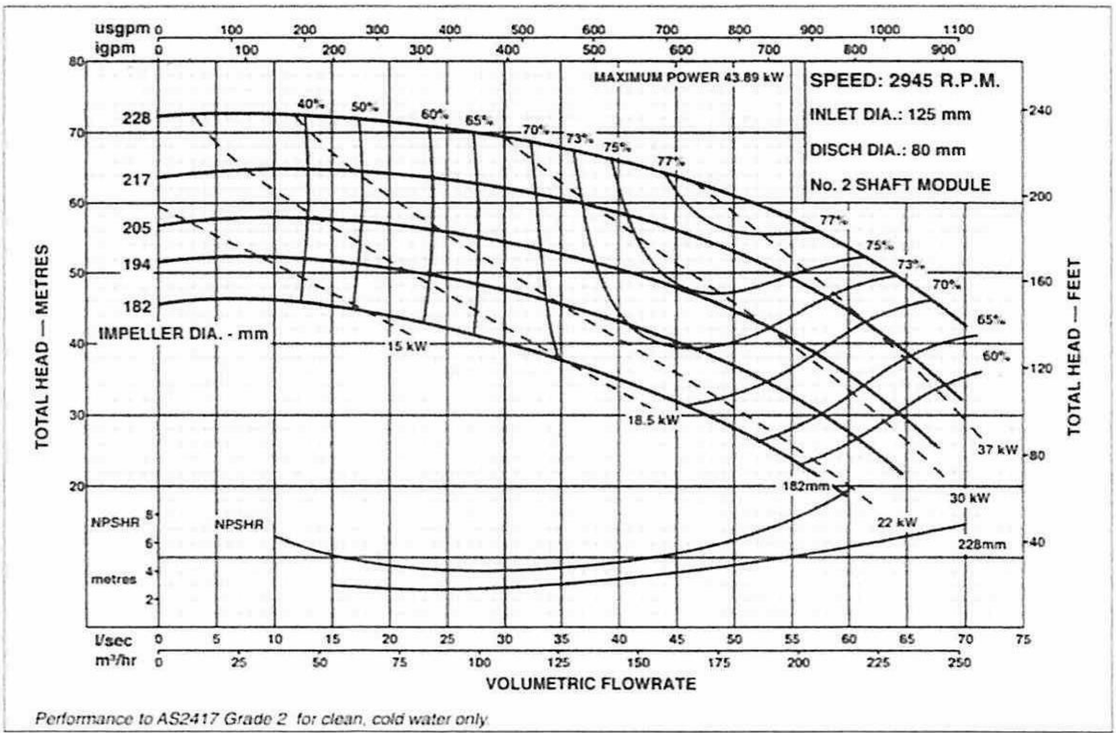


Figure Q4.1

(c) A water supply network consists of 3 similar pumps as shown in **Figure Q4.2**. The network supplies 30,000 L/s of water under a head of 15 m. The efficiency of pump is 78% with torque of 12 kNm. Determine :-

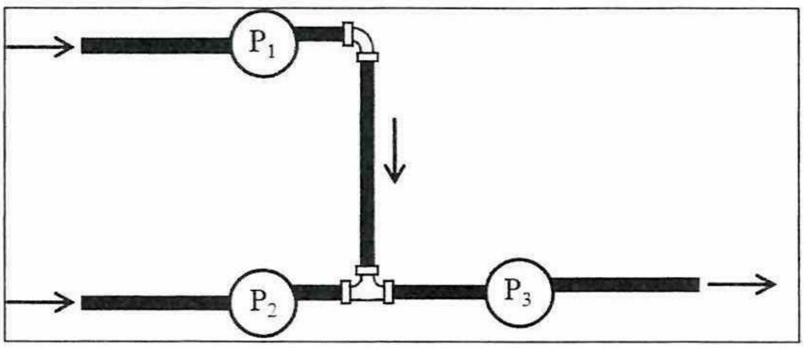


Figure Q4.2

(i) Head produced by each pump

(2 marks)

(ii) Power delivered to the flow by each pump

(1 mark)

(iii) Shaft power of each pump

(3 marks)

(iv) Speed of the pump

(2 marks)

(d) A 1:10 water turbine model develops 2.5 kW power under head of 2 m and speed of 350 rpm. Overall efficiency of both model and prototype is 78%. If the prototype is run under a head of 18 m, determine its :-

(i) Specific speed

(1 mark)

(ii) Rotational speed

(2 marks)

(iii) Power

(2 marks)

(iv) Discharge

(3 marks)

- END OF QUESTIONS -

APPENDIX A

Table APPENDIX A.1

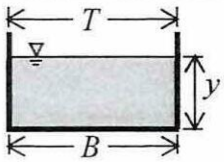
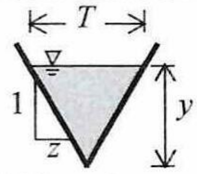
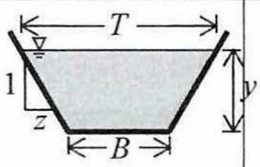
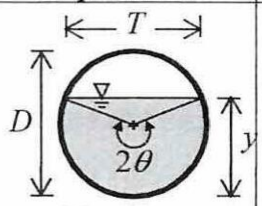
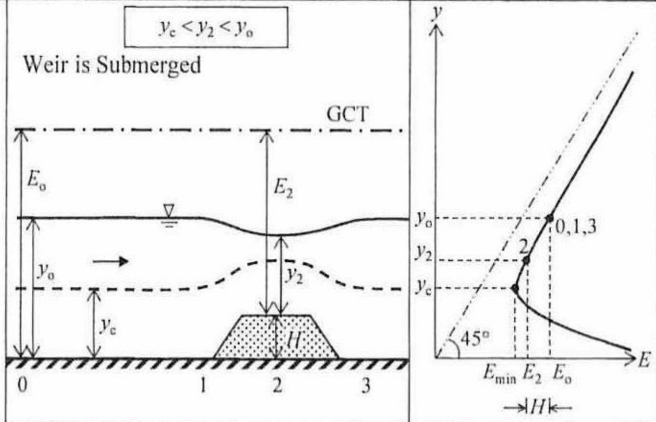
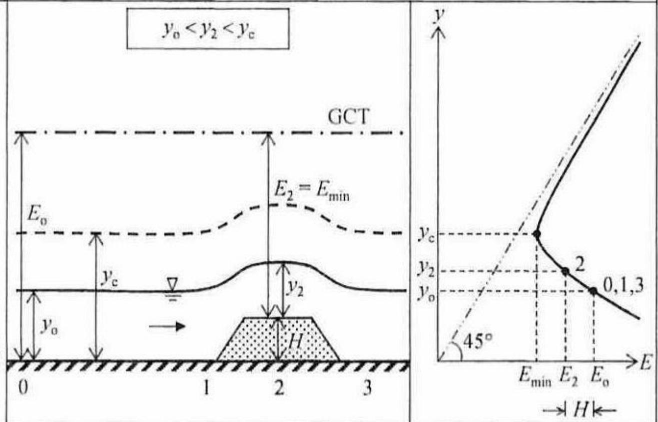
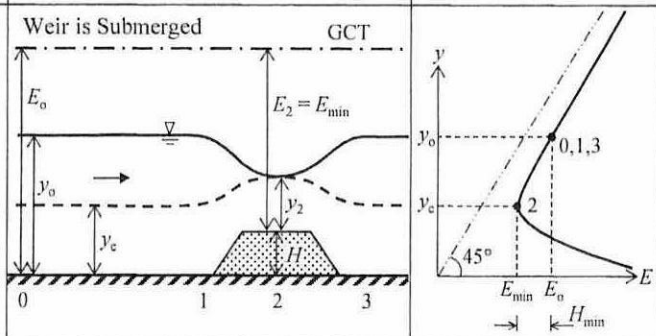
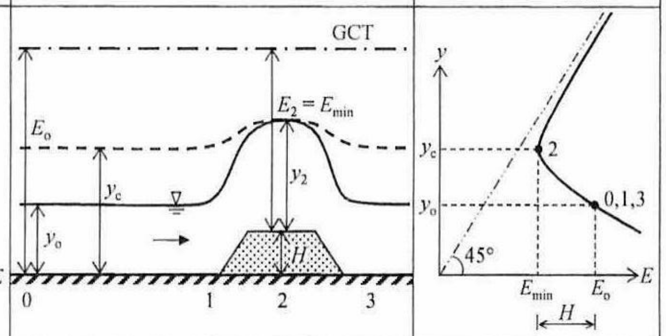
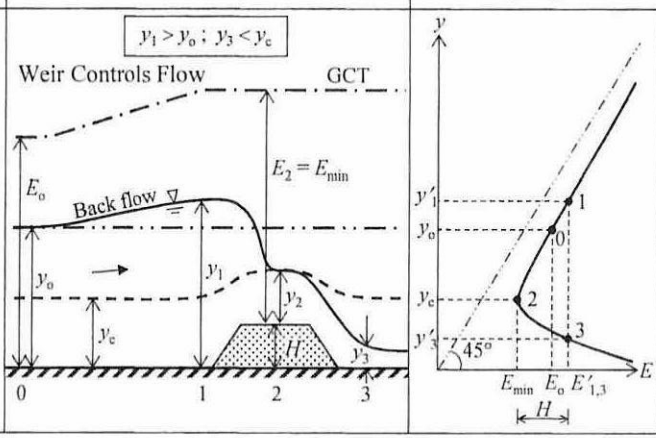
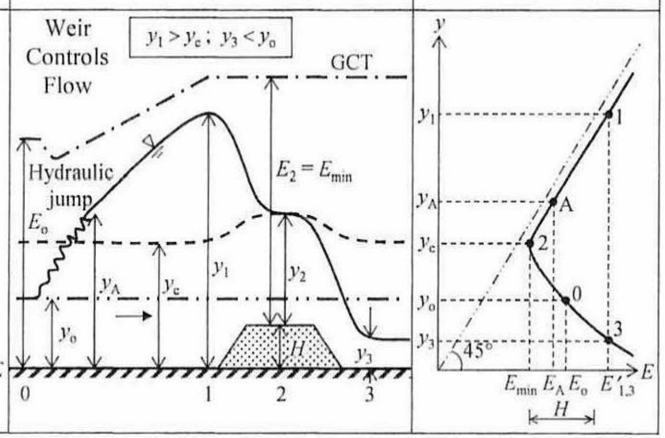
Section	Flow area A	Top width T	Wetted perimeter P
 Rectangular	By	B	$B + 2y$
 Triangular	zy^2	$2zy$	$2y\sqrt{1+z^2}$
 Trapezoidal	$By + zy^2$	$B + 2zy$	$B + 2y\sqrt{1+z^2}$
 Circular	$\frac{D^2}{8}(2\theta - \sin 2\theta)$	$D\sin\theta$	θD

Table APPENDIX A.2

	CONDITION	SUBCRITICAL AT POINT 0 ($y_o > y_c$)	SUPERCRITICAL AT POINT 0 ($y_o < y_c$)
CASE 1	$E_{min} + H < E_o$ or $H < H_{min}$ $y_1 = y_3 = y_o$ & $y_2 \neq y_c \rightarrow E_2 = E_o - H$		
CASE 2	$E_{min} + H = E_o$ or $H = H_{min}$ $y_1 = y_3 = y_o$ & $y_2 = y_c$		
CASE 3	$E_{min} + H > E_o$ or $H > H_{min}$ $y_1 \neq y_3 \neq y_o$ & $y_2 = y_c \rightarrow E'_{1,3} = E_{min} + H$		

APPENDIX B

EQUATIONS SHEET

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

$$y_c = \sqrt[3]{\frac{q^2}{g}} \quad R_e = \frac{VR}{v} \quad P_o = \rho gQH \quad C_H = \frac{ND}{\sqrt{H}} \quad L_e = L - (0.1nH_1)$$

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

$$\frac{Q_m}{N_m {D_m}^3} = \frac{Q_p}{N_p {D_p}^3} \quad \eta = \frac{P_o}{P_i} \quad P = \frac{2\pi N}{60}T \quad N_s = \frac{N\sqrt{P}}{H^{\frac{5}{4}}} \quad C_Q = \frac{Q}{ND^3}$$

$$Q = C_d ab\sqrt{2g(y_o - y_1)} \quad Q = C_d ab\sqrt{2g(y_o - y_2)}$$

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

$$\Delta x = \frac{\Delta y}{S_o}\left[\frac{1 - \left(\frac{y_c}{y_{avg}}\right)^3}{1 - \left(\frac{y_o}{y_{avg}}\right)^3}\right] \quad Q = \frac{2}{3}C_d\sqrt{2g}L{H_1}^{3/2} \quad C_P = \frac{P}{N^3 D^5} \quad \Delta x = \frac{\Delta y}{S_o}\left[\frac{1 - \left(\frac{y_c}{y_{avg}}\right)^3}{1 - \left(\frac{y_o}{y_{avg}}\right)^{10/3}}\right]$$

$$Q = \frac{8}{15}C_d\sqrt{2g}\,.\,tan\frac{\theta}{2}.{H_1}^{5/2} \quad Q = \frac{2}{3}C_d\sqrt{2g}L{H_1}^{3/2}\left(L + \frac{4}{5}H_1 tan\theta\right)$$

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

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

$$P_L = \rho gQE_L \quad \Delta y = \frac{y_{initial} - y_{end}}{Number\ of\ steps} \quad S_f = \frac{n^2 v^2}{R^{4/3}} \quad Q = CA\sqrt{RS_o}$$

$$\eta = \frac{Q_T H_T}{KP_T}$$

Where ;

$K = 0.102$ if P in kW and Q in m^3/s
$K = 6116$ if P in kW and Q in L/min

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