



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: August 2018

Module Number: CE5303 Module Name: Hydraulic Engineering

[Three Hours]

[Answer all questions, each question carries 12.5 marks]

Experimental values of Manning's n for different surfaces are provided

Q 1.

- (i) Briefly explain why the principle of conservation of energy shall not be used in developing the theory of hydraulic jump. (02 Marks)
- (ii) Using clear sketches, explain how and why the hydraulic jump is formed? Discuss practical applications of hydraulic jump. (02 + 1.5 Marks)
- (iii) Water flows in a wide channel at $q = 10 \text{ m}^3/(\text{s} \cdot \text{m})$ and $y_1 = 1.25 \text{ m}$. If the flow undergoes a hydraulic jump, compute;
- (a) Downstream depth, y_2
 - (b) Downstream velocity, V_2
 - (c) Downstream Froude Number, Fr_2
 - (d) Dissipation head loss across the jump, h_f
 - (e) The percentage energy dissipation,
 - (f) The power dissipated per unit width and
 - (g) The temperature rise due to power dissipation if $C_p = 4200 \text{ J}/(\text{kg} \cdot \text{K})$.

Conjugate depths for a hydraulic jump in a horizontal bed in standard notations may be taken as; $\frac{2y_2}{y_1} = -1 + (1 + 8Fr_1^2)^{1/2}$. Take power dissipated = $\dot{m} C_p \Delta T$ (where \dot{m} is mass flow rate).

(01 x 7 = 07 Marks)

Q 2.

(i) What is meant by the 'most economical channel section'? Show that for a trapezoidal channel section, the most economical section is represented by half a hexagon. (1.5 + 02 Marks)

(ii) (a) Define terms 'specific energy' and 'critical depth' in non-uniform flow.

(b) Show that the condition for critical depth can be represented by $\frac{Q^2 B}{gA^3} = 1$ with standard notations.

(01 + 01 + 03 Marks)

(iii)

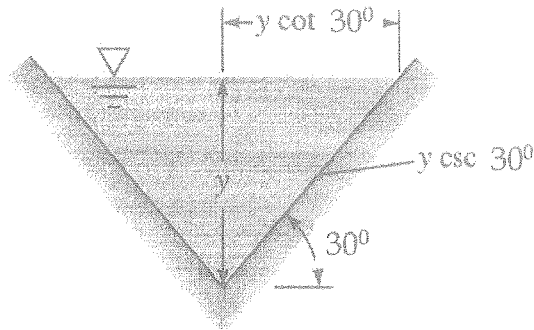


Figure Q2: Triangular-Shaped channel

A triangular asphalt-lined channel having 30° side slope angle (Fig. Q2) has a flow rate of 16 m³/s. Compute;

- (a) Critical depth
- (b) Critical velocity and
- (c) Critical slope

(04 Marks)

Q 3.

(i) A ventilated weir discharge, Q correlates with gravity and the blockage height to which the upstream flow is backed up above the weir elevation (Fig. Q3). Upstream flow is subcritical and accelerates over the weir and discharges as a supercritical flow stream that resembles a free jet. It has been experimentally found that depth of the flow jet varies as given in Fig Q3.

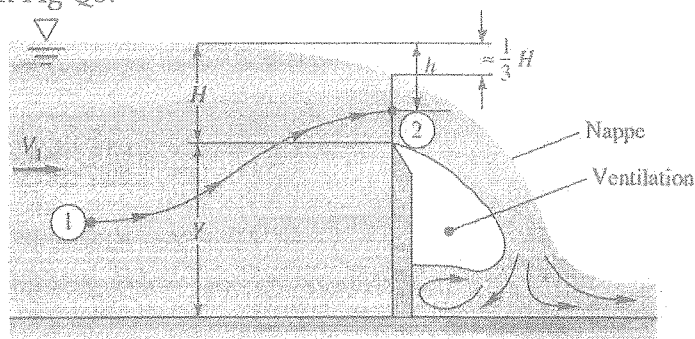


Figure Q3: Flow over a well ventilated sharp crested weir.

Q 3. Continued to page 3.

Show that the flow discharge over the weir can be represented by

$$Q_{weir} = C_d \frac{2}{3} b \sqrt{2g} H^{3/2} \text{ with standard notations. State all the assumptions.}$$

(04 + 1.5 Marks)

- (ii) A sharp-crested weir in a horizontal channel is 1 m high and 4 m wide. The water depth at upstream is 1.6 m. Neglect approach velocity head. If the width of the weir is 1.2 m, estimate the weir discharge. Discharge coefficient for sharp-crested weir shall be taken as; $C_d = 0.564 + 0.0846 \frac{H}{y}$ for $\frac{H}{y} \leq 2.0$

(04 Marks)

- (iii) It is required to increase the design discharge by 50% of the above part (ii) estimate. However, due to a site restriction the width of the weir shall not be changed. Discuss other design alteration(s) to accomplish the above requirement.

(03 Marks)

Q 4.

- (i) The depth gradient in gradually varied flow in a rectangular open channel with standard notations is articulated as; $\frac{d(d)}{dL} = \frac{(s_0 - s_f)}{\left(1 - \frac{BQ^2}{gA^3}\right)}$.

Deduce the surface flow profile shapes for gradually varied steady flow in a wide rectangular channel under

- (a) Mild slope condition,
- (b) Critical slope condition and
- (c) Steep slope condition.

(05 Marks)

- (ii) A gravelly earth wide channel is flowing at 10 m³/s per meter of width on a slope of 0.75°. Is this a mild, critical, or steep slope? What type of gradually varied solution curve are we on, if the local water depth is (a) 1.0 m, (b) 2.1 m, and (c) 3.0 m?

(04 + 1.5 Marks)

- (iii) Discuss practical application of evaluation of surface flow profiles.

(02 Marks)

Experimental values of Manning's n for different surfaces

Type of surface	Manning's n
<i>Artificial lined canals:</i>	
Glass	0.010
Brass	0.011
Steel, smooth	0.012
Painted	0.014
Riveted	0.015
Cast iron	0.013
Cement, finished	0.012
Unfinished	0.014
Planed wood	0.012
Clay tile	0.014
Brickwork	0.015
Asphalt	0.018
Corrugated metal	0.022
Rubble masonry	0.025
<i>Excavated earthen canals:</i>	
Clean	0.022
Gravelly	0.025
Weedy	0.030
Stony, cobbles	0.035
<i>Natural channels:</i>	
Clean and straight	0.030
Sluggish, deep pools	0.040
Major rivers	0.035
<i>Floodplains:</i>	
Pasture, farmland	0.035
Light brush	0.050
Heavy brush	0.075
Trees	0.150