UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: August 2014

Module Number: CE5314 **Module Name: Hydraulic Engineering**

[Three Hours]

[Answer **all** questions, each question carries 12 marks]

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

Q 1.

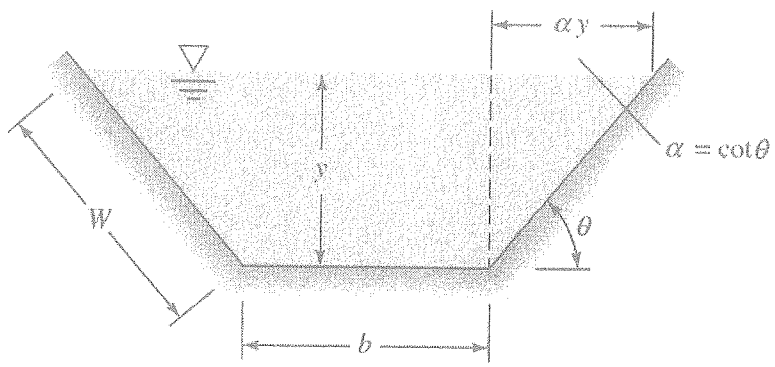

Figure Q1: Geometry of a trapezoidal canal section.

(i) (a) What is meant by the 'most economical canal section'?
(b) Show that for a trapezoidal section with any side slope θ, the most economical cross section for uniform flow occurs when the hydraulic radius is half the depth.

(02 + 02 Marks)

(ii) (a) Using the results of above part (i) (b) or otherwise deduce most economical section for a rectangular section is represented by $y = b/2$, where y and b are depth of flow and width of the channel section considered.
(b) What are the best dimensions for a rectangular brick canal designed to carry 5 m^3/s of water in uniform flow? The bed slope of the canal is 0.001.

(02 + 04 Marks)

(iii) Show that for a given depth and area, the most economical trapezoidal section is half a hexagon.

(02 Marks)

Q 2.

(i) Explain the following terms used in open channel flow:
(a) Normal depth
(b) Critical depth

(02 Marks)

Q 2. Continued to page 2.

(ii) In gradually varied flow, show that the slope of the water surface is given by:

$$\frac{d(d)}{dL} = \frac{s_0 - s_f}{1 - \frac{Q^2 B}{gA^3}}$$

where S_o = bed slope ; S_f = friction slope; Q = discharge ; B = width at free surface, and A = cross sectional area below the free surface.

(04 Marks)

(ii) A weir of height 3.0 m completely spans a rubble masonry canal of width 6.0 m. The discharge equation for the weir is $Q = 1.5\ L\ H^{3/2}$ in SI units. The bed slope of the canal is 0.0015. The head over the weir is 1.75 m.
(a) Show that the normal depth is approximately 1.99 m.
(b) Determine the critical depth and the location upstream of the weir at which the depth of flow is 4.70 m. Use direct step method.
(c) Describe the limitations associated with the direct step method in evaluation of surface profiles.

(02 + 03 + 01 Marks)

Q 3.

(i) In uniform open channel flow, what is meant by the 'balance of forces'? Can you use such a force balance to derive the Chezy equation? Explain.

(04 Marks)

(ii) In flood stage a natural channel consists of a deep main channel plus two floodplains, as shown in Fig. Q3. Main channel bed is clean and straight and the floodplains are shallow and rough with heavy brush.

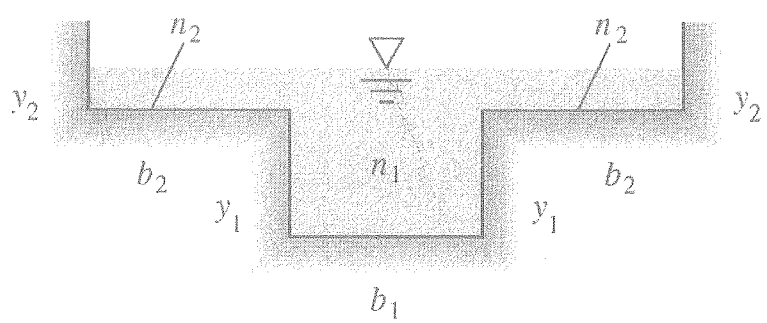

Figure Q3: A natural channel and its floodplains.

(a) Suppose that the channel dimensions are y_1=6 m, y_2=1.5 m, b_1 =12 m and b_2 =30 m. Estimate the total discharge in m^3/s if the longitudinal slope of the channel is 0.0002.
(b) State all the assumptions made during the computations in above part (ii) (a).
(c) Briefly explain under what conditions the above assumptions are not valid.

(05 + 02 + 01 Marks)

Q 4. A weir is a channel obstruction over which the flow must deflect. For simple geometries the channel discharge Q correlates with gravity and with the blockage height to which the upstream flow is backed up above the weir elevation. Upstream flow is subcritical and becomes critical as it approaches the weir. The liquid continues to accelerate and discharges as a supercritical flow stream that resembles a free jet (refer Fig. Q4).

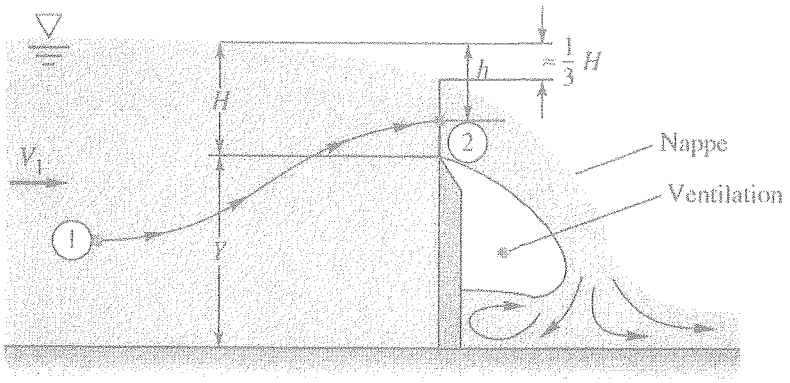

Figure Q4: Flow over wide, well ventilated sharp crested weir.

(i) (a) Show that the velocity at the top of the sharp crested weir for negligible approach velocity can be given by; $v = \sqrt{2gh}$

(03 Marks)

(ii) (a) Using the results in above part (i) (a) or otherwise show that the flow discharge over the sharp crested weir can be represented by $Q_{weir} = C_d \frac{2}{3} b\sqrt{2g}\, H^{3/2}$ with standard notations.

(b) Briefly explain, how the discharge coefficient for the weir is determined?

(04 + 01 Marks)

(iii) A weir in a horizontal channel is 1 m high and 4 m wide. The water depth upstream is 1.6 m. Estimate the discharge if the weir is a sharp crested. Assume the weir discharge coefficient as 0.6.

(a) Estimate the rate of discharge for steady flow conditions.

(b) State all the assumptions made during the computation of above part (iii) (a).

(02 + 02 Marks)

Q 5. A water conveyance structure is to be planned between a multipurpose reservoir and an irrigation field. Two alternative canal traces are suggested. First alternative is a tunnel drilled through mountainous area with relatively shorter path. Second alternative is an open channel running around the hilly terrain. After investigation with a rigorous study of the topography/geology of the area, the second alternative has been selected.

Q 5. Continued to page 4.

(i) (a) Briefly explain the possible reasons for not selecting the first alternative.
(b) Suggest suitable hydraulic structure(s) for the canal when the trace is crossing natural hydrological drainage paths.

(02 + 02 Marks)

(ii) It has been suggested to use rectangular canal with concrete as the lining material. The elevation drop of the canal trace between 20 km apart extreme points were estimated as 30 m and uniform slope for the entire canal trace was proposed. Design the canal to convey 20 m^3/s. Canal design parameters are given in Table Q5.1 and Table Q5.2.

Table Q5.1: Recommendations for free board

Q (m^3/s)	< 0.75	0.75 ~ 1.5	1.5 ~ 8.5	> 8.5
Free board (m)	0.45	0.6	0.75	0.90

Table Q5.2: Permissible velocities

Canal material	**Maximum Velocity (m/s)**	**Minimum Velocity (m/s)**
For Stratified Rock	2.40	1.0
For Hard Rock	3.96	
For Concrete	4.57	

(06 Marks)

(iii) Briefly discuss the major hydrological design modification(s) to be adopted if the conveyance structure is designed as erodible earthen canal.

(02 Marks)

Experimental values of Manning's n for different surfaces

Type of surface	Manning's n
Artificial lined canals:	
Glass	0.010
Brass	0.011
Steel, smooth	0.012
Painted	0.014
Riverted	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	0.016
Corrugated metal	0.022
Rubble masonry	0.025
Excavated earch canals:	
Clean	0.022
Gravelly	0.025
Weedy	0.030
Stony, cobbles	0.035
Natual channels:	
Clean and straight	0.030
Sluggish, deep pools	0.040
Major rivers	0.035
Floodplains:	
Pasture, farmland	0.035
Light brush	0.050
Heavy brush	0.075
Trees	0.150