UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: August 2015

Module Number: CE5303 **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

Q1.

(i) (a) What is meant by the 'most economical channel section'?

(b) Show that for a rectangular channel section, the most economical section is represented by $d = b/2$, where d and b are *depth* of flow and *width* of the channel section considered.

(c) The most economical sections for trapezoidal and circular open channel sections are half-hexagon and semicircular respectively. Briefly explain how these relationships would be derived highlighting the major differences with respective to above part (i) (b).

(02 + 02 + 02Marks)

(ii) (a) What are the best dimensions for a rectangular brick channel designed to carry 5 m^3/s of water in uniform flow with S_0= 0.001?

(b) Determine the flow rate for half-hexagon and semicircular channel sections of the same cross sectional area, S_0 and n as in above part (ii) (a).

(02 + 02 Marks)

(iii) Comment on the results of above part (ii) (b) with respect to most economical channel section criteria indicating limitations with actual usage.

(02 Marks)

Q2.

(i) Define the term *specific energy*. Identify and explain the associated parameters of specific energy curve.

(01 + 01 Marks)

(ii) Develop a relationship for the flow depth over a smooth frictionless hump (elevated bed). State all the assumptions.

(03 + 01 Marks)

Q 2. Continued to page 2.

(iii) Water is flowing at 1.5 m/s in a wide brickwork channel with a bed slope of 0.0005 under uniform flow conditions. The flow encounters a 10 cm high frictionless smooth hump. Estimate;

(a) the Froude Number for approach condition.

(b) the drop or rise of the water surface profile over the hump.

(c) the hump height which will cause the crest flow to be critical.

(01 + 04+ 01 Marks)

Q 3.

(i) Explain the following terms:

(a) Normal depth

(b) Critical depth

(02 Marks)

(ii) In evaluation of surface profiles, explain what is meant by direct step and standard step method. Highlight the advantages and limitation of each method.

(03 Marks)

(iii) A sharp edged weir is to be constructed across a 8 m wide urban river for hydropower electricity generation. The river upstream of the weir location may be approximated as rectangular, 8 m wide, sloping upstream at 0.4 m per 1000 m, and with a gravelly bed. The river sides are steep until about 2 km upstream, where there are low-lying residences. The town council is agreeable to construction of a weir as long as the new river levels near the houses do not exceed 1.8 m above the normal 30 year flood level. You, as project engineer, have to calculate how high the weir crest can be placed to meet this requirement. The 30-year flood rate is predicted as 30 m^3/s. The discharge equation for a sharp crested full width weir can be taken as $Q = C_d\, b\, g^{1/2}\, H^{3/2}$. Where $C_d = 0.6$, b is width of the weir and H is the depth of water above the weir crest.

(07 Marks)

Q 4.

(i) What is meant by a flood routing? Briefly discuss the major differences between reservoir routing and river routing.

(02 Marks)

(ii) The Muskingum method models the storage volume of flooding in a river channel using a combination of wedge and prism storage. The key parameters in Muskingum routing are k (travel time) and α (weighting coefficient). Briefly explain how the Muskingum routing parameters are estimated.

(02 Marks)

Q 4. Continued to page 3.

(iii) (a) For the inflow hydrograph shown below, perform the routing through the river reach and determine the outflow hydrograph at the end of the river reach. Assume k = 20 hours and α = 0.25. Give the results in the form of a table. The Muskingum model with standard notations may be taken as;

$$O_2 = I_1C_0 + I_2C_1 + O_1C_2$$

where, $C_0 = (\Delta t + 2k\alpha)/(\Delta t + 2k - 2k\alpha)$

$C_1 = (\Delta t - 2k\alpha)/(\Delta t + 2k - 2k\alpha)$

$C_2 = (-\Delta t + 2k - 2k\alpha)/(\Delta t + 2k - 2k\alpha)$

Time (hrs)	12	24	36	48	60	72	84	96	108	120
Discharge (m^3/s)	2.8	8.3	18.9	13.9	11.1	8.6	6.4	5.0	2.8	1.4

(b) Discuss application limitations associated with Muskingum method.

(06 + 02 Marks)

Q 5.

(i) Explain the significance of following parameters in relation to channel design.

(a) Maximum and Minimum permissible velocities

(d) Free board

(04 Marks)

(ii) Research has shown that the distribution of the shear stress along a channel is not uniform and the maximum values of shear stresses on the level bed and side slopes are approximated by; $\tau_L = wRs_0$ and $\tau_S = 0.76\ wRs_0$ with standard notations.

For a wide channel (B>>y) the hydraulic radius (R) shall be substituted by the flow depth y. Derive the formula $\tau_L = wRs_0$ from first principals and identify each term.

(02 Marks)

(iii) Design a trapezoidal channel to carry 20 m^3/s on a slope of 0.0015. The channel is to be excavated in coarse alluvium (gravelly soil), and with the particles on the perimeter of the channel moderately rounded. The channel side slope is selected to be 2H :1V. The permissible tractive force on the bottom of the channel is estimated as 14.3 N/m^2 for a median particle size of 20 mm. Unit tractive force ratio (with usual notations) for an earth channel of trapezoidal section may be taken as,

$$K = \tau_S/\tau_L = \cos\phi\sqrt{1-\frac{\tan^2\phi}{\tan^2\theta}}.$$

Related channel design parameters are illustrated in Figure Q5 and Table Q5.

(06 Marks)

Table Q5: 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

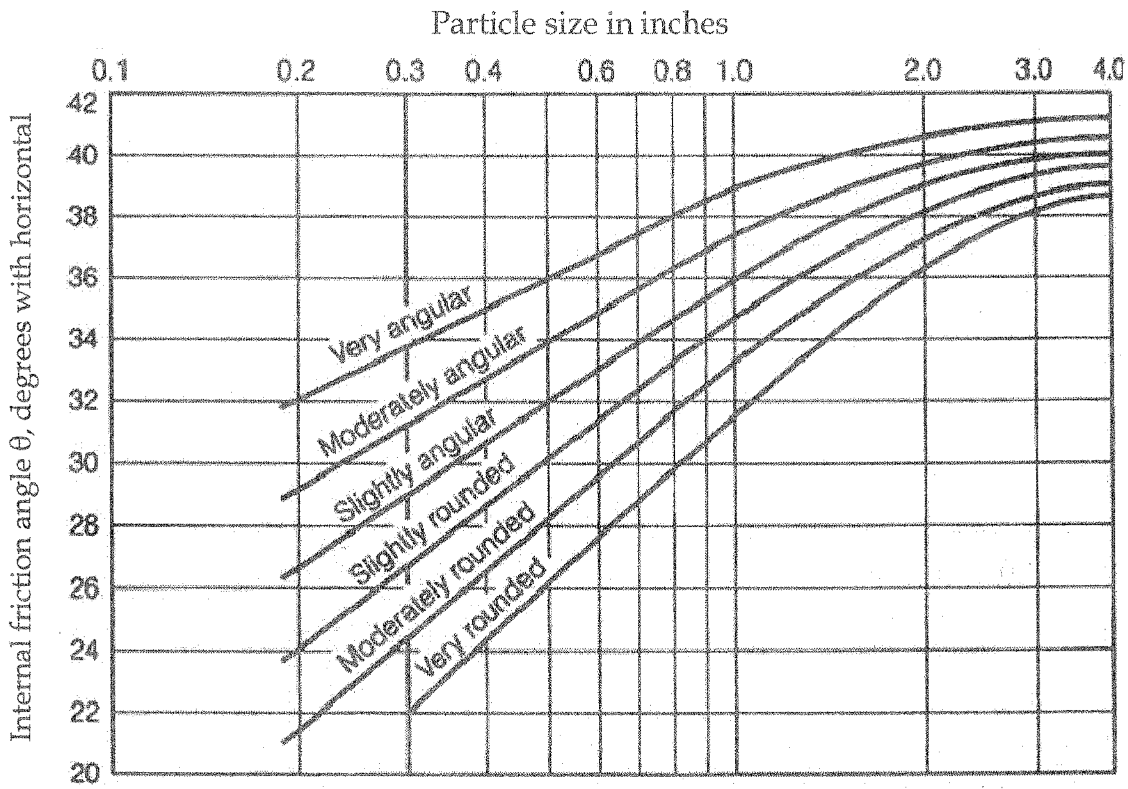

Figure Q5: Internal friction angle against particle size

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