(Please write your Exam Roll No.) Exam Roll No. 603180

END TERM EXAMINATION

SIXTH SEMESTER [B.TECH] MAY-JUNE 2016

Paper Code: ETCE-308 **Subject: Open Channel Flow and Numerical Hydraulics**

Time: 3 Hours **Maximum Marks: 75**

Note: Attempt any five questions including Q.no.1 which is compulsory. Internal choice is indicated.

Q1 Answer **any five** questions: **(5x5=25)**

(a) Define specific energy and critical depth, and explain the concept of alternate depth with the aid of specific energy diagram. A rectangular channel of width 2.5 m conveys a discharge of 5 m^3s^{-1} at a depth of 5.0 m. If the kinetic energy correction factor α is 1.20, compute the specific energy. Show that with α being 1.0 for the alternate flow, the alternate depth would be 0.413 m.

(b) A trapezoidal channel of bed width 3.0 m and side slope 1.5 horizontal : 1 vertical carries a full supply of 10^3s^{-1} at a depth of 1.5 m. What would be the discharge at half of full supply depth? Check if a depth of 1.043 m would be required to convey half of the full supply discharge.

(c) Sketch the Gradually Varied Flow profiles produced on the upstream and downstream of a sluice gated introduced in a steel slope, a mild slope and a horizontal-bed channel. A rectangular channel 15 m wide and 10 m along as a slope of 1 in 10,000 and connects two reservoirs. The water depth at the upstream and the downstream ends of the channel are 1.5 m and 2.0 m respectively. If manning's roughness coefficient is 0.015, determine the type of Gradually Varied Flow profile.

(d) A sluice gate in a 3.0 m wide rectangular, horizontal channel releases a discharge of 18 m^3s^{-1}. The gate opening is 0.67 m and the coefficient of contraction is 0.6. What would be the type of hydraulic jump formed when the tailwater is (i) 3.60 m, (ii) 5.00 m and (iii) 4.09 m?

(e) On what sediment properties the entertainment, transportation and deposition of sediments depend? Define critical velocity for the initiation of sediment motion and write down Lacey's definition of a regime channel in the context of flow in a mobile boundary channel.

(f) What do you mean by laminar and turbulent diffusion, dispersion, and advection in the context of mixing of pollutants in open channel flow?

Q2 (a) Using the concept of linear momentum, derive the momentum equation relating the forces acting on a control volume in a steady open channel flow. Hence write an expression of specific force and draw the general shape of a specific force diagram by clearly indicating the location of the critical depth. **(4)**

(b) Show that, for a rectangular channel, the specific energy at critical depth is 1.5 times the critical depth. Hence derive an expression relating critical depth to the discharge per unit width, and write the expression of Froude number for a rectangular channel. **(4)**

P.T.O.

ETCE-308

(c) For the purpose of discharge measurement in a rectangular channel, the width is reduced gradually from 3.0 m to 2.0 m and the bed is raised by 30 cm at a section. When the depth of approaching flow is 2.0 m, what discharge would be indicated by a drop of 15 cm in water surface elevation at the contracted section? **(4.5)**

OR

Q3 (a) Derive Chezy's equation for estimating uniform flow in an open channel and express Chezy's coefficient in terms of manning's roughness coefficient. **(4)**

(b) A rectangular channel with manning's roughness coefficient 0.015 is laid on a bottom slope of 0.0064. The channel is to carry a discharge of 20 m^3s^{-1}. Check if a width of 2.41 m would be required in order to cause the flow in the channel to be in critical condition. **(4)**

(c) What should be the proportion of a hydraulically efficient trapezoidal section with a given side slope and what would be the proportion of the hydraulically most efficient trapezoidal section to convey a given discharge? Design a hydraulically efficient trapezoidal channel section having side slope of 1.5 horizontal : 1 vertical and longitudinal slope of 1 in 2500 to carry a discharge of 25 m^3s^{-1}. Take the value of manning's roughness coefficient as 0.017. **(4.5)**

Q4 (a) Writing clearly the assumptions made, derive the dynamic equation of gradually varied flow in a prismatic channel. **(4)**

(b) A vertical sluice gate introduced in a rectangular channel spanning the entire width 3.5 m has the vertical opening section of height 0.75 m. The *vena contracta* of the flow jet issuing under the gate is located approximately 0.75 m downstream of the gate, coefficient of contraction for the gate flow section being 0.62. The channel has a bed slope of 1 in 600, the manning's roughness coefficient of 0.017, and carries a steady flow of 15 m^3s^{-1}. **(8.5)**

(i) Calculate the critical depth and check if the normal depth would be 1.9 m.

(ii) Calculate the associated critical slope and the Froude Number at the normal depth.

(iii) Using each of your results for parts (i), and (ii), determine whether the channel is of steep, mild or critical slope.

(iv) Show whether the flow at and immediately downstream of the *vena contracta* is subcritical, supercritical, or critical.

(v) Identify the form of flow profile immediately downstream of the *vena contracta* of the gate.

OR

Q5 (a) Derive expressions for conjugate depths and the energy loss in hydraulic jump in a horizontal, frictionless, rectangular channel. **(4)**

(b) Water discharging into a 10 m wide rectangular horizontal channel from a sluice gate is observed to have undergone a hydraulic jump. The flow depth and velocity before the jump are 0.9 m and 7 ms-1 respectively. Determine: **(8.5)**

(i) The flow depth and the Froude number after the jump.

(ii) The head loss and the energy dissipation ratio, and

(iii) The wasted power production potential due to the hydraulic jump.

(iv) Explain the use of hydraulic jump as an energy dissipater.

P.T.O.

ETCE-308

Q6 (a) What are the steps involved in the critical tractive force approach of design of stable alluvial channels carrying clear water? **(6)**

(b) Design a stable non-erodable channel to carry 10 m^3s^{-1} clear water through a bed having 10 mm rounded gravel. The longitudinal slope of the channel would be 0.0008 and the side slope would be 2 horizontal : 1 vertical. Adopt the angle of repose of the bed material as 32°C. Check if the bed width of the channel would be 12.4 m. **(6.5)**

OR

Q7 (a) Write down the equations describing the Kennedy's and the Lacey's theories of design of stable channels and state the differences between the two theories. **(6)**

(b) Design a Lacey's regime channel to convey 5 m^3s^{-1} discharge through sand of mean particle size 0.5 mm. **(6.5)**

Q8 (a) What do you mean by the finite volume method of solution of a partial differential equation? What are the steps involved? **(4)**

(b) Derive the one-dimensional steady state diffusion equation starting with the concept of mass balance on an infinitesimal stretch of the system. Identify Fick's first and second law as you proceed with the derivation. **(4.5)**

(c) What do you mean by finite volume method of solution of a convection-diffusion problem? What are the steps involved? **(4)**

OR

Q9 (a) An industry discharges an effluent containing 250 ppm of a conservative substance at rate of 0.1 m^3s^{-1} at the side of a river. The river is very wide and straight. The depth of flow, the slope and the manning's roughness coefficient are 5.0 m, 0.0004 and 0.025 respectively. Estimate the width of the plume and the maximum concentration 250 m downstream from the point of discharge. **(6.5)**

(b) Write down the mass-balance equations for the mathematical treatment of the transport of a conservative pollutant in streams. How would the equation change if the pollutant is non-conservative? What are the assumptions made in the case of longitudinal dispersion? **(6)**

****