Code : 011410

B.Tech 4th Semester Exam., 2018

HYDRAULICS AND OPEN CHANNEL FLOW

Time : 3 hours *Full Marks* : 70

Instructions :

(i) The marks are indicated in the right-hand margin.

*(ii) There are **NINE** questions in this paper.*

*(iii) Attempt **FIVE** questions in all.*

*(iv) Question No. **1** is compulsory.*

1. Choose the correct option (any *seven*) : 2×7=14

(a) Flow separation is caused by

(i) reduction of pressure to vapour pressure

(ii) a negative pressure gradient

(iii) a positive pressure gradient

(iv) the boundary layer thickness reducing to zero

(b) The laminar boundary layer thickness on a plate varies as

(i) $x^{(-1/2)}$

(ii) $x^{(4/5)}$

(iii) $x^{(1/2)}$

(iv) x^2

(c) Direct step method of computation for gradually varied flow is

(i) applicable to non-prismatic channels

(ii) applicable to prismatic channels

(iii) applicable to both prismatic and non-prismatic channels

(iv) not applicable to both prismatic and non-prismatic channels

(d) The Keifer and Chu varied-flow functions are useful for GVF computations in

(i) all types of channels

(ii) circular channels only

(iii) channels with closing top

(iv) rectangular channel only

(Continued)

(e) Bresse's backwater function is applicable to

(i) circular channel

(ii) trapezoidal channel

(iii) any shape of channel

(iv) wide rectangular channel

(f) The standard step method is

(i) an unguided trial and error method

(ii) a rapidly converging iterative procedure

(iii) not applicable to natural channels

(iv) not applicable to artificial channels

(g) The hydraulic jump is a phenomenon

(i) in which the water surface connects the alternate depths

(ii) which occurs only in frictionless channels

(iii) which occurs only in rectangular channels

(iv) None of the above

(h) If the Froude number of a hydraulic jump is 5·50, it can be classified as

(i) an oscillating jump

(ii) a weak jump

(iii) a strong jump

(iv) a steady jump

(i) The phenomenon occurring in an open channel, when a rapidly flowing stream abruptly changes to slowly flowing stream causing a distinct rise of liquid surface, is

(i) water hammer

(ii) hydraulic jump

(iii) critical discharge

(iv) None of the above

(j) The normal depth in a wide rectangular channel is increased by 10%. The percentage increase in the discharge in the channel is

(i) 20·1

(ii) 15·4

(iii) 17·2

(iv) 10·5

(Continued)

2. (a) Determine the displacement thickness and momentum thickness in terms of the nominal boundary layer thickness δ in respect of the following velocity profiles in the boundary layer on a flat plate : 8

(i) $\frac{u}{U_0} = 2\frac{y}{\delta} - \left(\frac{y}{\delta}\right)^2$

(ii) $\frac{u}{U_0} = \left(\frac{y}{\delta}\right)^{\frac{1}{m}}$

(b) Define stagnation point. How is the position of stagnation points for a rotating cylinder in a uniform flow determined? What is the condition for single-stagnation point? 6

3. (a) Prove that for the trapezoidal channel of most economical section : 8

(i) Half of top width = Length of one of the slopping sides

(ii) Hydraulic mean depth = Half of depth of flow

(b) Calculate the critical depth and corresponding specific energy for a discharge of 5·0 m^3/s in the following channels : 6

(i) Rectangular channel, B = 2·0 m

(ii) Triangular channel, $m = 0{\cdot}5$

(iii) Trapezoidal channel, $B = 2{\cdot}0$ m, $m = 1{\cdot}5$

(iv) Circular channel, $D = 2{\cdot}0$ m

4. A rectangular channel is 4·0 m wide and has $n = 0{\cdot}015$.

(a) Determine the bed slope required to maintain uniform flow in this channel with a flow depth of 1·25 m and a uniform flow Froude number of (i) 2·0, (ii) 1·0 and (iii) 0·50. Also, find the limit slope and the corresponding critical discharge. 9

(b) Find the longitudinal slope required to ensure that the uniform flow Froude number in this channel is equal to or less than 0·50 for all discharge. 5

5. (a) A trapezoidal channel is 10·0 m wide and has a side slope of 1·50 horizontal : 1 vertical. The bed slope is 0·0003. The channel is lined with smooth concrete of $n = 0{\cdot}012$. Compute the mean velocity and discharge for a depth flow of 3·0 m and also find the bottom slope necessary to carry only 50 m^3/s of the discharge at a depth of 3·0 m. 5

(Continued)

(b) Explain the gradually varied flow (GVF) and derive the differential equation for GVF. 9

6. (a) A rectangular channel, B = 4·0 m and n = 0·015, is laid on a slope of 0·0004. The channel is 500 m long and connects two reservoirs. The bed of the channel at the intake is at an elevation of 120·0 m, the intake is free and has a loss coefficient of 0·2.

(i) If a uniform flow takes place at a depth of 2·0 m, what are the elevations of the upstream and downstream reservoir?

(ii) If the elevation of the upstream reservoir is held constant and the downstream reservoir elevation is lowered by 1·0 m, what is the delivery of the channel? 9

(b) The flow rate of water in a 5 m wide horizontal open channel is being measured with a 0·60 m high sharp crested rectangular weir of equal width. If the water depth upstream is 1·5 m, determine the flow rate of water. 5

7. (a) Explain the characteristics of jump in a rectangular channel. 7

(b) A sluice gate in a 3·0 m wide rectangular, horizontal channel releases a discharge of 18·0 m^3/s. The gate opening is 0·67 m and the coefficient of contraction can be assumed to be 0·6. Examine the type of hydraulic jump formed when the tail water is *(i)* 3·60 m, *(ii)* 5·00 m and *(iii)* 4·09 m. 7

8. (a) What is surge? Explain the positive surge. 5

(b) A cylinder, whose axis is perpendicular to the stream of air having a velocity of 20 m/s, rotates at 300 r.p.m. The cylinder is 2 m in diameter and 10 m long. Find *(i)* the circulation, *(ii)* the theoretical lift force per unit length, *(iii)* the position of stagnation points and *(iv)* the actual lift, drag and direction of resultant force. For determining actual drag and lift, assume

$$\frac{U_c}{U_0} = 1{\cdot}57,\ C_L = 3{\cdot}4 \text{ and } C_D = 0{\cdot}65$$

where U_c represents the peripheral velocity due to circulation and for air $\rho = 1{\cdot}24$ kg/m^3. Also determine the speed of rotation of the cylinder which yields only a single-stagnation point. 9

9. *(a)* A 3·0 m wide rectangular channel has a flow of 3·60 m^3/s with a velocity of 0·8 m/s. If a sudden release of additional flow at the upstream end of the channel causes the depth to rise by 50%, determine the absolute velocity of resulting surge and the new flow rate. 5

(b) A television transmitting antenna is fixed on the top of a pipe, 30 m high and 50 cm diameter, which stands on a tall building. What will be the total drag of the pipe and the moment at its base when it is exposed to a wind of uniform velocity at 125 km/hr? How this moment will change if the diameter of pipe gradually changes from 50 cm at the base to 30 cm at the top? For the turbulent flow corresponding to Reynolds number encountered, take average value of C_D equal to 0·3. 9

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