**Open channel hydraulics**

**SHEET (1)**

1**–** A wide stream carries approximately uniform flow at a depth of 3.5 m. The velocities at 0.2 and 0.8 depths are found to be 0.6 (maximum) and 0.4 m/sec respectively. Estimate:

1. The discharge per unit width.
2. The values of momentum and energy coefficients.

2 **–** A rectangular channel has a longitudinal slope 10 cm/km, bed width 20 m Manning n=0.02, carries a discharge at a depth of 3.0 m. It is found that the value of maximum water velocity is equal to 1.1m/s. Estimate the value of the energy and momentum coefficients.

3 **–** While measuring the discharge in an open channel, it was found that the depth of flow increases at a rate of 0.1m/hr. If the discharge at the section was 12 m3/sec and the surface width was 15m, Estimate the discharge at 1km downstream.

4 **–** A smooth square plate 2.0 m side is kept immersed in water, which moves at a velocity 40 cm/sec, Find the Boundary layer thickness at a distance 0.6m from the leading edge. Take the kinematic viscosity of water as 10-6 m2/sec.

5 – A smooth plate of length 1.0 m and width 3.0 m is immersed parallel to air flow of velocity 2.0 m/sec. Find the drag force on one side of the plate and at the trailing edge find the boundary layer thickness and the displacement thickness. (For air: ρ =1.23 kg/m3 and υ = 1.46×10-5 m2/sec.)

6 - Water flows through a convex channel that has a 15 m radius of curvature; determine the pressure head if the velocity of water is 7 m/s and the flow depth is 3m.

**SHEET (2)**

1- A flow of 7.0 m3/sec passing through channel has 2.5 m wide. Calculate the alternate depths and corresponding Froude numbers if the specific energy for the channel is 1.45 m.

2- A steep flume of triangular section and apex angle of 900 runs from a large tank in which the water surface level is 6.0m above the flume invert where it joins the tank. Find the discharge in the flume.

3- Water flow from a lake into a steep rectangular channel 3.0 m wide, and the lake level is 3.0 m above the channel bed at the outfall. Find the discharge.

4- Water flow in a channel of rectangular section with a velocity of 1.5 m/sec and a depth of 1.2 m. determine *(a)*: the specific energy of the flow; *(b)*: the critical depth; *(c)*: the maximum discharge under critical flow condition if the channel is 3.0 m wide.

5- A channel of trapezoidal cross section, width of base 0.6 m and side slope 450 carries 0.34 m3/sec. Determine the critical depth.

6- A rectangular channel 4.0 m wide and carries a discharge of 20 m3/sec at a depth 2.0 m. At a certain location, it is proposed to build a hump. Calculate the water surface elevation at upstream of the hump and over the hump, if the hump height is: *(a):* 0.33 m; and *(b):* 2.0 m. *(Assume no loss of energy at hump)*.

7- A uniform flow of 12 m3/sec occurs in a long rectangular channel of 5.0 m width and 1.5 m water depth. A flat hump is to be build at a certain section. Assuming head loss equal to the upstream velocity head, compute the minimum height at hump provide critical flow. What will happen: *(a):* if the height of hump is higher than that causing critical flow. *(b):* if the energy loss is less than the assumed value.

8- A uniform flow of 20 m3/sec occurs in a rectangular channel of 5.0 m width and 2.5 m water depth. A smooth hump of height 0.5m is placed in the bottom of the channel. *Determine:*

*(a):* The difference in water levels before and at the hump;

*(b):* The height of hump to produce critical depth on it, and the drop in water level;

*(c):* Draw a relationship between y1 (u.s. the hump), y2 (at the hump) versus Δz (the hump size);

*(d):* What the effect of increasing the height of hump to 1.0m on the water levels; and

*(e):* How can the water levels before and after the hump remain the same.

9- A uniform flow of 20 m3/sec occurs in a rectangular channel of 5.0 m width and 2.5 m water depth. The channel bed is gradually contracted to a width of 3.0m. *Find:*

*(a):* The difference in water levels just before and after the contraction;

*(b):* The width of contraction to produce critical depth on it, and the drop in water levels;

*(c):* Draw a relationship between y1, y2 versus b2; and

*(d):* The difference in water levels if the width is contracted to 2.0 m.

10- A trapezoidal canal 10.0m bed width, 1:1 side slope, 3.0 m water depth and carries a discharge of 25 m3/sec. The canal is constricted by raising the sides to vertical positions. *Calculate:*

*(a):* The depth of water in the constriction; and

*(b):* The minimum height of hump which may be installed in the constriction to produce critical depth there.

11- A 50 wide rectangular channel is carrying a flow of 250m3/sec at a flow depth of 5m. To produce a critical flow in this channel, *determine:*

*(a):* The height of step in the channel bottom if the width remains constant;

*(b):* The reduction in the channel width if the channel bottom level remains unchanged;

*(c):* A combination of the width reduction and the bottom step; and

*(d):* what is the minimum channel width without affecting the upstream water level?

12- A rectangular open channel of width 3.0 m is contracted 10 cm from each side at given section. If the water depth of the approaching flow is 1.0 m, calculate the rate of flow indicated by each of the following cases:

*(a):* 10 cm rise in the water surface elevation over the contracted portion;

*(b):* 10 cm drop in the water surface elevation over the contracted portion.

Determine the maximum contraction allowable for each of the indicated cases to produce critical flow.

13- A trapezoidal channel with base width 6.0 m and side slope 2:1 carries a flow of 30 m3/sec at a depth 2.4 m. There is a smooth transition to a rectangular section 3.0 m wide also, there is a hump 0.6m. *Find:*

*(a):* The depth of water within the rectangular section and the change in water surface level;

*(b):* The hump in channel bed to produce a critical flow; *(c):* The depression in bed channel to produce unchanged water surface upstream and downstream of the depression; and

*(d):* The depression in bed channel to produce a drop in the water surface equal to 0.25 m.

14- An open channel of rectangular section having 1.0 m width, and 0.6 m water depth. If the floor is raised with 6 cm calculate the following:

*(a):* The rate of flow in case of 4 cm drop in the water surface over the raised bottom;

*(b):* The minimum rise in the floor to produce minimum specific energy;

*(c):* The rate of flow in case of 10 cm rise in the water surface over the raised bottom; and

*(d):* The minimum rise in the floor to produce minimum specific energy in case of 10 cm rising in the water surface.

15- Water flows at a velocity of 1 m/sec and depth of 2 m in an open channel of rectangular section and bed width of 3m. At certain section the width is reduced to 1.8 m and the bed is raised by 0.65 m. Will the upstream be affected and if so, to what extent.

**SHEET (3)**

1- Prove that for a given discharge, the momentum function has its minimum value, whether the channel is rectangular or non-rectangular.

2- A spillway discharges a flood flow at a rate of 8.0 m3/sec/m. At the downstream horizontal apron, the depth was found to be 0.6 m, what tail water depth is needed to form a hydraulic jump. If the jump is formed, find its type, length and the power dissipated by the jump.

3- A hydraulic jump is to be formed in a trapezoidal channel with a base width of 6.0 m and side slopes 2H:1V. The two conjugate depths are 0.9 m and 2.4 m. Find the discharge and the horsepower dissipated in the jump.

4- Water flows under sluice into a rectangular stilling basin having the same width as the gate. After the contraction of the jet, the flow has an average velocity of 24.4 m/sec and depth of 1.8 m. Determine:

* 1. The sequent total water depth.
	2. The length of the basin required to confine the jump.
	3. The effectiveness of the basin to dissipate energy (i.e. efficiency of the jump).
	4. The type of the jump to be expected.
	5. The energy dissipated in watts per unit width.

5- A rectangular channel 4.0 m wide conveys a discharge of 18 m3/sec at a depth of 2.25 m. Determine the depth and celerity of the positive surge wave resulting from sudden total gate closure.

6- A rectangular channel 10.0 m width, bed slope 0.0001, manning's roughness coefficient 0.025, receives inflow from a reservoir with gated inlet. When a steady discharge of 30 m3/sec is being conveyed, the gate is suddenly opened to release a discharge of 70 m3/sec. Calculate the initial celerity and depth of the surge wave.

7- A vertical sluice gate with an opening 0.7 m produced a downstream jet of 0.45 m when installed in along rectangular channel 6.0 m wide conveying a steady discharge of 30.0 m3/sec. Assuming the flow downstream of the gate eventually returns to the uniform flow depth of 3.0 m:

* 1. Verify that the hydraulic jump occurs.
	2. Find the type jump and its length.
	3. Calculate the horsepower dissipated in the jump.
	4. If the head loss through the gate is (0.06 V2jet/ 2g), calculate the depth upstream the gate and the force on the gate.

8- A hydraulic jump is formed in a 5 m wide outlet at a short distance downstream of a control gate. If the flow depths just upstream and downstream the gate are 10 m and 2 m, respectively, and the outlet discharge is 150 m3/sec. Assuming there is no losses in the flow through the gate, determine:

* 1. Flow depth downstream of the jump.
	2. Thrust on the gate.
	3. Head losses in the jump.

9- What do you understand by the term a positive surge wave? A river is flowing at a depth of 2.4 m and velocity of 0.9 m/sec. When it meets a tidal bore which abruptly increases the depth to 3.6 m. Find the speed with which the bore moves upstream and the magnitude and direction of the velocity of the water behind the bore.

10- At low tide the steady fresh water flow in an estuarine channel, 20.0 m wide, bed slope 0.0005, manning's roughness coefficient 0.02, is 20 m3/sec. A tidal bore forms on the flood tide and is observed to propagate upstream at celerity of 4 m/sec. Neglecting the density difference between the fresh water and saline water, determine the depth and the discharge immediately after the bore has passed.

11- A gate is to be dropped into place closing a rectangular channel 2.0 m depth and 3.0 m wide in which 6.0 m3/sec are flowing at a depth of 1.5 m. Will the channel overflow? Assuming the sides of the channel is to be sufficiently high to prevent overflowing, what will be the velocity of the surge produced?

**SHEET (4)**

1 – An open channel carries water with a velocity 0.6 m/sec. If the average shear stress is 1.0 N/m2. Determine Chezy's coefficient C.

2 – At a measured discharge of 40 m3/sec, the depth of uniform flow in a rectangular channel of 5.0 m wide and with bed slope of 1:1000 was 3.0 m. Determine: (i) The mean effective roughness size and Manning's roughness coefficient. (ii) By using Colebrook-White equation find the discharge at a depth of 4.0 m.

3 – A rectangular channel 4 m wide carries water of 20oc at a depth of 2.0 m is laid on slope 0.0004

(i) Find the hydrodynamic nature of the surface if the channel is made from rough concrete ks = 3.0 mm.

(ii) Estimate the discharge by using Chezy's equation with Colebrook-White equation.

4 – A rectangular channel 6.0 m wide, bed slope of 0.005 has a gravel bed (n=0.025) and concrete sides (n=0.013). Calculate the uniform discharge when the depth of flow is 2.0 m using:

(i) The Einstien. (ii) The Pavlovskij.

(iii) The Lotter methods

5 – A trapezoidal channel with side slopes 1:1 and bed slope of 1/1000 has bed width 13.0 m composed of sand (n=0.02) and sides of concrete (n=0.014) Estimate the discharge for a depth of flow 2.0 m using:

(i) The Einstien. (ii) The Pavlovskij.

(iii) The Lotter methods

6 – A rectangular channel 4.0 m wide had badly damaged surface and had Manning's n=0.03. For repair, its bed was lined with concrete (n=0.015). If the depth of flow remains the same at 1.5 m before and after repair, what is the increase of discharge as a result of this repair?