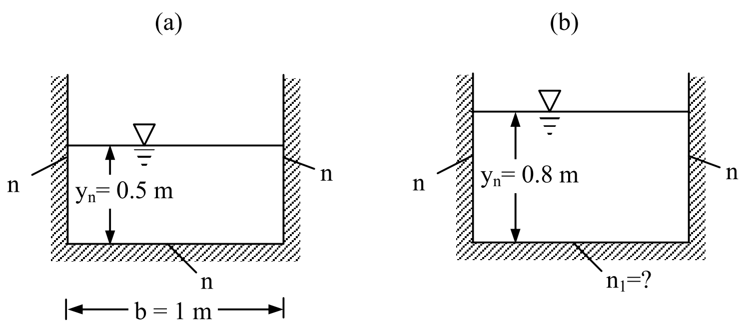
CVE 372 HYDROMECHANICS

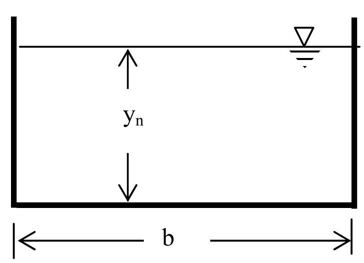
EXERCISE PROBLEMS – OPEN CHANNEL FLOWS

**1)** A rectangular irrigation channel of base width 1 m, is to convey 0.2 $m^3/s$ discharge at a depth of 0.5 m under uniform flow conditions. The slope of the channel is 0.0004.

**a)** Find the channel roughness n.
**b)** At the end of a dry period, it has been observed that there is a change in the roughness of the base, such that the same discharge, 0.2 $m^3/s$, could be conveyed at a depth of 0.80 m, under uniform flow conditions. Calculate the base roughness. ( Note that side wall roughness do not change.)




**2)** For a rectangular open channel the following information is given: Discharge, Q=125 $m^3/s$, cross-section width, b = 10 m, Manning roughness coefficient n = 0.025, channel bottom slope $S_o$ = 0.00015. Determine:
**a)** Uniform flow depth, $y_n$. (For the first iteration assume $y_n$ = 10 m)
**b)** State of the flow.
**c)** Resistance to the flow, $\tau$.

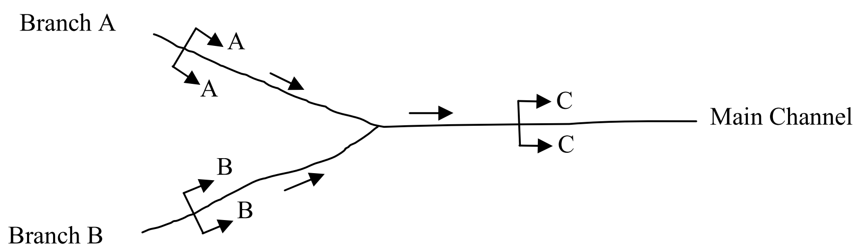


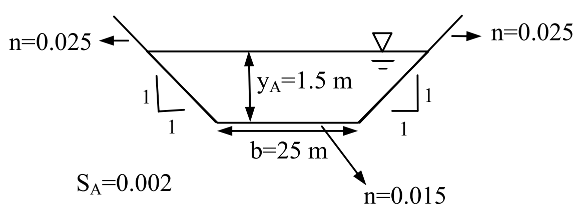
**3)** Water flows with a velocity of 2 m/s in a rectangular channel 3 m wide at a depth of 3 m. What is the change in depth and in water surface elevation produced by a gradual upward change in bottom elevation (upstep) of 60 cm? What would be the depth and elevation changes if there were a gradual downstep of 15 cm? What is the maximum size of upstep that could exist before upstream changes would result?

Neglect head losses

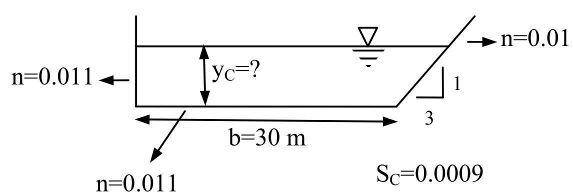
**4)** Two branches of different sections and discharges merge and continue to flow in a main channel with trapezoidal section as shown in the figure below.

**a)** Find the discharge in branch A,
**b)** Find the discharge in branch B,
**c)** Find the depth of flow in the main channel.

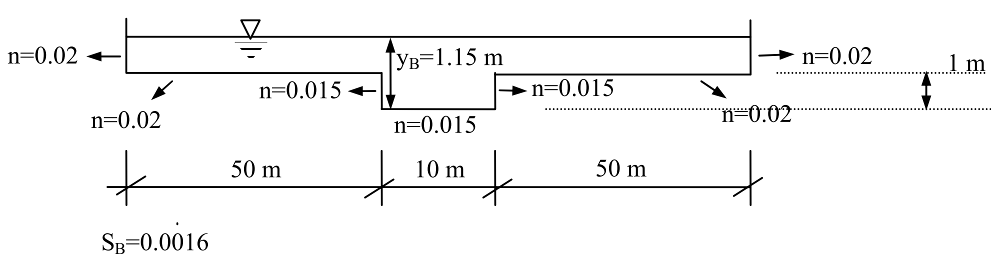



Section A-A.




Section C-C.



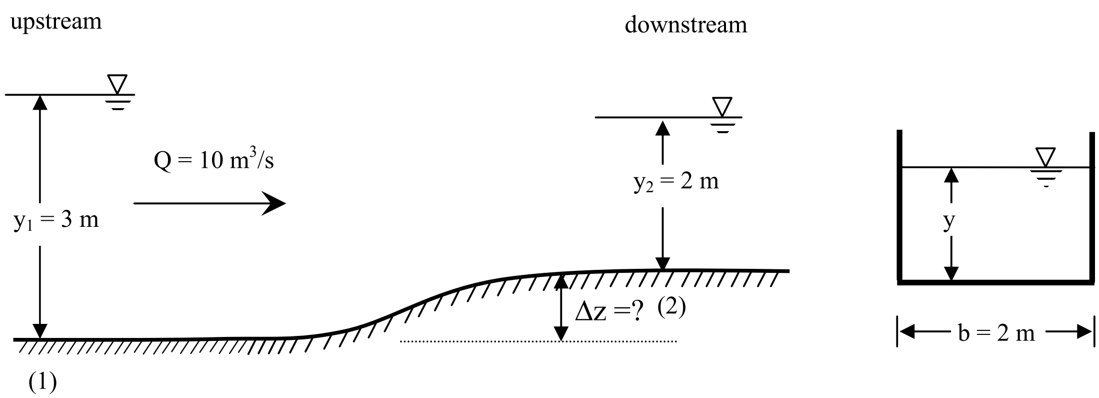

Section B-B.

**5)** Water flows in a rectangular open channel having a width of 2 m with a flow rate of 10 $m^3/s$ as shown in the figure. If the flow depths before and after the step are given as $y_1$ = 3 m, $y_2$ = 2 m, determine;

**a)** State of flow at upstream and down stream sections.

**b)** Step height $\Delta z$ =?

**c)** Draw the specific energy versus flow depth (E-y) curve and show the values of $y_1$, $y_2$, $y_c$, $E_1$, $E_2$, and $\Delta z$ on the curve.

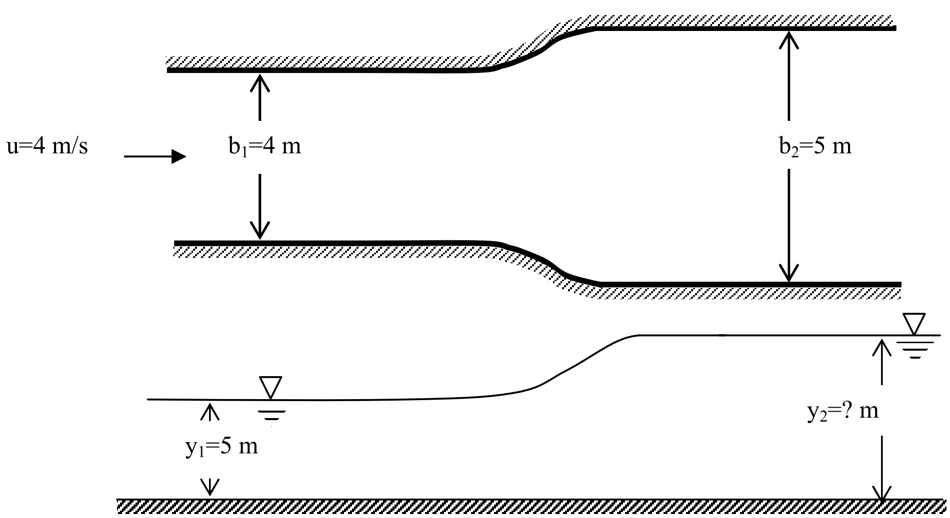



**6)** Water is flowing at a velocity of 4 m/s and depth of 5 m in a channel of rectangular section of 4 m wide.

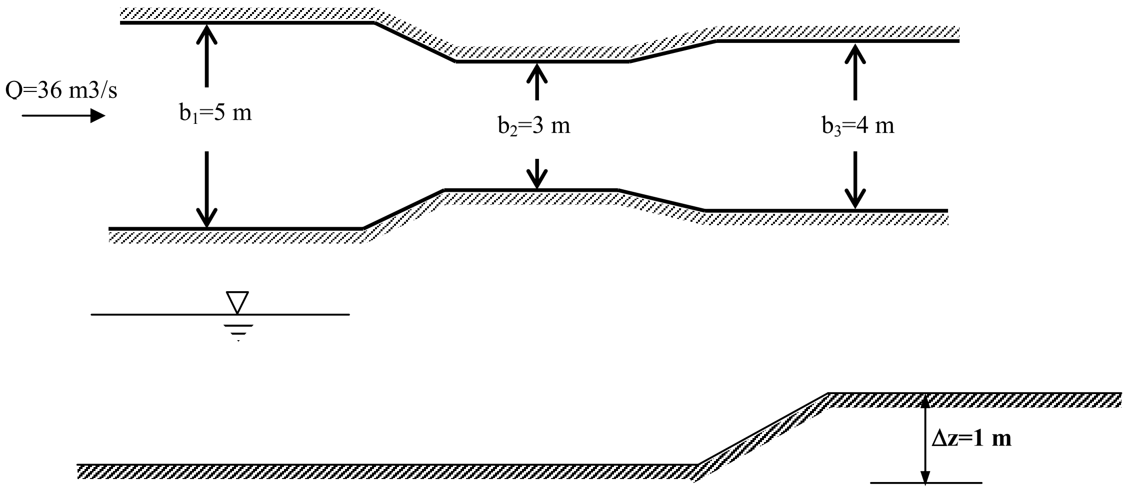
**a)** At downstream if there is a smooth expansion in width to 5 m; determine the depth in the expanded section.

**b)** Find the maximum allowable contraction in the width without any choking.

**c)** If the width is contracted to 3 m, what is the minimum amount by which the bed must be lowered for the upstream flow to be possible as specified?

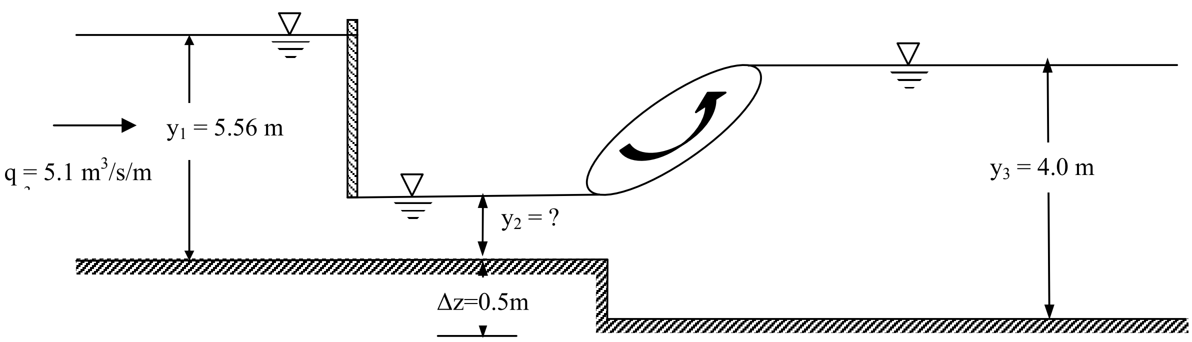


**7)** For the horizontal rectangular channel shown what is the minimum specific energy required for the discharge to be $Q = 36\ m^3/s$

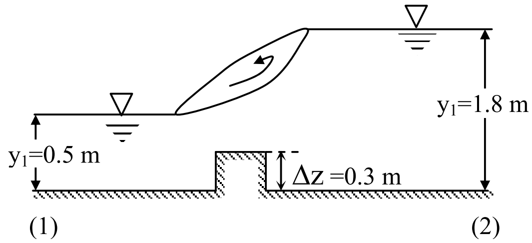


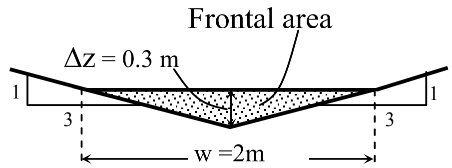

**8)** A hydraulic jump is to be formed in a trapezoidal channel width a base width of 6 m and side slopes of 2H:1V. The downstream depth is 2.4 m and the discharge is 27 $m^3/s$. Find the upstream depth, the head loss, and the horsepower dissipated in the jump.

**9)** Water flows in a rectangular channel of 5 m wide as shown in figure below. Calculate a) the force on the step.
b) the head loss through the jump

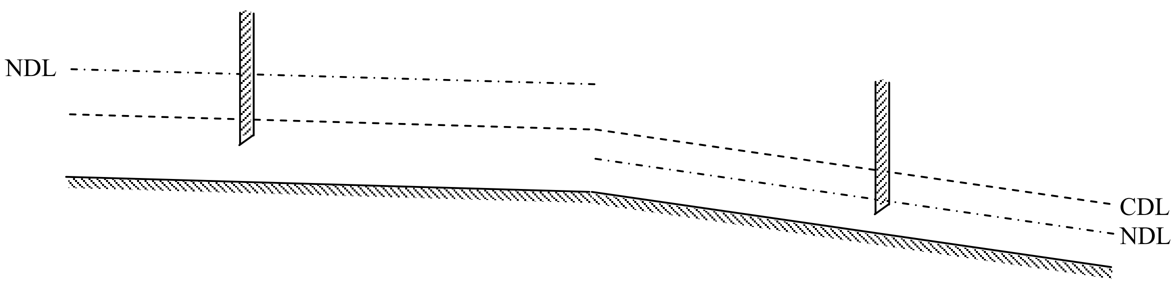



10) A hydraulic jump occurs over a sill located in triangular channel with water flowing as shown. The inverse side slopes are $m_1 = m_2 = 3$, the drag coefficent $C_D$=0.40, and the height of the sill $\Delta z$ = 0.3 m. Determine the discharge Q if $y_1$=0.50 m and $y_2$=1.8 m. Note that the force on the sill is given by $F_{sill} = \frac{1}{2} C_D \rho U_1^2 A_{sill}$, where $\rho$ = 1000 kg/$m^3$, $A_{sill}$ = frontal area of the sill.



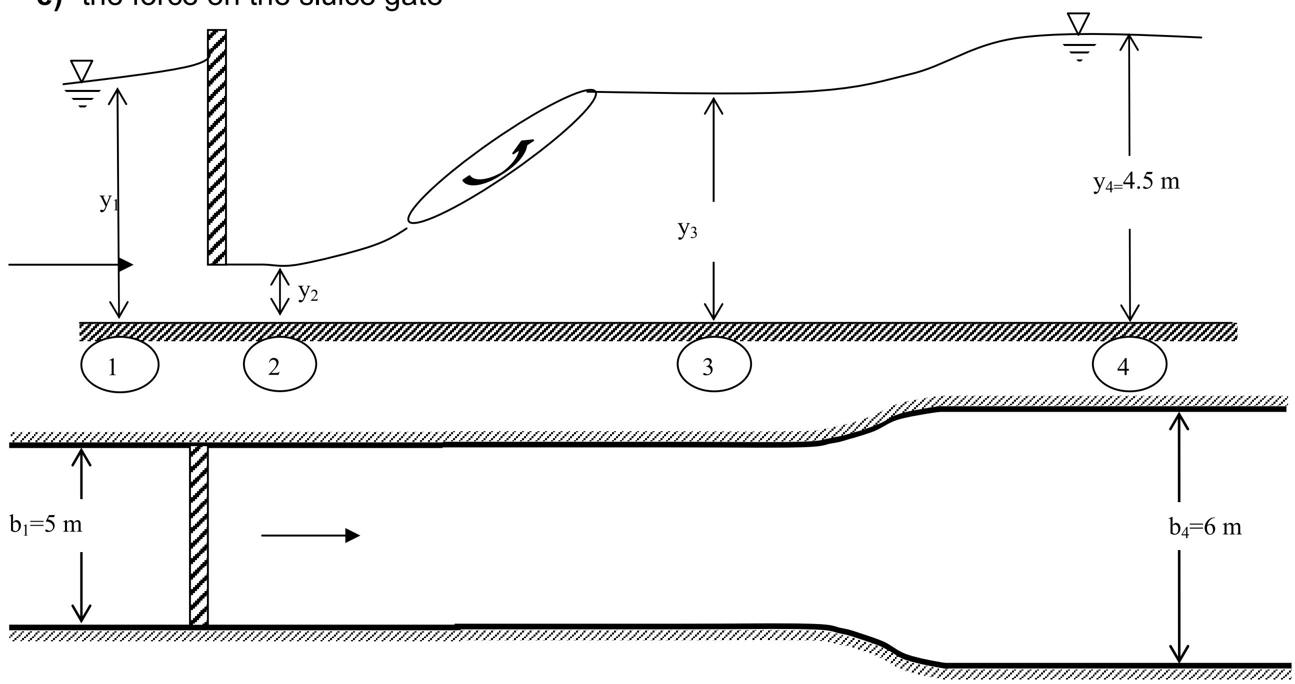




**11)** Classify the channel bottom slopes and sketch the possible flow profiles. Assume no energy loss in the channel.

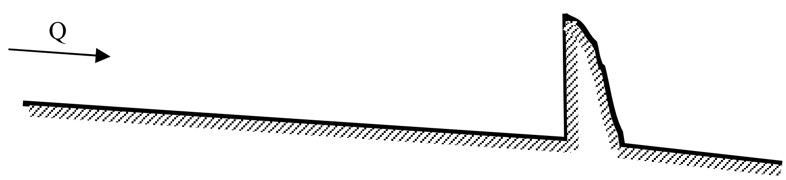


**12)** Water flows at a discharge of 36 $m^3$/s in a rectangular channel of 5 m wide. A hydraulic jump forms under the sluice gate. After the jump, the channel smoothly expands to a width of 6 m. At the expanded section, the depth of flow is 4.5 m. Determine

- **a)** the conjugate depths of the jump
- **b)** water depth before sluice gate
- **c)** head loss through the jump
- **d)** the force on the walls of the expanded section
- **e)** the force on the sluice gate




**13)** Water flowing at the normal depth in a rectangular concrete channel (n=0.013) that is 12.0 m wide encounters an obstruction, as shown in the Figure, causing the water level to rise above the normal depth at the obstructers and for some distance upstream. The water discharge is 126 $m^3$/s and the channel bottom slope is 0.00086. The depth of water just upstream from the obstruction is 4.55 m. Find the distance upstream to the point where the water surface is at the normal depth. Show the water surface profile on a graph.



**14)** A trapezoidal main channel carries 10 $m^3$/sec discharge and it will be built with concrete lining. If this channel has a slope of 0.0016 and n=0.025, z=1 find the section dimensions. Minimum allowed velocity is 0.7 m/sec.

**15)** Design an unlined trapezoidal canal on a sandy soil whose particle size, D, is 10 mm and is very angular. Take n=0.02, z=2, $S_0$=0.0016. The design discharge is 1.5 $m^3$/sec.

**16)** An unlined canal is constructed in a slightly rounded coarse noncohesive soil which has an average particle diameter of 20 mm. The canal has z = 2, n = 0.02, So = 0.0016, b = 2.5 m and $\theta$ = 33$^o$ (angle of repose from Fig. 9). Determine the greatest discharge which can be conveyed without causing erosion in the canal. Use tractive force approach.