CVG 3116 Fall 2017

Hydraulics – Tutorial 8

November 21, 2017

University of Ottawa

Lecture 12: Control Points and Non-uniform Flow Profiles (review)

1 – Control points:

- Bed rise (or hump) - if flow becomes critical $\Delta z \geq \Delta z^*$
- Channel contraction - if flow becomes critical $(b < b_c)$
- Change in the slope from mild to steep
- Free overfall (flow becomes critical to maximize the discharge)

2 - Normal depth (i.e. flow is controlled by channel friction).

3 - Sluice gate: water depth after the gate ≈ 0.6 x gate opening.

We saw that variations of water depth in channels in gradually varied flows can be calculated using:

$$\frac{dy}{dx} = \frac{S_0 - S_f}{1 - Fr^2}$$

We can find out if the water depth increases or decreases using the above equation.

Lecture 12: Water Depth in Channels and Rivers (review)

We have already shown that the energy equation leads to:

$$\frac{dy}{dx} = \frac{S_0 - S_f}{1 - Fr^2}$$

We can numerically integrate the above equation to calculate *y* at each point.
The derivative dy / dx is approximated between two points as $\Delta y / \Delta x$.

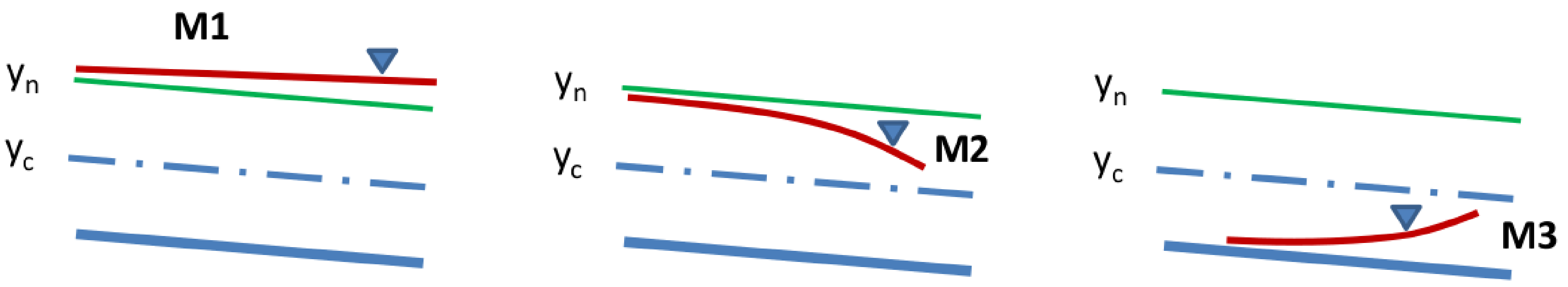
$$\frac{\Delta y}{\Delta x} = \left(\frac{S_0 - S_f}{1 - Fr^2}\right)_{mean}$$

where "mean" is the average value between the two points.

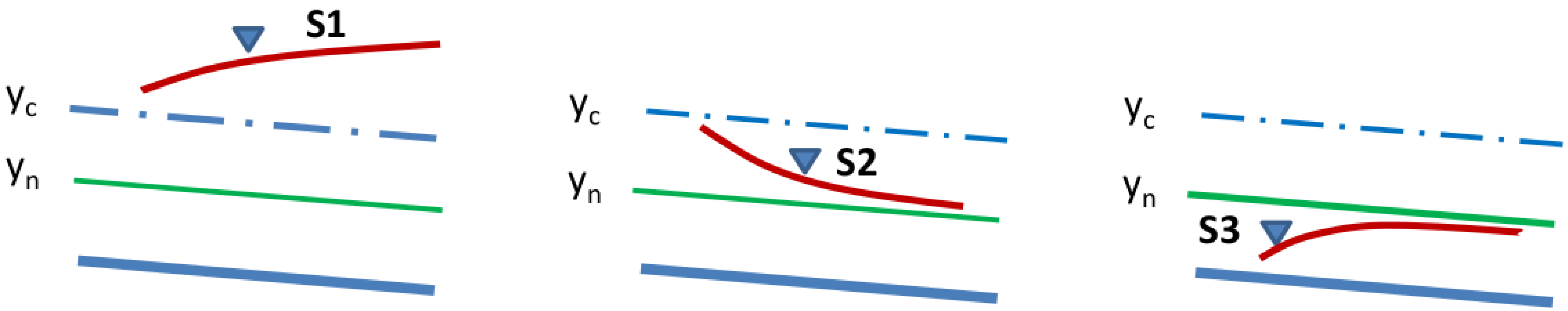
- **The Direct Step Method:** Δy is assumed, Δx is calculated.
- **The Standard Step Method:** Δx is assumed, Δy is calculated (iteration required).

Lecture 12: Non-uniform Flow Profiles (review)

- **Mild slope** $y_n > y_c$



- **Steep slope** $y_n < y_c$



Lecture 12: Calculation of Water Depth

Basic idea: **Energy equation**

Between any two sections, we can use the energy equation:

$$z_1 + y_1 + \alpha \frac{V_1^2}{2g} = z_2 + y_2 + \alpha \frac{V_2^2}{2g} + h_f + h_L$$

Where $V_1 A_1 = V_2 A_2$ and

$h_f = S_f \, \Delta x$, $S_f = n^2 Q^2 P^{4/3} / A^{10/3}$

h_L = local head losses: bend, expansion and contraction, ...

If y_1 is known, the energy equation gives y_2.

Lecture 12: Alternative Solution

$$\frac{\Delta y}{\Delta x} = \left(\frac{S_0 - S_f}{1 - Fr^2}\right)_{mean} \qquad Fr = \frac{V}{\sqrt{gL}} \qquad E_s = y + \alpha\frac{V^2}{2g}$$

- An alternative form of the gradually varied flow equation (given above) is obtained by differentiating the energy equation with respect to distance along the channel bed (x-direction):

Use the energy equation

$$z_{up} + y_{up} + \alpha\frac{V_{up}^2}{2g} = z_{dn} + y_{dn} + \alpha\frac{V_{dn}^2}{2g} + h_f + h_L$$

And $\quad z_{up} - z_{dn} = S_0 \Delta x \quad$ *and* $\quad h_f = S_f^{mean}\Delta x$

Thus

$$\Delta x = \frac{h_L + E_s^{dn} - E_s^{up}}{S_0 - S_f^{mean}}$$