Example Problem

Channel width (rectangular) = 2m, Depth = 1m, Q = 3.0 m^3/s, Height above datum = 2m. **Compute specific and total energy**

Ans: A = b*y = 2.0*1.0 = 2 m^2

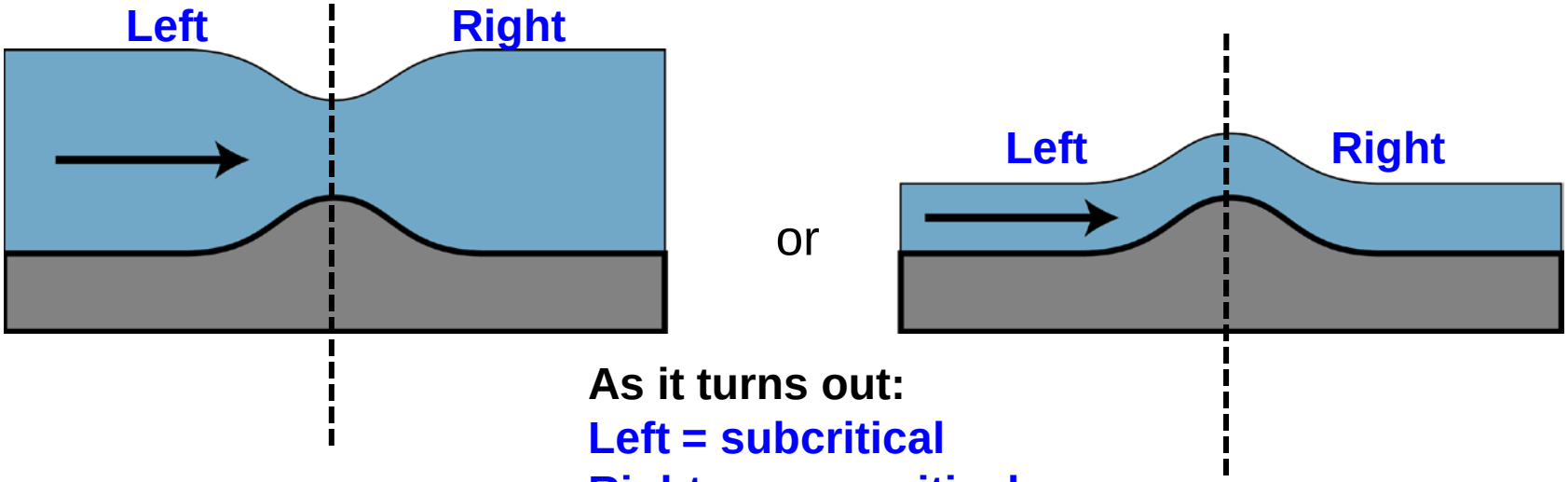
Specific energy = $E = y + Q^2 / 2gA^2$

Total energy = $E = 1 + 3^2 / 2*9.81*2^2$

Datum height + specific energy = 2.0 + 1.20 = **3.20 m**

Example Problem

Will the flow over a bump be supercritical or subcritical?



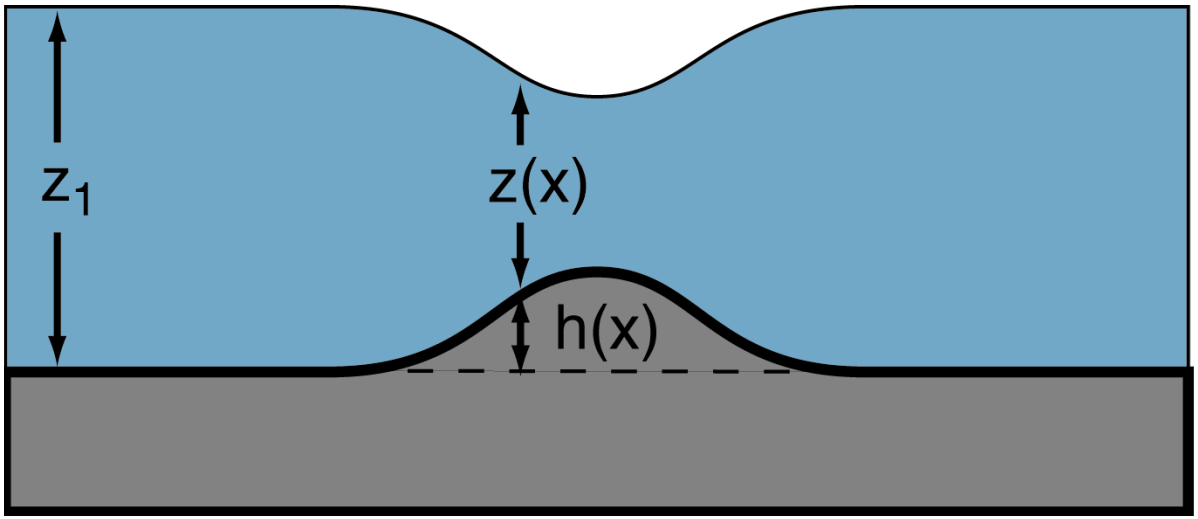
As it turns out:
Left = subcritical
Right = supercritical

Using the Bernoulli equation for frictionless, steady, incompressible flow along a streamline:

$$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2$$

Example Problem Contd…

Apply Bernoulli equation along free surface streamline (p=0):



$$\frac{V_1^2}{2g} + z_1 = \frac{V(x)^2}{2g} + z(x) + h(x)$$

For a channel of rectangular cross-section,

$$Q = V\ b\ z$$

Example Problem Contd…

Substitute $Q = V\ z\ b$ into Bernoulli equation:

$$\frac{Q^2}{2gb^2z_1^2} + z_1 = \frac{Q^2}{2gb^2z(x)^2} + z(x) + h(x)$$

To find the shape of the free surface, take the x-derivative:

$$0 = -\frac{Q^2}{wgb^2z(x)^3}\frac{dz}{dx} + \frac{dz}{dx} + \frac{dh}{dx}$$

Solve for dz / dx:

$$\frac{dz}{dx} = \frac{dh/dx}{\left[\frac{Q^2}{gb^2z^3} - 1\right]} = \frac{dh/dx}{\left[\frac{V^2}{gy} - 1\right]} = \frac{dh/dx}{Fr^2 - 1}$$

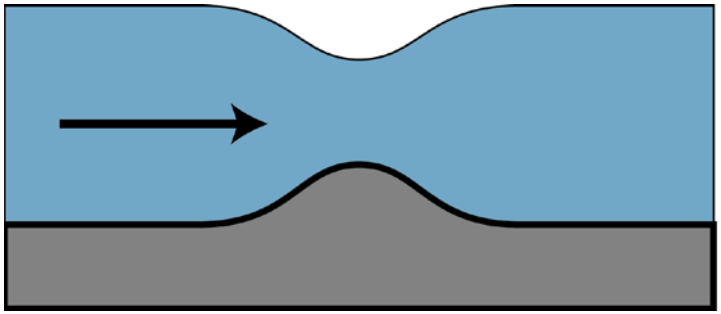
Example Problem

Contd…

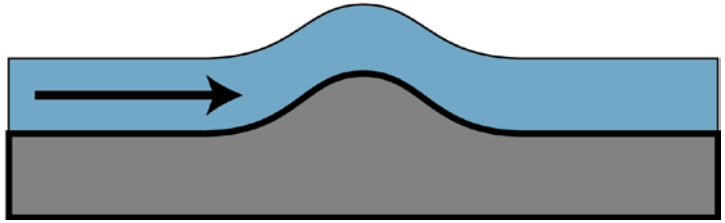
$$\frac{dz}{dx} = \frac{dh/dx}{Fr^2 - 1}$$

Since subcritical: Fr < 1
supercritical: Fr > 1

Subcritical flow with dh / dx > 1 ⇒ dz / dx < 1
Supercritical flow with dh / dx > 1 ⇒ dz / dx > 1



if flow is subcritical



if flow is supercritical

Exercises

1) A rectangular channel 4m wide has a flow discharge of 10.0 m3/s and depth of flow as 2.5 m. Draw specific energy diagram and find critical and alternate depth.
2) A triangular channel with side slopes having ratio of 1:1.5 has a discharge capacity of 0.02 m3/s. Calculate:
    a. critical depth
    b. Emin
    c. Plot specific energy curve
    d. Determine energy for 0.25 ft and alternate depth
    e. Velocity of flow and Froude number
    f. Calculate required slopes if depths from d are to be normal depths for given flow.