3.5 CELERITY

The celerity is defined as the wave velocity with respect to the velocity of the medium in which the wave is traveling.

To derive an expression for the wave celerity, let us consider a small wave in a horizontal, frictionless channel, The wave is considered to be small if $|\delta y| << y$. Let us assume that this wave is traveling in the downstream direction with absolute wave velocity, Vw and that, as a result of the wave motion, the flow velocity is changed from V to V + δV . By superimposing a constant velocity Vw in the upstream direction, the component of the weight of water in the control volume in the downstream direction is zero. Similarly, there is no shear force acting on the channel boundary, since the channel is assumed to be frictionless.

$$Vw = V \pm \sqrt{gy}$$

celerity, c, is thewave velocity relative to the medium in which the wave is traveling – i.e., Vw = V ± c.

$$c = \sqrt{gy}$$

We proved in a previous section that the Froude number Fr = 1 when the flow is critical. By substititing the expression for Fr and using subscript c to denote various quantities for critical flow, we obtain

$$Vc \sqrt{gy} = 1$$

$$Vc = \sqrt{gy}$$

$$Vc = c$$

Thus, the celerity of a small wave is equal to the flow velocity when the flow is critical. Since, V < Vc in subcritical flows, it follows that V < c in these flows. Similarly, we may prove that V >c in the supercritical flows. Three different flow situations for the propagation of a disturbance are possible depending upon the relative magnitudes of V and c, i.e., whether the flow is subcritical, critical, or supercritical