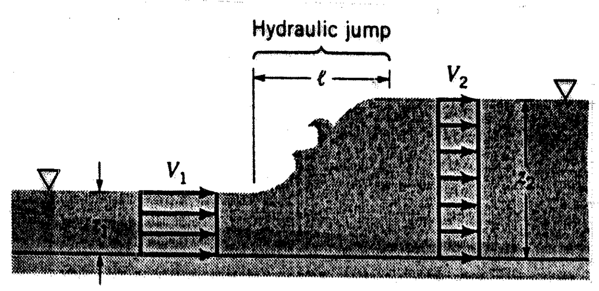
4.25

4.25 A hydraulic jump is a rather sudden change in depth of a liquid layer as it flows in an open channel as shown in Fig. P4.25 and **Video V10.6**. In a relatively short distance (thickness = ℓ) the liquid depth changes from z_1 to z_2, with a corresponding change in velocity from V_1 to V_2. If $V_1 =$ 1.20 ft/s, $V_2 =$ 0.30 ft/s, and $\ell =$ 0.02 ft, estimate the average deceleration of the liquid as it flows across the hydraulic jump. How many g's deceleration does this represent?



■ FIGURE P4.25

$$\vec{a} = \frac{\partial \vec{V}}{\partial t} + \vec{V}\cdot\nabla\vec{V} \quad \text{so with } \vec{V} = u(x)\hat{i}, \quad \vec{a} = a_x\hat{i} = u\frac{\partial u}{\partial x}\hat{i}$$

Without knowing the actual velocity distribution, $u = u(x)$, the acceleration can be approximated as

$$a_x = u\frac{\partial u}{\partial x} \approx \frac{1}{2}(V_1+V_2)\frac{(V_2-V_1)}{\ell} = \frac{1}{2}(1.20+0.30)\frac{ft}{s}\,\frac{(0.30-1.20)\frac{ft}{s}}{0.02\ ft}$$

$$= -33.8\ \frac{ft}{s^2}$$

Thus, $$\frac{|a_x|}{g} = \frac{33.8\ \frac{ft}{s^2}}{32.2\ \frac{ft}{s^2}} = 1.05$$