7.49

7.4 A 1/50 scale model is to be used in a towing tank to study the water motion near the bottom of a shallow channel as a large barge passes over. (See Video V7.16) Assume that the model is operated in accordance with the Froude number criteria for dynamic similitude. The prototype barge moves at a typical speed of 15 knots. (a) At what speed (in ft/s) should the model be towed? (b) Near the bottom of the model channel a small particle is found to move 0.15 ft in one second so that the fluid velocity at that point is approximately 0.15 ft/s. Determine the velocity at the corresponding point in the prototype channel.

(a) For Froude number similarity

$$\frac{V_m}{\sqrt{g_m \ell_m}} = \frac{V}{\sqrt{g \ell}}$$

where ℓ is some characteristic length, and with $g_m = g$

$$\frac{V_m}{V} = \sqrt{\frac{\ell_m}{\ell}} \qquad (1)$$

Thus, $V_m = \sqrt{\frac{1}{50}}\,(15 \text{ knots}) = 2.12 \text{ knots}$

From Table A.1 $1 \text{ knot} = \left(0.514 \frac{m}{s}\right)\left(3.281 \frac{\frac{ft}{s}}{\frac{m}{s}}\right) = 1.69 \frac{ft}{s}$

so that $V_m = (2.12 \text{ knots})\left(1.69 \frac{ft/s}{\text{knot}}\right) = \underline{\underline{3.58 \frac{ft}{s}}}$

(b) Since from Eq. (1)

$$\frac{V_m}{V} = \sqrt{\frac{\ell_m}{\ell}} = \sqrt{\frac{1}{50}}$$

so that $V = \sqrt{50}\left(0.15 \frac{ft}{s}\right) = \underline{\underline{1.06 \frac{ft}{s}}}$