

7.59

7.59 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

$$\frac{V_m}{\sqrt{g_m l_m}} = \frac{V}{\sqrt{g l}}$$

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

$$\frac{V_m}{V} = \sqrt{\frac{l_m}{l}} \quad (1)$$

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

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

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

(b) Since from Eq. (1)

$$\frac{V_m}{V} = \sqrt{\frac{l_m}{l}} = \sqrt{\frac{1}{50}}$$

so that

$$V = \sqrt{50} (0.15 \frac{\text{ft}}{\text{s}}) = \underline{\underline{1.06 \frac{\text{ft}}{\text{s}}}}$$