7.49

7.49 A model of a submarine, 1 : 15 scale, is to be tested at 180 ft/s in a wind tunnel with standard sea-level air, while the prototype will be operated in seawater. Determine the speed of the prototype to ensure Reynolds number similarity.

Let $(\ )_m$ and $(\ )_p$ denote model and prototype, respectively.
Thus, $Re_m = Re_p$, or

$$\frac{V_m l_m}{\nu_m} = \frac{V_p l_p}{\nu_p}, \text{ where } l_m = \frac{1}{15} l_p$$

Hence,

$$V_m = \left(\frac{\nu_m}{\nu_p}\right)\left(\frac{l_p}{l_m}\right) V_p = 15\left(\frac{\nu_m}{\nu_p}\right) V_p$$

Also,

$\nu_m = 1.57 \times 10^{-4} \frac{ft^2}{s}$ and $\nu_p = 1.26 \times 10^{-5} \frac{ft^2}{s}$ so that

$$V_m = 15\left(\frac{1.57 \times 10^{-4}\ ft^2/s}{1.26 \times 10^{-5}\ ft^2/s}\right) V_p = 187\, V_p$$

Thus,

$$V_p = \frac{V_m}{187} = \frac{180 \frac{ft}{s}}{187} = \underline{\underline{0.963 \frac{ft}{s}}}$$