7.50

7.50 SAE 30 oil at 60 °F is pumped through a 3-ft-diameter pipeline at a rate of 6400 gal/min. A model of this pipeline is to be designed using a 3-in.-diameter pipe and water at 60 °F as the working fluid. To maintain Reynolds number similarity between these two systems, what fluid velocity will be required in the model?

For Reynolds number similarity,

$$\frac{V_m D_m}{\nu_m} = \frac{V D}{\nu}$$

or

$$V_m = \frac{\nu_m}{\nu} \frac{D}{D_m} V \qquad (1)$$

Since,

$$V = \frac{Q}{\text{area}}$$

and

$$Q = \frac{\left(6400 \frac{\text{gal}}{\text{min}}\right)\left(231 \text{ in.}^3\right)\left(\frac{1 \text{ ft}^3}{1728 \text{ in.}^3}\right)}{60 \frac{\text{s}}{\text{min}}} = 14.3 \frac{\text{ft}^3}{\text{s}}$$

then

$$V = \frac{14.3 \frac{\text{ft}^3}{\text{s}}}{\frac{\pi}{4}(3 \text{ ft})^2} = 2.02 \frac{\text{ft}}{\text{s}}$$

Thus, from Eq. (1)

$$V_m = \frac{\left(1.21 \times 10^{-5} \frac{\text{ft}^2}{\text{s}}\right)(3 \text{ ft})}{\left(4.5 \times 10^{-3} \frac{\text{ft}^2}{\text{s}}\right)\left(\frac{3}{12} \text{ ft}\right)} \left(2.02 \frac{\text{ft}}{\text{s}}\right) = \underline{\underline{6.52 \times 10^{-2} \frac{\text{ft}}{\text{s}}}}$$