The aerodynamic behavior of a flying insect is to be investigated in a wind tunnel using a ten-times scale model. If the insect flaps its wings 50 times a second when flying at 4 ft/s, determine the wind tunnel air speed and wing oscillation frequency required for dynamic similarity.

SOLUTION:

Maintain Reynolds number similarity,

$$\mathrm{Re}_M = \mathrm{Re}_P \;\Rightarrow\; \left.\frac{VL}{\nu}\right|_M = \left.\frac{VL}{\nu}\right|_P \;\Rightarrow\; V_M = V_P\left(\frac{L_P}{L_M}\right)\left(\frac{\nu_M}{\nu_P}\right) \tag{1}$$

where $L_P/L_M = 1/10$ and $\nu_M/\nu_P = 1$ (air used in both cases). Hence,

$$\boxed{V_M = (1/10)V_P = 0.4 \text{ ft/s}} \tag{2}$$

Also maintain Strouhal number similarity,

$$\mathrm{St}_M = \mathrm{St}_P \;\Rightarrow\; \left.\frac{\omega L}{V}\right|_M = \left.\frac{\omega L}{V}\right|_P \;\Rightarrow\; \omega_M = \omega_P\left(\frac{L_P}{L_M}\right)\left(\frac{V_M}{V_P}\right) \tag{3}$$

where $L_P/L_M = 1/10$ and $V_M/V_P = 1/10$. Hence,

$$\boxed{\omega_M = (1/100)\omega_P = 0.5 \text{ Hz}} \tag{4}$$