6.62. Solve: (a) The terminal velocity for a falling object is reached when the downward gravitational force is balanced by the upward drag force.

$$F_G = D$$

$$mg = bv_{term} = 6\pi\eta R v_{term}$$

$$\Rightarrow v_{term} = \frac{mg}{6\pi\eta R}$$

(b) The mass of the spherical sand grain of density $p = 2400 \text{ kg/m}^3$ is $m = \rho\left(\frac{4}{3}\pi R^3\right)$.

Thus
$$v_{term} = \frac{2\rho g R^2}{9\eta} = \frac{2}{9}\frac{\left(2400 \text{ kg/m}^3\right)\left(9.80 \text{ m/s}^2\right)\left(5.0\times10^{-4} \text{ m}\right)^2}{\left(1.0\times10^{-3} \frac{\text{Ns}}{\text{m}^2}\right)} = 1.3 \text{ m/s}$$

The time required for the sand grain to fall 50 m at this speed is $t = \frac{50 \text{ m}}{1.3 \text{ m/s}} = 38 \text{ s}$.

Assess: The speed of 1.3 m/s for a sand grain falling through water seems about right.