Drag coefficient plots versus Reynolds number in a very smooth fashion and is well fit (to ±1%) by the power-law formula $\mathbf{C_D \approx 0.81Re_L^{-0.17}}$.

The new velocity is V = 15 m/s, and for glycerin at 20°C (Table A-3), take $\rho \approx 1260$ kg/m^3 and $\mu \approx 1.49$ kg/m·s. Then compute the new Reynolds number and use our experimental correlation to estimate the drag coefficient:

$$\mathrm{Re}_{glycerin} = \frac{\rho VD}{\mu} = \frac{(1260)(15)(0.08)}{1.49} = 1015 \ (\textit{within the range}), \quad \textit{hence}$$

$$C_D = 0.81/(1015)^{0.17} \approx 0.250, \quad \textit{or:} \quad \mathbf{F}_{glycerin} = 0.250(1260)(15)^2(0.08)^2 = \mathbf{453\ N} \quad \textit{Ans.}$$

5.7 A body is dropped on the moon (g = 1.62 m/s^2) with an initial velocity of 12 m/s. By using option 2 variables, Eq. (5.11), the ground impact occurs at $t^{**} = 0.34$ and $S^{**} = 0.84$. Estimate (a) the initial displacement, (b) the final displacement, and (c) the time of impact.

Solution: (a) The initial displacement follows from the "option 2" formula, Eq. (5.12):

$$S^{**} = gS_o/V_o^2 + t^{**} + \frac{1}{2}t^{**2} = 0.84 = \frac{(1.62)S_o}{(12)^2} + 0.34 + \frac{1}{2}(0.34)^2$$

$$\text{Solve for} \quad S_o \approx \mathbf{39\ m} \quad \textit{Ans.}\ \text{(a)}$$

(b, c) The final time and displacement follow from the given dimensionless results:

$$S^{**} = gS/V_o^2 = 0.84 = (1.62)S/(12)^2, \quad \text{solve for } S_{final} \approx \mathbf{75\,m} \quad \textit{Ans.}\ \text{(b)}$$

$$t^{**} = gt/V_o = 0.34 = (1.62)t/(12), \quad \text{solve for } t_{impact} \approx \mathbf{2.52\ s} \quad \textit{Ans.}\ \text{(c)}$$

5.8 The *Morton number* Mo, used to correlate bubble-dynamics studies, is a dimensionless combination of acceleration of gravity g, viscosity μ, density ρ, and surface tension coefficient Y. If Mo is proportional to g, find its form.

Solution: The relevant dimensions are $\{g\} = \{LT^{-2}\}$, $\{\mu\} = \{ML^{-1}T^{-1}\}$, $\{\rho\} = \{ML^{-3}\}$, and $\{Y\} = \{MT^{-2}\}$. To have g in the numerator, we need the combination:

$$\{Mo\} = \{g\}\{\mu\}^a\{\rho\}^b\{Y\}^c = \left\{\frac{L}{T^2}\right\}\left\{\frac{M}{LT}\right\}^a\left\{\frac{M}{L^3}\right\}^b\left\{\frac{M}{T^2}\right\}^c = M^0L^0T^0$$

$$\text{Solve for} \quad a = 4,\ b = -1,\ c = -3, \quad \text{or:} \quad \boldsymbol{Mo = \frac{g\mu^4}{\rho Y^3}} \quad \textit{Ans.}$$
