

## Problem 1.35

[Difficulty: 1]

**1.35** In Chapter 9 we will study aerodynamics and learn that the drag force  $F_D$  on a body is given by

$$F_D = \frac{1}{2} \rho V^2 A C_D$$

Hence the drag depends on speed  $V$ , fluid density  $\rho$ , and body size (indicated by frontal area  $A$ ) and shape (indicated by drag coefficient  $C_D$ ). What are the dimensions of  $C_D$ ?

**Given:** Equation for drag on a body.

**Find:** Dimensions of  $C_D$ .

**Solution:** Use the drag equation. Then "solve" for  $C_D$  and use dimensions.

The drag equation is

$$F_D = \frac{1}{2} \cdot \rho \cdot V^2 \cdot A \cdot C_D$$

"Solving" for  $C_D$ , and using dimensions

$$C_D = \frac{2 \cdot F_D}{\rho \cdot V^2 \cdot A}$$

$$C_D = \frac{F}{\frac{M}{L^3} \times \left(\frac{L}{t}\right)^2 \times L^2}$$

But, From Newton's 2nd law

$$\text{Force} = \text{Mass} \cdot \text{Acceleration} \quad \text{or} \quad F = M \cdot \frac{L}{t^2}$$

Hence

$$C_D = \frac{F}{\frac{M}{L^3} \times \left(\frac{L}{t}\right)^2 \times L^2} = \frac{M \cdot L}{t^2} \times \frac{L^3}{M} \times \frac{t^2}{L^2} \times \frac{1}{L^2} = 0$$

The drag coefficient is dimensionless.