#1

The *mean free path* of a gas, l, is defined as the average distance traveled by molecules between collisions. A proposed formula for estimating l of an ideal gas is

$$l = 1.26 \frac{\mu}{\rho\sqrt{RT}}$$

What are the dimensions of the constant 1.26?

#2

If p is pressure and y is a coordinate, state, in the {MLT} system, the dimensions of the quantities (*a*) $\partial p/\partial y$, (*b*) $\int p\, dy$, (*c*) $\partial^2 p/\partial y^2$, and (*d*) ∇p.

#3

Suppose we know little about the strength of materials but are told that the bending stress σ in a beam is *proportional* to the beam half-thickness y and also depends on the bending moment M and the beam area moment of inertia I. We also learn that, for the particular case $M = 2900$ in · lbf, $y = 1.5$ in, and $I = 0.4$ in^4, the predicted stress is 75 MPa. Using this information and dimensional reasoning only, find, to three significant figures, the only possible dimensionally homogeneous formula $\sigma = y\, f(M, I)$.

#4

The Stokes-Oseen formula [18] for drag force F on a sphere of diameter D in a fluid stream of low velocity V, density ρ, and viscosity μ is

$$F = 3\pi\mu DV + \frac{9\pi}{16}\rho V^2 D^2$$

Is this formula dimensionally homogeneous?

#5

Engineers sometimes use the following formula for the volume rate of flow Q of a liquid flowing through a hole of diameter D in the side of a tank:

$$Q = 0.68D^2\sqrt{gh}$$

where g is the acceleration of gravity and h is the height of the liquid surface above the hole. What are the dimensions of the constant 0.68?

#6

When we in the United States say a car's tire is filled "to 32 lb," we mean that its internal pressure is 32 lbf/in^2 above the ambient atmosphere. If the tire is at sea level, has a volume of 3.0 ft^3, and is at 75°F, estimate the total weight of air, in lbf, inside the tire.

#7

A blimp is approximated by a prolate spheroid 90 m long and 30 m in diameter. Estimate the weight of 20°C gas within the blimp for (*a*) helium at 1.1 atm and (*b*) air at 1.0 atm.