

ES201 Homework Set #2

Problem 2.1

One of the challenges for new and experienced engineers is correctly handling the many traditional units that have developed over the years. These units exist precisely because engineers and scientists found them to be useful and physically understandable in a given discipline or application.

For the following physical quantities, fill in the blanks to calculate the magnitude of the physical quantity in the indicated units. Show explicitly how you used *unit conversion factors* to make the conversion by writing them down and crossing out units as they cancel out.

(a) Physical Quantity — Kinematic viscosity. Kinematic viscosity is important in describing the motion of fluid (air flow in the lungs, blood in an artery, air over a wing, or oil in a pipe). The “stoke” is a non-SI unit that was historically used to quantify the kinematic viscosity of a fluid (1 stoke = 1 cm²/s).

$$1 \text{ stoke} = \underline{\hspace{2cm}} \text{ m}^2/\text{s} = \underline{\hspace{2cm}} \text{ ft}^2/\text{s}$$

(b) Physical Quantity — Mass. Although we typically measure mass in terms of lbm or kg, the “blob” was proposed as a unit (1 blob = 1 lbf·s²/in) that could be useful in the study of machinery dynamics.

$$\begin{aligned} 1 \text{ blob} &= \underline{\hspace{2cm}} \text{ lbm} &= \underline{\hspace{2cm}} \text{ slug} \\ &= \underline{\hspace{2cm}} \text{ kg} &= \underline{\hspace{2cm}} \text{ g} \end{aligned}$$

(c) Physical Quantity — Pressure or Stress. The size of pressures and stresses in biomedical engineering or some MEMS applications are so small that the typical units, N/m² or lbf/in², give very small numbers. An alternative held over from the cgs-unit system is the dyne/cm².

$$\begin{aligned} 1 \text{ dyne/cm}^2 &= \underline{\hspace{2cm}} \text{ N/m}^2 = \underline{\hspace{2cm}} \text{ kPa} = \underline{\hspace{2cm}} \text{ bar} \\ &= \underline{\hspace{2cm}} \text{ psi} = \underline{\hspace{2cm}} \text{ atm} \end{aligned}$$

Problem 2.2

The auctioneer says they are selling a “2500 pound” car, and based on your knowledge you know that at the auction site the local acceleration of gravity $g = 0.95g_{\text{standard}}$, where $g_{\text{standard}} = 9.810 \text{ m/s}^2 = 32.174 \text{ ft/s}^2$.

- If the auctioneer was telling you the mass of the car is 2500 lbm, determine
 - ... the mass of the car in kg and slugs, and
 - ... the weight of the car in N and lbf.
- If the auctioneer was telling you the weight of the car is 2500 lbf, determine
 - ... the weight of the car in N, and
 - ... the mass of the car in kg, lbm, and slugs.
- Examine your answers in (a) and (b). Depending on how you interpreted “pound” as lbm or lbf, compare your answers for mass and weight. Are they the same or different?
- Repeat (a), (b), and (c) only this time assume we had no special knowledge and just assumed that the local acceleration of gravity $g = g_{\text{standard}}$. How do the numerical values for weight in lbf and mass in lbm change? What can you learn from this?