Background

Many professional CAE applications, as well as expert CAE applications, do not incorporate built-in unit systems. Instead, it is up to the user to select a consistent unit system and apply it consistently throughout their simulation. The remainder of this document is a copy of Appendix C in the publicly available user manual for Sandia National Laboratory's *Sierra Solid Mechanics* – a finite element code used by the United States national laboratories.[1] You can find this manual through the US Department of Energy's Office of Scientific and Technical Information (OSTI) here: https://www.osti.gov/biblio/1433781-sierra-solid-mechanics-user-guide

Appendix C of Sierra: Solid Mechanics User Manual

This appendix describes common consistent sets of units. Maintaining a consistent set of units is crucial in using Sierra/SM when entering material properties and interpreting results. The only variables that have intrinsic units are rotations, which are in radians. All other variables depend on the consistent set of units that the user uses in inputting the material properties and dimensioning the geometry.

A consistent set of units is made by picking the base units. When using the International System (SI), these are length, mass, and time, while in the English unit systems, these base units are length, force, and time. All other units are then derived from these base units. Table 1 provides several examples of commonly used consistent sets of units. In general, the names of the unit systems in this table are taken from the names of the base units. For example, CGS stands for (centimeters, grams, seconds) and IPS stands for (inches, pounds, seconds).

One of the most common mistakes related to consistent units comes in when entering density. For example, in the IPS system, a common error is to enter the density of stainless steel as $0.289\ lb/in^3$, when it should be entered as $7.48 \cdot 10^{-4}\ lb \cdot s^2/in^4$. The weight per unit volume should be divided by the gravitational constant ($386.4\ in/s^2$ in this case) to obtain a mass per unit volume.

[1] Merewether, Mark Thomas, Crane, Nathan K., de Frias, Gabriel Jose, Le, San, Littlewood, David John, Mosby, Matthew David, Pierson, Kendall H., Porter, Vicki L., Shelton, Timothy, Thomas, Jesse David, Tupek, Michael R., Veilleux, Michael, Gampert, Scott, Xavier, Patrick G., and Plews, Julia A. Thu . "Sierra/Solid Mechanics 4.48 User's Guide". United States. doi:10.2172/1433781. https://www.osti.gov/servlets/purl/1433781.

Table 1: Common consistent unit systems

Unit	Unit System				
	SI	CGS	IPS	FPS	MMTS
Mass	kg	g	$lb \cdot s^2/in$	$slug$	$tonne$
Length	m	cm	in	ft	mm
Time	s	s	s	s	s
Density	$\frac{kg}{m^3}$	$\frac{g}{cm^3}$	$\frac{lb \cdot s^2}{in^4}$	$\frac{slug}{ft^3}$	$\frac{tonne}{mm^3}$
Force	N	dyn	lb	lb	N
Pressure	Pa	$\frac{dyn}{cm^2}$	psi	psf	MPa
Moment	$N \cdot m$	$dyn \cdot cm$	$in \cdot lb$	$ft \cdot lb$	$N \cdot mm$
Temperature	K	K	$^\circ R$	$^\circ R$	K
Energy	J	erg	$lb \cdot in$	$lb \cdot ft$	mJ
Velocity	$\frac{m}{s}$	$\frac{cm}{s}$	$\frac{in}{s}$	$\frac{ft}{s}$	$\frac{mm}{s}$
Acceleration	$\frac{m}{s^2}$	$\frac{cm}{s^2}$	$\frac{in}{s^2}$	$\frac{ft}{s^2}$	$\frac{mm}{s^2}$