# UNITS

This handbook uses the metric system of units. Ultimately, the FE examination will be entirely metric. However, currently some of the problems use both metric and U.S. Customary System (USCS). In the USCS system of units, both force and mass are called pounds. Therefore, one must distinguish the pound-force (lbf) from the pound-mass (lbm).

The pound-force is that force which accelerates one pound-mass at 32.174 ft/s$^2$. Thus, 1 lbf = 32.174 lbm-ft/s$^2$. The expression 32.174 lbm-ft/(lbf-s$^2$) is designated as $g_c$ and is used to resolve expressions involving both mass and force expressed as pounds. For instance, in writing Newton's second law, the equation would be written as $F = ma/g_c$, where $F$ is in lbf, $m$ in lbm, and $a$ is in ft/s$^2$.

Similar expressions exist for other quantities. Kinetic Energy: $KE = mv^2/2g_c$, with $KE$ in (ft-lbf); Potential Energy: $PE = mgh/g_c$, with $PE$ in (ft-lbf); Fluid Pressure: $p = \rho gh/g_c$, with $p$ in (lbf/ft$^2$); Specific Weight: $SW = \rho g/g_c$, in (lbf/ft$^3$); Shear Stress: $\tau = (\mu/g_c)(dv/dy)$, with shear stress in (lbf/ft$^2$). In all these examples, $g_c$ should be regarded as a unit conversion factor. It is frequently not written explicitly in engineering equations. However, its use is required to produce a consistent set of units.

Note that the conversion factor $g_c$ [lbm-ft/(lbf-s$^2$)] should not be confused with the local acceleration of gravity $g$, which has different units (m/s$^2$) and may be either its standard value (9.807 m/s$^2$) or some other local value.

If the problem is presented in USCS units, it may be necessary to use the constant $g_c$ in the equation to have a consistent set of units.

| METRIC PREFIXES | | |
|---|---|---|
| Multiple | Prefix | Symbol |
| $10^{-18}$ | atto | a |
| $10^{-15}$ | femto | f |
| $10^{-12}$ | pico | p |
| $10^{-9}$ | nano | n |
| **$10^{-6}$** | **micro** | **$\mu$** |
| $10^{-3}$ | milli | m |
| $10^{-2}$ | centi | c |
| $10^{-1}$ | deci | d |
| $10^{1}$ | deka | da |
| **$10^{2}$** | **hecto** | **h** |
| $10^{3}$ | kilo | k |
| $10^{6}$ | mega | M |
| $10^{9}$ | giga | G |
| $10^{12}$ | tera | T |
| **$10^{15}$** | **peta** | **P** |
| $10^{18}$ | exa | E |

| COMMONLY USED EQUIVALENTS | |
|---|---|
| 1 gallon of water weighs | 8.34 lbf |
| 1 cubic foot of water weighs | 62.4 lbf |
| 1 cubic inch of mercury weighs | 0.491 lbf |
| The mass of one cubic meter of water is | 1,000 kilograms |

| TEMPERATURE CONVERSIONS |
|---|
| ºF = 1.8 (ºC) + 32 |
| ºC = (ºF – 32)/1.8 |
| ºR = ºF + 459.69 |
| K = ºC + 273.15 |

## FUNDAMENTAL CONSTANTS

| Quantity | | Symbol | Value | Units |
|---|---|---|---|---|
| electron charge | | $e$ | $1.6022 \times 10^{-19}$ | C (coulombs) |
| Faraday constant | | $\mathcal{F}$ | 96,485 | coulombs/(mol) |
| gas constant | metric | $\bar{R}$ | 8,314 | J/(kmol·K) |
| gas constant | metric | $\bar{R}$ | 8.314 | kPa·m$^3$/(kmol·K) |
| gas constant | USCS | $\bar{R}$ | 1,545 | ft-lbf/(lb mole-ºR) |
| | | $\bar{R}$ | 0.08206 | L-atm/mole-K |
| gravitation - newtonian constant | | $G$ | $6.673 \times 10^{-11}$ | m$^3$/(kg·s$^2$) |
| gravitation - newtonian constant | | $G$ | $6.673 \times 10^{-11}$ | N·m$^2$/kg$^2$ |
| gravity acceleration (standard) | metric | $g$ | 9.807 | m/s$^2$ |
| gravity acceleration (standard) | USCS | $g$ | 32.174 | ft/s$^2$ |
| molar volume (ideal gas), $T$ = 273.15K, $p$ = 101.3 kPa | | $V_m$ | 22,414 | L/kmol |
| speed of light in vacuum | | $c$ | 299,792,000 | m/s |