

Problem 1.18

[Difficulty: 2]

1.18 For each quantity listed, indicate dimensions using force as a primary dimension, and give typical SI and English units:

- (a) Power
- (b) Pressure
- (c) Modulus of elasticity
- (d) Angular velocity
- (e) Energy
- (f) Momentum
- (g) Shear stress
- (h) Specific heat
- (i) Thermal expansion coefficient
- (j) Angular momentum

Given: Basic dimensions F, L, t and T.

Find: Dimensional representation of quantities below, and typical units in SI and English systems.

Solution:

(a) Power	$\text{Power} = \frac{\text{Energy}}{\text{Time}} = \frac{\text{Force} \times \text{Distance}}{\text{Time}} = \frac{F \cdot L}{t}$	$\frac{N \cdot m}{s}$	$\frac{lbf \cdot ft}{s}$
(b) Pressure	$\text{Pressure} = \frac{\text{Force}}{\text{Area}} = \frac{F}{L^2}$	$\frac{N}{m^2}$	$\frac{lbf}{ft^2}$
(c) Modulus of elasticity	$\text{Pressure} = \frac{\text{Force}}{\text{Area}} = \frac{F}{L^2}$	$\frac{N}{m^2}$	$\frac{lbf}{ft^2}$
(d) Angular velocity	$\text{AngularVelocity} = \frac{\text{Radians}}{\text{Time}} = \frac{1}{t}$	$\frac{1}{s}$	$\frac{1}{s}$
(e) Energy	$\text{Energy} = \text{Force} \times \text{Distance} = F \cdot L$	$N \cdot m$	$lbf \cdot ft$
(f) Momentum	$\text{Momentum} = \text{Mass} \times \text{Velocity} = M \cdot \frac{L}{t}$ From Newton's 2nd law $\text{Force} = \text{Mass} \times \text{Acceleration}$ so $F = M \cdot \frac{L}{t^2}$ or $M = \frac{F \cdot t^2}{L}$ Hence $\text{Momentum} = M \cdot \frac{L}{t} = \frac{F \cdot t^2 \cdot L}{L \cdot t} = F \cdot t$	$N \cdot s$	$lbf \cdot s$
(g) Shear stress	$\text{ShearStress} = \frac{\text{Force}}{\text{Area}} = \frac{F}{L^2}$	$\frac{N}{m^2}$	$\frac{lbf}{ft^2}$
(h) Specific heat	$\text{SpecificHeat} = \frac{\text{Energy}}{\text{Mass} \times \text{Temperature}} = \frac{F \cdot L}{M \cdot T} = \frac{F \cdot L}{\left(\frac{F \cdot t^2}{L}\right) \cdot T} = \frac{L^2}{t^2 \cdot T}$	$\frac{m^2}{s^2 \cdot K}$	$\frac{ft^2}{s^2 \cdot R}$
(i) Thermal expansion coefficient	$\text{ThermalExpansionCoefficient} = \frac{\text{LengthChange}}{\text{Temperature}} = \frac{1}{T}$	$\frac{1}{K}$	$\frac{1}{R}$
(j) Angular momentum	$\text{AngularMomentum} = \text{Momentum} \times \text{Distance} = F \cdot t \cdot L$	$N \cdot m \cdot s$	$lbf \cdot ft \cdot s$