

## Problem 1.17

[Difficulty: 2]

**1.17** For each quantity listed, indicate dimensions using mass 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) Moment of a force
- (g) Momentum
- (h) Shear stress
- (i) Strain
- (j) Angular momentum

**Given:** Basic dimensions M, L, t and T.

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

**Solution:**

(a) Power	$\text{Power} = \frac{\text{Energy}}{\text{Time}} = \frac{\text{Force} \times \text{Distance}}{\text{Time}} = \frac{F \cdot L}{t}$		
	From Newton's 2nd law      Force = Mass $\times$ Acceleration      so $F = \frac{M \cdot L}{t^2}$		
	Hence $\text{Power} = \frac{F \cdot L}{t} = \frac{M \cdot L \cdot L}{t^2 \cdot t} = \frac{M \cdot L^2}{t^3}$	$\frac{\text{kg} \cdot \text{m}^2}{\text{s}^3}$	$\frac{\text{slug} \cdot \text{ft}^2}{\text{s}^3}$
(b) Pressure	$\text{Pressure} = \frac{\text{Force}}{\text{Area}} = \frac{F}{L^2} = \frac{M \cdot L}{t^2 \cdot L^2} = \frac{M}{L \cdot t^2}$	$\frac{\text{kg}}{\text{m} \cdot \text{s}^2}$	$\frac{\text{slug}}{\text{ft} \cdot \text{s}^2}$
(c) Modulus of elasticity	$\text{Pressure} = \frac{\text{Force}}{\text{Area}} = \frac{F}{L^2} = \frac{M \cdot L}{t^2 \cdot L^2} = \frac{M}{L \cdot t^2}$	$\frac{\text{kg}}{\text{m} \cdot \text{s}^2}$	$\frac{\text{slug}}{\text{ft} \cdot \text{s}^2}$
(d) Angular velocity	$\text{AngularVelocity} = \frac{\text{Radians}}{\text{Time}} = \frac{1}{t}$	$\frac{1}{\text{s}}$	$\frac{1}{\text{s}}$
(e) Energy	$\text{Energy} = \text{Force} \times \text{Distance} = F \cdot L = \frac{M \cdot L \cdot L}{t^2} = \frac{M \cdot L^2}{t^2}$	$\frac{\text{kg} \cdot \text{m}^2}{\text{s}^2}$	$\frac{\text{slug} \cdot \text{ft}^2}{\text{s}^2}$
(f) Moment of a force	$\text{MomentOfForce} = \text{Force} \times \text{Length} = F \cdot L = \frac{M \cdot L \cdot L}{t^2} = \frac{M \cdot L^2}{t^2}$	$\frac{\text{kg} \cdot \text{m}^2}{\text{s}^2}$	$\frac{\text{slug} \cdot \text{ft}^2}{\text{s}^2}$
(g) Momentum	$\text{Momentum} = \text{Mass} \times \text{Velocity} = M \cdot \frac{L}{t} = \frac{M \cdot L}{t}$	$\frac{\text{kg} \cdot \text{m}}{\text{s}}$	$\frac{\text{slug} \cdot \text{ft}}{\text{s}}$
(h) Shear stress	$\text{ShearStress} = \frac{\text{Force}}{\text{Area}} = \frac{F}{L^2} = \frac{M \cdot L}{t^2 \cdot L^2} = \frac{M}{L \cdot t^2}$	$\frac{\text{kg}}{\text{m} \cdot \text{s}^2}$	$\frac{\text{slug}}{\text{ft} \cdot \text{s}^2}$
(i) Strain	$\text{Strain} = \frac{\text{LengthChange}}{\text{Length}} = \frac{L}{L}$	Dimensionless	
(j) Angular momentum	$\text{AngularMomentum} = \text{Momentum} \times \text{Distance} = \frac{M \cdot L}{t} \cdot L = \frac{M \cdot L^2}{t}$	$\frac{\text{kg} \cdot \text{m}^2}{\text{s}}$	$\frac{\text{slugs} \cdot \text{ft}^2}{\text{s}}$