



Problem 1.21 The equation

$$\sigma = \frac{My}{I}$$

is used in the mechanics of materials to determine normal stresses in beams.

- (a) When this equation is expressed in terms of SI base units, M is in newton-meters (N·m), y is in meters (m), and I is in meters to the fourth power (m^4). What are the SI units of σ ?
- (b) If $M = 2000$ N·m, $y = 0.1$ m, and $I = 7 \times 10^{-5}$ m^4 , what is the value of σ in U.S. Customary base units?

Solution:

$$(a) \quad \sigma = \frac{My}{I} = \frac{(N \cdot m)(m)}{m^4} = \frac{N}{m^3}$$

$$(b) \quad \sigma = \frac{My}{I} = \frac{(2000 \text{ N} \cdot m)(0.1 \text{ m})}{7 \times 10^{-5} \text{ m}^4} \left(\frac{1 \text{ lb}}{4.448 \text{ N}} \right) \left(\frac{0.3048 \text{ m}}{1} \right)^3 = 59,700 \frac{\text{lb}}{\text{in}^2}$$

Problem 1.22 The acceleration due to gravity on the surface of the moon is 1.62 m/s^2 . (a) What would the mass of the C-clamp in Active Example 1.4 be on the surface of the moon? (b) What would the weight of the C-clamp in newtons be on the surface of the moon?

Solution:

$$(a) \quad \text{The mass does not depend on location. The mass in kg is } 0.0272 \text{ slug} \left(\frac{14.59 \text{ kg}}{1 \text{ slug}} \right) = 0.397 \text{ kg} \quad \boxed{\text{mass} = 0.397 \text{ kg}}$$

$$(b) \quad \text{The weight on the surface of the moon is } W = mg = (0.397 \text{ kg})(1.62 \text{ m/s}^2) = 0.643 \text{ N} \quad \boxed{W = 0.643 \text{ N}}$$

Problem 1.23 The $1 \text{ ft} \times 1 \text{ ft} \times 1 \text{ ft}$ cube of iron weighs 490 lb at sea level. Determine the weight in newtons of a $1 \text{ m} \times 1 \text{ m} \times 1 \text{ m}$ cube of the same material at sea level.

Solution: The weight density is $\gamma = \frac{490 \text{ lb}}{1 \text{ ft}^3}$.
The weight of the 1 m^3 cube is:

$$W = \gamma V = \left(\frac{490 \text{ lb}}{1 \text{ ft}^3} \right) (1 \text{ m})^3 \left(\frac{1 \text{ ft}}{0.3048 \text{ m}} \right)^3 \left(\frac{1 \text{ N}}{0.2248 \text{ lb}} \right) = 77.0 \text{ kN}$$



Problem 1.24 The area of the Pacific Ocean is 64,186,000 square miles and its average depth is 12,925 ft. Assume that the weight per unit volume of ocean water is 64 lb/ft^3 . Determine the mass of the Pacific Ocean (a) in slugs; (b) in kilograms.

Solution: The volume of the ocean is

$$V = (64,186,000 \text{ mi}^2)(12,925 \text{ ft}) \left(\frac{5,280 \text{ ft}}{1 \text{ mi}} \right)^2 = 2.312 \times 10^{18} \text{ ft}^3$$

$$(a) \quad m = \rho V = \left(\frac{64 \text{ lb/ft}^3}{32.2 \text{ ft/s}^2} \right) (2.312 \times 10^{18} \text{ ft}^3) = 4.60 \times 10^{18} \text{ slugs}$$

$$(b) \quad m = (4.60 \times 10^{18} \text{ slugs}) \left(\frac{14.59 \text{ kg}}{1 \text{ slug}} \right) = 6.71 \times 10^{20} \text{ kg}$$

Problem 1.25 The acceleration due to gravity at sea level is $g = 9.81 \text{ m/s}^2$. The radius of the earth is 6370 km. The universal gravitational constant is $G = 6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2/\text{kg}^2$. Use this information to determine the mass of the earth.

Solution: Use Eq. (1.3) $a = \frac{Gm}{R^2}$. Solve for the mass.

$$m_E = \frac{gR^2}{G} = \frac{(9.81 \text{ m/s}^2)(6370 \text{ km})^2 \left(10^3 \frac{\text{m}}{\text{km}} \right)^2}{6.67(10^{-11}) \left(\frac{\text{N} \cdot \text{m}^2}{\text{kg}^2} \right)} = 5.9679 \dots (10^{24}) \text{ kg} = 5.97(10^{24}) \text{ kg}$$

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