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Chapter 2

2.1. Convert the information given in the accompanying table from SI units to U.S. Customary units. Show all steps of your solutions. See Example 2.3.

Convert from SI Units	To U.S. Customary Units
120 km/h	miles/h and ft/s
100 m^3	ft^3
80 kg	lbm
900 N	lbf
9.81 m/s^2	ft/s^2

SOLUTION

$$120\frac{\text{km}}{\text{h}}\left(\frac{1000\text{ m}}{1\text{ km}}\right)\left(\frac{3.28\text{ ft}}{1\text{ m}}\right)\left(\frac{1\text{ mile}}{5280\text{ ft}}\right) = 74.5\text{ miles/h}$$

$$120\frac{\text{km}}{\text{h}}\left(\frac{1000\text{ m}}{1\text{ km}}\right)\left(\frac{3.28\text{ ft}}{1\text{ m}}\right)\left(\frac{1\text{h}}{3600\text{ s}}\right) = 109.3\text{ ft/s}$$

$$100(\text{m}^3)\left(\frac{3.28\text{ ft}}{1\text{ m}}\right)^3 = 3529\text{ ft}^3$$

$$80(\text{kg})\left(\frac{2.2046\text{ lbm}}{1\text{ kg}}\right) = 176.4\text{ lbm}$$

$$900(\text{N})\left(\frac{224.809\times10^{-3}\text{ lbf}}{1\text{N}}\right) = 202.3\text{ lbf}$$

$$9.81\frac{\text{m}}{\text{s}^2}\left(\frac{3.28\text{ ft}}{1\text{ m}}\right) = 32.2\frac{\text{ft}}{\text{s}^2}$$

2.2. Convert the information given in the accompanying table from U.S. Customary to SI units. Show all steps of your solutions. See Example 2.3.

Convert from U.S. Customary Units	To SI Units
65 miles/h	km/hr and m/s
120 lbm/ft³	kg/m³
200 lbm	kg
200 lbf	N

SOLUTION

$$65\ \frac{\text{miles}}{\text{h}}\left(\frac{5280\ \text{ft}}{1\ \text{mile}}\right)\left(\frac{1\ \text{km}}{1\,000\ \text{m}}\right)\left(\frac{1\ \text{m}}{3.28\ \text{ft}}\right) = 104.6\ \text{km/h}$$

$$104.6\ \frac{\text{km}}{\text{h}}\left(\frac{1000\ \text{m}}{1\ \text{km}}\right)\left(\frac{1\ \text{h}}{3600\ s}\right) = 29\ \text{m/s}$$

$$120\ \frac{\text{lbm}}{\text{ft}^3}\left(\frac{1\ \text{kg}}{2.2046\ \text{lbm}}\right)\left(\frac{3.28\ \text{ft}}{1\ \text{m}}\right)^3 = 1{,}920\ \text{kg/m}^3$$

$$200\ (\text{lbm})\left(\frac{1\ \text{kg}}{2.2046\ \text{lbm}}\right) = 90.7\ \text{kg}$$

$$200\ (\text{lbf})\left(\frac{1\ \text{N}}{224.809\times10^{-3}\ \text{lbf}}\right) = 890\ \text{N}$$

2.4. A house has a given floor space of 2,000 ft^2. Convert this area to m^2.

SOLUTION

$$A = (2000\ ft^2)\left(\frac{1\ m}{\ }\right)^2 = 185.9\ m^2$$

2.5. Calculate the volume of water in a large swimming pool with dimensions of 50 m × 25 m × 2 m. Express your answer in liters, m^3, gallons, and ft^3.

SOLUTION

$$V = (50\ m)(25\ m)(2\ m) = 2{,}500\ m^3$$

$$V = (2{,}500\ m^3)\left(\frac{100\ cm}{1\ m}\right)^3\left(\frac{1\ liter}{1000\ cm^3}\right) = 2{,}500{,}000\ liters$$

$$V = (2{,}500\ m^3)\left(\frac{3.28\ ft}{1\ m}\right)^3 = 88{,}219\ ft^3$$

$$V = (88{,}219\ ft^3)\frac{7.48\ gallons}{1 ft^3}\ H\ 660{,}000\ gallons$$

2.6. A 500 sheet ream of copy paper has thickness of 2.25 in. What is the average thickness of each sheet in mm?

SOLUTION

$$Thickness = \frac{2.25\ in.}{500\ sheets}\ \frac{25.4\ mm}{1\ in.} = 0.1143\ mm\ /sheet$$

2.7. A barrel can hold 42 gallons of oil. How many liters of oil are in the barrel?

SOLUTION

$$42 \text{ gallons} \times \frac{3.78 \text{ liters}}{\text{gallon}} = 158.76 \text{ liters}$$

2.8. Express the kinetic energy [½ (mass)(speed)^2] of a car with a mass of 1,200 kg moving at a speed of 100 km/h. First, you need to convert the speed from km/h to the fundamental units of m/s. Show the conversion steps. (Note: We explain the concept of kinetic energy in Chapter 3.)

SOLUTION

$$\text{speed} = (100)\frac{\text{km}}{\text{h}}\left(\frac{1\text{h}}{3600\text{ s}}\right)\left(\frac{1\,000\text{ m}}{1\text{ km}}\right) = 27.7 \text{ m/s}$$

$$\text{K.E.} = \frac{1}{2}(1200\text{ kg})\left(27.7\frac{\text{m}}{\text{s}}\right)^2 = 4.6\times10^5 \text{kg}\cdot\frac{\text{m}}{\text{s}^2}\cdot\text{m} = 4.6\times10^5 \text{ N}\cdot\text{m} = 4.6\times10^5 \text{ J}$$

$$\text{K.E.} = (4.6\times10^5 \text{ J})\left(\frac{1 \text{ ft}\cdot\text{lbf}}{1.3558 \text{ J}}\right) = 3.4\times10^5 \text{ft}\cdot\text{lbf}$$

2.9. A machine shop has a rectangular floor shape with dimensions of 30 ft by 50 ft. Express the area of the floor in ft^2, m^2, in.^{2}, and cm^2. Show the conversion steps.

SOLUTION

$$A = (30 \text{ ft})(50 \text{ ft}) = 1500 \text{ ft}^2$$

$$A = (1500\ \text{ft}^2)\left(\frac{1\ \text{m}}{3.28\ \text{ft}}\right)^2 = 139.4\ \text{m}^2$$

$$A = (1500\ \text{ft}^2)\left(\frac{12\ \text{in}}{1\ \text{ft}}\right)^2 = 216{,}000\ \text{in}^2$$

$$A = (1500\ \text{ft}^2)\left(\frac{1\ \text{cm}}{0.0328\ \text{ft}}\right)^2 = 139.4 \times 10^4\ \text{cm}^2$$

2.10. A trunk of a car has a listed luggage capacity of 18 ft^3. Express the capacity in $in.^3$, m^3, and cm^3. Show the conversion steps.

SOLUTION

$$V = (18\ \text{ft}^3)\left(\frac{12\ \text{in}}{}\right)^3 = 31{,}104\ \text{in}^3$$

$$V = (18\ \text{ft}^3)\left(\frac{1\ \text{m}}{3.28\ \text{ft}}\right)^3 = 0.51\ \text{m}^3$$

$$V = (18\ \text{ft}^3)\left(\frac{1\ \text{cm}}{0.0328\ \text{ft}}\right)^3 = 51 \times 10^4\ \text{cm}^3$$

2.11. An automobile has a 3.5 liter engine. Express the engine size in $in.^3$. Show the conversion steps. Note that 1 liter is equal to 1,000 cm^3.

SOLUTION

$$V = (3.5\ \text{liters})\left(\frac{1000\ \text{cm}^3}{1\ \text{liter}}\right)\left(\frac{1\ \text{in}}{2.54\ \text{cm}}\right)^3 = 214\ \text{in}^3$$

2.12. The density of air that we breathe at standard room conditions is 1.2 kg/m^3. Express the density in U.S. Customary units. Show the conversion steps.

SOLUTION

$$\text{Density} = 1.2\ \frac{\text{kg}}{\text{m}^3}\left(\frac{1\ \text{m}}{3.28\ \text{ft}}\right)^3\left(\frac{1\ \text{lbm}}{0.4536\ \text{kg}}\right) = 0.075\ \frac{\text{lbm}}{\text{ft}^3}$$

2.13. On a summer day in Phoenix, Arizona, the inside room temperature is maintained at 68°F while the outdoor air temperature is a sizzling 110°F. What is the outdoor–indoor temperature difference in degrees (a) Fahrenheit or (b) Celsius?

SOLUTION

(a) $T_{OUTDOOR} - T_{INDOOR} = 110\ \text{F} - 68\ \text{F} = 42\ \text{F}$

(b) $T_{OUTDOOR}(\ \text{C}) = \frac{5}{9}(T_{OUTDOOR}(\ \text{F}) - 32) = \frac{5}{9}(110 - 32) = 43.3\ \text{C}$

$$T_{INDOOR}(\ \text{C}) = \frac{5}{9}(T_{INDOOR}(\ \text{F}) - 32) = \frac{5}{9}(68 - 32) = 20\ \text{C}$$

$$T_{OUTDOOR} - T_{INDOOR} = 43.3\ \text{C} - 20\ \text{C} = 23.3\ \text{C}$$

2.14. A person who is 180 cm tall and weighs 750 newtons is driving a car at a speed of 90 kilometers per hour over a distance of 80 kilometers. The outside air temperature is 30°C and has a density of 1.2 kg/m^3. Convert all of the values given from SI to U.S. Customary units.

SOLUTION

Person's height, *H*

$$H = (180\ \text{cm})\left(\frac{1\ \text{ft}}{30.48\ \text{cm}}\right) = 5.9\ \text{ft}$$

Person's weight, W

$$W = (750\ \text{N})\left(\frac{1\ \text{lbf}}{4.448\text{N}}\right) = 168.6\ \text{lbf}$$

Speed of the car, S = 90 km/h = 90,000 m/h

$$S = \left(90{,}000\ \frac{\text{m}}{\text{h}}\right)\left(\frac{1\ \text{ft}}{0.3048\ \text{m}}\right)\left(\frac{1\ \text{mile}}{5280\ \text{ft}}\right) = 55.9\ \text{(miles/h)}$$

Distance traveled, D

$$D = (80\ \text{km})\left(\frac{1000\ \text{m}}{1\ \text{km}}\right)\left(\frac{1\ \text{ft}}{0.3048\ \text{m}}\right)\left(\frac{1\ \text{mile}}{5280\ \text{ft}}\right) = 49.7\ \text{miles}$$

Temperature of air, T

$$T(\text{C}) = \frac{9}{5}(30)+32=86\ \text{F}$$

Density of air, ρ

$$\rho = \left(1.2\ \frac{\text{kg}}{\text{m}}\right)\left(\frac{1\ \text{lbm}}{0.453\ \text{kg}}\right)\left(\frac{0.3048\ \text{m}}{1\ \text{ft}}\right)^3 = 0.075(\text{lbm/ft}^3)$$

2.15. Convert the given values: (a) area A = 16 in.^{2} to ft^2 and (b) volume V = 64 in.^{3} to ft^3.

<u>SOLUTION</u>

$$\text{(a)}\ (16\ \text{in}^2)\left(\frac{1\ \text{ft}^2}{\ }\right) = 0.1111\ \text{ft}^2$$

(b) $(64\ in^3)\left(\frac{1\ ft}{in}\right)^3 = 0.037\ ft^3$ 12

2.16. The acceleration due to gravity g is 9.81 m/s^2. Express the value of g in U.S. Customary units. Show all conversion steps.

SOLUTION

$$(9.81\ m/s^2)\left(\frac{1\ ft}{0.3048\ m}\right) = 32.18\ ft/s^2$$

2.17. Atmospheric pressure is the weight of the column of air over an area. For example, under standard conditions, the atmospheric pressure is 14.7 lbf/in.^{2}. This value means that the column of air in the atmosphere above a surface with an area of 1 in.^{2} will exert a force of 14.7 lbf. Convert the atmospheric pressure in the given units to the requested units: (a) 14.7 lbf/in.^{2} to lbf/ft^2, (b) 14.7 lbf/in.^{2} to Pa, (c) 14.7 lbf/in.^{2} to kPa, and (d) 14.7 lbf/in.^{2} to bars. Show all of the conversion steps. [Note: One Pascal (1 Pa) is equal to one newton per meter squared (1 Pa = 1 N/m^2) and 1 bar = 100 kPa.]

SOLUTION

(a) $14.7\left(\frac{lbf}{in^2}\right)\left(\frac{144\ in^2}{1\ ft^2}\right) = 2{,}117\left(\frac{lbf}{ft^2}\right)$

(b) $14.7\ \frac{lbf}{in^2}\ \frac{6{,}895\ Pa}{\frac{1\ lbf}{in^2}} = 101{,}357\ Pa$

(c) 101,357 Pa = 101.357 kPa

(d) 101.357 kPa = 1.01 bar

2.18. The density of water is 1,000 kg/m^3. Express the density of water in lbm/ft^3 and lbm/gallon. (Note: 7.48 gallons = 1 ft^3)

SOLUTION

$$1000\ \frac{\text{kg}}{\text{m}^3}\left(\frac{1\ \text{m}}{3.28\ \text{ft}}\right)^3\frac{2.20\ \text{lbm}}{1\ \text{kg}} = 62.34\ \text{lbm/ft}^3$$

$$62.34\ \frac{\text{lbm}}{\text{ft}^3}\ \frac{\text{ft}^3}{7.48\ \text{gallons}} = 8.33\ \text{lbm/gallon}$$