

## 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 <sup>3</sup>	ft <sup>3</sup>
80 kg	lbm
900 N	lbf
9.81 m/s <sup>2</sup>	ft/s <sup>2</sup>

### SOLUTION

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

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

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

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

$$900 \left( \text{N} \right) \left( \frac{224.809 \times 10^{-3} \text{ lbf}}{1 \text{ N}} \right) = 202.3 \text{ lbf}$$

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

- 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/ft <sup>3</sup>	kg/m <sup>3</sup>
200 lbm	kg
200 lbf	N

**SOLUTION**

$$65 \left( \frac{\text{miles}}{\text{h}} \right) \left( \frac{5280 \text{ ft}}{1 \text{ mile}} \right) \left( \frac{1 \text{ km}}{1000 \text{ m}} \right) \left( \frac{1 \text{ m}}{3.28 \text{ ft}} \right) = 104.6 \text{ km/h}$$

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

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

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

$$200 \text{ (lbf)} \left( \frac{1 \text{ N}}{224.809 \times 10^{-3} \text{ lbf}} \right) = 890 \text{ N}$$

**2.4.** A house has a given floor space of 2,000 ft<sup>2</sup>. Convert this area to m<sup>2</sup>.

**SOLUTION**

$$A = (2000 \text{ ft}^2) \left( \frac{1 \text{ m}}{3.28 \text{ ft}} \right)^2 = 185.9 \text{ m}^2$$

**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<sup>3</sup>, gallons, and ft<sup>3</sup>.

**SOLUTION**

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

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

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

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

**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**

$$\text{Thickness} = \frac{2.25 \text{ in.}}{500 \text{ sheets}} \left( \frac{25.4 \text{ mm}}{1 \text{ in.}} \right) = 0.1143 \text{ mm /sheet}$$

**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 [ $\frac{1}{2}(\text{mass})(\text{speed})^2$ ] 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**

$$\text{speed} = (100) \left( \frac{\text{km}}{\text{h}} \right) \left( \frac{1 \text{ h}}{3600 \text{ s}} \right) \left( \frac{1000 \text{ m}}{1 \text{ km}} \right) = 27.7 \text{ m/s}$$

$$\text{K.E.} = \left( \frac{1}{2} \right) (1200 \text{ kg}) \left( 27.7 \frac{\text{m}}{\text{s}} \right)^2 = 4.6 \times 10^5 \text{ kg} \cdot \frac{\text{m}}{\text{s}^2} \cdot \text{m} = 4.6 \times 10^5 \text{ N} \cdot \text{m} = 4.6 \times 10^5 \text{ J}$$

$$\text{K.E.} = (4.6 \times 10^5 \text{ J}) \left( \frac{1 \text{ ft} \cdot \text{lbf}}{1.3558 \text{ J}} \right) = 3.4 \times 10^5 \text{ ft} \cdot \text{lbf}$$

**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<sup>2</sup>, m<sup>2</sup>, in.<sup>2</sup>, and cm<sup>2</sup>. 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  $18 \text{ ft}^3$ . Express the capacity in  $\text{in}^3$ ,  $\text{m}^3$ , and  $\text{cm}^3$ . Show the conversion steps.

**SOLUTION**

$$V = (18 \text{ ft}^3) \left( \frac{12 \text{ in}}{1 \text{ ft}} \right)^3 = 31,104 \text{ in}^3$$

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

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

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

**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  $1.2 \text{ kg/m}^3$ . Express the density in U.S. Customary units. Show the conversion steps.

**SOLUTION**

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

- 2.13.** On a summer day in Phoenix, Arizona, the inside room temperature is maintained at  $68^\circ\text{F}$  while the outdoor air temperature is a sizzling  $110^\circ\text{F}$ . What is the outdoor–indoor temperature difference in degrees (a) Fahrenheit or (b) Celsius?

**SOLUTION**

$$(a) T_{\text{outdoor}} - T_{\text{indoor}} = 110^\circ\text{F} - 68^\circ\text{F} = 42^\circ\text{F}$$

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

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

$$T_{\text{outdoor}} - T_{\text{indoor}} = 43.3^\circ\text{C} - 20^\circ\text{C} = 23.3^\circ\text{C}$$

- 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  $30^\circ\text{C}$  and has a density of  $1.2 \text{ kg/m}^3$ . 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,  $S = 90 \text{ km/h} = 90,000 \text{ m/h}$

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

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,  $T$

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

Density of air,  $\rho$

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

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

### **SOLUTION**

$$(a) (16 \text{ in}^2)\left(\frac{1 \text{ ft}^2}{144 \text{ in}^2}\right) = 0.1111 \text{ ft}^2$$

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

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

### **SOLUTION**

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

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

### **SOLUTION**

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

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

$$(c) 101,357 \text{ Pa} = 101.357 \text{ kPa}$$

$$(d) 101.357 \text{ kPa} = 1.01 \text{ bar}$$



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

**SOLUTION**

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

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

