Section B.1: Standardized Unit Systems: U.S. and Metric

Different system of standardized units

There are different systems of standardized units: the international metric system, called SI (from the French Système International d'Unités) and the English system, called the U.S. customary system (USCS).

The U.S. Customary System

The U.S. Customary System

- Units of length are inches, feet, yards, and miles.
- Units of mass are ounces and pounds.
- For volumes we use quarts, gallons, and barrels.

Ex.1 The Kentucky Derby.
In the Kentucky Derby, horses race a distance of 10 furlongs. How many miles is the race?
(Hint: 1 furlong $= 1/8$ miles.)

Ex.2 $20,000$ Leagues Under the Sea.
In the Jules Verne's novel $20,000$ Leagues Under the Sea, does the title refer to an ocean depth? How do you know? (Hint: 1 league = 3 miles.)

The International Metric System

The International Metric System
The basic units of length, mass, time and volume in the metric system are

- *meter* for length (m);
- *kilogram* for mass (kg);
- *second* for time (s);
- *liter* for volume (L).

In the international metric system we use powers of 10 to find all the other units, and we write the new units adding a prefix which indicates multiplication by a power of 10.

Ex.3

(1) Convert 2759 centimeters to metes.
(2) How many nanoseconds are in a microsecond?

Metric-USCS Conversions

This is a table of conversions:

USCS to Metric	Metric to USCS
1 in. = 2.54 cm	1 cm = 0.3937 in.
1 ft = 0.3048 m	1 m = 3.28 ft
1 yd = 0.9144 m	1 m = 1.094 yd
1 mi = 1.6093 km	1 km = 0.6214 mi
1 lb = 0.4536 kg	1 kg = 2.205 lb
1 gal = 3.785 L	1 L = 0.2642 gal

Ex.4 Gas Price per Liter.
At a gas station in Mexico, the price of gasoline is 8 pesos per liter. What is the price in dollars per gallons? We know that 1 peso $= \$0.092$.

Ex.5 Square Kilometers to Square Miles.
How many square kilometers are in a square mile?

Temperature Units: Fahrenheit, Celsius and Kelvin

Temperature Units

There are three temperature scales commonly used today: Fahrenheit, Celsius and Kelvin.

- The *Fahrenheit scale* is used in the United States and it is defined so that water freezes at $32°F$ and boils at $212°F$.
- Internationally, temperature is measured on the *Celsius scale*, which places the freezing point of water at $0°C$ and the boiling point at $100°C$.
- The *Kelvin scale* is used in science and is the same as the Celsius scale except for its zero point: a temperature of $0\ K$ is the coldest possible temperature, known as absolute zero and it correspond to $-273.15°C$ or $-459.67°F$.

The conversions are:

- from Celsius to Fahrenheit:
$$F = 1.8\,C + 32$$
- from Fahrenheit to Celsius:
$$C = \frac{F - 32}{1.8}$$
- from Celsius to Kelvin:
$$K = C + 273.15$$
- from Kelvin to Celsius:
$$C = K - 273.15.$$

Ex.6 Human Body Temperature.
Average human body temperature is $98.6°F$. What is it in Celsius and Kelvin?

Ex.7
The local weather report says that tomorrow the temperature will be $59°$, but does not specify whether it is in Celsius or Fahrenheit. Can you tell which it is? Why?

Section B.2: Units of Energy and Power

Definition of energy
Energy is what makes matter move or heat up. The international metric unit of energy is the *joule*.

Calories
For example, we need energy from food to walk or run. The most familiar energy unit is the food *Calorie* used to measure the energy our body can draw from food:

$$1 \text{ Calorie} = 4184 \text{ joules}.$$

Definition of power
Power is the rate at which energy is used. The international metric unit of energy is the *watt*:

$$1 \text{ watt} = 1 \frac{\text{joule}}{\text{s}}.$$

Ex.8
You are riding an exercise bicycle at a fitness center. The readout states that you are using 500 Calories per hour. Are you generating enough power to light a 100-watt bulb?

Definition of kilowatt-hour
A *kilowatt-hour* is a unit of energy:

$$1 \text{ kilowatt-hour} = \frac{1000 \text{ joule}}{1 \text{ s}} \times 1 \text{ hr} = \frac{1000 \text{ joule}}{1 \text{ s}} \times 3,600 \text{ s} = 3,600,000 \text{ joule}.$$

Ex.9
Your utility company charges 8 cents per kilowatt-hour of electricity. How much does it cost to keep a 100-watt light bulb on for a week?

Section B.3: Units of Density and Concentration

Definition of density

Density describes compactness or crowding. There are three different kinds of densities:

- *Material density* is given in units of mass per unit volume, such as grams per cubic centimeter $\left(\frac{\text{g}}{\text{cm}^3}\right)$. For example, the density of water is $1\frac{\text{g}}{\text{cm}^3}$. Objects with densities less than $1\frac{\text{g}}{\text{cm}^3}$ float in the water, while objects with densities more than $1\frac{\text{g}}{\text{cm}^3}$ sink.
- *Population density* is given by the number of people per unit area. For example, if 500 people live in a square region that is 2 miles on a side, the population density of the area is
$$\frac{500\text{ people}}{4\text{mi}^2} = 125\frac{\text{people}}{\text{mi}^2}.$$
- *Information density* is used to describe how much memory can be stored by digital media. For example, each square inch surface of a DVD hold about 100 megabytes of information, so we say that a DVD has an information density of $100\frac{\text{MB}}{\text{in}^2}$.

Definition of concentration

Concentration describes the amount of one substance mixed with another. There are many types of concentration, for example:

- The *concentration of an air pollutant* is often measured by the numbers of molecules of the pollutant per million molecules of air. For example, if there are 20 molecules of carbon monoxide in each 1 million molecules of air, we state the carbon monoxide concentration as 20 parts per million (ppm).
- *Blood alcohol content* (BAC) describes the concentration of alcohol in a person's body. It is usually measured in units of grams of alcohol per 100 milliliter of blood. For example, in most states a person is considered legally intoxicated if his/her blood alcohol content is at or above 0.08 gram of alcohol per 100 milliliters of blood $\left(\frac{0.08\text{ g}}{100\text{ mL}}\right)$.

Ex.10

Manhattan Island has a population of about 1.5 million people living in an area of about 57 square kilometers. What is its population density? If there were no high-rise apartments, how much space would be available per person?