

INTRODUCTION

Physics, chemistry, and mathematics are essential in gaining an understanding of the principles that govern most of the unit operations commonly found in the food industry. For example, if a food engineer is asked to design a food process that involves heating and cooling, then he or she must be well aware of the physical principles that govern heat transfer. The engineer's work is often expected to be quantitative, and therefore the ability to use mathematics is essential. Foods undergo changes as a result of processing; such changes may be physical, chemical, enzymatic, or microbiological. It is often necessary to know the kinetics of chemical changes that occur during processing. Such quantitative knowledge is a prerequisite to the design and analysis of food processes. It is expected that prior to studying food engineering principles, the student will have taken basic courses in mathematics, chemistry, and physics.

DIMENSIONS: A physical entity, which can be observed and/or measured, is defined qualitatively by a dimension. For example, time, length, area, volume, mass, force, temperature, and energy are all considered dimensions. The quantitative magnitude of a dimension is expressed by a unit; a unit of length may be measured as a meter, centimeter, or millimeter.

Primary dimensions, such as length, time, temperature, and mass, express a physical entity.

Secondary dimensions involve a combination of primary dimensions (e.g., volume is length cubed; velocity is distance divided by time). Thus, if the dimension of the left-hand side of an equation is "length," the dimension of the right-hand side must also be "length"; otherwise, the equation is incorrect. This is a good method to check the accuracy of equations. In solving numerical problems, it is also useful to write the units of each dimensional quantity within the equations. This practice is helpful to avoid mistakes in calculations.

ENGINEERING UNITS: Physical quantities are measured using a wide variety of unit systems. The most common systems include the Imperial (English) system; the centimeter, gram, second (cgs) system; and the meter, kilogram, second (mks) system. However, use of these systems, entailing myriad symbols to designate units, has often caused considerable confusion. International organizations have attempted to standardize unit systems, symbols, and their quantities. As a result of international agreements, the *Système International d'Unités*, or the SI units, have emerged. The SI units consist of seven base units, two supplementary units, and a series of derived units.

Base Units: The SI system is based on a choice of seven well-defined units, which by convention are regarded as dimensionally independent. The definitions of these seven base units are as follows:

1. Unit of length (meter): The meter (m) is the length equal to 1,650,763.73 wavelengths in vacuum of the radiation corresponding to the transition between the levels 2p₁₀ and 5d₅ of the krypton-86 atom.
2. Unit of mass (kilogram): The kilogram (kg) is equal to the mass of the

international prototype of the kilogram. (The international prototype of the kilogram is a particular cylinder of platinum-iridium alloy, which is preserved in a vault at Sèvres, France, by the International Bureau of Weights and Measures.)

3. Unit of time (second): The second (s) is the duration of 9,192,631,770 periods of radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom.

4. Unit of electric current (ampere): The ampere (A) is the constant current that, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1m apart in vacuum, would produce between those conductors a force equal to 2×10^{-7} newton per meter length.

5. Unit of thermodynamic temperature (Kelvin): The Kelvin (K) is the fraction $1/273.16$ of the thermodynamic temperature of the triple point of water.

6. Unit of amount of substance (mole): The mole (mol) is the amount of substance of a system that contains as many elementary entities as there are atoms in 0.012 kg of carbon 12.

7. Unit of luminous intensity (candela): The candela (cd) is the luminous intensity, in the perpendicular direction, of a surface of $1/600,000 \text{ m}^2$ of a blackbody at the temperature of freezing platinum under a

Derived units are algebraic combinations of base units expressed by means of multiplication and division. For simplicity, derived units often carry special names and symbols that may be used to obtain other derived units. Definitions of some commonly used derived units are as follows:

1. Newton (N): The newton is the force that gives to a mass of 1kg an acceleration of 1 m/s^2

2. Joule (J): The joule is the work done when due to force of 1 N the point of application is displaced by a distance of 1m in the direction of the force.

3. Watt (W): The watt is the power that gives rise to the production of energy at the rate of 1J/s.

4. Volt (V): The volt is the difference of electric potential between two points of a conducting wire carrying a constant current of 1 A, when the power dissipated between these points is equal to 1W.

5. Ohm (Ω): The ohm is the electric resistance between two points of a conductor when a constant difference of potential of 1 V, applied between these two points, produces in this conductor a current of 1 A, when this conductor is not being the source of any electromotive force.

Supplementary Units This class of units contains two purely geometric units, which may be regarded either as base units or as derived units.

1. Unit of plane angle (radian): The radian (rad) is the plane angle between two radii of a circle that cut off on the circumference an arc equal in length to the radius.
2. Unit of solid angle (steradian): The steradian (sr) is the solid angle that, having its vertex in the center of a sphere, cuts off an area of the surface of the sphere equal to that of a square with sides of length equal to the radius of the sphere.