Chapter 1

Units, Physical Quantities, and Vectors

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1 Standards and Units

The metric system is also known as the "SI" system of units. (SI ≡ Système International).

A. **Length** — The unit of length in the metric system is the meter. A meter is the distance that light travels in a vacuum. ($\frac{1}{299{,}792{,}457}$ seconds).

B. **Mass** — The unit of *mass* in the metric system is the kilogram. A *kilogram* is the mass of a particular cylinder of platinum-iridium alloy kept at the International Bureau of Weights and Measures in Paris, France.

C. **Time** — The unit of *time* in the metric system is the *second*. A second is the time required for 9,192,631,770 cycles of a particular microwave radiation associated with cesium atoms that occurs in the transition between its two lowest energy states.

2 Uncertainty and Significant Figures

When a value is not known precisely, the amount of uncertainty is usually called an "error". Error represents uncertainty and has nothing to do with mistakes or sloppiness.

A significant figure is a reliably known digit. When we say that a quantity has the value 3, we mean by convention that the value could actually be anywhere between 2.5 and 3.5. However, if we say that the value is 3.0, then we mean the value lies between 2.95 and 3.05.

2.1 Significant Figures in Addition or Subtraction:

The number of decimal places in the result should equal the smallest number of decimal places of any term from the original equation.

$$23.45 + 1.345 = 24.795 \Rightarrow 24.80 \tag{1}$$

$$56 - 34.56 = 21.44 \Rightarrow 21 \tag{2}$$

2.2 Significant Figures in Multiplication or Division:

The number of significant figures in the final product is the same as the number of significant figures in the factor with the lowest number of significant figures.

$$123.56(7.89) = 974.8884 \Rightarrow 975 \tag{3}$$

$$\frac{564}{0.0034} = 165882.352941 \Rightarrow 1.7x10^5 \tag{4}$$

3 Vectors and Vector Addition

A. **Scalar** — A *scalar* quantity is a physical quantity that has only magnitude. Examples:

1. Mass m (in kilograms, kg)
2. time t (in seconds, s or sec)
3. temperature T (in Kelvin, K)
4. volume V (in cubic meters, m^3)
5. density ρ (in kg/m^3)
6. energy E (in Joules, J)
7. distance d (in meters, m)
8. speed v (in meters per second, m/s)
9. electric charge q (in Coulombs, C)

B. **Vector** — A *vector* quantity is a physical quantity that has both magnitude and a direction. Examples:

1. displacement Δr (in meters, m)
2. velocity $\vec{v}$ (in meters per second, m/s)
3. acceleration $\vec{a}$ (in meters per second square, m/s^2)
4. force $\vec{F}$ (in Newtons, N)
5. linear momentum $\vec{p}$ (in kgm/s)
6. angular momentum $\vec{L}$(in kgm^2/sec)

3.1 The Displacement Vector Δr

The displacement vector Δr of an object is defined as the vector whose magnitude is the shortest distance between the initial and final positions of the object, and whose direction points from the initial position to the final position.

3.2 Components of Vectors

The components of a vector are the projections of the vector along the axes of a rectangular coordinate system.

$$A_x = \text{the x-component of vector } \vec{A}$$
$$A_y = \text{the y-component of vector } \vec{A}$$
$$|\vec{A}| = \text{the magnitude of vector } \vec{A}$$