✓ *mass* — resistance to force, which causes objects to move (the more massive the object, the more force is needed to move the object from rest)

✓ *amount of substance* — amount of material contained in an object in terms of the number of atoms or molecules

✓ *temperature* — hotness or coldness of a substance

✓ *electric current* — amount of negative charges flowing

✓ *luminous intensity* — brightness of light

✓ *MKS* — stands for the first letters of the three base units of length (meter), mass (kilogram), and time (seconds)

✓ *standard of time in the SI system* — second (s)
— the time required for a cesium – 133 atom to undergo 9,192,631,770 vibrations

Two advantages of the SI system:

1. conveniently measures very large and very small quantities
2. conveniently relates different units of measure using the SI prefixes added to the unit.

SI Prefixes

Factor	Prefix	Symbol	Factor	Prefix	Symbol
10^{18}	exa-	E	10^{-1}	deci-	d
10^{15}	peta-	P	10^{-2}	centi-	c
10^{12}	tera-	T	10^{-3}	milli-	m
10^{9}	giga-	G	10^{-6}	micro-	μ
10^{6}	mega-	M	10^{-9}	mano-	n
10^{3}	kilo-	k	10^{-12}	pico-	p
10^{2}	hecto-	h	10^{-15}	femto-	f
10^{1}	deka-	da	10^{-18}	atto-	a

Examples:

1 gigahertz = 1 GHz = 1×10^{9} Hz 1 centimeter = 1 cm = 1×10^{-2} m

area = A • B → wrong! Since A is in SI while B is in the FPS system
area = A • C → wrong! Although both are in SI system, since A is in meters while C is in mm
area = A • D → correct!

- ✓ *Lack of dimensional consistency* — requires conversion of units from one system to another to achieve consistency.
- ✓ *Chain link conversion* — a method of changing units by multiplication or division of the physical quantity with the necessary conversion factors.
- ✓ *Conversion factor* — a ratio of units that is equal to one.

Example 3:

$$60\,\text{s} = 1\,\text{min} \rightarrow \begin{cases} \dfrac{60\,\text{s}}{1\,\text{min}} = \dfrac{1\,\text{min}}{1\,\text{min}} = 1 \rightarrow \text{conversion factor (CV1)} = 60\dfrac{\text{s}}{\text{min}} \\ \dfrac{60\,\text{s}}{1\,\text{min}} = \dfrac{1\,\text{min}}{60\,\text{s}} = 1 \rightarrow \text{conversion factor (CV2)} = \dfrac{1}{60}\dfrac{\text{min}}{\text{s}} \end{cases}$$

2.5 min = 2.5 min • CV1 = 2.5 min • 60 $^{s}/_{min}$ = 15 s ← multiplication

Equivalently,

$$2.5\,\text{min} = \frac{2.5\,\text{min}}{\text{CV2}} = \frac{2.5\,\text{min}}{\dfrac{1\,\text{min}}{60\,\text{s}}} = 2.5 \bullet 60\,\text{s} = 15\,\text{s} \quad \leftarrow \quad \text{division}$$

Example 4:

Express 36.5 fathoms per minute diving speed of a submarine underwater in $^{m}/_{s}$.

1 fathom (fath) = 6 ft → conversion factor of 6 $^{ft}/_{fath}$
60 s = 1 min → conversion factor of 60 $^{s}/_{min}$
3.28 ft = 1 m → conversion factor of 3.28 $^{ft}/_{m}$

$$36.5\,^{fath}/_{min} = \frac{(36.5\,^{\cancel{fath}}/_{\cancel{min}})(6\,^{ft}/_{\cancel{fath}})}{(60\,^{s}/_{\cancel{min}})(3.28\,^{ft}/_{m})} = 1.11\,^{m}/_{s}$$

Note that the conversion factor can be multiplied $\left(\text{like the } 6\,{}^{\text{ft}}\!/_{\text{fath}}\right)$ or divided $\left(\text{like the } 60\,{}^{\text{s}}\!/_{\text{min}} \text{ or } 3.28\,{}^{\text{ft}}\!/_{\text{m}}\right)$ with the given quantity, depending upon which unit is desired to be eliminated.

LESSON 2: **VECTORS AND SCALARS**

Introduction

This lesson dealt with scalar and vector quantities. The difference between scalar and vector quantities are specified as well as the different mathematical operations involved graphically and analytically.

Learning Outcomes:

After successful completion of this lesson, you should be able to:

☞ Know the difference between vectors and scalar quantities.

☞ Study the different mathematical operations involving vectors in two dimensions.

2.1 Definition of Vectors and Scalars

Scalars are physical quantities with magnitude only, described either with a positive or a negative number. Some examples of scalar quantities are:

- ✓ the number of chairs in a room
- ✓ the distance between two points
- ✓ the temperature of an object
- ✓ the age of a person
- ✓ the speed of a moving object

Vectors are physical quantities with both magnitude and direction. A few examples of vectors are as follows:

- ✓ the position of an object, telling not only how far an object is from a certain reference point, but also where to go, starting from the reference point, in order to find the object.
- ✓ the velocity of a moving object, specifying the speed of the object and the direction the motion is taking place.
- ✓ the force acting on a moving object causing it to move with changing speed or direction..

The normal rules of algebraic addition, subtraction, multiplication and division are used with scalars, while special mathematical rules are needed to manipulate vectors.

Sample Problems with Solutions:

1. A ball is dropped from a height of 200 m. In how may seconds will it drop to the ground and with what velocity will it hit the ground?

Solution:

$$H = v_o t + \tfrac{1}{2} g t^2$$
$$= .0 + \tfrac{1}{2} g t^2$$
$$= \tfrac{1}{2} g t^2$$

$$v_f = v_o + gt$$
$$= 0 + (9.8)(6.4)$$
$$= 62.72 \, {}^{m}/_{s}$$

$$t^2 = \frac{2H}{g}$$
$$t = \sqrt{\frac{2H}{g}}$$
$$= \sqrt{\frac{2 \bullet 200}{9.8}}$$
$$= 6.4s$$

2. At what velocity must a stone be thrown vertically upward to reach a height of 20 m?

Solution:

At H = 20 m, $v_f = 0$

$$v_f^{\,2} = v_o^{\,2} - 2gH$$
$$v_o^{\,2} = v_f^{\,2} - 2gH$$
$$= 0 - 2\left(-9.8 \, {}^{m}/_{s^2}\right)(20m)$$
$$v_o = 19.8 \, {}^{m}/_{s}$$

3. A stone is dropped from the top of a tall cliff, and one second later, a second stone is thrown vertically downward with a velocity of 20 ${}^{m}/_{s}$. How far below the top of the cliff will the second stone overtake the first?