ENGINEERING GATORTRAX MATH EXCELLENCE PROJECT
ENGINEER-FOR-A-DAY LABORATORY MODULES

MECHANICAL ENGINEERING
INTERMEDIATE LEVEL - LECTURE
MIDDLE SCHOOL
VOLUME MEASUREMENTS

1.0 INTRODUCTION

Today we are practicing mechanical engineers. As such, we will examine how some of our basic mathematical concepts are used by mechanical engineers. One such mathematical concept is that of volume. Mechanical engineers utilize volume as they design systems for fluid storage and fluid flow.

1.1 MECHANICAL ENGINEERING

Mechanical engineering is about motion and the creation of structures that are designed to move, through conversion of energy forms. Mechanical engineers conceive, design, manufacture, test, and market devices and systems that alter, transform, and use energy. They build intelligent machines, and robots, create engines that power spacecraft, aircraft, automobiles, ships, and trains, and design pumps, turbines, and power plants that extract useful energy from fuels, atoms, water, sunlight, and various forms of renewable biomass.

2.0 MATHEMATICS REVIEW

2.1 Linear Measurements

Linear measurements define the **distance** along a line. They are commonly expressed as standard or metric units. Standard units of metric measurements are inches, feet, yards, and miles; metric units are centimeters, meters, and kilometers.

Common applications of linear measurements are for measuring the distance around the outer edge of a shape, called the **perimeter**.

For a circle, the distance measured through the center, across the circle is called the **diameter**, and the distance around the outside edge of a circle is called the **circumference**. The mathematical equation for circumference is:

Circumference = 3.14 x diameter

Example 2.1-1

The length of each of the four walls measured along the floor of your classroom is as follows: 20 feet, 30 feet, 20 feet, 30 feet. What is the perimeter of your classroom?

Answer: 20 feet + 30 feet + 20 feet + 30 feet = 100 feet .

Example 2.1-2

What is the circumference of a circle with a diameter of 3 meters?

Answer: Circumference = 3.14 x 3 meters = 9.42 meters

2.2 Area Measurements

These measurements are used to define the size of the **surface** on an object. Commonly used units for area measurements are expressed as 'squared'. They include square inches, square feet, square yards, square miles, with metric measurements being expressed as units are square millimeters, square centimeters, and square meters.

For a rectangle, the surface area A = length x width

For a triangle, the surface area A = $\frac{\text{base x height}}{2}$

For a circle, the surface area is A = 0.7854 x $(\text{diameter})^2$ or 3.14 x $(\text{radius})^2$

Example 2.2-1

A rectangular tank is containing water 10 meters wide and 50 meters long. What is the surface area of the water in the tank?

Answer: Surface area = 10 meters x 50 meters = 500 square meters

3.0 VOLUME MEASUREMENTS

What is volume? It is the measure of the 3-dimensional space occupied by a solid object, or the amount of 3-dimension space which can be occupied by a body. The basis of this measurement is the cube, a square-sided box with all edges of equal length. We can best understand this by looking at some examples. We will learn how to calculate volumes of shapes such as boxes, cylinders, cones and spheres. Also, we will look at common applications of volumetric measurements by engineers.

Example 3.0-1.
If we have a solid cube (sides of equal length) which has sides of length 'a' centimeters, width 'a' centimeters, and height 'a' centimeters.

a) Express the volume of the cube in terms of the given values
b) If 'a' is given a value of 3 feet, what is the volume of the cube?

Answer:
a) Volume, V = length x width x height = a x a x a = a^3 cubic centimeters

b) Volume V = 3 feet x 3 feet x 3 feet = 27 cubic feet
This is the amount of **space** occupied by the solid cube. The units are **cubic** units

Thus we see that three measurements, or dimensions are required to determine the volume of an object, or the available space in a container.

Example 3.0-2.
If we have a hollow cube which has inside measurements on each side of length ‘a’ centimeters, then the volume of the space inside the cube (box) is given by:

$$\text{Volume, } V = a \times a \times a = a^3 \text{ cubic centimeters}$$

This is the amount of **space inside** the box which can be occupied by substances which can be placed inside the box (cube).

Now suppose that we did not have a cube but a rectangular box, how do we determine the volume of the space inside the box?

Example 3.0-3
Consider a rectangular box which has the following dimensions: length ‘a’ centimeters, width ‘b’ centimeters, height ‘c’ centimeters, then the volume of the box is given by

$$\text{Volume, } V = \text{length} \times \text{width} \times \text{height} = a \times b \times c = abc \text{ cubic centimeters}$$

Again, you will notice that all three dimensions are required to calculate the volume of the box.

Now, let us assume that we had a piece of pipe of length ‘L’ and inside diameter D, how do we calculate the volume of our piece of pipe?

Note:
Instructors should present students with other problem-solving opportunities in this subject.