TRIANGLE

A *triangle* is a three-sided figure. The sum of the three angles in a triangle is always equal to 180°. Triangles are often classified by their sides. An *equilateral* triangle has 3 sides of equal length. An *isosceles* triangle has 2 sides of equal length. A *scalene* triangle has three sides of differing length. Triangles can also be classified by their angles: An *acute* triangle has all three angles less than 90°. A *right triangle* has one right angle (*a 90° angle*). An *obtuse* triangle has one angle greater than 90°. Each of these types of triangles is shown in ***Figure 1-18***.
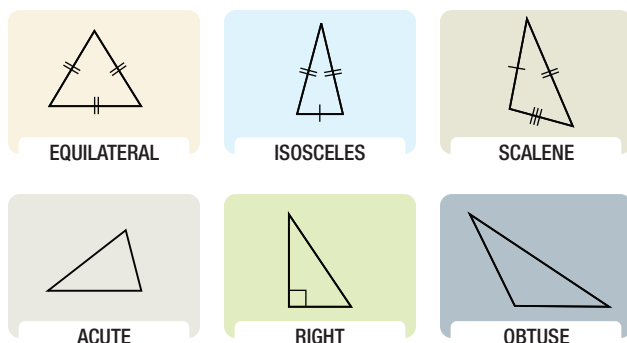

Figure 1-18. Types of triangles.

The formula for the area of a triangle is:

$$Area = ½ × (Base × Height) \quad or \quad A = ½\ BH$$

Example:
Find the area of the right triangle shown in ***Figure 1-19***. First, substitute the known values into the area formula.

$$A = ½\ (B × H) = ½\ (1.2\ m × 750\ cm)$$

Next, convert all dimensions to centimeters (or meters):

$$A = ½\ (1\ 200\ cm × 750\ cm)\ or;$$
$$A = ½\ (1.2\ m × .75\ m)$$
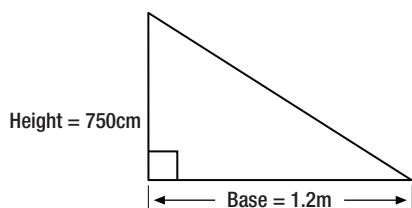
Figure 1-19. An right triangle.

Now, solve the formula for the unknown value:

$$A = ½\ (900\ 000\ cm^2) \quad or \quad A = ½\ (.9\ m^2)$$
$$A = 450\ 000\ cm^2 \qquad A = .45\ m^2$$

PARALLELOGRAM

A *parallelogram* is a four-sided figure with two pairs of parallel sides. (***Figure 1-20***) Parallelograms do not necessarily have four right angles like rectangles. However, the sum of the angles in a parallelogram is 360º. Similar to a rectangle, the formula for the area of a parallelogram is:

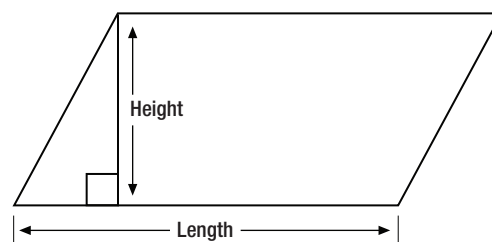$$Area = Length × Height \quad A = LH$$

Figure 1-20. A Parallelogram.

To find the area of a parallelogram, simply substitute values into the formula or multiply the length times the height.

TRAPEZOID

A *trapezoid* is a four-sided figure with one pair of parallel sides known as base$_1$ and base$_2$ and a height which is the perpendicular distance between the bases. (***Figure 1-21***) The sum of the angles in a trapezoid is 360°. The formula for the area of a trapezoid is:

$$Area = ½\ (Base_1 + Base_2) × Height$$

Example:
What is the area of the trapezoid in ***Figure 1-22*** whose bases are 35 centimeters and 25 centimeters, and whose height is 15 centimeters?
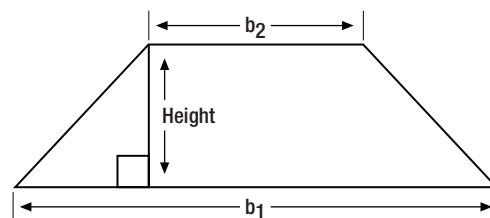

Figure 1-21. A trapezoid has 1 set of parallel sides known as base1 and base2 and a height which is the perpendicular distance between the bases.
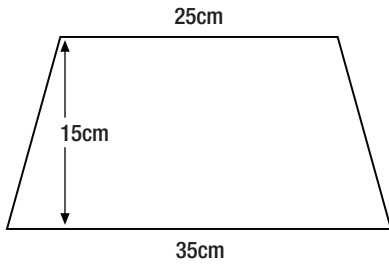
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Figure 1-22. A trapezoid with dimensions.

Substitute the known values into the formula and perform the arithmetic.

$$A = ½ (b_1 + b_2) × H$$
$$A = ½ (35 \text{ cm} + 25 \text{ cm}) × 15 \text{ cm}$$
$$A = ½ (60 \text{ cm}) × 15 \text{ cm}$$
$$A = 450 \text{ cm}^2$$

CIRCLE

A *circle* is a closed, curved, plane figure. (***Figure 1-23***) Every point on the circle is an equal distance from the center of the circle. The *diameter* is the distance across the circle (*through the center*). The *radius* is the distance from the center to the edge of the circle. The diameter is always twice the length of the radius. The *circumference* of a circle, or distance around a circle is equal to the diameter times π (3.141 6).

Written as a formula:

$$Circumference = π × d \quad or \quad C = 2 π × r$$

The formula for finding the area of a circle is:

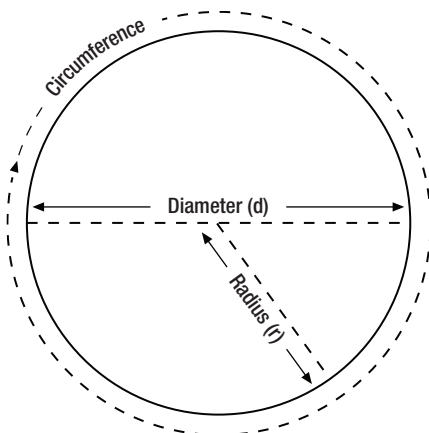$$Area = π × radius^2 \quad or \quad A = π r^2$$

Figure 1-23. A circle.

Example:
The bore, or "inside diameter," of a certain aircraft engine cylinder is 12 centimeters. Find the area of the cross section of the cylinder.

First, substitute the known values into the formula:

$$A = π r^2 = 3.141\ 6 × (^{12}/_2 \text{ cm})^2$$

Note that the diameter is given but since the diameter is always twice the radius, dividing the diameter by 2 gives the dimension of the radius (*6 cm*). Now perform the arithmetic:

$$A = 3.141\ 6 × 36 \text{ cm}^2$$
$$A = 113.097\ 6 \text{ cm}^2$$

Example:
A cockpit instrument gauge has a round face that is 3 inches in diameter. What is the area of the face of the gauge? From ***Figure 1-11*** for N = 3, the answer is 7.068 6 square inches. This is calculated by: If the diameter of the gauge is 3 inches, then the radius = $^d/_2 = ^3/_2 = 1.5$ inches.

$$Area = π × r^2 = 3.141\ 6 × 1.5^2 = 3.141\ 6 × 2.25$$
$$= 7.068\ 6 \text{ square inches.}$$

ELLIPSE

An *ellipse* is a closed, curved, plane figure and is commonly called an *oval*. (***Figure 1-24***)

In a radial engine, the articulating rods connect to the hub by pins, which travel in the pattern of an ellipse (*i.e., an elliptical path*). The formulas for the circumference and area of an ellipse are given in ***Figure 1-24***.

WING AREA

Wing surface area is important to aircraft performance. There are many different shapes of wings. To calculate wing area exactly requires precise dimensions for the clearly defined geometric area of the wing. However, a general formula for many wing shapes that can be described using an average wing "chord" dimension is similar to the area of a rectangle. The wingspan, S, is the length of the wing from wingtip to wingtip.
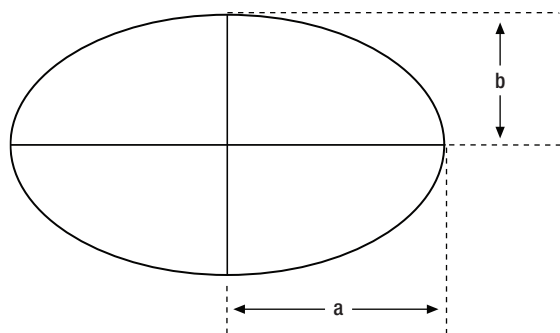
$$\text{Circumference} = C = 2\pi \sqrt{\frac{a^2 + b^2}{2}}$$

π = 3.141 6
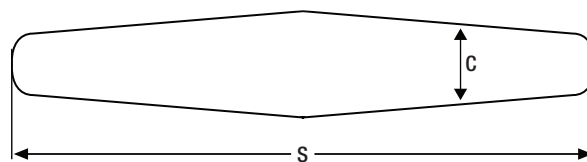a = Length of one of the semi-axis
b = Length of the other semi-axis

Area = A = πab

Figure 1-24. An ellipse with formulas for calculating circumference and area.

The chord (*C*) is the average or mean width of the wing from leading edge to trailing edge as shown in ***Figure 1-25***.

The formula for calculating wing area is:

Area of a Wing = Wing Span × Mean Chord or AW = SC

C = Average Chord
S = Span

Figure 1-25. Area of an aircraft wing.

Example:
Find the area of a tapered wing whose span is 15 meters and whose mean chord is 2 meters. As always, substitute the known values into the formula.

AW = SC
AW = 15 meters x 2 meters
AW = 30 square meters (30 m2)

VOLUME

Three-dimensional objects have length, width, and height. The most common three dimensional objects are *rectangular solids*, cubes, cylinders, spheres, and cones. *Volume* is the amount of space within an object. Volume is expressed in cubic units. Cubic centimeters are typically used for small spaces and cubic meters for larger spaces, however any distance measuring unit can be employed if appropriate. A summary of common three-dimensional geometric shapes and the formulas used to calculate their volumes is shown in ***Figure 1-26***.

RECTANGULAR SOLIDS
A rectangular solid is any three-dimensional solid with six rectangle-shaped sides. (***Figure 1-27***)

The volume is the number of cubic units within the rectangular solid. The formula for the volume of a rectangular solid is:

Volume = Length × Width × Height   or,   V = LWH

OBJECT	VOLUME
Rectangular Solid	LWH
Cube	S³
Cylinder	∏r²H
Sphere	4/3∏r³
Cone	1/3∏r²H

Figure 1-26. Formulas to compute volumes of common geometric three-dimensional objects.
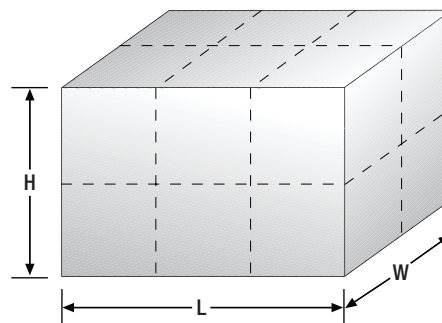
L = 3
W = 2
H = 2

Figure 1-27. A rectangular solid.

Example:
A rectangular baggage compartment measures 2 meters in length, 1.5 meters in width, and 1 meter in height. How many cubic meters of baggage will it hold?

Substitute the known values into the formula and perform the arithmetic.

$$V = LWH$$
$$V = 2\ m \times 1.5\ m \times 1\ m$$
$$V = 3\ m^3 \quad or \quad V = 3\ cubic\ meters$$

CUBE

A *cube* is a solid with six square sides. (*Figure 1-28*) A cube is just a special type of rectangular solid. It has the same formula for volume as does the rectangular solid which is Volume = Length × Width × Height = L × W × H. Because all of the sides of a cube are equal, the volume formula for a cube can also be written as:

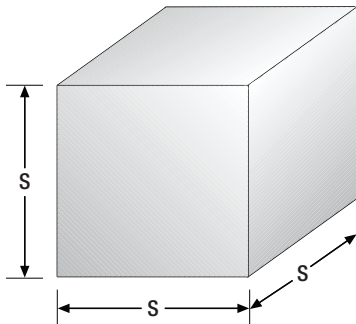$$Volume = Side \times Side \times Side \quad or \quad V = S^3$$

Figure 1-28. A cube.

Example:
A cube-shaped carton contains a shipment of smaller boxes inside of it. Each of the smaller boxes is 10 cm × 10 cm × 10 cm. The measurement of the large carton is 30 cm × 30 cm × 30 cm. How many of the smaller boxes are in the large carton?

Substitute the known values into the formula and perform the arithmetic:

Large Box
V = L × W × H
V = 30 cm × 30 cm × 30 cm
V = 27 000 cubic centimeters of volume in large carton

Small Box
V = L × W × H
V = 10 cm × 10 cm × 10 cm
V = 1 000 cubic centimeters of volume in small cartons.

Therefore, since each of the smaller boxes has a volume of 1 000 cubic centimeters, the large carton will hold 27 boxes (27 000 ÷ 1 000).

Substitute the known values into the formula and perform the arithmetic:

Large Box
V = S³
V = 30 cm × 30 cm × 30 cm
V = 27 000 cubic centimeters of volume in large carton.

Small Box
V = S³
V = 10 cm × 10 cm × 10 cm
V = 1 000 cubic centimeters of volume in small cartons.

Therefore:, since each of the smaller boxes has a volume of 1 000 cubic centimeters, the large carton will hold 27 boxes (27 000 ÷ 1 000).

CYLINDER

A *cylinder* is a hollow or solid object with parallel sides the ends of which are identical circles. (*Figure 1-29*)

The formula for the volume of a cylinder is:

$$Volume = \pi \times radius^2 \times height\ of\ the\ cylinder$$
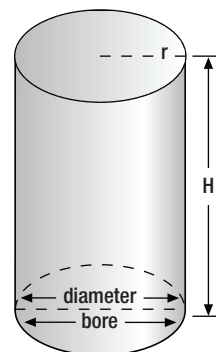$$or,\ V = \pi\ r^2 H$$

Figure 1-29. A cylinder.

One of the most important applications of the volume of a cylinder is finding the *piston displacement* of a cylinder in a reciprocating engine. Piston displacement is the total volume (in cubic inches, cubic centimeters, or liters) swept by all of the pistons of a reciprocating engine as they move during one revolution of the crankshaft. The formula for piston displacement is given as:

Piston Displacement =
π × (bore divided by 2)² × stroke × (# cylinders)

The bore of an engine is the inside diameter of the cylinder. The stroke of an engine is the length the piston travels inside the cylinder. (*Figure 1-30*)
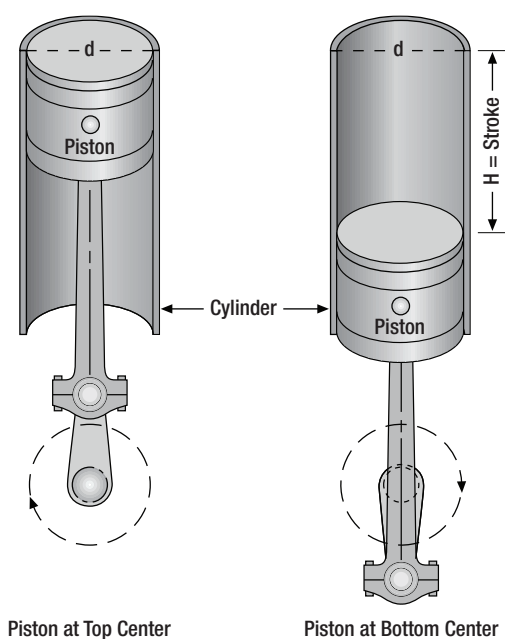

Figure 1-30. Piston displacement in an engine cylinder.

Example:
Find the piston displacement of one cylinder in a multi-cylinder aircraft engine. The engine has a cylinder bore of 13.97 centimeters and a stroke of 13.716 centimeters. First, substitute the known values in to the cylinder formula.

$$V = \pi r^2 h = (3.141\ 6) \times (13.97\ cm \div 2)^2 \times (13.716\ cm)$$
$$V = (3.141\ 6) \times (6.985\ cm)^2 \times 13.716\ cm$$
$$= 2\ 102.379\ 8\ cm^3$$

Piston displacement of one cylinder is 2 102.379 8 cubic centimeters.

For a 6-cylinder engine, then the total engine displacement would be:

Total Displacement for 6 cylinders =
6 × 2 102.379 8 cm³ = 12 614.278 8
cubic centimeters of displacement.

SPHERE
A solid having the shape of a ball is called a *sphere*. (*Figure 1-31*) A sphere has a constant diameter. The radius (*r*) of a sphere is one-half of the diameter (*D*). The formula for the volume of a sphere is:

$$Volume = \frac{4}{3} \times \pi \times radius^3 \quad or \quad V = \frac{4}{3} \times \pi r^3$$

Example:
A pressure tank inside the fuselage of a cargo aircraft is in the shape of a sphere with a diameter of 80 centimeters. What is the volume of the pressure tank?

$$V = \frac{4}{3} \pi r^3 = \frac{4}{3} \times (3.141\ 6) \times \left(\frac{80}{2} cm\right)^3$$
$$= 1.33 \times 3.141\ 6 \times (40 cm)^3$$
$$= 1.33 \times 3.141\ 6 \times 64\ 000 cm^3$$
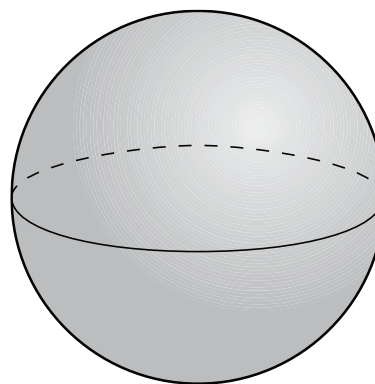$$V = 267\ 412.99\ cubic\ centimeters$$

Figure 1-31. A sphere.

CONE
A solid or hollow object with a circle as a base and with sides that gradually taper to a point is called a *cone*. (*Figure 1-32*)

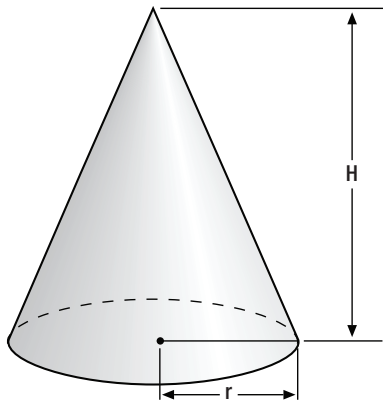The formula for the volume of a cone is:

$$V = \frac{1}{3} \pi r^2 H$$

To find the volume of a cone, determine the radius and height, substitute the values into the formula and perform the arithmetic. *(Figure 1-26)*

Figure 1-32. A cone.

WEIGHTS AND MEASURES

In nearly every country, a system of weights and measures is in place. Often, it has been handed down from generation to generation derived from localized customs of how various items are measured by society. In 1870, international standardization was born. A meeting of 15 countries in Paris ultimately led to the establishment of a permanent International Bureau of Weights and Measures in 1875. A General Conference on Weights and Measures was constituted to handle all international matters concerning the metric system. The first meeting was in 1889 at which the kilogram and the meter were legalized as the international units of weight and length. Over the years, an increasingly larger group of countries have met periodically at this conference to ensure worldwide uniformity in units of measurement. In 1960, the current name, International System of Units (SI) was adopted. New units of measurement have been agreed upon and refinements made at periodic meeting since that time.

The International Organization for Standardization (ISO) is a worldwide federation of national standards institutes from numerous countries. It provides recommendations for the use of SI and certain other units. The ISO publishes documents that provide extensive detail on the application of SI units. ICAO, the International Civil Aviation Organization, maintains liaison with the ISO regarding the standardized application of SI units in aviation. ICAO publishes ANNEX 5 - Units of Measurement to be Used in Air and Ground Operations to guide aviation organizations and individuals in the use of SI, the standardized system of weights and measures in aviation.

Effort was made in the assembly of this series to incorporate SI standards and practices as guided by ICAO. There are some exceptions. Should the reader encounter non-SI units of weights and measurements, it is owing to the continued widespread use of certain non-SI units in aviation or the learning value of presenting examples in non-SI units.

For most people, there are two basic systems of weights and measure: the Imperial System and the SI/Metric System. The Imperial System is rooted in Great Britain and is the dominant system of weights and measure in the United States of America. It uses widely familiar units that for years have dominated aviation such as feet for distance and pounds for weight. The other system is the metric system which has a strong foothold in Europe and other regions around the world. It uses meters and kilometers for distance measuring units and kilograms for weight units. The metric system is formalized in SI (the International System of Units) which is the official system of weights and measure of ICAO, the International Civil Aviation Organization.

As a major aviation force and dominant manufacturer of civil aircraft, the United States continues to use the Imperial System with gradual integration of SI over recent decades. Aviators in most countries around the world are familiar with some units from the Imperial System and SI with a tendency towards common use of one or the other. It is important to be able to convert values from one system to another to ensure the accurate incorporation of critical data for aviation operations. In the reference pages at the end of this module, several tables exist. Some define the units of measurement standards incorporated in ANNEX 5 for world aviation standardization. Other tables provide conversion between the Imperial System and SI. Many conversion factors are also listed. These are numerical values that can be used to multiply or divide a value in one system to give the value in the other system. A sample of a few conversion values are listed in *Figure 1–33*.

COMMON CONVERSIONS

IMPERIAL SYSTEM		SI (METRIC)	SI (METRIC)		IMPERIAL SYSTEM
Distance			*Distance*		
1 Inch	is equal to	2.54 Centimeters	1 Centimeter	is equal to	0.394 Inches
1 Foot	is equal to	0.304 8 Meters	1 Meter	is equal to	3.28 Feet
1 (Statute) Mile	is equal to	1.609 3 Kilometers	1 Kilometer	is equal to	0.621 Miles
Weight			*Weight*		
1 Pound	is equal to	0.453 59 Kilograms	1 Kilogram	is equal to	2.204 Pounds
Volume			*Volume*		
1 Quart	is equal to	0.946 35 Liters	1 Liter	is equal to	1.057 Quarts
1 Gallon	is equal to	3.785 4 Liters	1 Lites	is equal to	0.264 Gallons
Temperature			*Temperature*		
0 Fahrenheit	is equal to	(-)17.778 Celsius	0 Celsius	is equal to	33.8 Fahrenheit
0 Fahrenheit	is equal to	255.37 Kelvin	0 Kelvin	is equal to	(-)437.87 Fahrenheit
Area			*Area*		
1 Square Inch	is equal to	6.451 6 Square Centimeters	1 Square Centimeter	is equal to	0.155 Square Inches
1 Square Foot	is equal to	0.092 903 Square Meters	1 Square Meter	is equal to	10.763 91 Square Feet
1 Square Mile	is equal to	2.59 Square Kilometers	1 Square Kilometer	is equal to	0.386 Square Miles
Speed			*Speed*		
1 Foot Per Second	is equal to	0.304 8 Meters Per Second	1 Meters Per Second	is equal to	3.281 Feet Per Second
1 Mile Per Hour	is equal to	1.609 3 Kilometers Per Hour	1 Kilometer Per Hour	is equal to	0.621 Miles Per Hour
1 Knot	is equal to	1.852 Kilometers Per Hour	1 Kilometer Per Hour	is equal to	0.540 Knots

Figure 1-33. Common conversions chart.

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