MODULE 01

FOR B1 & B2 CERTIFICATION

MATHEMATICS

Aviation Maintenance Technician Certification Series

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Author	Collete Clarke
Contributor	Viktoras Bolotinas
Layout/Design	Michael Amrine

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REVISION LOG

VERSION	EFFECTIVE DATE	DESCRIPTION OF CHANGE
001	2016 01	Module Creation and Release
002	2017 05	Format Update and Minor Corrections
002.1	2019 07	Added "Solving Word Problems" to end of Sub-Module 02.
002.2	2020 10	Style and Layout updates.

MATHEMATICS

SUB-MODULE 01

ARITHMETIC

SUB-MODULE 02
ALGEBRA

SUB-MODULE 03
GEOMETRY

MULTIPLICATION OF DENOMINATED NUMBERS

When multiplying denominated numbers by non-denominated numbers, multiply differently denominated numbers separately, then, examine the products for any combining that might simplify the expression of the values.

Example:
3 × (5 yards, 2 feet, 6 inches)

$$\begin{array}{r} 5\text{ yd. } 2\text{ ft. } 6\text{ in.} \\ \times \qquad\qquad 3 \\ \hline 15\text{ yd. } 6\text{ ft. } 18\text{ in.} \end{array} = 17\text{ yd. } 1\text{ ft. } 6\text{ in.}$$

Simplifying: 18 inches = 1 feet 6 inches. Thus, the product can be re-written by combining feet: 15 yards, 7 feet, 6 inches. However, simplifying further, 7 feet = 2 yards + 1 foot.

Combining numbers denominated in feet and yards into yards, the product can now be written 17 yards, 1 foot, 6 inches.

When one denominated number is multiplied by another, a question arises concerning the products of the units of measurement. The product of one unit times another of the same kind is one square unit. For example, 1 meter × 1 meter = 1 square meter (*abbreviated 1 m^2*). If it becomes necessary to multiply such numbers as 2 yards, 2 feet × 6 yards, 2 feet, the foot units may be converted to fractions of a yard or yards may be converted to feet so that the entire multiplication problem takes place using a single denomination.

Example:
Multiply 4 *yd.* 2 *ft.* × 3 *yd.* 2 *ft.*

The foot units may be converted to fractions of a yard, as follows:

$$(4\text{ yd. } 2\text{ ft.}) \times (3\text{ yd. } 2\text{ ft.}) = 4\tfrac{2}{3}\text{yd.} \times 3\tfrac{2}{3}\text{yd.} =$$
$$\tfrac{154}{9} = \text{sq. yd.} = 17\tfrac{1}{9}\text{sq. yd.}$$

Alternately, the values presented in yards could be converted to feet before the arithmetic is performed for an answer that results in square feet:

$$(4\text{ yd. } 2\text{ ft.}) \times (3\text{ yd. } 2\text{ ft.}) = 14\text{ ft.} \times 11\text{ ft.}$$
$$= 154\text{ sq. ft.}$$

DIVISION OF DENOMINATED NUMBERS

Division of denominated numbers is accomplished easily by converting all denominated numbers into the same units of denomination and performing the arithmetic. If division is by a non-denominated number, the denomination of the quotient will be the same as the units into which the divisor and dividend were converted before the division took place.

Example:

4 liters, 400 milliliters / 2 = 4 liters + .4 liters / 2
= 4.4 liters / 2 = 2.2 liters

Division of a denominated number by a denominated number is usually performed in square units divided by a value denominated in the same units.

Example:

$$20\text{ m}^2 / 2\text{ m} = 10\text{ m.}$$

AREA AND VOLUME

Area is a measurement of the amount of surface of an object. Also, the space inside the borders of a geometric construction is the area of that figure. Area is expressed in square units. For small objects, square centimeters is a common denomination. Larger objects may use square meters or square kilometers.

Mensuration is the measuring of geometric magnitudes, lengths, areas and volumes. Specific formulas are used to calculate the areas of various geometric shapes. In the following paragraphs, common geometric shapes are defined and the formula for calculating the area of each are given. A summary of shapes and area formulas is shown in ***Figure 1-15***.

RECTANGLE

A *rectangle* is a 4-sided figure with opposite sides that are equal in length and parallel to each other. All of the angles of a rectangle are right angles and the sum of all of the angles is 360°. (A right angle is a 90° angle.) The rectangle is a very familiar shape in aircraft sheet metal fabrication. (***Figure 1-16***)

OBJECT	AREA	FORMULA
Rectangle	Length × Width	A = LW
Square	Length × Width	A = LW
	Side × Side	$A = S^2$
Triangle	½ × (Base × Height)	A = ½ BH
Parallelogram	Length × Height	A = LH
Trapezoid	½ × ($base_1$ + $base_2$) × Height	$A = ½ (b_1 + b_2)H$
Circle	π × $radius^2$	$A = \pi r^2$
Ellipse	π × semi-axis a × semi-axis b	A = πab

Figure 1-15. Formulas to compute areas of common geometric constructions.

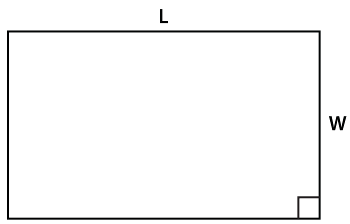


Figure 1-16. A rectangle.

The formula for the area of a rectangle is:

Area = Length × Width or A = L × W

To calculate the area of a rectangle, determine the length and width and multiply them together.

Example:
A rectangular aircraft floor panel has a length of 24 centimeters and a width of 12 centimeters. What is the area of the floor panel expressed in square centimeters?

$A = L \times W, \quad A = 24\ cm \times 12\ cm, \quad A = 288\ cm^2$

SQUARE

A *square* is a 4-sided figure with all four sides of equal length and opposite sides that are parallel to each other. (***Figure 1-17***) All the angles contained in a square are right angles and the sum of all of the angles is 360°. A square is actually a rectangle with 4 equal sides. Therefore the area of a square is the same as that of a rectangle: Area = Length × Width or, A = L × W. However, since the sides of a square are always the same value (*S*), the formula for the area of a square can also be written as follows:

$Area = Side \times Side \quad or \quad A = S^2$

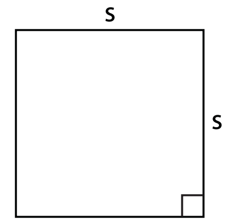


Figure 1-17. A square.

To calculate the area of a square, determine the length of a side and perform the arithmetic in the formula.

Example:
What is the area of a square access plate whose side measures 25 centimeters?

$A = S^2, \quad A = 25\ cm \times 25\ cm, \quad A = 625\ cm^2$

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***.

The formula for the area of a triangle is:

Area = ½ × (Base × Height) or 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.

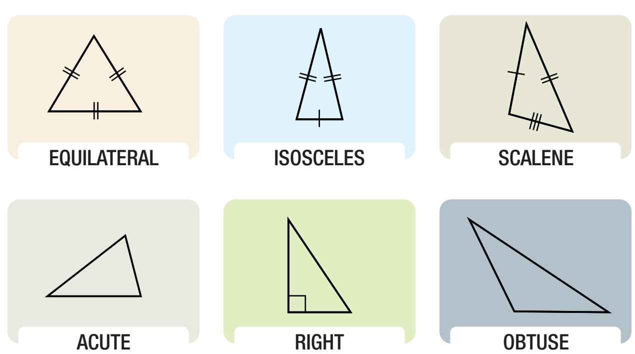


Figure 1-18. Types of triangles.

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

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

$$A = ½\,(1\,200\ cm \times 750\ cm)\ \ or;$$
$$A = ½\,(1.2\ m \times .75\ m)$$

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 360°. Similar to a rectangle, the formula for the area of a parallelogram is:

$$Area = Length \times Height \qquad A = LH$$

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:

$$Area = ½\,(Base_1 + Base_2) \times Height$$

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

$$A = ½\,(b_1 + b_2) \times H$$
$$A = ½\,(35\ cm + 25\ cm) \times 15\ cm$$
$$A = ½\,(60\ cm) \times 15\ cm$$
$$A = 450\ cm^2$$

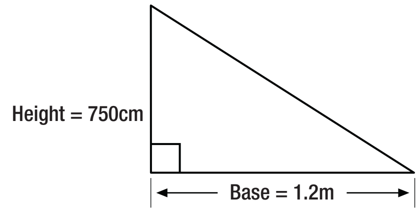


Figure 1-19. An right triangle.

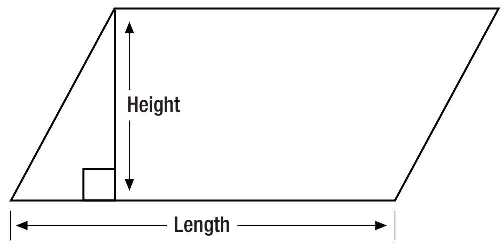


Figure 1-20. A Parallelogram.

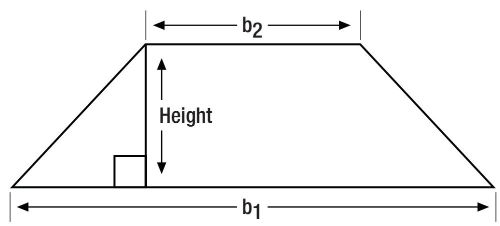


Figure 1-21. A trapezoid has 1 set of parallel sides known as base1 and base2 and a height which is the perpendicular distance between the bases.

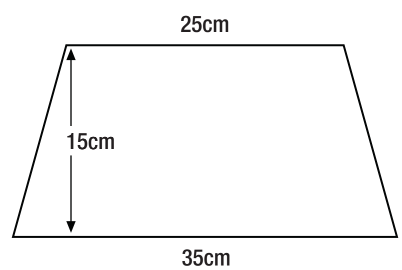


Figure 1-22. A trapezoid with dimensions.

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:

$$Circumference = \pi \times d \quad or \quad C = 2\,\pi \times r$$

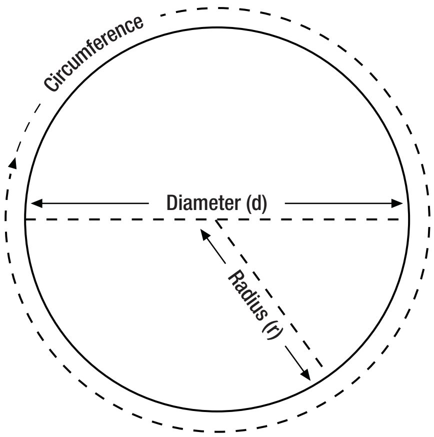


Figure 1-23. A circle.

The formula for finding the area of a circle is:

$$Area = \pi \times radius^2 \quad or \quad A = \pi r^2$$

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:

$$A = \pi r^2 = 3.141\ 6 \times (12/2\ cm)^2$$

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:

$$A = 3.141\ 6 \times 36\ cm^2$$
$$A = 113.097\ 6\ cm^2$$

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.

$$Area = \pi \times r^2 = 3.141\ 6 \times 1.5^2 = 3.141\ 6 \times 2.25$$
$$= 7.068\ 6\ square\ inches.$$

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***.

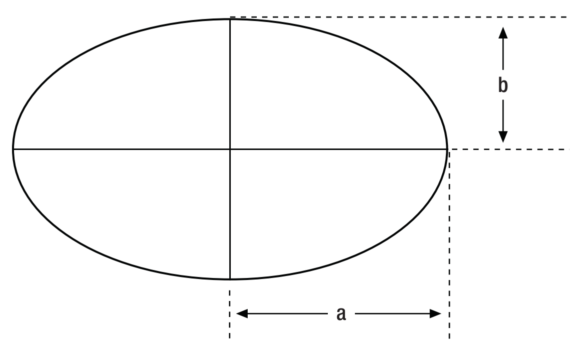
WING AREA

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.

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:

$$Area\ of\ a\ Wing = Wing\ Span \times Mean\ Chord \quad or \quad AW = SC$$

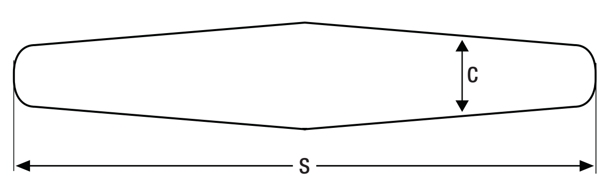


$$Circumference = C = 2\pi\sqrt{\frac{a^2 + b^2}{2}}$$

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

Area = $A = \pi ab$

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



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.

$AW = SC$
$AW = 15 \text{ meters} \times 2 \text{ meters}$
$AW = 30 \text{ square meters } (30 \text{ m2})$

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:

$$Volume = Length \times Width \times Height \quad or, \quad V = LWH$$

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.

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

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:

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

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?

OBJECT	VOLUME
Rectangular Solid	LWH
Cube	S^3
Cylinder	$\pi r^2 H$
Sphere	$4/3 \pi r^3$
Cone	$1/3 \pi r^2 H$

Figure 1-26. Formulas to compute volumes of common geometric three-dimensional objects.

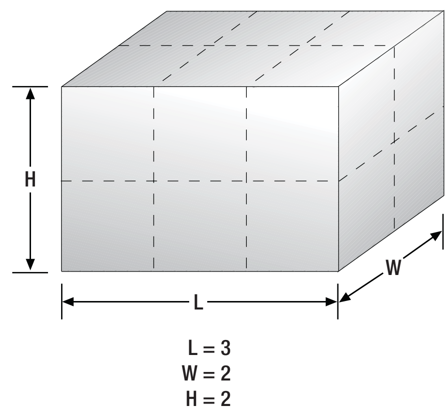


Figure 1-27. A rectangular solid.

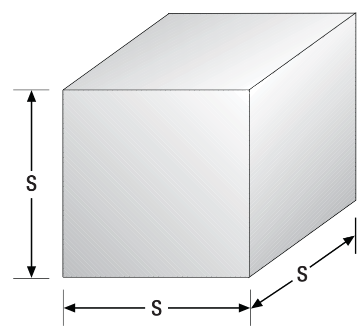


Figure 1-28. A cube.

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

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

Small Box
$V = L \times W \times H$
$V = 10\ cm \times 10\ cm \times 10\ cm$
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
$V = S^3$
$V = 30\ cm \times 30\ cm \times 30\ cm$
V = 27 000 cubic centimeters of volume in large carton.

Small Box
$V = S^3$
$V = 10\ cm \times 10\ cm \times 10\ cm$
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***)

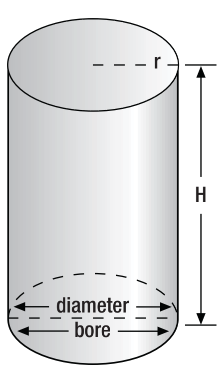


Figure 1-29. A cylinder.

The formula for the volume of a cylinder is:

Volume = $\pi \times$ *radius2* $\times$ *height of the cylinder*
or, $V = \pi\ r2H$

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 =
$\pi \times$ *(bore divided by 2)*$^2 \times$ *stroke* $\times$ *(# 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***)

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.

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

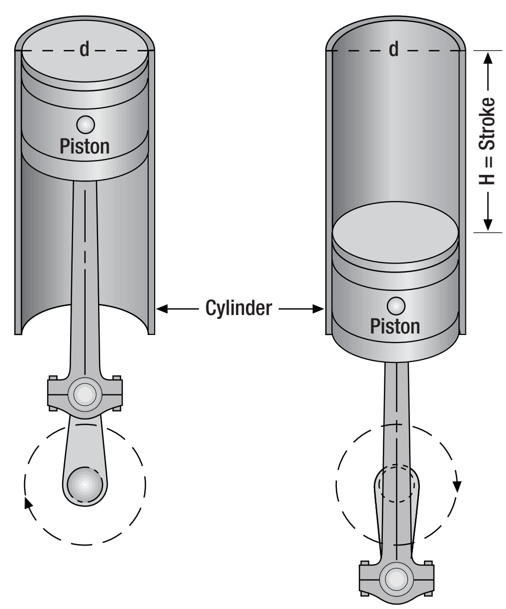


Figure 1-30. Piston displacement in an engine cylinder.