Take Flight

toward a career in aviation and aerospace

Essential Skills Volume 3 - Numeracy

FOR USE WITH THE AVIATION AND AEROSPACE ORIENTATION PROGRAM

Acknowledgements

The Canadian Council for Aviation & Aerospace (CCAA) wishes to express appreciation for the contribution of the many individuals who directly or indirectly contributed to this publication.

CCAA with assistance of Canadore College of Applied Arts and Technology developed this Aviation and Aerospace Orientation Program Essential Skills Workbook. Special thanks go to Deidre Bannerman, Project Leader in the Learning Innovation and Development department at Canadore for coordinating the project; Debbie Bridge and Wendy Hillis for proofing and editing; Debbie Porter Norman, Graphic Designer, for creating the covers and layout; and content experts, Don Dell, Michel Chenier and Karen Wickett for providing the workbook content, which was invaluable to the success of this endeavour.

We would like to thank those individuals who participated in the collaborative survey/interview process. These participants came from colleges with CCAA-accredited courses (Canadore College, Centennial College, Red River College – Stevenson Aviation and Aerospace Training Centre, Southern Alberta Institute of Technology); Aviation and Aerospace Orientation Program secondary schools (Bradford District High School, Steveston-London Secondary School, Georges Vanier Secondary School, Holy Cross Catholic Academy, John Paul II Catholic Secondary School, R.D. Parker Collegiate, Technical Vocational High School and West Ferris Secondary School); and industry (Aveos). Their input was used by the developers to prepare the content and address the Essential Skills in most need of attention.

Special acknowledgement is extended to the CCAA Youth Initiatives Advisory Committee members who provided essential feedback in the review of the draft materials.

Finally, we would like to express our gratitude to the industry companies/organizations who contributed to this workbook and the Authentic Workplace Materials by granting us permission to reproduce their documentation. Thank you to: Air Canada, Algonquin Flight Centre, Bell Helicopter, Federal Aviation Administration, Flight Safety Foundation, Gateway Helicopters Ltd., Helicopters Canada, International Air Transport Association, Recochem, SkillPlan, Transport Canada, and VIH Helicopters Ltd.

This project is funded by the Government of Canada’s Sector Council Program.

Using the Aviation and Aerospace Orientation Program Essential Skills Workbook

The Aviation and Aerospace Orientation Program Essential Skill workbook is not intended for use as a self-directed independent learning tool. It has been designed to augment the Aviation and Aerospace Orientation Program curriculum and support the learner in attaining Essential Skills that are paramount for success in the workforce. The activities serve to strengthen foundational skills and reinforce basic concepts.

There may be activities in the workbook that require students to solve mathematical calculations or respond with a long passage. While there is space allotted for the activities within the workbook, it may be necessary for the student to work on a separate page/notebook.

Where applicable the workbook is accompanied by an Answer Guide containing sample answers/responses. These Answer Guides also cross-reference the workbook topics to the Aviation and Aerospace Orientation Program curriculum.

Table of Contents

Section One: Numerical Estimation

Numerical Estimation

In aviation, number calculations and estimation have real life and death consequences. Being able to quickly estimate the answer to a mathematical situation is critical. Do I put 100 gallons of fuel into this aircraft or 1,000? One decimal place can make a big difference.

Example: If an aircraft is rated to hold 8 passengers, round up to 10 passengers as an easy multiplier.

A pilot must first ensure his plane has enough fuel to complete any planned trip. (Canadian Aviation Regulations (CARs) states fuel for the trip + fuel for an extra 30 minutes). To calculate the amount of fuel required, the time, speed and distance of the trip must be known. The fuel consumption of the aircraft is found in the Aircraft Operating Manual (AOM) and it is expressed in gallons (gal) or pounds (lb) of fuel consumed per hour; i.e., 7gph or 45lb/hour.

Note: 1 imperial gallon of aviation gasoline = 7.2 pounds

Each aircraft is rated for a maximum (or gross) takeoff weight that can never be exceeded. When estimating the useful weight of an aircraft for a trip, a pilot must first give priority to the weight of the fuel. Then, the weight of the pilot and co-pilot must be taken into account and lastly the weight of the passengers and cargo.

Activity 1-1 – Estimating Fuel Quantities

1. Estimate the following quantities of aviation gasoline:

a.	7 gal	=	______ lb	f.	______ gal	=	217 lb
b.	______ gal	=	14 lb	g.	46 gal	=	______ lb
c.	9 gal	=	______ lb	h.	______ gal	=	57 lb
d.	92 gal	=	______ lb	i.	103 gal	=	______ lb
e.	______ gal	=	68.2 lb	j.	______ gal	=	366.8 lb

Regulations state that when estimating weight of people the following weight factors must be used: women = 135 pounds
men = 182 pounds

2. Estimate the weight of the following quantities of people:

a. 2 men = ______________________

b. 3 women = ______________________

c. 1 man and 1 woman = ______________________

d. 3 men and 2 women = ______________________

e. 4 women and 1 man = ______________________

3. Using the formula time = distance/speed, estimate the time required for the noted distances and speeds.

a. Aircraft travels 400 statute miles at 180 miles per hour (mph).
Elapsed time = ________

b. Aircraft travels 150 nautical miles at 142 knots.
Elapsed time = ________

c. Aircraft travels 211 nautical miles at 158 knots.
Elapsed time = ________

Activity 1-2 – Estimating Fuel for Aircraft and Trip

1. Estimate the quantities of aviation gasoline required for the noted aircraft and trips.

a. An aircraft is rated at 22 gph and the trip is estimated to take 3.8 hours.

Required fuel: ____________________

b. An aircraft is rated at 309 pounds/hour and the trip is estimated to take 2 hours and 6 minutes.

Required fuel: ____________________

2. Solve the following situation, given that the useful load of an aircraft is as follows:

Useful load = weight of fuel + weight of pilots + weight of passengers + weight of cargo

ABC Airways has been chartered for a pilot to fly in a group of 4 male moose hunters with 287 pounds of gear to a remote outpost camp 105 miles from base camp. The aircraft has a fuel capacity of 120 gallons, a fuel consumption of 25 lb/hour, a cruising speed of 143 mph and its useful load is 2530 lbs. If the hunters are successful, will they be allowed to bring back their harvest? Will the plane be required to refuel? Assume 750 lbs for the dressed moose and the cargo bay volume is adequate.

____

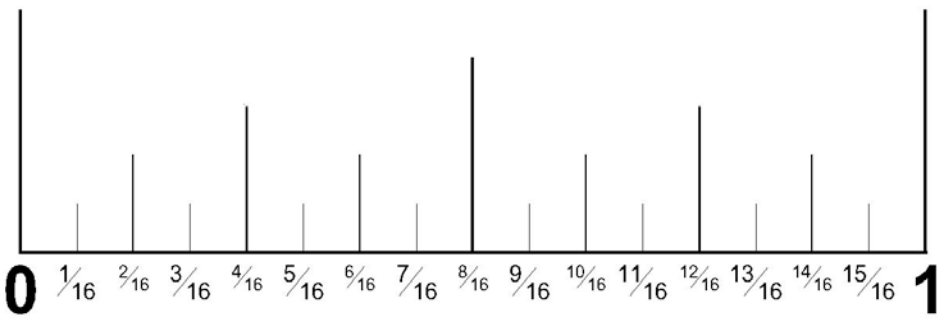
Section Two: Numerical Calculation

Measurement and Calculation Math

Imperial Measurement

A technician is required to make accurate fractional measurements constantly. Therefore we will begin with using the 6 inch (6″) rule.

When an inch is divided into 16 (equal) parts, it is said to be divided into 16^{th} of an inch.



$^{1}/_{16}$, $^{2}/_{16}$, $^{3}/_{16}$ …….

These divisions or *fractions* must be expressed in their lowest terms. Consider the following:

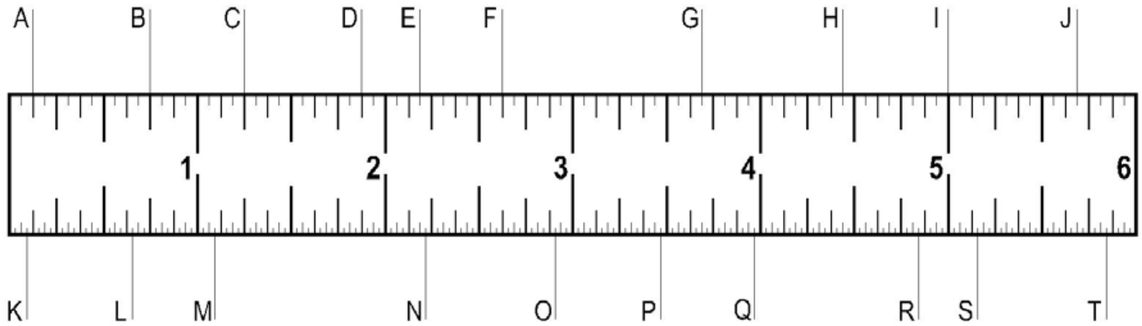
$^{2}/_{16}'' = {}^{1}/_{8}''$
$^{4}/_{16''} = {}^{2}/_{8}'' = ¼''$
$^{6}/_{16}'' = {}^{3}/_{8}''$
$^{8}/_{16}'' = {}^{4}/_{8}'' = ½''$

$^{10}/_{16''} = {}^{5}/_{8}''$
$^{12}/_{16}'' = {}^{6}/_{8}'' = ¾''$
$^{14}/_{16}'' = {}^{7}/_{8}''$
$^{16}/_{16}'' = 1''$

Activity 2-1 – Reading a Ruler

1. Read the indicated measurements on the 6″ rule below and reduce to lowest terms.

Figure 2-1 – Six Inch Rule



A.	____________	K.	____________
B.	____________	L.	____________
C.	____________	M.	____________
D.	____________	N.	____________
E.	____________	O.	____________
F.	____________	P.	____________
G.	____________	Q.	____________
H.	____________	R.	____________
I.	____________	S.	____________
J.	____________	T.	____________

2. Indicate the following measurements on the 6" rule below.

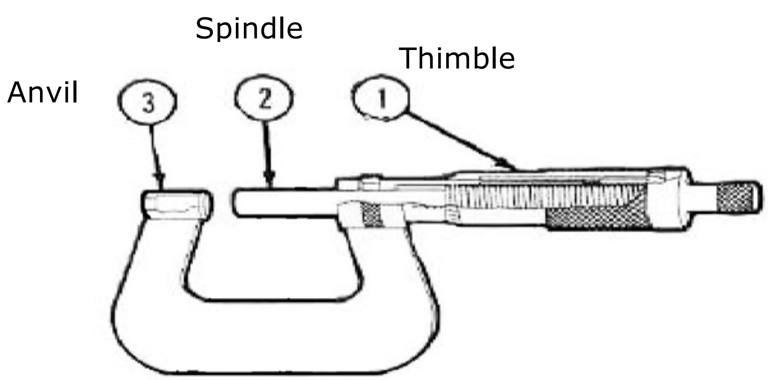
a.	1 ¼	f.	$^{5}/_{32}$
b.	4 $^{2}/_{16}$	g.	$^{8}/_{32}$
c.	4 $^{5}/_{8}$	h.	3 $^{7}/_{16}$
d.	5 $^{1}/_{16}$	i.	3 $^{18}/_{32}$
e.	4 $^{18}/_{16}$	j.	$^{29}/_{32}$

Figure 2-2 – Six Inch Rule

Reading the Standard Micrometer

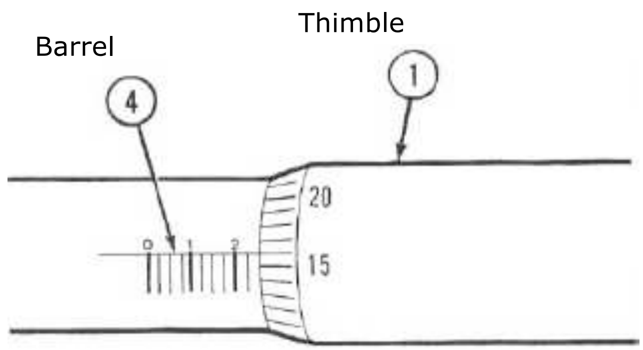
In some instances a small item may require a more precise instrument or tool for taking measurements. A standard micrometer is used by technicians for measurement precision and accuracy.

Figure 2-3 - Micrometer



Reading a micrometer involves counting the revolutions of the thimble and adding to this any fraction of a revolution. The micrometer thimble has 40 threads per inch. This means that one exact revolution of the micrometer thimble (1) moves the spindle (2) away from or toward the anvil (3) exactly $^{1}/_{40}$ or 0.025 inch.

Figure 2-4 – Enlarged Micrometer

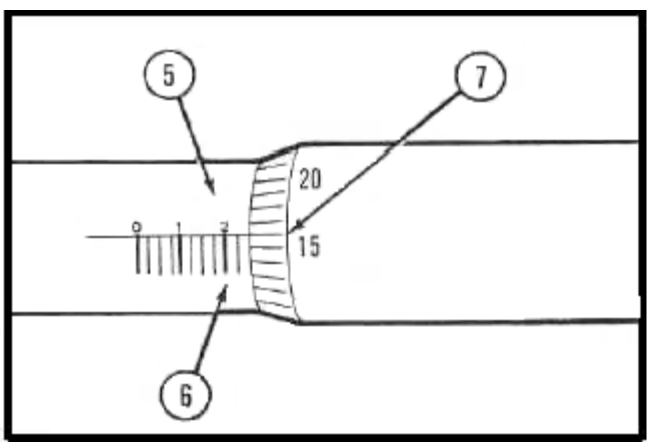


The lines on the barrel (4) conform to the pitch of the micrometer thimble (1), with each line indicating 0.025 inch. Each fourth line is numbered 1, 2, 3, and so forth. The bevelled edge of the thimble is graduated into 25 parts, with each line indicating 0.001 inch, or 0.025 inch covered by one complete and exact revolution of the thimble. Every fifth line on the thimble is numbered to read a measurement in thousandths ($^{1}/_{1000}$) of an inch.

Directions for Reading a Measurement:

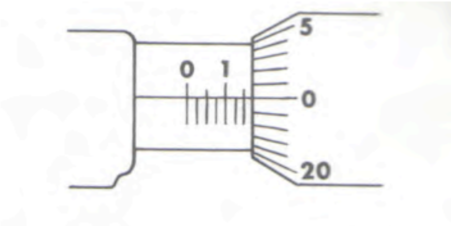
Read highest figure visible on barrel (5)……………………………….	=	0.200 in.
Number of lines visible between 2 and thimble edge (6)......	=	0.025 in.
The line on the thimble that coincides with or has passed the revolution or long line in the barrel (7)……………………………	=	0.016 in.
TOTAL	=	0.241 in.

Figure 2-5 – Reading a Micrometer

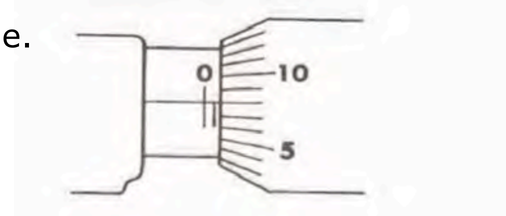


3. Read the following measurements:

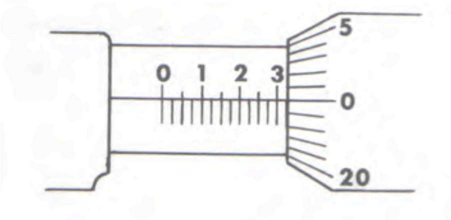
a.



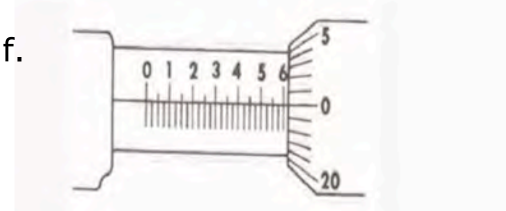
e.



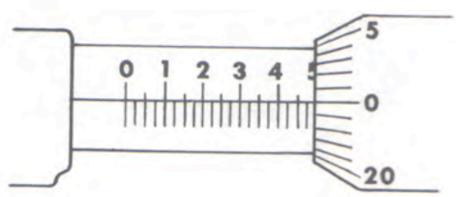
b.



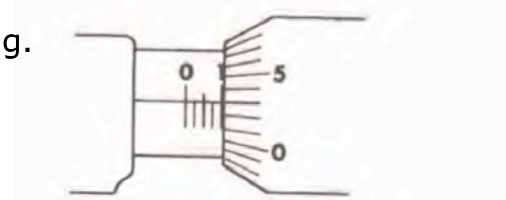
f.



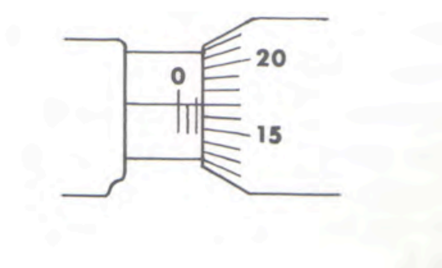
c.



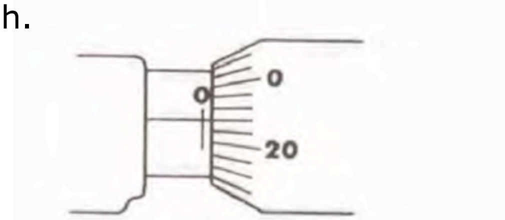
g.



d.



h.



a. ____________ e. ____________

b. ____________ f. ____________

c. ____________ g. ____________

d. ____________ h. ____________

Decimal and Fractional Conversions

As a technician, you must be able to convert fractions to decimals with ease. Determining drill bit sizes for riveting is one application that requires this skill.

Example:

The mathematical procedure to change fractions to decimals is to divide the top number (numerator) by the bottom number (denominator).
¼ = 1 ÷ 4 = 0.25

To change decimals into fractions, drop the decimal point and write the given number as the numerator (number on top). Express the denominator (bottom number) as a power of ten (10, 100, 1000, etc.), using as many zeros as there are decimal places in the decimal number.

$0.25 = {}^{25}/_{100} = ¼$
$0.035 = {}^{35}/_{1000} = {}^{7}/_{200}$
$8.6 = {}^{86}/_{10} = 8\ {}^{3}/_{5}$
Hint: Always reduce to lowest terms

Activity 2-2 – Working With Fractions and Decimals

1. Express the following fractions as decimal fractions.

a.	½	=	________	f.	$^{7}/_{8}$	=	________
b.	¼	=	________	g.	$^{3}/_{64}$	=	________
c.	$^{9}/_{16}$	=	________	h.	$^{43}/_{64}$	=	________
d.	$^{29}/_{32}$	=	________	i.	$^{33}/_{564}$	=	________
e.	$^{5}/_{32}$	=	________	j.	$^{23}/_{128}$	=	________

2. Express the following decimal fractions as fractions.

a.	0.5	=	________	f.	0.53125	=	________
b.	0.35	=	________	g.	0.546875	=	________
c.	0.75	=	________	h.	0.25	=	________
d.	0.78125	=	________	i.	0.95	=	________
e.	0.6875	=	________	j.	0.125	=	________

3. **Match** each decimal fraction to the appropriate fraction.

a.	$5\ ^{7}/_{100}$	____________	A.	5.007
b.	$20\ ^{19}/_{10000}$	____________	B.	12.43
c.	$5\ ^{7}/_{100000}$	____________	C.	5.07
d.	$12\ ^{43}/_{1000}$	____________	D.	20.019
e.	$5\ ^{7}/_{1000}$	____________	E.	5.0007
f.	$20\ ^{19}/_{1000}$	____________	F.	12.043
g.	$12\ ^{43}/_{10000}$	____________	G.	5.00007
h.	$12\ ^{43}/_{100}$	____________	H.	20.0019
i.	$5\ ^{7}/_{10000}$	____________	I.	12.0043

Metric and Imperial Conversions

Standard aviation regulations require that the Imperial system of measurement be used. However, many of the tools, hardware and equipment may use the metric system of measurement. In Canada, many companies that support the aviation industry will use the metric system as their standard measuring system and accurate conversions between the two are very important.

Example: In Canada, fuel can be delivered in litres. Due to weight restrictions, the pilots are required to convert litres of fuel into pounds.

Table 2-2 – Conversion Factors

SI* (MODERN METRIC) CONVERSION FACTORS									
APPROXIMATE CONVERSIONS TO SI UNITS					**APPROXIMATE CONVERSIONS FROM SI UNITS**				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**	**Symbol**	**When You Know**	**Multiply By**	**To Find**	**Symbol**
LENGTH					***LENGTH***				
in	inches	25.4	millimeters	mm	mm	millimeters	0.039	inches	in
ft	feet	0.305	meters	m	m	meters	3.28	feet	ft
yd	yards	0.914	meters	m	m	meters	1.09	yards	yd
mi	miles	1.61	kilometers	km	km	kilometers	0.621	miles	mi
AREA					***AREA***				
in^2	square inches	645.2	square millimeters	mm^2	mm^2	square millimeters	0.0016	square inches	in^2
ft^2	square feet	0.093	square meters	m^2	m^2	square meters	10.764	square feet	ft^2
yd^2	square yards	0.836	square meters	m^2	m^2	square meters	1.195	square yards	ac
ac	acres	0.405	hectares	ha	ha	hectares	2.47	acres	mi^2
mi^2	square miles	2.59	square kilometers	km^2	km^2	square kilometers	0.386	square miles	
VOLUME					***VOLUME***				
fl oz	fluid ounces	29.57	milliliters	ml	ml	milliliters	0.034	fluid ounces	fl oz
gal (US)	gallons	3.785	liters	L	L	liters	0.264	gallons	gal (US)
gal (Imp)	gallons	4.546	liters	L	L	liters	0.219	gallons	gal (Imp)
ft^3	cubic feet	0.028	cubic meters	m^3	m^3	cubic meters	35.71	cubic feet	ft^3
NOTE: Volumes greater than 1000 L shall be shown in m^3									
MASS					***MASS***				
oz	ounces	28.35	grams	g	g	grams	0.035	ounces	oz
lb	pounds	0.454	kilograms	kg	kg	kilograms	2.202	pounds	lb
TEMPERATURE (exact)					***TEMPERATURE (exact)***				
F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C	°C	Celcius temperature	1.8C +32	Fahrenheit temperature	°F
FORCE and PRESSURE or STRESS					***FORCE and PRESSURE or STRESS***				
lbg	poundforce	4.45	Newtons	N	N	newtons	0.225	poundforce	lbf
psi	poundforce per square inch	6.89	kilopascals	kPa	kPa	kilopascals	0.145	poundforce per square inch	psi

Activity 2-3 – Drill Bit Size

1. Fill in the shaded area in the following drill bit size table.

Millimetres	Inches	Designation	Tap Drill/Pilot Drill Uses
.7938mm	.03125"		#1 Pilot, Hard & Softwood #2 Pilot, Softwood
1.5875mm		1/16"	#3 Pilot, Hard-Wood, #4 Pilot, Hardwood #5 Pilot, Softwood, #6 Pilot, Softwood, #7 Pilot, Softwood
2.3813mm	.09375"		#2 Wood Shank Hole, #7 Pilot, Hardwood, #8 Pilot, Hardwood, #10 Pilot, Softwood, #11 Pilot, Softwood
3.175mm		1/8"	#5 Wood Shank Hole, #11 Pilot, Hardwood, #12 Pilot, Hardwood
3.9688mm	.15625"		#7 Wood Shank Hole, #16 Pilot, Hardwood
4.7625mm		3/16"	#9 Wood Shank Hole, #10 Wood Shank Hole, #18 Pilot, Hardwood
5.5563mm		7/32"	#12 Wood Shank Hole
6.35mm	.25"		#14 Wood Shank Hole
7.1438mm			-
7.9375mm	.3125"		3/8"-16 UNC
8.7313mm		11/32"	-
9.525mm	.375"		-
10.3188mm	.40625"		-
11.1125mm		7/16"	1/4"-18 NPT
11.9063mm		15/32"	-
12.7mm	.5"		-
13.4938mm	.53125"		5/8"-11 UNC
14.2875mm		9/16"	5/8"-18 UNF
15.0813mm	.59375"		-
15.875mm	.625"		-
16.6688mm	.65625"		-
17.4625mm		11/16"	3/4"-16 UNF
18.2563mm	.71875"		-
19.05mm		3/4"	-
19.8438mm		25/32"	-
20.6375mm		13/16"	7/8"-14 UNF
21.4313mm	.84375"		-
22.225mm		7/8"	1"-8 UNC
23.0188mm	.90625"		1"-12 UNF
24.6063mm	.96875"		-
25.4mm	1.000"	1"	-

Using the conversion table (Table 2.2) on the previous pages, solve the following:

2. Which is longer, 1 yard or 1 metre?

____

3. One centimetre equals how many inches?

____

4. An aircraft has a measured fuel onboard of 50 litres. What is this quantity expressed in gallons?

____

5. The electrical gap of an aviation spark plug is measured at $^{35}/_{1000}$ inch. What is this distance in millimetres?

____

6. A water bomber can hold 1000 gallons of water. Express this quantity in litres.

____

7. A forest fire in Northern Ontario, has burned 800 hectares of the 1000 km^2 forest. Express these quantities in Imperial units.

   a. 800 hectares = _______________ acres
   b. 1000 km^2 = _______________ mi^2

8. The cargo bay of an aircraft measures 28.3 m^3. Express this quantity in cubic yards.

____

9. A bush airstrip measures 3000 feet and an aircraft needs 500 meters to land. Can the aircraft land safely on this airstrip?

____

10. The useful weight of an aircraft is 2003 pounds. Express this weight in kilograms.

____

11. The tires of an aircraft are required to be inflated to 105 kPa. Express this pressure in psi.

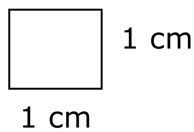
____

Calculating Area

Structures is the aspect of aviation that deals with maintenance and repair of an aircraft skeleton and skin. To repair damages to the aluminum skin, the engineer will be required to calculate the amount of material required to complete the repair. It is a two dimensional calculation, which is done by multiplying the length by the width, given in square units.

Often formulas are used to calculate the area of plane figures such as squares, rectangles, triangles or circles.

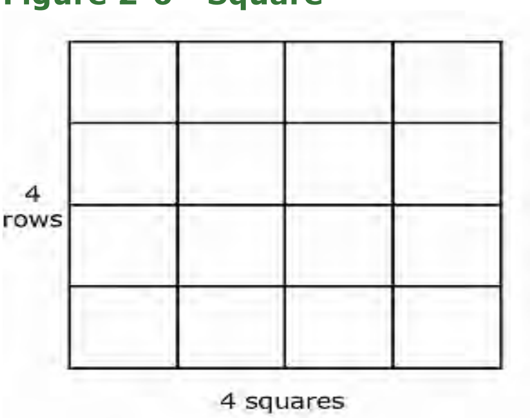
Area of a Square



The area of a square that has a side length of 1 cm is 1 square centimetre (or 1 cm^2). To find the area of a square by the method of counting squares, we divide the square into smaller squares one centimetre long and one centimetre wide.

Consider a square that has a side length of 4 cm.

Figure 2-6 - Square



Using the method of counting squares, we find that the area of the square is 16 cm^2. The square contains 4 rows of 4 squares.

Therefore:

Area	= 4 cm x 4 cm
	= 16 cm^2

The area of a square is equal to its side (length) multiplied by its other side (length).

That is:

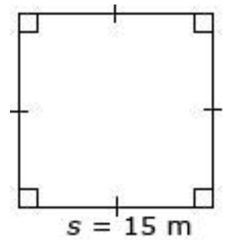
Area	= Length x Length
	= $(\text{Length})^2$

Using ***A*** for area and ***s*** for side length, we can write it simply as: $\boldsymbol{A = s^2}$. This is the formula for the area of a square.

Example:
Find the area of a square flower bed of side 15 m.

$A = s^2$
$= 15^2$
$= 225$

So the area is $225 m^2$

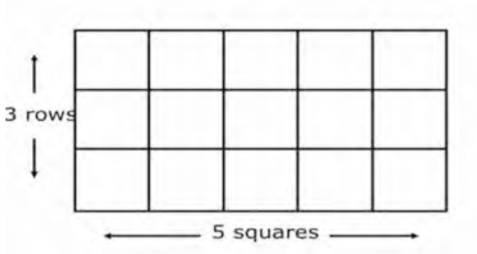


Area of a Rectangle

To find the area of a rectangle by the method of counting squares, we divide the rectangle into small squares of one centimetre side length.

Consider a rectangle of length 5 cm and width 3 cm.

Figure 2-7 - Rectangle



Using the method of counting squares, we find the area of the rectangle is 15 cm^2.

Clearly, the rectangle contains 3 rows of 5 squares.

Therefore:

Area = 5cm x 3cm
= $15cm^2$

This suggests that:

The area of a rectangle is equal to its length multiplied by its width.

That is:

Area = Length x Width

Using ***A*** for area, ***l*** for length and ***w*** for width, we can write it simply as: ***A* = *lw***

Example:

This is the formula for the area of a rectangle.
Find the area of a rectangular field 20 m long and 10 m wide.

w = 10 m

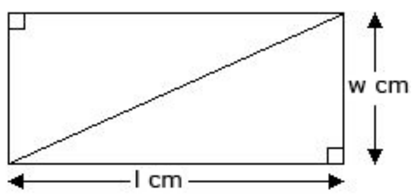
A = *l* *lw* 20
= 20 x 10
= 200

Thus, the area of the field is 200 m^2

Area of a Triangle

Consider a rectangle of length ***l*** cm and width ***w*** cm.

Figure 2-8 – Two Triangles



Draw a diagonal and cut out the rectangle. Then cut along the diagonal to form two right-angled triangles.

By arranging one triangle over the other, we find that the triangles are the same size and equal in area. This suggests that the area of a triangle is equal to half the area of a rectangle around it. Therefore:

Area of Triangle	= $^1/_2$ x Area of Rectangle around it
	= $^1/_2$ x length x width
	= $^1/_2$ *lw*

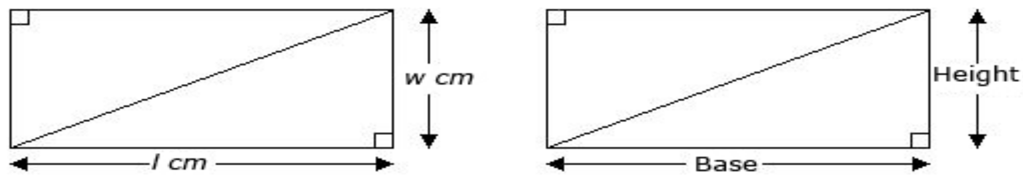
In the diagram below, we notice that the length of the rectangle is one side of the triangle. This is said to be the **base** of the triangle. So:

Base of the triangle = Length of the rectangle

The distance from the top of the triangle to the base is called the **height** of the triangle. Therefore:

Height of the triangle = Width of the rectangle

Figure 2-9 – Half Rectangle



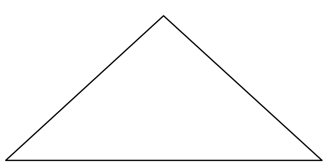
Replacing *l* and *w* with the Base and Height in the formula for the area of a rectangle, we obtain:

Area of Triangle = ½ Base X Height

Using ***A*** for area, ***b*** for base and ***h*** for height, we can write the formula for the area of a right-angled triangle as:

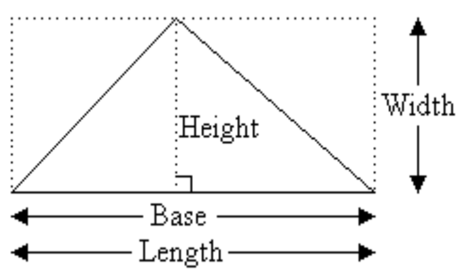
$$A = \frac{1}{2} bh$$

Consider the following triangle.



Enclose the triangle by drawing a rectangle around it as shown below.

Figure 2-10 - Triangle



Area of Triangle = $^1/_2$ x Area of Rectangle around it

= $^1/_2$ x length x width

= $^1/_2$ x base x height

$A = ½\, bh$

= ½ x 8 x 5

= 20

So, the area is 20 cm^2

h

h = 5

b

b = 8

From the diagram, the length of the rectangle is one side of the triangle. This is the **base** of the triangle. So:

Base of the triangle = Length of the rectangle

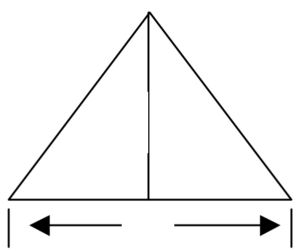
The distance from the top of the triangle to the base is called the height of the triangle.

Height of the triangle = Width of the rectangle

Using ***A*** for area, ***b*** for base and ***h*** for height, we can write the formula for the area of a triangle as:

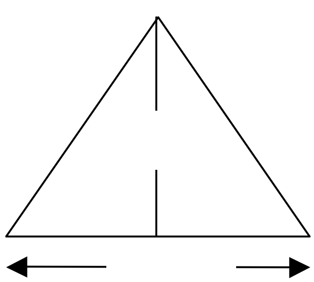
Figure 2-11

A = ½ *bh*



Example

Find the area of a triangle with base 8 cm and height 5 cm.



$A = \pi r^2$

r

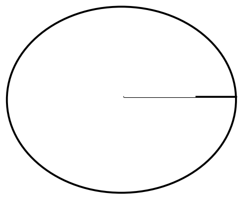
14 m

Centre

Area of a Circle

The area, *A*, of a circle is given by the following formula where *r* is the radius of the circle and π is known as 3.14 (pi):

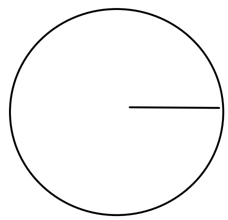
Figure 2-12 - Circle



Find the area of a circle whose radius is 14m using a value for π as 3.14.

r = 14m

$A = \pi r^2$
$= 3.14 \times 14^2$
$= 3.14 \times 196$
$= 615.44$



So, the area is 615 m^2.

Activity 2-4 – Calculate Area

Solve the following:

1. Find the area of a square which side measures 1.75 m.

    ____

2. What is the area of a rectangle measuring 3 m by 0.80 m?

    ____

3. Find the area of a triangle with base 12 cm and height 23 cm.

    ____

4. What is the area of a circle whose radius is 3.2 m?

____

5. What is the area of a square switch plate that measures 3″ x 3″?

____

6. Find the area of a square window that measures 42 cm on each side.

____

7. What is the area of a rectangular duct measuring 11.25 cm by 17.5 cm?

____

8. Find the area of a rectangular airstrip measuring 12 m by 2500 m?

____

9. Find the area of a triangle with base 34″ and height 81″.

____

10. Find the area of a triangular gasket with base 3 ¼″ and height 15 ½″.

____

11. What is the area of a circular port hole whose radius is 73 mm?

____

$V = Ah$ 7″ 18″
= Volume = Area of base x height = (1 x 1) x 1 A
$= 1^2 \times 1$ $V = Ah$
$= 1^3$ A B
23″

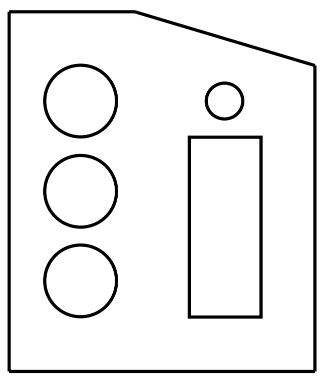
12. What is the area of a circular helipad whose diameter is 15.24 m?

A 19″
C

____

A
13. What is the surface area of the following instrument panel?

____



WHERE:
Diameter for A = 2.5″
Diameter for B = 1.75″
Size of C = 2″ x 7.89″

Calculating Volumes

Volume calculation plays a major role in aviation, since it determines the capacity (size) of an engine, cargo bay, fuselage, etc. This is a three-dimensional calculation, which is done my multiplying the length by the width and by the height, given in cubic units.

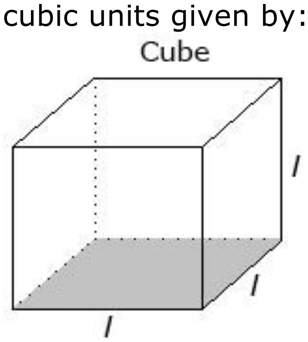
The volume, V, of a solid is given by:

where ***A*** is the area of the base of the solid and h is the height.

The volume of the following objects are often required to solve real world problems.

Figure 2-13 – Volume of a Cube

A cube of side length ***l*** units has a volume of ***V*** cubic units given by:



$V = lwh$

$V = 20 \times 10 \times 5$

$V = Ah$

$= (l \times w) \times h$

$= l \times w \times h$

$= lwh$

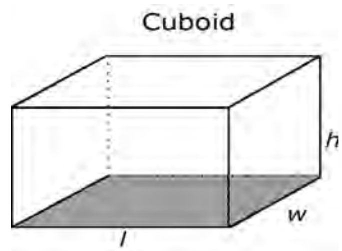
radius

14

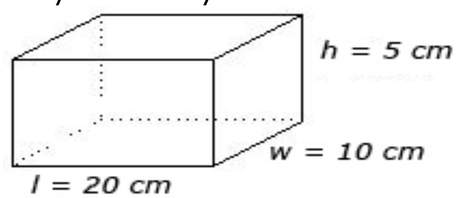
height

Figure 2-14 – Volume of a Cuboid

A cuboid with length ***l*** units, width ***w*** units and height ***h*** units has a volume of ***V*** cubic units given by:



Example:
Find the volume of a brick 20 cm by 10 cm by 5 cm.



Thus, the volume of the brick is 1000 cm^3.

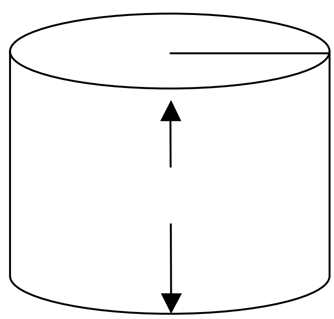
To calculate the volume of a cylinder we need to know the radius of the base and the height of the cylinder.

The volume, *V*, of a cylinder is given by the following formula where *A* is the area of the base of the cylinder and *h* is the height:

Figure 2-15 – Volume of a Cylinder

$V = Ah$

$V = (\pi r^2) \times h$
$= 3.14 \times 14^2$
$= 3.14 \times 196$
$= 615.44$



So, the area is 615 m^2.

Example: Find the volume of a cylinder having a radius of 5 cm and a height of 15 cm.

$V = Ah$
$V = (\pi r^2) \times h$
$= (3.14 \times 5^2) \times 15$
$= (3.14 \times 25) \times 15$
$= 78.5 \times 15$
$= 1177.5$

Therefore, the volume of the cylinder is 1178 cm^3 (cubic centimetres).

Activity 2-5 – Calculate Volume

1. Calculate the volume of a storage crate measuring 1 m x 1 m x 1.5 m.

____

2. Find the volume of a cargo bay which measures 1.8 m x 2.4 m x 150 cm.

____

3. What is the volume of a bulkhead measuring 10 cm in diameter and 60 cm in length?

____

4. What is the total volume of an aircraft's two pontoons, where each one measures 32″ in diameter and 11′0″ in length?

____

5. An aircraft's baggage compartment measures 6 feet 9 inches in length, 4 feet in width and 3 feet 3 inches in height. How many cubic feet of luggage will it hold?

____

6. A bush plane's cargo bay measures 2100 mm x 390 mm x 1220 mm. How many cubic meters of cargo can be loaded on board the plane?

____

7. A fuel tank measures 450 mm x 853 mm x 1525 mm. How many litres of gasoline can the tank hold?

____

8. The cylinder of an aircrafts engine is 5 ½" in diameter (bore) and the piston moves 6" (stroke). Calculate the volume of air inside the cylinder when the piston is in the bottom position (displacement).

____

9. *ABC Airways* has been chartered by *DIG-DIG Miners* to deliver 12 hydraulic oil drums to a remote mining camp. Each drum measures 34.5" (height) x 22.5" (diameter). If the aircraft chartered has a cargo bay which measures 16.7' (length) x 5.2' (width) x 4.3' (height), calculate the number of trips required to deliver the drums.

____

10. *DIG-DIG Miners* would also like *ABC Airways* to deliver a piece of equipment measuring 900 mm wide x 1200 mm long x 1525 mm high. Can this be accomplished? Explain your answer.

____

____

____

11. An aircraft's cargo pod (luggage compartment) has a capacity of 111.5 cubic feet. The following luggage must be loaded into the pod: 2 packs – 13″ x 10″ x 22″, 3 bags – 16″ x 24″ x 12″ and 1 – chest 36″ x 22″ x 14″. Will this luggage fit into the cargo pod? Assume an opening of 37″ x 24″ and explain your answer.

____

____

____

12. The bore of an aircraft's engine is 6 ¼″ with a stroke of 7 ½″. The motor has 6 pistons. Calculate the total displacement of the aircraft's engine.

____

Ratios and Proportions

Aircraft painting is an aviation occupation that uses ratios. Hardener or catalyst must be added to the paint in very precise amounts to produce a hard and durable finish.

Example: 2 ml hardener to 1 litre of paint
2:1000 = 1:500

Ratios may be written using the colon (:) or expressed as a fraction.

Example: 7:8 can also be expressed as $^{7}/_{8}$

Proportion is a comparison between two or more ratios.

In any proportion, the product of the *extremes* (1st and last) numbers is equal to the product of the *means* (2nd and third) numbers.

In the proportion:

2:3 = 4:6,

we find,

2 x 6 (the *extremes*) = 12
and
3 x 4 (the *means*) = 12

Example: An aircraft flies 300 miles and uses 24 gallons of fuel. How many gallons are required for 750 miles?

In proportion,
300:24 = 750:?
300 = 24 x 750
300 = 18000
= $^{18000}/_{300}$
= 60

Therefore, the aircraft would require 60 gallons.

Activity 2-6 - Ratios

1. Express the following fractions as colon ratios.

a.	$^{4}/_{2}$	=	______	e.	$^{9}/_{21}$	=	______
b.	$^{2}/_{1}$	=	______	f.	$^{12}/_{4}$	=	______
c.	$^{7}/_{12}$	=	______	g.	$^{7}/_{3}$	=	______
d.	$^{24}/_{48}$	=	______	h.	$^{21}/_{63}$	=	______

2. Express the following decimal ratios as fractional ratios.

a.	0.5	=	______	e.	0.025	=	______
b.	0.35	=	______	f.	40	=	______
c.	0.75	=	______	g.	0.02	=	______
d.	0.875	=	______	h.	0.25	=	______

3. **Match** each fraction ratio to the appropriate colon ratio.

a.	$^{7}/_{100}$	______	A.	20:19
b.	$^{20}/_{19}$	______	B.	3:1
c.	$^{5}/_{7}$	______	C.	1:2
d.	$^{12}/_{43}$	______	D.	5:7
e.	$^{7}/_{14}$	______	E.	1:24
f.	$^{10}/_{1}$	______	F.	7:100
g.	$^{6}/_{144}$	______	G.	12:43
h.	$^{9}/_{3}$	______	H.	10:1

4. The total useable fuel capacity of an aircraft is 348.2 L. This aircraft will travel 1235 km before needing to refuel. How many litres of fuel would be required for this aircraft to fly 678 km?

______

5. If an aircraft used 34 pounds of fuel to fly 150 miles, how much fuel will it use on a 436 mile trip?

____

6. A small engine requires a 40:1 gasoline and oil mixture. If 53 L of gasoline is in the fuel tank, how much oil should be added to the tank?

____

7. An aircraft's four cylinder engine has a total displacement of 300 cubic inches. If the optimum fuel to air mixture for an aircraft engine is 50:1, how much fuel must be injected in each chamber?

____

Layout and Cutting Calculations

Many materials used in aircraft maintenance are supplied in predetermined sheet sizes. Sheet aluminum is manufactured in 3′ x 8′ sheets. You must be able to cut odd shaped pieces from various expensive materials with as little waste as possible. You must estimate the area of all the pieces, then divide that number by the area of the sheet to estimate the number of sheets required. A cutting plan will show where each odd shaped piece can be cut from the sheet. This can be done directly on the 3′ x 8′ sheet or using grid paper to reduce all sizes and shapes proportionately (scaled down). This becomes very much like a jigsaw puzzle.

Activity 2-7 – Cutting Exercise

1. Using the graph paper on the following pages, produce a cutting plan for the shapes listed below. Your layout must allow for minimum waste and be "to scale". Assume an aircraft aluminum sheet size of 3′ x 8′.

Shape	Dimensions	Quantity
Square	16″ x 16″	two
	12″ x 12″	one
Rectangle	8″ x 21″	two
Triangle (right angle)	24″ x 42″	two
Circle	10″ diametre	six

2. How many sheets of aluminum are required to produce all the shapes?

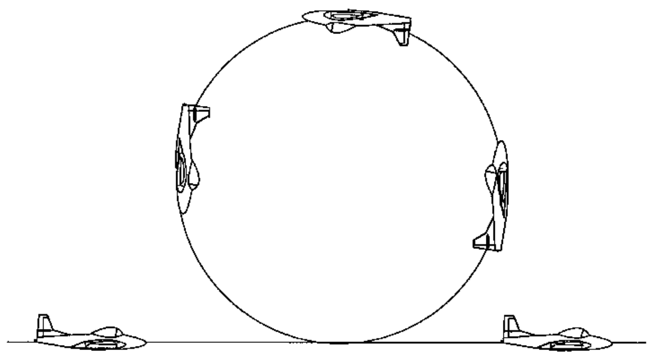
____

DMS Angular Measure

An aviation technician must also be competent with the measurement of angles (measuring a change in position relative to a centre point or baseline). When flying, the pilot will raise the nose of the aircraft above the horizon (baseline) in order to gain altitude. The amount the nose is raised will determine the rate of climb and this is measured in degrees up. The same is true when the pilot lowers the nose of the aircraft below the baseline to lose altitude. When the nose is lowered, the descent is measured in degrees down.

> *A stunt pilot is able to raise the nose of the plane until the plane goes upside-down and continue around until he is straight and level where he began. He has pitched or looped the aircraft in a complete 360° circle.*

Figure 2-16 – Degrees, Minutes and Seconds



The movement of any object around a centre point (e.g., flight controls – elevator, aileron or rudder) is also measured in degrees up or degrees down. Because control movements are so critical to the aircraft's flight path, the unit degree must be further broken down into smaller units called minutes; 60 minutes equal 1 degree. The minute is further broken down into 60 smaller bits called seconds, similar to time.

Therefore,

60 seconds = 1 minute (60″ = 1′)
60 minutes = 1 degree (60′ = 1°)
360 degrees = 1 circle (360° = 1 full rotation)

Note: ″ = seconds
′ = minutes

Example: 15° 20′ 18″ = 15 degrees, 20 minutes, 18 seconds

Activity 2-8 – DMS Calculations

1. How many minutes are there in a circle? ______________

2. How many degrees are there in a half circle? ______________

3. How many minutes are there in 90°? ______________

4. Add the following angle measurements.

   a. 10° 10′ + 1° 30′ = ______________
   b. 14° 5′ 2″ + 3° 3′ 4″ = ______________
   c. 16° 13′ + 34° 48′ = ______________
   d. 143° 25′ 12″ + 23° 32′ 48″ = ______________
   e. 164° 52′ + 132° 25′ = ______________
   f. 223° 22′ 22″ + 123° 38′ 57″ = ______________
   g. 270° 10′ + 45° 55′ = ______________
   h. 339° 25′ + 23° 0′ 48″ = ______________
   i. 0° 13′ + 360° 1′ = ______________
   j. 315° 45′ 1″ + 75° 15′ 59″ = ______________

5. Subtract the following angle measurements.

   a. 30° 15′ - 15° 40′ = ______________
   b. 180° 45′ 20″ - 40° 1′ 19″ = ______________
   c. 37° 15′ - 16° 48′ = ______________
   d. 132° 57′ 31″ - 43° 32′ 46″ = ______________
   e. 222° 19′ - 223° 19′ = ______________
   f. 315° 30′ 30″ - 375° 5′ 45″ = ______________
   g. 137° 1′ - 287° 21′ = ______________
   h. 330° 25′ 5″ - 35° 0′ 46″ = ______________
   i. 2° 15′ - 315° 41′ 1″ = ______________
   j. 232° 17′ 11″ - 48° 3′ = ______________

6. If a flight control (aileron) can move up 8° 30′ (+) and down 15° 45′ (-) what is the total travel of the aileron?

____

These angle measurements may also be expressed in decimal form.

Example: 5.5° = 5 degrees, 30 minutes

7. Change the following angles into decimal forms.

a. 37° 15′ = ______________
b. 10° 10′ = ______________
c. 75° 1′ = ______________
d. 112° 45′ = ______________
e. 180° 53′ 30″ = ______________
f. 131° 38′ 45″ = ______________
g. 215° 22′ 1″ = ______________
h. 315° 6′ 4″ = ______________
i. 360° 0′ 1″ = ______________
j. 415° 45′ 43″ = ______________

8. Change the following angles into angles expressed to the nearest minute.

a. 32.3° = __________________
b. 278.9° = __________________
c. 11.41° = __________________
d. 79.81° = __________________
e. 315.36° = __________________
f. 235.39° = __________________
g. 151.4° = __________________
h. 369.1° = __________________

A pilot uses the aircraft's magnetic compass (expressed in DMS) to determine the direction of travel, where 0° is North, 90° is East, 180° is South and 270° is West.

Figure 2-17 - Compass

Example: An aircraft travelling north made a turn of 120° to the left. What is the new heading and direction?

Notes: Heading is a number (90°)
Direction is a word (east)
360° = 0° (must subtract sum from 360°)

360° - 120° = 240° west – south west

9. An aircraft's heading is 330° and the pilot makes a right turn of 90°. What is the new heading?

____

10. An aircraft's heading is 90° and the pilot makes a right turn at a rate of 3° per second for 45 seconds. What is the new heading and direction?

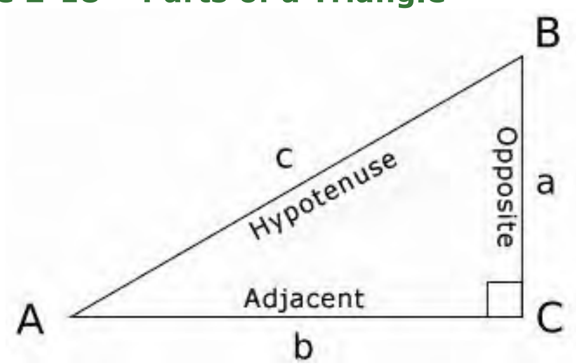
____

Geometric Measurements and Applications

Using triangles and becoming familiar with how they work will prove to be very helpful and practical to the aircraft technician. The use of the triangle and the relationship between the lengths of its three sides and between the three angles within it is known as trigonometry. Trigonometry is used when laying out work onto sheet metal. Although trigonometry can be fairly complex, we will be looking at the functions of the right angle triangle only.

Anatomy of the right angle triangle and its functions

Figure 2-18 – Parts of a Triangle



Trigonometric Functions

Using the above picture we come up with the following: SOH – CAH – TOA

The SOH stands for "Sine of an angle is Opposite over Hypotenuse."

$$\sin A = \frac{\text{Opposite}}{\text{Hypotenuse}}$$

The CAH stands for "Cosine of an angle is Adjacent over Hypotenuse."

$$\cos A = \frac{\text{Adjacent}}{\text{Hypotenuse}}$$

The TOA stands for "Tangent of an angle is Opposite over Adjacent."

$$\tan A = \frac{\text{Opposite}}{\text{Adjacent}}$$

Table 2-3: Table of Trigonometric Functions

m° *L A*	sin A	cos A	tan A	m° *L A*	sin A	cos A	tan A
1	0.0175	0.9998	0.0175	**46**	0.7193	0.6947	1.0355
2	0.0349	0.9994	0.0349	**47**	0.7314	0.6820	1.0724
3	0.0523	0.9986	0.0524	**48**	0.7431	0.6691	1.1106
4	0.0698	0.9976	0.0699	**49**	0.7547	0.6561	1.1504
5	0.0872	0.9962	0.0875	**50**	0.7660	0.6428	1.1918
					0.		
6	0.1045	0.9816	0.1051	**51**	0.7771	0.6293	1.2349
7	0.1219	0.9925	0.1228	**52**	0.7880	0.6157	1.2749
8	0.1392	0.9903	0.1405	**53**	0.7986	0.6018	1.3270
9	0.1564	0.9877	0.1584	**54**	0.8090	0.5878	1.3764
10	0.1736	0.9848	0.1763	**55**	0.8192	0.5736	1.4281
					0.		
11	0.1908	0.9816	0.1944	**56**	0.8290	0.5592	1.4826
12	0.2079	0.9781	0.2126	**57**	0.8387	0.5446	1.5399
13	0.2250	0.9744	0.2309	**58**	0.8480	0.5299	1.6003
14	0.2419	0.9703	0.2493	**59**	0.8572	0.5150	1.6643
15	0.2588	0.9659	0.2679	**60**	0.8660	0.50	1.7321
					0.		
16	0.2756	0.9613	0.2867	**61**	0.8746	0.4848	1.8040
17	0.2924	0.9563	0.3057	**62**	0.8829	0.4695	1.8807
18	0.3090	0.9511	0.3249	**63**	0.8910	0.4540	1.9626
19	0.3256	0.9455	0.3443	**64**	0.8988	0.4384	2.0503
20	0.3420	0.9397	0.3640	**65**	0.9063	0.4226	2.1445
					0.		
21	0.3584	0.9336	0.3839	**66**	0.9135	0.4067	2.2460
22	0.3746	0.9272	0.4040	**67**	0.9205	0.3097	2.3559
23	0.3907	0.9205	0.4245	**68**	0.9272	0.3746	2.4751
24	0.4067	0.9135	0.4452	**69**	0.9336	0.3584	2.6051
25	0.4226	0.9063	0.4663	**70**	0.9397	0.3420	2.475
					0.		
26	0.4384	0.8988	0.4877	**71**	0.9455	0.3256	2.9042
27	0.4540	0.8910	0.5095	**72**	0.9511	0.3090	3.0777
28	0.4695	0.8829	0.5317	**73**	0.9563	0.2924	3.2709
29	0.4848	0.8746	0.5543	**74**	0.9613	0.2756	3.4874
30	**0.50**	0.8660	0.5774	**75**	0.9659	0.2588	3.7321
					0.		
31	0.5150	0.8572	0.6009	**76**	0.9703	0.2419	4.0108
32	0.5299	0.8480	0.6249	**77**	0.9744	0.2250	4.3315
33	0.5446	0.8387	0.6494	**78**	0.9781	0.2079	4.7046
34	0.5592	0.8290	0.6745	**79**	0.9816	0.1908	5.2446
35	0.5736	0.8192	0.7002	**80**	0.9848	0.1736	5.6713
36	0.5878	0.8090	0.7265	**81**	0.9877	0.1564	6.3138
37	0.6018	0.7986	0.75336	**82**	0.9903	0.1392	7.1154
38	0.6157	0.7880	0.7813	**83**	0.9925	0.1219	8.1443
39	0.6293	0.7771	0.8098	**84**	0.9945	0.1045	9.5144
40	0.6428	0.7660	0.8391	**85**	0.9962	0.0872	11.4301
41	0.6561	0.7547	0.8693	**86**	0.9976	0.0698	14.3007
42	0.6691	0.7431	0.9004	**87**	0.9986	0.0523	19.0811
43	0.6820	0.7314	0.9325	**88**	0.9994	0.0349	28.6363
44	0.6947	0.7193	0.9657	**89**	0.9998	0.0175	57.2900
45	0.7071	0.7071	1	**90**	1	0	Undefined

Using the trigonometric function table we find that the sine of 30° is 0.50

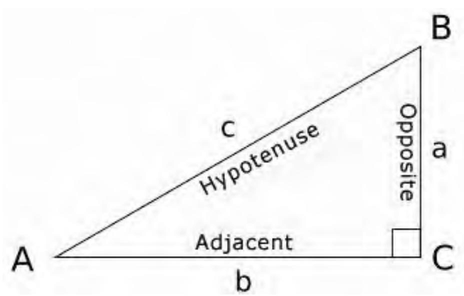
Activity 2-9 – Trigonometric Exercises

1. Find the following:

a.	sine of 71°	___________	c.	cosine of 13°	___________
b.	cosine of 25°	___________	d.	tangent of 89°	___________

The sum of all three angles of a triangle is always 180°. In a right angle triangle, angle C is always 90°. If the length of one side is known, and the value of another angle is known, we then can calculate the missing sides and angle of the triangle.

Example:



If angle A = 25°, what is angle B?
180° - 90° - 25° = 65°

Where: 180° is sum of all angles
90° is the right angle and
25° is given

2. Find the following:
   a. If angle B = 72°, what is angle A?

   ____

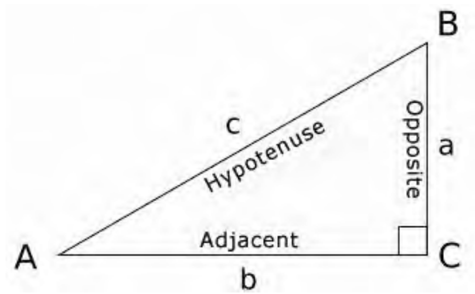
   b. If angle A = 22.5°, what is angle B?

   ____

Solving the Right Angle Triangle

25°

To solve a triangle means to know the length of all three sides and the value of all the angles. When we don't know all the values, we must use the table of trigonometric functions. An assessment of known and unknown values must be made to determine which function to use to calculate the unknowns.



Example: In a given triangle, angle A = 25° and side *a* is 5 meters. Find length c.

KNOWNS = angle A (25°)
angle C (90°)
length *a* or opposite (5m)

UNKNOWNS = length c or hypotenuse

Since SOH (Sine of an angle = Opposite over Hypotenuse) contains our *KNOWNS* in the formula, therefore:

$$\sin A = \frac{\text{Opposite}}{\text{Hypotenuse}}$$

Sin 25° = 5 meters ÷ hypotenuse
From the table sin 25° = 0.4226

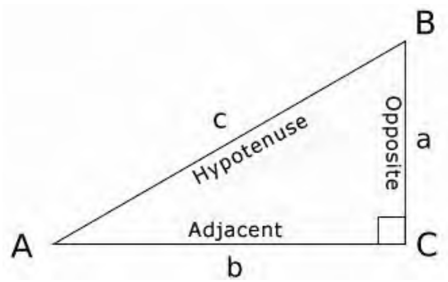
0.4226 = 5 m ÷ hyp.
Solve for hyp.

Hyp = 5m ÷ 0.4226
Hyp = 11.83 m

Therefore the length of side c is 11.83 meters.

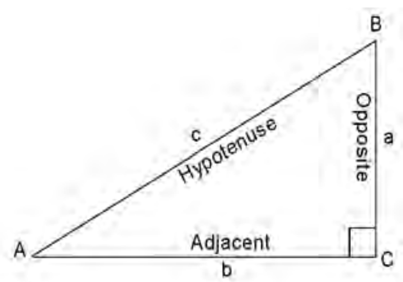
3. Solve the following triangle.
   In a given triangle, angle A = 19° and side "*b*" is 7.89 meters.
   Find length "*a*".

   ____



4. Solve the following triangle.
   In a given triangle, side "a" is 6 meters and side "c" is 9.2 meters.
   Find length "b".

   ____



5. The landing gear of an aircraft is 6′ in length. If the actuator pivots the gear through an angle of 90°, how far have the wheels travelled?

   ____

6. An aircraft has an overall length of 96′11″. The main wheels are 50′4″ aft of the aircraft nose. On the ground with the aircraft leveled, the tail cone is 12′ above the taxiway. On takeoff roll, what is the maximum rotation angle that the crew can pull back without scraping the tail on the runway?

   ____

Section Three: Numerical Calculation - Data Analysis Math, Money Math, and Scheduling or Budgeting and Accounting Math

Money Math

Regardless of the trade or occupation you choose, the ability to generate accurate time cards, calculate labour rates, fill out an invoice or even read your pay stub for accurate deductions, is a skill we must all acquire. The following activity will challenge you in the areas of money math that are important in aviation maintenance.

Activity 3-1 – Calculate Money Matters

Calculate the percent difference between an old and new contract for Mike, a second year aircraft maintenance technician apprentice. Mike is interested in what he would actually make in the next contract term. An added element in his calculations is the fact that he will be in another wage rate category when he becomes a third year apprentice.

Old Contract – Mike

- Regular rate: $21.50/hour
- Hours worked for the year: 2,000
- Year 2 apprentice rate: 70% of the regular rate
- Overtime premium: time and a half (1.5 times regular wage rate)
- Mike was paid for 103 hours overtime in the year

New Contract – Mike

- Regular rate: $23.15/hour
- This new contract provides an adjustment to the apprentice rates as follows:

Apprentice Year	Old Contract	New Contract
1	65% of regular rate	65% of regular rate
2	70% of regular rate	75% of regular rate
3	75% of regular rate	85% of regular rate
4	85% of regular rate	95% of regular rate

Mike expects to work:

- 525 hours at the year 2 rate
- 1,000 hours at the year 3 rate
- 66 hours overtime at year 2 rate
- 32 hours overtime at year 3 rate
- There is no shift work at this shop
- Overtime rate is time and a half (1.5 times regular wage rate)