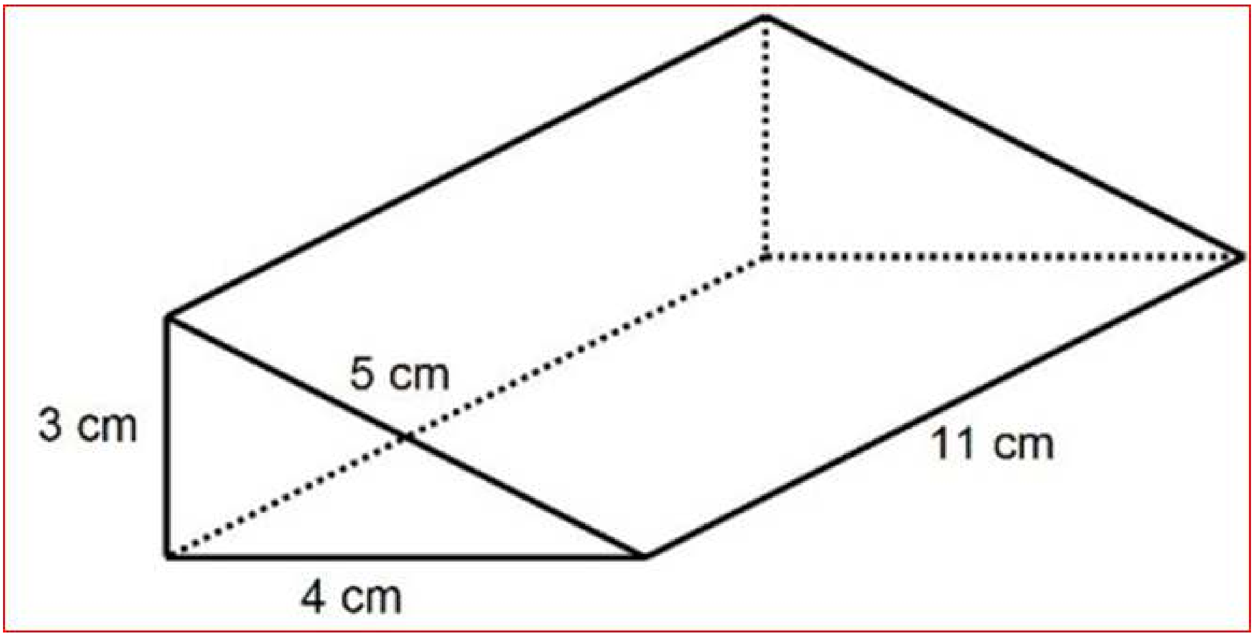
Structural Construction Work

Level-I

Based on March 2021, Curriculum Version 1



Module Title: - Carry Out Measurements and Simple Calculations

Module code: EIS SCW1 M03 0322

Nominal duration: 40Hour

Prepared by: Ministry of Labour and Skill

August, 2022

Addis Ababa, Ethiopia

Table of Content

Acknowledgment

Ministry of Labor and Skills wish to extend thanks and appreciation to the many representatives of TVET instructors and respective industry experts who donated their time and expertise to the development of this Teaching, Training and Learning Materials (TTLM).

Acronym

Introduction to the Module

In structural construction work filed ; the measurement and quantity estimation of structural construction project helps to know the quantity of work; to estimate the quantity of material required; to determine the cost of the work; to estimate the expect project completion time and to know the amount of structural construction filed.

This module is designed to meet the industry requirement under the structural construction work occupational standard, particularly for the unit of competency: select measuring instruments

This module covers the units:

- Measuring instruments
- Carry out measurements and calculations

Learning Objective of the Module

- Apply measuring instrument
- Perform Calculation

Module Instruction

For effective use this modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Do the “LAP test” giver at the end of each unit and
5. Read the identified reference book for Examples and exercise

Unit one: Measuring instruments

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Geometrical shape
- Measuring tools
- Specifications.
- Measuring instruments.
- Alternative measuring tools

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

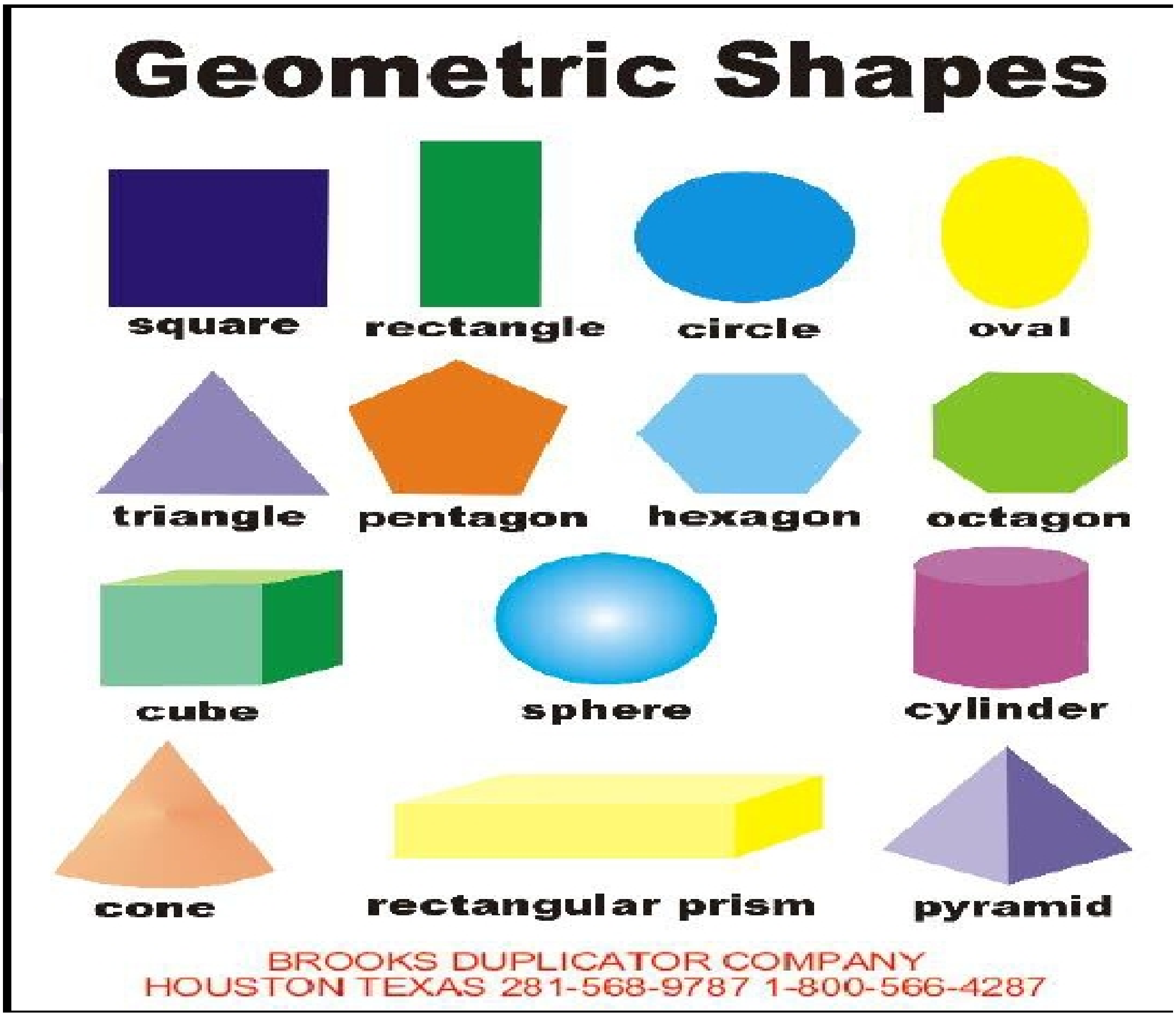
- Classified geometric shape
- Identify measuring tools
- Obtain correct Specifications.
- Appropriate Measuring instruments.
- Use alternative measuring tools

1.1. Measure Geometrical Shape

Introduction:

Geometric shape is one that is defined by the rules of construction. Any shape or form that is mathematical in origin. Having a distinct and characteristics shape, you may find that geometric shapes are used in combination to construct a larger object. Like a primitive picture of a house using the square and a triangle for the roof. The picture isn't a geometric shape but it consist a simple geometric shape in combination.

The following are the different types of geometric shapes;



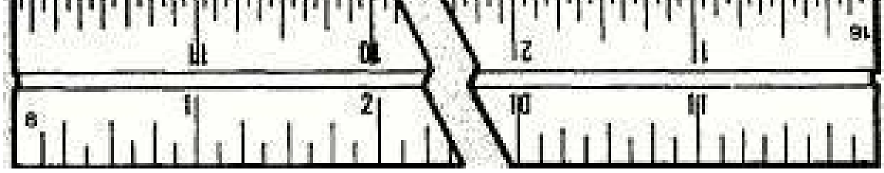
1.2. Measuring Tools /Instruments

Measurement Scales

This information sheet is designed to provide a basic understanding of how to read scales, dials, and gages. It will not provide any information on the actual use of the tools. Reference to this chapter will be made throughout the remainder of the manual.

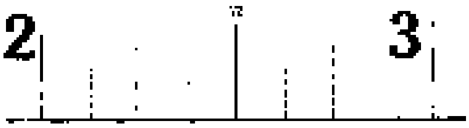
Reading the scale of a rule or tape

The more common type rules and tapes are divided into fractions, inches, and feet. Explained here are the scales on a 12-inch steel machinist's rule. The rule is divided into twelve inches. The inches are further divided into eighth, sixteenths, thirty-seconds, and Sixty-fourths.



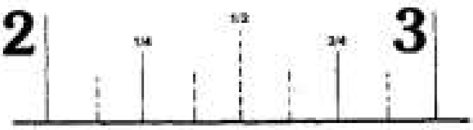
Look at the rule. There is a small numeral marked on the end of the rule nearest the l-inch mark. This numeral indicates the number of divisions per inch. When referring to fractions, always use the reduced name. This is the smallest numerator (top number) and denominator (bottom number). For example, 3/6 can be reduced to 1/2 by dividing both the top and bottom by 3. Generally, fractions may be reduced to their lowest forms by repeated division by 2 or 3.

Look at the section between the “2” and the “3” on the edge marked with an “8” for eighths. There are eight equally spaced lines. The lengths of these lines differ and indicate different fractions or parts of an inch. The longest line is in the center and is equal to 4/8 or 1/2 inch.

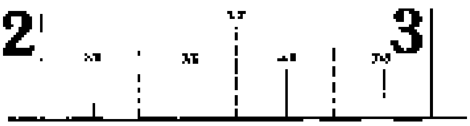


Each half-inch is divided in half by a slightly shorter line indicating 2/8 or 1/4 on the left and 6/8 or 3/4 on the right.

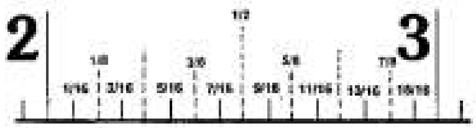
\

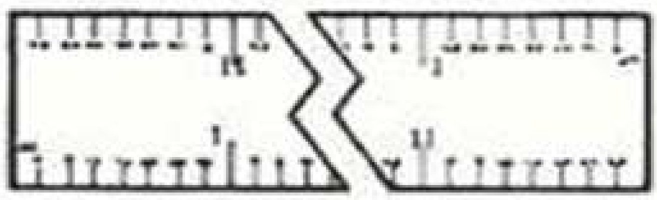


Each 1/4 inch is divided in half by the shortest line which indicates 1/8 inch, and will indicate 1/8, 3/8, 5/8 and 7/8.



Now turn the rule and look at the edge with a 16 marked on it.

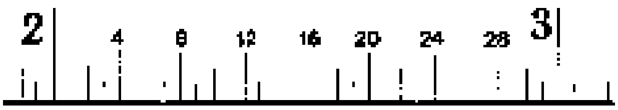




There are now 16 equal divisions between each inch. Since 2/16 reduces to 1/8, divide each 1/8 into two equal parts producing 1/16, 3/16, 5/16, 7/16, 9/16, 11/16, 13/16, and 15/16.

Common tapes and rules usually are not graduated smaller than sixteenths. However, precision measurements require smaller graduations.

Look at the back of the rule. Find the edge marked 32 and once again look between the numbers “2” and “3.”

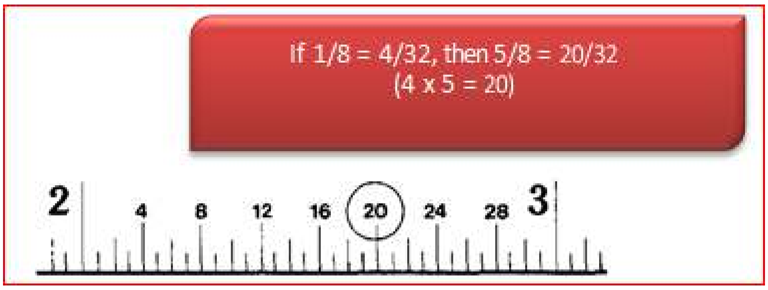


To read this rule, remember:

A. Sixteen divisions (16/32) are equal to 1/2 inch.
B. Eight divisions (8/32) are equal to 1/4 inch.
C. Four divisions (4/32) are equal to 1/8 inch.
D. Two divisions (2/32) are equal to 1/16 inch.

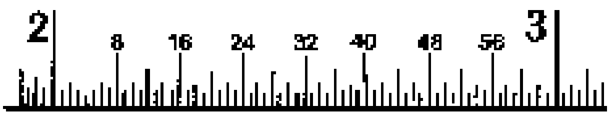
To read 2-5/8 inches on the scale, first find the two inch mark, and then determine the number of 32nds in 5/8.

To determine the number of 32nds in 5/8, remember four divisions or 4/32 are equal to 1/8 inch. If 1/8 is equal to 4/32, then 5/8 is equal to 20/32 as shown:



1. Find the 20/32 reading on the scale as shown above.
2. Write the new fraction 2-20/32 inches.

Finally, look at the edge marked 64. Each inch is now divided into 64 equal parts.

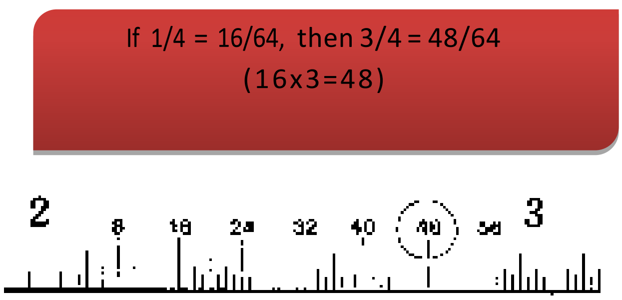


To read this rule, remember:

A).Thirty-two divisions (32/64) are equal to 1/2 inch.
B).Sixteen divisions (16/64) are equal to 1/4 inch.
C).Eight divisions (8/64) are equal to 1/8 inch.
D).Four divisions (4/64) are equal to 1/16 inch.
E).Two divisions (2/64) are equal to 1/32 inch.

To read 2-3/4 inches on this scale, first find the two inch mark. Next, determine the number of 64ths in 3/4.

Determine the number of 64ths in 3/4; remember every sixteen divisions or 16/64 are equal to 1/4 inch. If
1/4 is equal to 16/64, then 3/4 is equal to 48/64 as shown:



1).Locate the number 48 between the 2 and 3 inch marks on the scale.

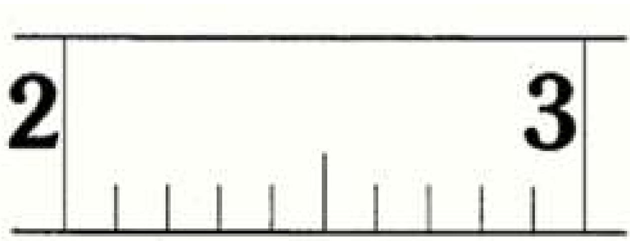
2).Write the new fraction 2-48/64.

Reading a Metric Rule

The metric system is based upon multiples of ten. For example, there are 10 millimeters in a centimeter and 100 centimeters in a meter.

The example provided will deal only with millimeters (mm).

The meter will become the starting point and from-this, two additional scales can be developed for measuring. A meter divided by 100 equals a centimeter (cm), 1/100 or 0.01 meter. Next divide a centimeter (cm) by 10. This will equal a millimeter (mm), 1/1000 or 0.001 meter

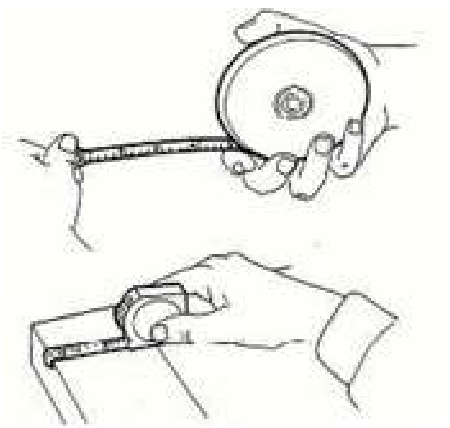


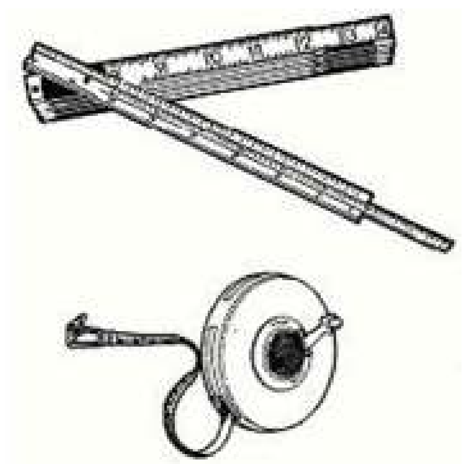
Now let‘s look at a section of the rule between 2 cm and 3 cm. here are 10 equal division which are equal to 1/10 cm or 1 mm. Next count 6 additional lines to find 26 mm

RULES AND STEEL TAPES

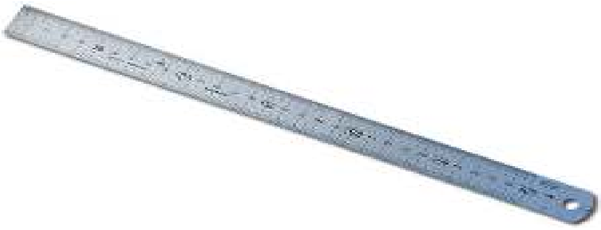
The type and uses section provides you with a list of the types of rules and tapes. These pages should help you select the right rule or tape for the job

The using rules and tapes section tells you how to use the various types of measuring instruments. The care procedures tell you how to care for rules and tapes





Steel rule is the most basic important measuring tool that is used for short measurements that do not require any great accuracy. The common lengths are 150 mm and 300 mm. Metric steel rules are graduated in millimeters (mm) and centimeters (cm).

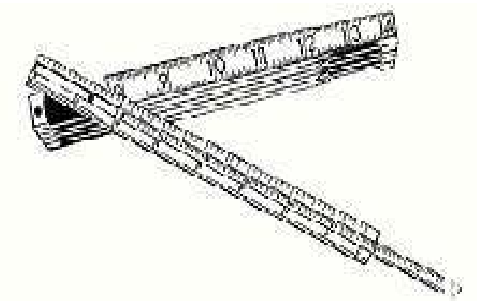


Tape rule have blades made of flexible steel, which are spring-loaded into a case. They are longer than steel rules and can therefore be used to measure much greater lengths (typically up to 3 m). They are portable, and can be carried about in the pocket.

FOLDING RULES

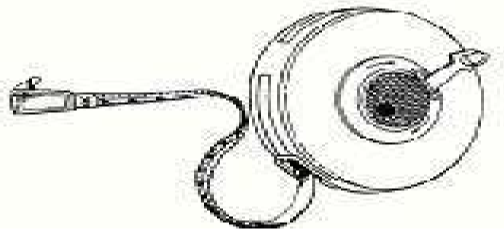
These folding rules are usually from two to six feet long. The folding rules cannot be relied on for extremely accurate measurements because a certain amount of play develops at the joints after continued use

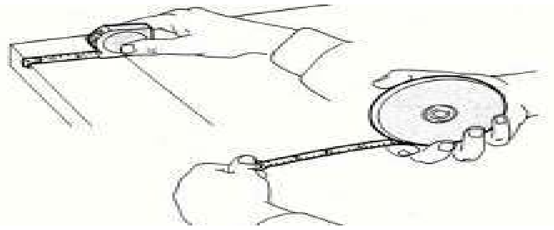
.



STEEL TAPES

Steel tapes are made from 6 to about 300 feet in length. The shorter tapes are made with a curved, but rigid, cross section flexible enough to be rolled up. Long, flat tapes need support over their full length to avoid sagging. Lack of support can cause reading errors. The most common types of steel tapes have a hook at one end to let one person take all the readings.

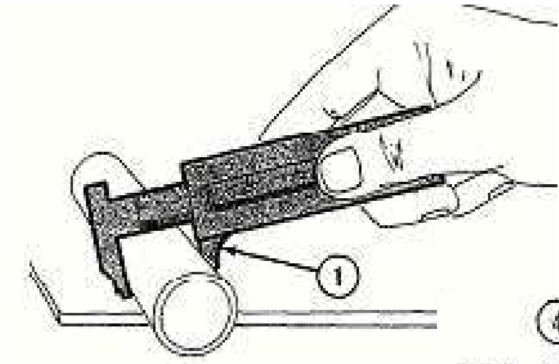


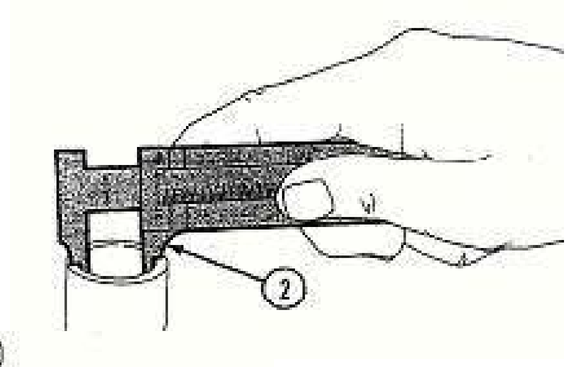


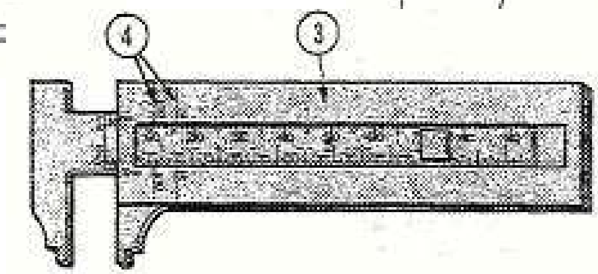
CALIPERS

Calipers are used to measure outside and inside diameters. Simple calipers are used along with a scale to find the measurement. Slide calipers and Veneer calipers have their own scales.

Slide calipers can be used for measuring outside and inside dimensions. Graduations are in inches, fractions, or millimeters. As shown above, one side of the caliper is used to measure outside (1) and the other side is used to measure inside (2) dimensions. Stamped on the frame (3) are the words IN': and OUT (4). You use them when taking inside and outside measurements. The other side of the caliper is used as a straight measuring rule.

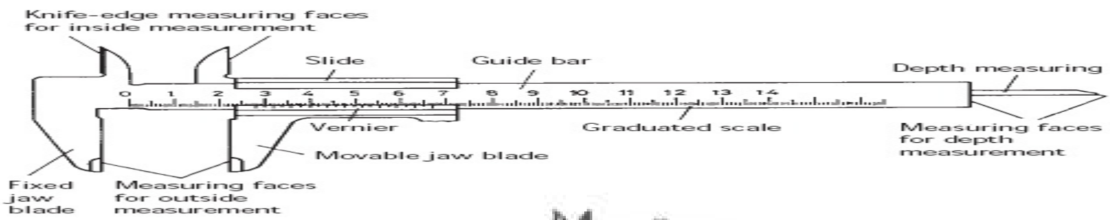






VERNEER CALIPERS

Veneer calipers work like slide calipers. As shown above, Veneer calipers can make very accurate outside or inside measurements. A Veneer caliper is used by loosening the two locking screws (1) and (2). This allows the movable jaw (3) to move along the rule until desired position is obtained. The locking screw (1) is then retightened securing the movable jaw (3). Any fine adjustments to the Veneer scale (4) are then made using adjustment control (5). Locking screw (2) is then secured and Veneer caliper is ready to read.



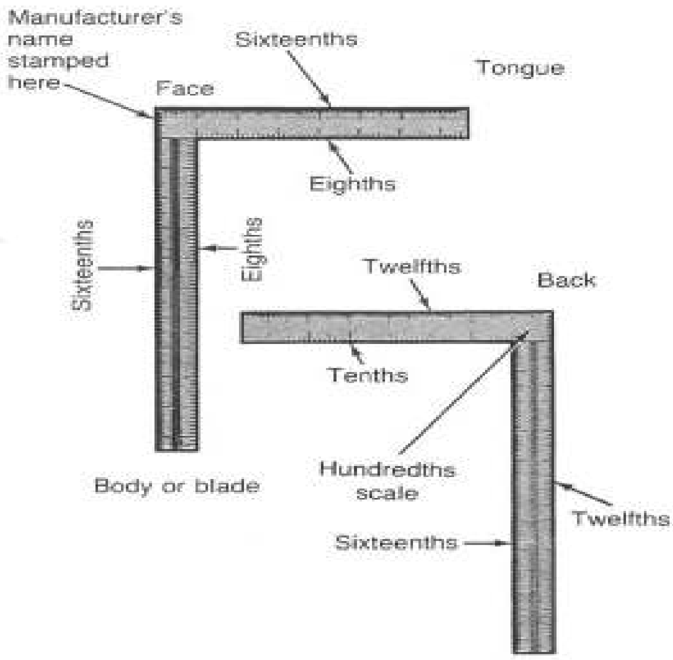
SQUARE

The Types and Uses section provides you with a list of the types of squares. These pages should help you select the right square for the job.

The steel square is often called the carpenter's square or framing square. The steel square is used in measuring boards, testing corners, and setting the bevel of boards and tools to various angles.

It is made of steel, having two flat blades at right angles to each other and having measuring scales on every edge. The long side of the steel square is known as the **blade**

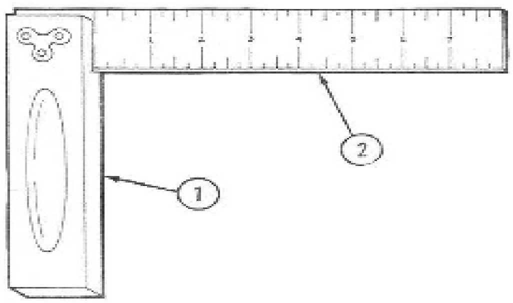
(or body) and the short side as the **tongue.** It has inches divided into eighths, tenths, twelfths, and sixteenths. The face side contains the manufacturer's name and the inches are divided into eighths and sixteenths as shown.



Try Square

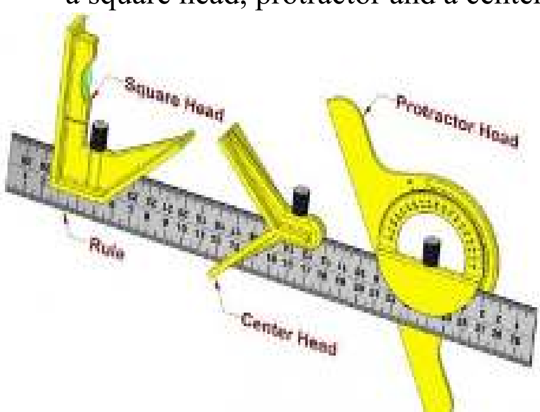
IS made of a steel or wood stock (1) and a blade (2). The blade is from 2 to 12 inches long and is graduated in eighths.

The try square is used to set or check lines which are at right angles (90 degrees) to each other.

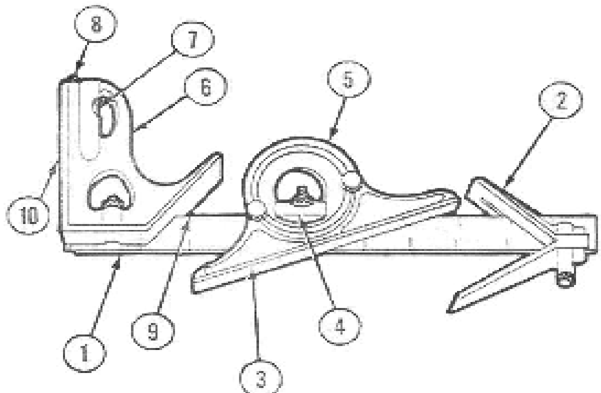


Combination square set

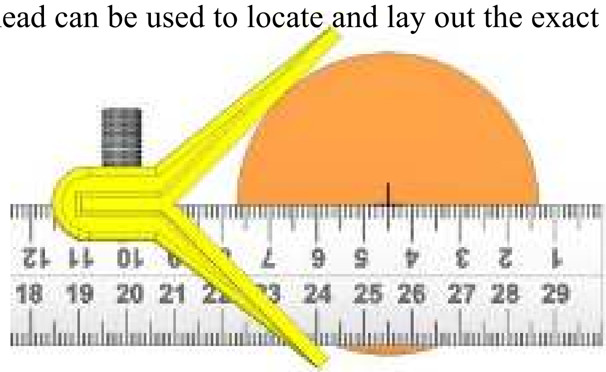
The combination square set consist of a blade (graduated steel rule) and moving heads called a square head, protractor and a center head.



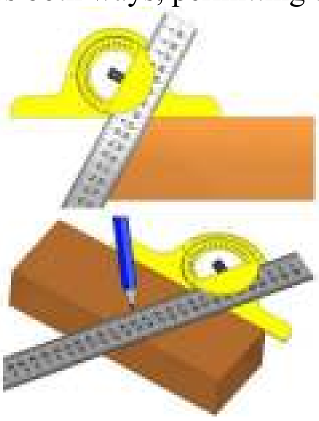
and ht	Carry

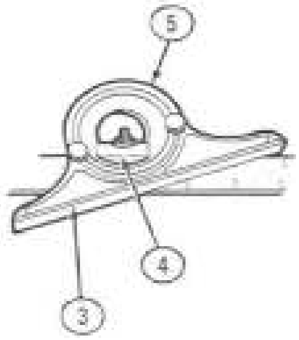


1. A slotted 12-inch stainless steel rule which is graduated in eighths, sixteenths, thirty-seconds, and sixty-fourths of an inch. By removing all the heads, the blade may be used alone as a rule or a straight edge.
2. The center head can be used to locate and lay out the exact center of round stock.

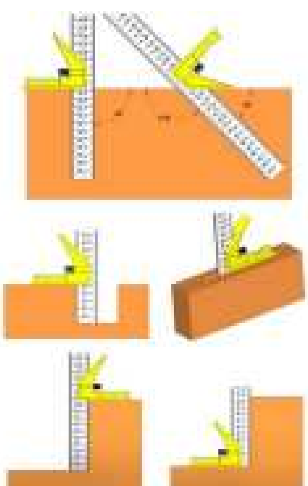


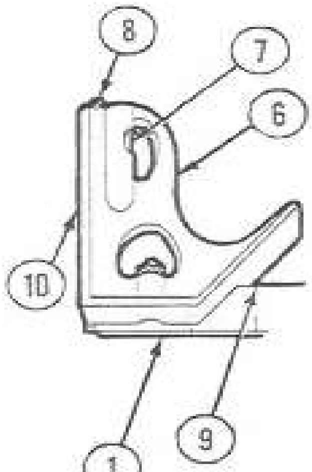
3. The protractor has a level (4) and a revolving turret (5) and can be used to mark off or measure any angle through 180. Angular graduations usually read from 0 to 180 degrees both ways, permitting the supplement of the angle to be read.





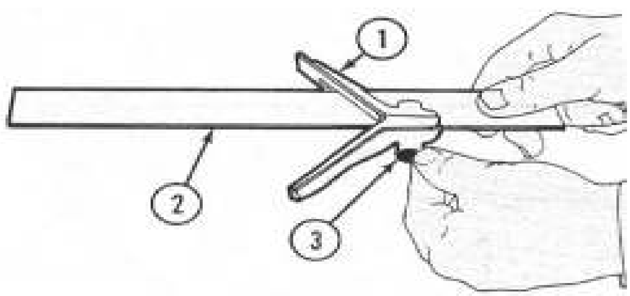
The square head (6) has a level (7), a scribe (8), and 45 degree (9) and 90 degree sides (10). It is used to lay out 45 and 90 degree angles and to check level. It may also be used as a height or depth gage.

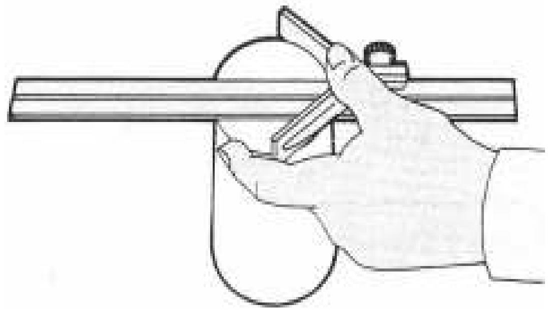


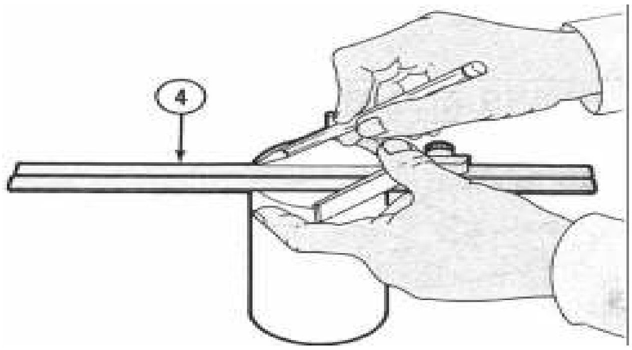


Using A Combination Square

1. Slide center head (1) on rule (2) and fasten by tightening setscrew (3).
2. Put the center head flush against the cylinder.
3. Mark the diameter on the cylinder using a pencil or marking crayon by drawing a straight line along the inside edge (4). Make sure the square does not slip while marking.







1.3. Specifications.

A **specification** often refers to a set of documented requirements to be satisfied by a material, design, product, or service. A specification is often a type of technical standard.

There are different types of technical or engineering specifications (specs), and the term is used differently in different technical contexts. They often refer to particular documents, and/or particular information within them. The word *specification* is broadly defined as "to state explicitly or in detail" or "to be specific".

A specification may refer to a standard which is often referenced by a contract or procurement document, or an otherwise agreed upon set of requirements (though still often used in the singular). In any case, it provides the necessary details about the specific requirements.

Standards for specifications may be provided by government agencies, standards organizations.) Trade associations, corporations, and others.

A **requirement specification** is a documented requirement, or set of documented requirements, to be satisfied by a given material, design, product, service, etc.

In engineering, manufacturing, and business, it is vital for suppliers, purchasers, and users of materials, products, or services to understand and agree upon all requirements.

Metrology-Introduction

Engineering metrology is defined as the measurement of dimensions: length, thickness, diameter, taper, angle, flatness, profiles and others. An important aspect of metrology in manufacturing processes is dimensional tolerances. That is, the permissible variation in the dimensions of a part. Tolerances are important not only for proper functioning's of products, they also have a major economic impact on manufacturing costs.

1. Accuracy:-It is desirable quality in measurement. It is defined as the degree of the closeness with which instrument reading approaches the true value of the quantity being measured. Accuracy can be expressed in three ways point accuracy.

1. Accuracy as the percentage of scale of range
2. Accuracy as percentage of true value.
2. **Sensitivity**:-It is also desirable quality in the measurement. It is defined as the ratio of the magnitude response of the output signal to the magnitude response of the input signal.
3. **Reproducibility**:-It is again a desirable quality. It is defined as the degree of the closeness with which a given quantity may be repeatedly measure

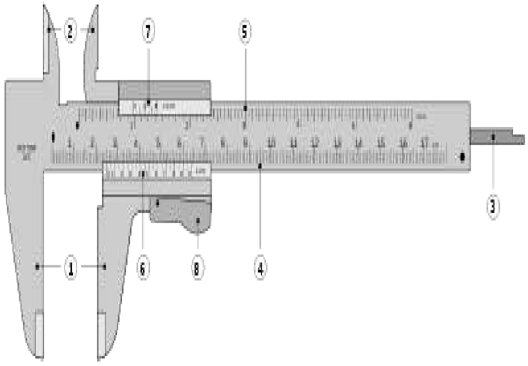
1.4. Measuring Instruments

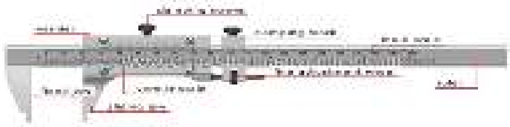
Measuring instruments- that shows the extent or amount or degree of something and which define the instrument's use are the means by which these relations of numbers are obtained. All measuring instruments are subject to varying degrees of instrument error and measurement uncertainty. Humans use a vat range of instruments to perform their measurements. These instruments may range from simple objects such as rulers and stopwatches to electron microscopes and particles accelerators.
The following are the common measuring instruments use in constructions:

1. Vernier Caliper (outside, inside)
2. Straight edge
3. Thickness gauge
4. Try square
5. Protractor
6. Combination Gauge
7. Steel Rule
8. Measuring Tape
9. Spirit Level
10. Framing Square

1. <u>Vernier Caliper (Out, Inside)</u>

- Are precision measuring tools use to make an accurate measurements to within **0.001in?** For inch verniers or to 0.002mm for metric verniers. The bar and the movable jaw may be graduated on both sides and both edges. One side is used to take outside measurements the other to take the inside measurements.
- Are available in inch and metric graduations. However some types have both inch and metric graduation in the same caliper.





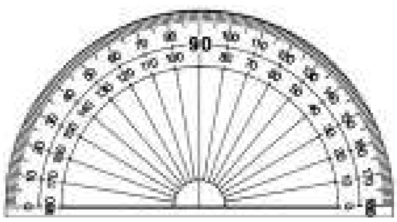
<u>Straight Edge</u> – is a tool with an edge free from curves, or a straight, used for transcribing straight lines, or checking the straightness of lines. If it has equally spaced markings along its length it is usually called a *ruler*.

- A strip of plastic wood or a metal with at least one straight edge and units of length marked on it.

- It is used for measuring length and for drawing straight lines as well.

3. <u>Try Square</u> - a tool used test and mark out right angles, consisting of a rectangular handle with a thin flat rectangular metal blade fitted perpendicular to it.

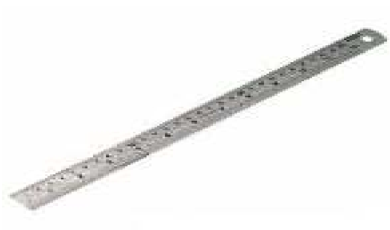
4. <u>Protractor</u> - an instrument shaped like a semicircle marked with degrees of a circle, used to measure or mark out angles. An instrument used to measure angles.



5. **Combination Gauge -** used to measure and mark angles from 0 to 360 degrees.

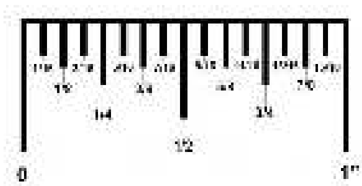
- can also be used to adjust power tools.

6. **Steel Rule** - are used for making linear measurements that do not require great accuracy. Available in lengths from 15cm. to 1m.

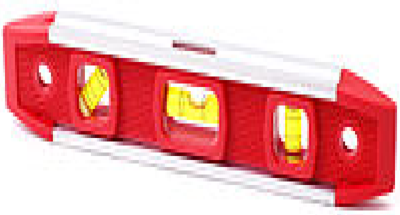


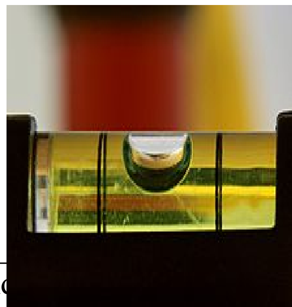
7. **Measuring Tape -** it extends smoothly to full length. It returns quickly to its compact case when the return button is pressed or winds it up by crank handle. It is used to measure and determine the size of the object. It is a flexible form of ruler. It is consists of a ribbon of cloth, plastic, fiber glass, or metal strip with linear – measurement markings.



8. **Spirit Level -** used to check whether the surfaces are level (horizontal) or plumb (vertical). Available in various length with either traditional bubble gauges or electronic display.





9. **<u>Steel Square Or Framing Square</u> -** used to lay out a “square” or right angle

- refers to a specific long-armed square that has additional uses for measurement, especially of angles, as well as simple right angles. It consists of a long arm and shorter one, which meet at an angle of 90 degrees (a right angle). It can also be made of metals like aluminum, which is light and resistant to rust.

- The wider arm, two inches wide is called the ***blade;*** the narrower arm and a half inches wide, the ***tongue.*** The square has many uses, including laying out common rafter, hip rafters and stairs. It has a diagonal scale, board foot scale and an octagona

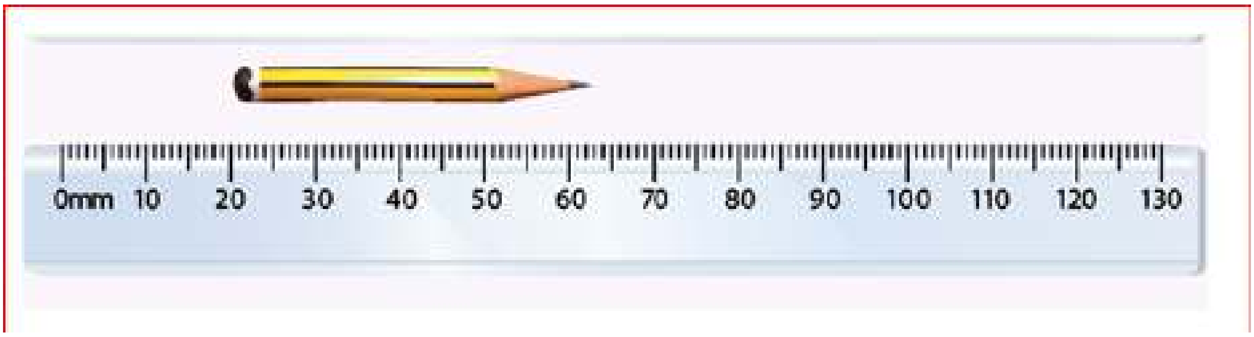
1.5. Alternative Measuring Tools

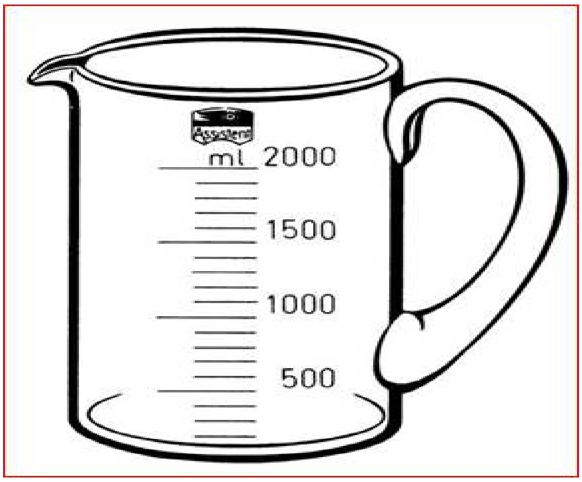
Alternative measuring instruments

Some measuring instruments are substituted by other types of measuring instruments to get the same value/magnitude.

The Wattmeter that measures dc power or real ac power uses fixed coils to indicate current in the circuit and the movable coil indicates voltage, can be substitute by ammeter which measures current and volt meter that measures voltage since power is the product of current and voltage. The current also can be obtained from the result of volt meter and ohmmeter in the circuit.

Many alternative measuring instruments can be used by applying simple arithmetical operations.





Uses graduated scaled instruments to measure and compare lengths, masses, capacities and temperatures

Measurements

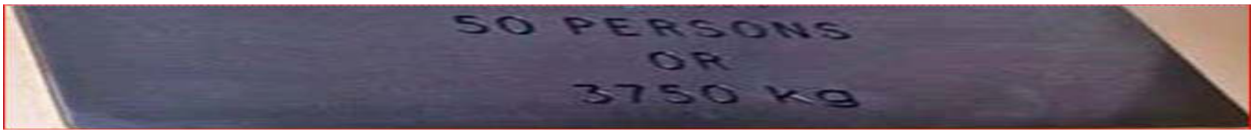
Capacity and Volume

Capacity is how much the container is able to hold

- How much wine can be stored?

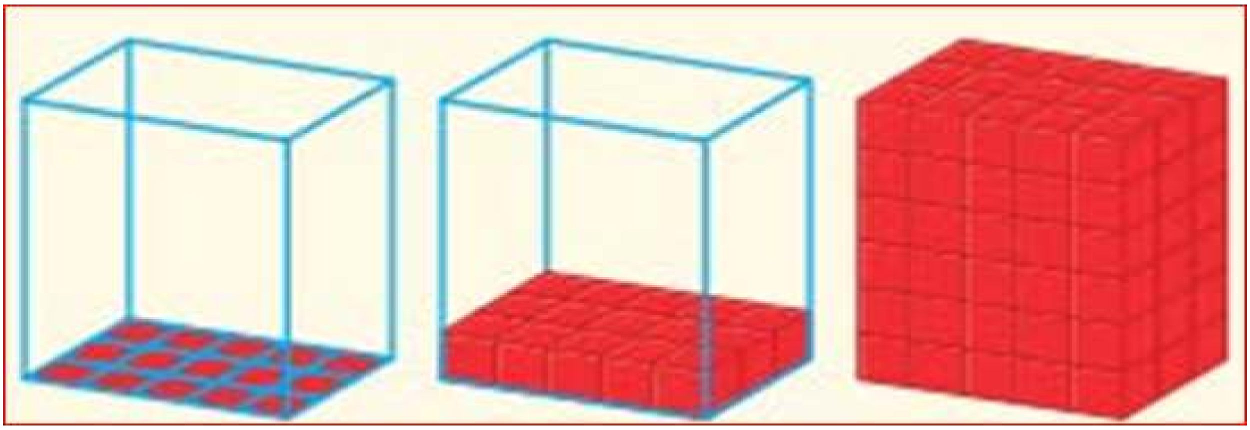
Volume is the measure of the space taken up by something (this includes the keg itself)
Connects volume and capacity and their units of measurement
(e.g. recognize that 1mL is equivalent to $1cm^3$)

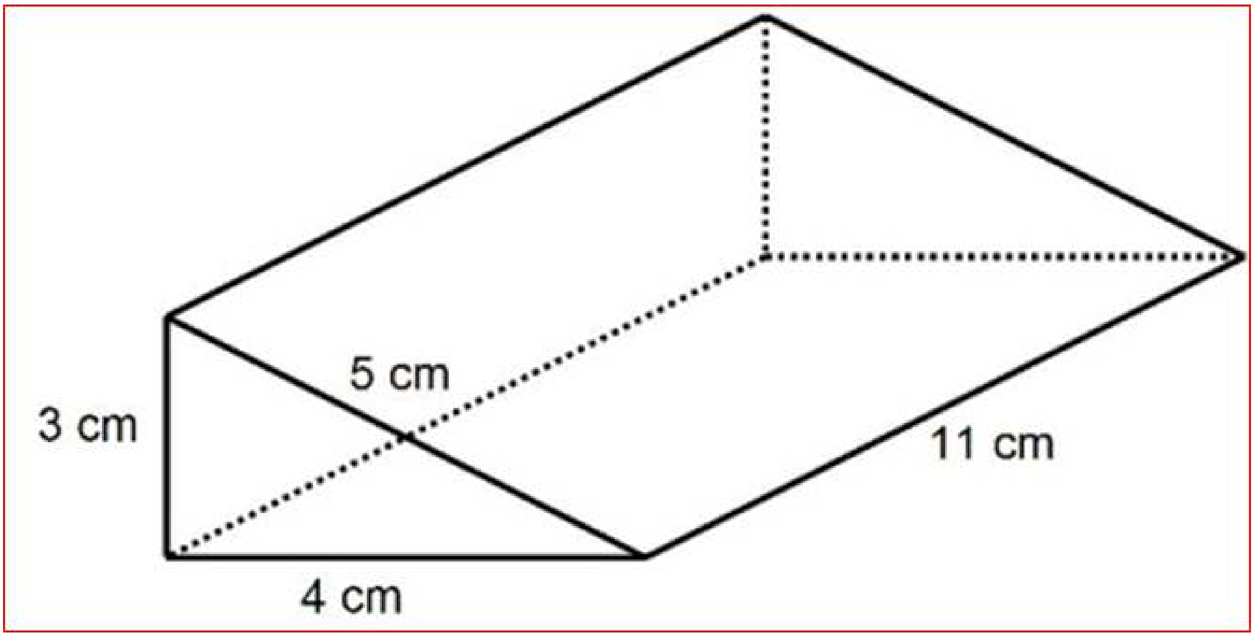
Measurements
Capacity and Volume



Measurement
Volume

Why is the volume of a prism equal to area of base multiplied by height

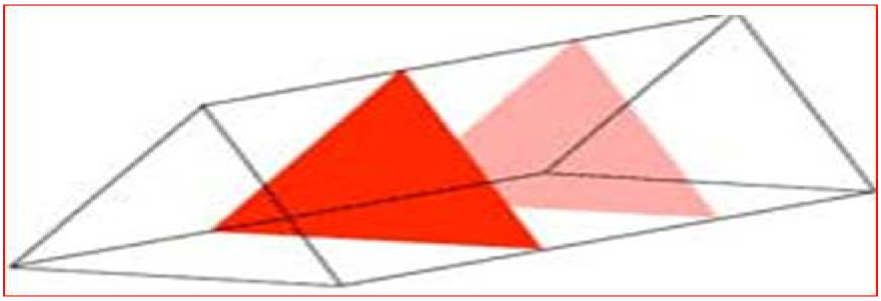




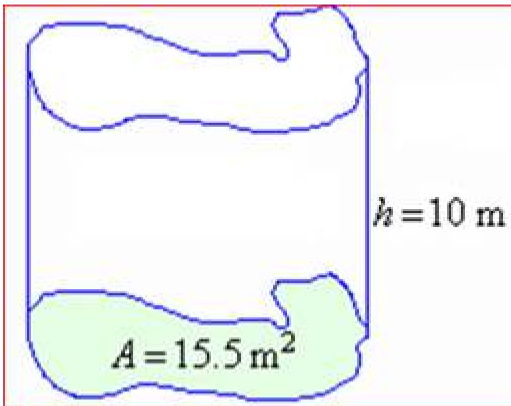
Develops the formulas for volumes of rectangular and triangular prisms and prisms in general.
Uses formulas to solve problems involving volume Cross section

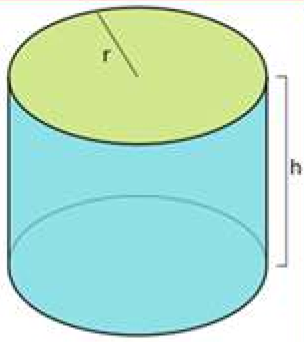
If you take a solid and slice it, then the face you create is called a cross-section and the area of the face is called the cross-sectional area.

A prism is a solid with **straight** sides which has the same cross-sections.



Volume of a prism = Area of base (cross section) x height





Volume = Area of base x height
= 15.5 x 10
= 155 m3

Volume = Area of base x height
= πr2 h

Calculates the surface area and volume of cylinders and solves related problems

Prism and Pyramid

Investigation

How many times can a pyramid fit into a prism, both with the same base and height?

$$\text{Volume of a pyramid} = \frac{1}{3}\ \text{Area of base} \times \text{height}$$

Solve problems involving surface area and volume of right pyramids, right cones, spheres and related composite solids

Self-check-1

Test-I Write True or False

Instruction: Write True or False for the give question. You have given 1 Minute for each question. Each question carries 2 Point.

1. Folding rules is un instrument used for set out or check lines which are at right angle (90 degrees) to each others?
2. A street Edge a straight un instrument used for transcribing straight lines, or checking the straightness of lines?
3. Sprite level is used to check whether the surfaces are level (horizontal) or plumb (vertical)?

Test-II choose

Instruction: select the correct answer for the give choice. You have given 1 Minute for each question. Each question carries 2 Point.

4. ———— is an instrument shaped like a semicircle marked with degrees of a circle, used to measure or mark out angles.
   A. Set square
   B. Try square
   C. Protractor
   D. Sprite level
5. Which one of the following instrument is used for measuring the diameter of a bar?

A. Folding Rulers C. Protractor

B. Scales D. verner caliper

Test-III Matching

Instruction: select the correct answer for the give choice. You have given 1 Minute for each question. Each question carries 2 Point.

A	B
1. Accuracy	A. The degree of the closeness to a repeatedly measured quantity
2. Reproducibility	B. The ratio of the magnitude
3. Sensitivity	C. The degree of the closeness to the true value

Test IV: Short answer writing

Instruction: Give short answer to the following questions. Time allotted for each item is 2mniut and each question carry 4 point.

1. What is measurement?
2. Identify measuring tools?
3. What is the use of Combination gauge?
4. What are the purposes of measurement?

Unit Two: Carry out measurements and calculation

This unit to provide you the necessary information regarding the following content coverage and topics:

- Geometrical Shape Measurement and Calculation
- Measurements and calculations
- Fractions, percentages and mixed numbers
- Numerical computation
- Reading instruments
- Measurement systems
- Measuring work pieces

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Accurate measurements and calculation
- Measure five separate task with in 1mm accuracy using tape or ruler
- Perform numerical computation
- Read instruments
- Converting measurement systems
- Measuring work pieces

2.1. Geometrical Shape Measurement and Calculation

2.1.1. **Performing calculations**

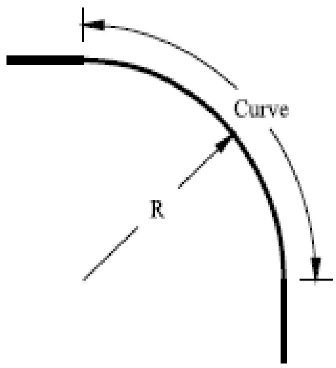
- **Lengths**

Definition = the standard unit for length is the **meter** (m). For shorter lengths **centimeter** (1m = 100cm) is again subdivided into **millimeters** (1cm = 10mm). For longer distances however, **kilometer** (1000m = 1km) is used.

Conversion:

	mm	cm	m	km
1mm	1	0.1	0.001	0.000001
1cm	10	1	0.01	0.00001
1m	1,000	100	1	0.001
1km	1,000,000	10,000	1,000	1

- **Width:** The width of a road, or the layers of a road, is normally given in meters (m).
- **Thickness:** The thickness of a layer in a road, the thickness of the surface or the thickness of concrete work is given in millimeters (mm). (1 000 mm = 1 m)
- **Radius:** Straight sections of a road are joined with curves; the radius (R) of a curve on a road is given in meters (m).

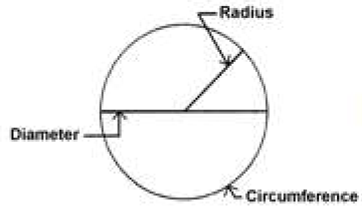


NB. Diameter is two times radius

- **Circle**

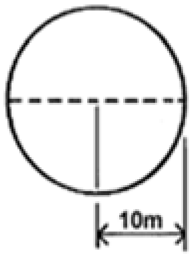
The circumference of a circle is ð times the diameter. The area of a circle is ð times the square of the radius where ð = 3 1/7 or 3.142

Area of a Circle



Area of a circle = δr²
Radius r = 1/2 diameter

Example: Calculate the area and circumference of the given circle:



Radius = 10m
δ = 3.142
Area = δr²
= 3.142 x 10 x 10
= 314.2m²

Circumference of a Circle

Circumference = δ x diameter = δ r²

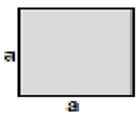
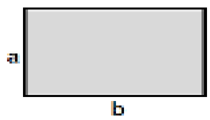
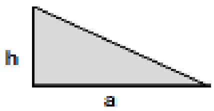
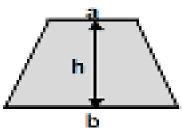
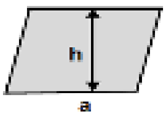
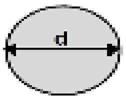
Example = 3.142 x 2 x 10

= 62.84m

- **Area**

The unit of measurement for an area is in square meter (m2).

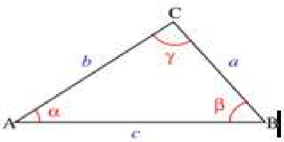
Calculations for areas:

	square: a x a		rectangle: a x b
	triangle: $\frac{a \times h}{2}$		trapezoid: $\frac{a + b}{2} \times h$
	rhombus: a x h		circle: area = $\frac{d^2 \times \pi}{4}$ circumference = d x π

Trigonometric functions

Knowing SAS: Using the labels in the image on the left, the altitude is h = a sin γ. Substituting this in the formula Area = ½bh derived above, the area of the triangle can be expressed as:

$$\text{Area} = \frac{1}{2}ab\sin\gamma = \frac{1}{2}bc\sin\alpha = \frac{1}{2}ca\sin\beta$$



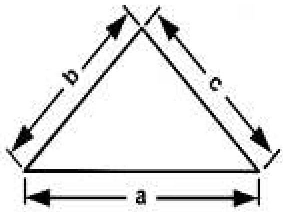
(where α is the interior angle at A, β is the interior angle at B, γ is the interior angle at C and c is the line AB).

Using Heron's Formula

The shape of the triangle is determined by the lengths of the sides alone. Therefore the area can also be derived from the lengths of the sides.

$$\text{Area} = \sqrt{s(s-a)(s-b)(s-c)}$$

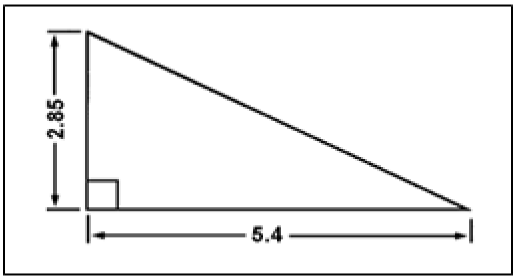
$$s = \frac{a+b+c}{2}$$



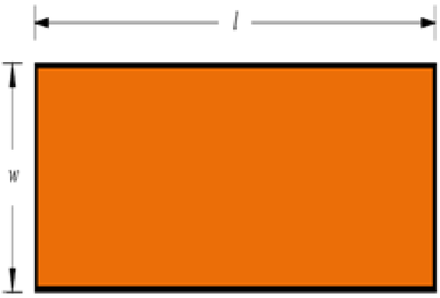
Where is the semi perimeter, or half of the triangle's perimeter?

Example 1 Given base and altitude.
Area = ½ Base x Altitude (0.5 ba)
Or = 0.5 Base x Altitude (0.5 ba)
Base = 5.4
Alt = 2.85

1/2 Base x Alt	or 0.5 Base x Alt
½ x 5.4 x 2.85	or 0.5 x 5.4 x 2.85
½ x 15.39	or 0.5 x 15.39m
Area = 7.695m²	= 7.695m²



- **Rectangle**

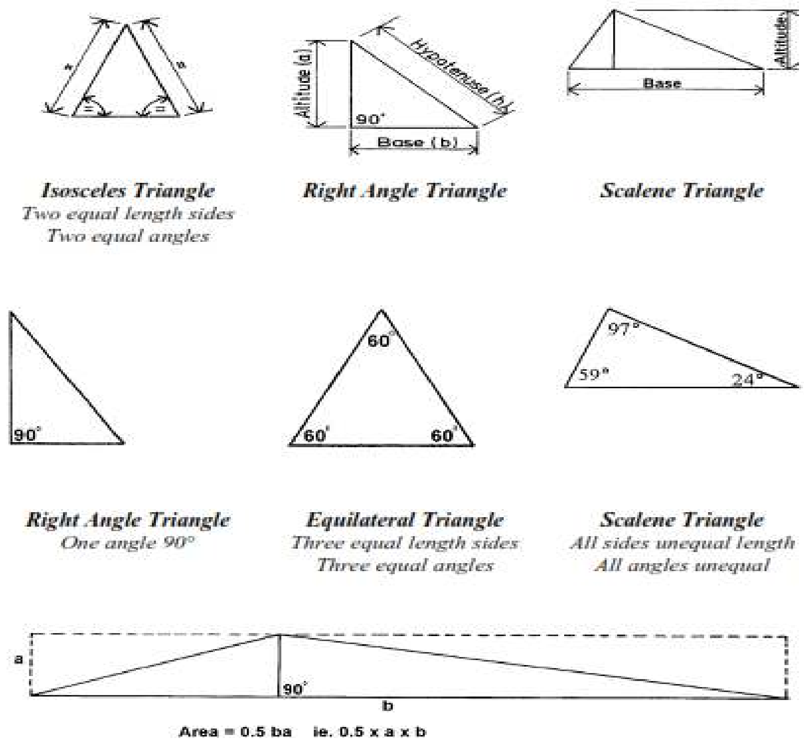


The area of a section of road is normally rectangular in shape and the area is obtained by multiplying the length of the road by the width of the road. The unit used for *l* and *w* must be the same (normally both are expressed in meters (m).

For example: if floor, that is 4m long by 3m wide, is to be compacted, then the area to be compacted is:

5km* 7m or 5000m * 7m = 35000 m²

- **Triangle**



Notice how the area of a triangle is exactly half that of a rectangle having the same base and altitude.

- **VOLUMES**

Definition = 1m3 is the volume of a cube where each side is 1m. Volumes are calculated by multiplying a base area (m2) with a third dimension.

The calculation of volumes is the most common calculation for road construction work. This is required to develop the bill of quantities, then to measure work for actual construction purposes (estimating resource requirements and time to complete work, material requirements, etc.), and finally to measure the completed work items.

a. Volume of material

The most frequently used unit of measurement for volume is the cubic metre (m^3). This term is mostly encountered in determining the amount of material to be:

- Excavated
- Used in the construction and compaction of a layer

- Carted away

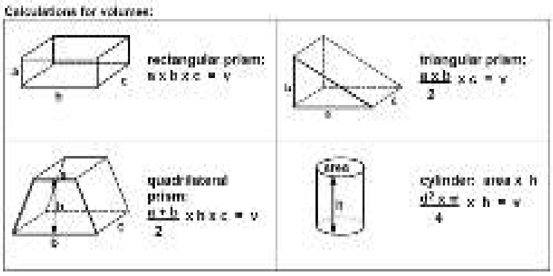
The volume of compacted material in a road layer is obtained by multiplying the thickness of the layer (t) by the width of the layer (w) by the length of the layer (l). The problem here is that the length could be in km, the width in m, and the thickness in mm. They must all be brought to the same unit, normally meters to give a volume in m3 (cubic meters).

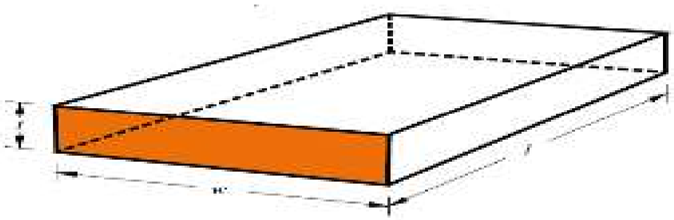
b. Volume of liquids

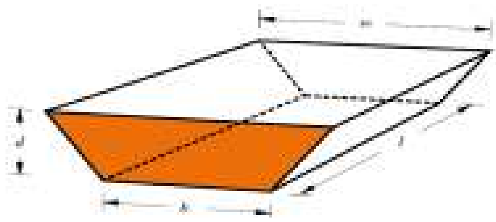
The volume of liquid is normally measured in liters (l). The term is encountered in determining the amount of Water.

Relationship between the various units of volume:

	cm^3	dm^3 1 litre	m3
$1cm^3$	1	0.001	0.000001
$1dm^3$	1000	1	0.001
$1m^3$	1,000,000	1,000	1







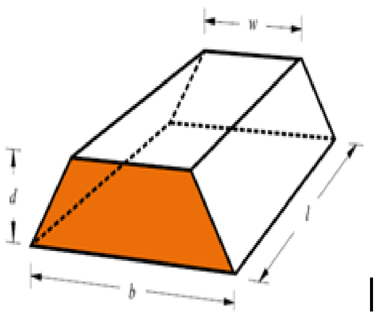
The amount of material to be excavated from a drain of the shape above is:

$$1/2(w + b)\ l \times d$$

Again all the measurements must be brought to the same units, usually meters, giving a volume of material in m3 (cubic meters).

c. Volume of material in a fill or embankment

A fill or embankment is, in effect, an upside down excavation; and the amount of fill material is calculated in the same way as the amount of excavated material.



The amount of material in a fill or embankment of the shape above is: 1/2(*w* + *b*) lxd

Again all the measurements must be brought to the same units, usually meters, giving a volume of material in m3 (cubic meters).

- **Weight**

Definition = 1 kilogram (kg) is the weight of one cubic decimeter (dm3) or one liter of water with a temperature of 4° C. Other units commonly used in construction are: gram (g) and tone (t).

Relationship between the various units of volume:

	gram	kilogram	tonne
1g	1	0.001	0.000001
1kg	1,000	1	0.001
1t	1,000,000	1000	1

- **Capacity**

Definition= 1 liter of water is the volume of water contained in one cubic decimeter (dm3) at 4°C

$1dm^3$ = 1 litre	$1m^3$ = 1000 litre	1 litre = $0.001m^3$

Relationship between volume, capacity and weight (of water):

$1dm^3$ = 1 litre = 1kg	$1m^3$ = 1000 litre = 1tonne	1 litre = $0.001m^3$ = 0.001tonne

Weight of Water:

$1m^3$ water weight = 1000 kg

$1dm^3$ water weight = 1 kg

1 cm^3 water weight = 1 gram

- **Density**

Definition= weight in kg per m3 volume in normal processed condition of the material

	kg/m³		kg/m³
Steel and Iron	7800	Stone for masonry work (dense)	2500-3000
Aluminium	2700	Stone for masonry work (porous)	2200-2500
Copper	8900	Building Sand (natural moisture)	1900-2100
Lead	11,3400	Building Sand (dry)	1800-2000
		Gravel (clean, without fines)	1500-1800
Wood	400 - 800	Cohesive Soil	1800-2000
Hardwood	700-1000	Heavy Clay	1800-2000
Asphalt	1600-2000	Cement or Lime Mortar	1900-2100
Bitumen	1100	Cement (loose)	1200-1400
		Lime (loose)	900-1300
Cement Stone Wall (with mortar)	1800-2000		
Lime Stone Wall (with mortar)	1600-2000	Concrete with reinforcement	2300-2500
Brick Wall (with mortar)	1300-1500		
Masonry wall (with mortar)	2000-2200	*Water*	*1000*

- **Perimeter**

Perimeter is the distance around a two dimensional shape, or the measurement of the distance around something; the length of the boundary. A perimeter is a path that surrounds an area. The word comes from the peri (around) and meter (measure). The term may be used either for the path or its length - it can be thought of as the length of the outline of a shape. The perimeter of a circular area is called circumference.

Basic mathematics

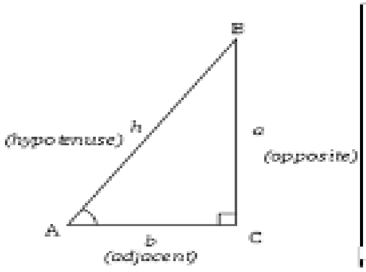
a. Trigonometric ratios

There are various standard methods for calculating the length of a side or the size of an angle. Certain methods are suited to calculating values in a right-angled triangle; more complex methods may be required in other situations.

A right triangle always includes a 90° ($\pi/2$ radians) angle, here with label C. Angles A and B may vary. Trigonometric functions specify the relationships among side lengths and interior angles of a right triangle.

In right triangles, the trigonometric ratios of sine, cosine and tangent can be used to find unknown angles and the lengths of unknown sides. The sides of the triangle are known as follows:

- The adjacent side is the side that is in contact with the angle we are interested in and the right angle, hence its name. In this case the adjacent side is **b**.



- The *hypotenuse* is the side opposite the right angle, or defined as the longest side of a right-angled triangle, in this case **h**.
- The *opposite side* is the side opposite to the angle we are interested in, in this case **a**.

The sine of an angle is the ratio of the length of the opposite side to the length of the hypotenuse. In our case

$$\sin A = \frac{\text{opposite side}}{\text{hypotenuse}} = \frac{a}{h}.$$

Note that this ratio does not depend on the particular right triangle chosen, as long as it contains the angle A, since all those triangles are similar.

The cosine of an angle is the ratio of the length of the adjacent side to the length of the hypotenuse. In our case

$$\cos A = \frac{\text{adjacent side}}{\text{hypotenuse}} = \frac{b}{h}.$$

The tangent of an angle is the ratio of the length of the opposite side to the length of the adjacent side. In our case

$$\tan A = \frac{\text{opposite side}}{\text{adjacent side}} = \frac{a}{b} = \frac{\sin A}{\cos A}.$$

b. Inverse functions

The inverse trigonometric functions can be used to calculate the internal angles for a right angled triangle with the length of any two sides.

Arc sin can be used to calculate an angle from the length of the opposite side and the length of the hypotenuse

$$\theta = \arcsin\left(\frac{\text{opposite side}}{\text{hypotenuse}}\right)$$

Arc cos can be used to calculate an angle from the length of the adjacent side and the length of the hypotenuse.

$$\theta = \arccos\left(\frac{\text{adjacent side}}{\text{hypotenuse}}\right)$$

Ar ctan can be used to calculate an angle from the length of the opposite side and the length of the adjacent side.

$$\theta = \arctan\left(\frac{\text{opposite side}}{\text{adjacent side}}\right)$$

In introductory geometry and trigonometry courses, the notation $\sin^{-1}$, $\cos^{-1}$, etc., are often used in place of arcsin, arccos, etc. However, the arcsin, arccos, etc., notation is standard in higher mathematics where trigonometric functions are commonly raised to powers, as this avoids confusion between multiplicative inverse and compositional inverse.

b.Sine, Cosine and Tangent Rules

The law of sines, or sine rule, states that the ratio of the length of a side to the sine of its corresponding opposite angle is constant, that is

$$\frac{a}{\sin\alpha} = \frac{b}{\sin\beta} = \frac{c}{\sin\gamma}.$$

This ratio is equal to the diameter of the circumscribed circle of the given triangle. Another interpretation of this theorem is that every triangle with angles α, β and γ is similar to a triangle with side lengths equal to sinα, sinβ and sinγ. This triangle can be constructed by first constructing a circle of diameter 1, and inscribing in it two of the angles of the triangle. The length of the sides of that triangle will be sinα, sinβ and sinγ. The side whose length is sinα is opposite to the angle whose measure is α, etc.

The law of cosines, or cosine rule, connects the length of an unknown side of a triangle to the length of the other sides and the angle opposite to the unknown side. As per the law:

For a triangle with length of sides a, b, c and angles of α, β, γ respectively, given two known lengths of a triangle a and b, and the angle between the two known sides γ (or the angle opposite to the unknown side c), to calculate the third side c, the following formula can be used:

$$c^2 = a^2 + b^2 - 2ab\cos(\gamma)$$

$$b^2 = a^2 + c^2 - 2ac\cos(\beta)$$

$$a^2 = b^2 + c^2 - 2bc\cos(\alpha)$$

If the lengths of all three sides of any triangle are known the three angles can be calculated:

$$\alpha = \arccos\left(\frac{b^2 + c^2 - a^2}{2bc}\right)$$

$$\beta = \arccos\left(\frac{a^2 + c^2 - b^2}{2ac}\right)$$

$$\gamma = \arccos\left(\frac{a^2 + b^2 - c^2}{2ab}\right)$$

The law of tangents or tangent rule, is less known than the other two. It states that:

$$\frac{a-b}{a+b} = \frac{\tan[\frac{1}{2}(\alpha - \beta)]}{\tan[\frac{1}{2}(\alpha + \beta)]}.$$

It is not used very often, but can be used to find a side or an angle when you know two sides and an angle or two angles and a side.

c. **Algebraic computations**

The Pythagorean Theorem: The sum of the areas of the two squares on the legs (a and b) equals the area of the square on the hypotenuse (c). The Pythagorean equation provides a simple relation among the three sides of a right triangle so that if the lengths of any two sides are known, the length of the third side can be found. Another corollary of the theorem is that in any right triangle, the hypotenuse is greater than any one of the legs, but less than the sum of them.

The theorem can be written as an equation relating the lengths of the sides a, b and c, often called the Pythagorean equation:

$$a^2 + b^2 = c^2$$

Where c represents the length of the hypotenuse, and a and b represent the lengths of the other two sides.

If the length of both a and b is known, then c can be calculated as follows:

$$c = \sqrt{a^2 + b^2}.$$

If the length of hypotenuse c and one leg (a orb) are known, the length of the other leg can be calculated with the following equations:

$$a = \sqrt{c^2 - b^2}.$$ or

$$b = \sqrt{c^2 - a^2}.$$

d. Fractions

If there are 2 oranges and 3 apples, the ratio of oranges to apples is 2:3, whereas the fraction of oranges to the total fruit is 2/5.

If orange juice concentrate is to be diluted with water in the ratio 1:4, then one part of concentrate is mixed with four parts of water, giving five parts total; the fraction of concentrate is 1/5 and the fraction of water is 4/5.

Number of Terms, In general, when comparing the quantities of a two-quantity ratio, this can be expressed as a fraction derived from the ratio. For example, in a ratio of 2:3, the amount/size/volume/number of the first quantity will be $\frac{2}{3}$ that of the second quantity. This pattern also works with ratios with more than two terms. However, a ratio with more than two terms cannot be completely converted into a single fraction; a single fraction represents only one part of the ratio since a fraction can only compare two numbers. If the ratio deals with objects or amounts of objects, this is often expressed as "for every two parts of the first quantity there are three parts of the second quantity".

e. Percentages

Percent (%) means out of 100. For example, 10% means 10 out of 100. To find a percentage of a number, multiply the number by the percent and divide by 100. For example: 20% of 300.00 Birr = 300.00 Birr x 20/100 = 60.00 Birr

Using a percentage

- To add on GST

Gross service tax(GST) of 10% needs to be added to the cost of all goods and services.

For example: How to do it direct labor costs for 4 hours work with rate of 30.00Birr/hour

4 * 30 Birr = 120.00Birr

GST on these labor costs = 10% of 120.00 Birr = 120.00Birr x 10 ÷100 = 12.00Birr

So direct labor costs including GST = 120.00 Birr + 12.00Birr = 132.00 Birr

- To add on additional costs

Profit might be charged at 15% of labor and material costs.

For example: Labor and material costs = 370.00 Birr

Profit = 15% of 370.00Birr

= 370.00Birr x 15/100

= 55.50Birr

Now add this to the labor and material costs:

= 370.00 Birr + 55.50Birr

= 425.50 Birr

- To take off a discount

Discount of 5% might be offered to a client for prompt payment. Work out the amount of the discount, then subtract it from the price.

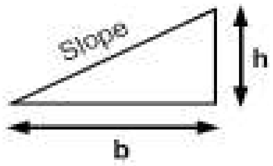
For example: Cost to client = 425.50Birr

5% discount = 425.50Birr x 5/100 = 21.28Birr

So cost after discount = 425.50Birr - 21.28Birr = 404.2Birr

SLOPES (as ratio and percentage)

Definition = the slope shows the steepness of an ascent or descent.



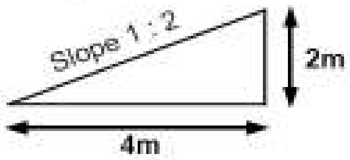
h = vertical distance
b = base = horizontal distance

$$\text{Slope} = \frac{\text{vertical distance}}{\text{horizontal distance}}$$

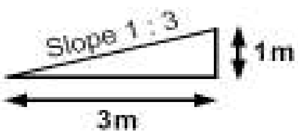
Slope calculation = slopes can be expressed as a ratio or in percentage.

Slope given as a ratio:

Examples



$$\text{Slope} = \frac{\text{vertical distance}}{\text{horizontal distance}} = \frac{2}{4} = \frac{1}{2} = 1 : 2$$

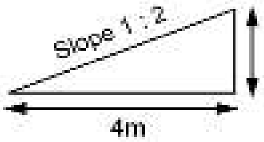


$$\text{Slope} = \frac{\text{vertical distance}}{\text{horizontal distance}} = \frac{1}{3} = 1 : 3$$

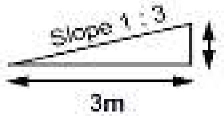
Note:
- The figure on top should always be the vertical distance and the figure below should always be the horizontal distance.

Slope given in **percentage (%):**
Any fraction (ratio) can be expressed in % by dividing the result by 100%.

Examples



$$\text{Slope} = \frac{\text{vertical distance}}{\text{horizontal distance}} \times 100\% = \frac{2}{4} \times 100\% = 50\%$$



$$\text{Slope} = \frac{\text{vertical distance}}{\text{horizontal distance}} \times 100\% = \frac{2}{3} \times 100\% = 33.33...\%$$

Formulas:

slope = height / base
height = base x slope
base = height / slope

PRESSURE

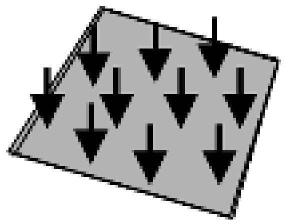
Pressure is defined as the distributed force (F) acting on an area (A). The standard unit for pressure is Pasqual (Pa)

Pressure:

P = $\frac{\textbf{Force}}{\textbf{Area}}$ $\frac{\textbf{F}}{\textbf{A}}$

F is measured in Newton (N)

A is usually measured in m^2 or in cm^2



However, force measured in Newton is not a value we easily recognize in daily life. To fact that one liter (or 1000 cm3) of Water weighs 1kg. Hence a 10 meter water column produces a force of 1kg per every cm^2.

Intensity of pressure and total pressure

Intensity of pressure is the force created (kPa) by the weight of a given mass of water acting on a unit area (m2). Total pressure is the intensity of pressure multiplied by the area acted on.

Perimeter The perimeter is the total length of the sides or outer boundary of a plane figure.

Example The perimeter of a shape is the total length of the sides. Refer to Figure below. The perimeter of this building is the total length of ALL the sides.

6000 + 10 000 + 4 000 + 4 000 + 2000 + 6 000

Perimeter = 32 000

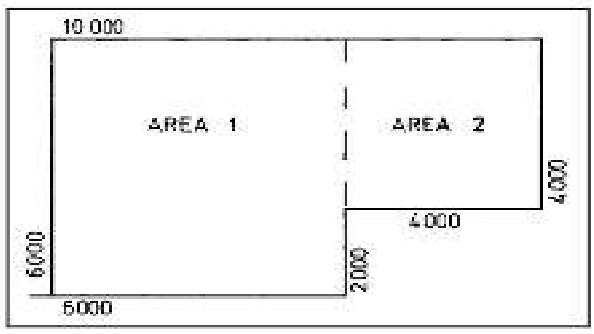


Figure : Plan Of An L-Shaped Building

Area

Area is the extent of a surface or the amount of ground covered by a building. Area is measured in square meters and in the case of a rectangular shape is found by multiplying the length by the breadth (or depth) of the building. Refer to Figure 6. Because this is an L shaped building you must first divide it into two simple rectangles. See the dotted line.

For general use area is always given in m therefore it is easier if you convert the dimensions into meters prior to calculating the area.

i.e 6 000 = 6.0

10 000 = 10.0

4 000 = 4.0

Area 1 = 6.0 x 6.0 = 36m

Area 2 = 4.0 x 4.0 = 16m

Total Area = 36 +16 = 52m

2.2. Measurement and Calculation

For each type of measurement, there is a particular measuring instrument which is most suitable to do the job. It will be impossible to list all the possible measuring instruments, thus we will look at the most common instruments and welcome your knowledge and experience to enhance understanding of this unit.

2.2.1. Rulers

A ruler that is in good condition is a practical instrument for measuring shorter, straight lines (linear lines). We can measure millimetres and centimetres with a ruler. A ruler is not suitable to measure long lengths and round shapes. **Figure 2.1** below present the typical type of ruler used for measurement.

Figure 2.1.Rurle

2.2.2. Venire Caliper

The venire caliper is used to make semi- accurate measurements for inside, outside and depth dimensions. Standard venire calipers are available in sizes 150mm to 250mm. Custom- made vernier calipers can be made to specifications if required. Graduations, (that determine the accuracy of the instrument) are usually 0,02mm or 0,05mm on the venire scale.

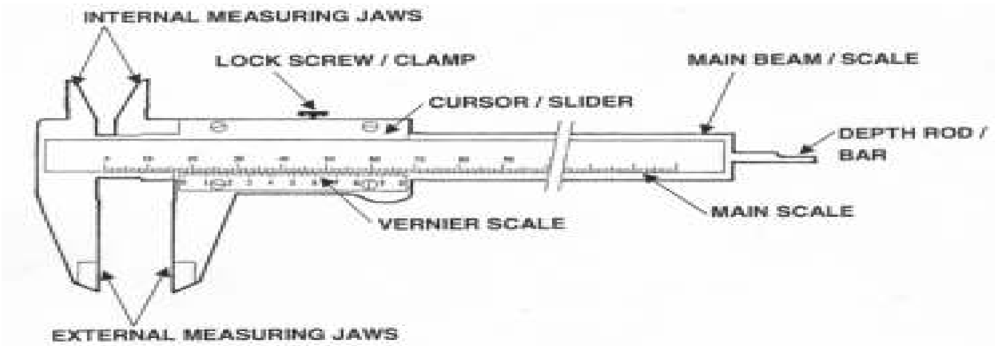


Figure 2.3. The venire caliper

2.2.3. Measuring Tape

A measuring tape is used when a ruler is too short to measure the distance or length. We use the measuring tape to measure short distances in meters. Measuring tapes are usually gradated in millimetres, centimetres and meters.

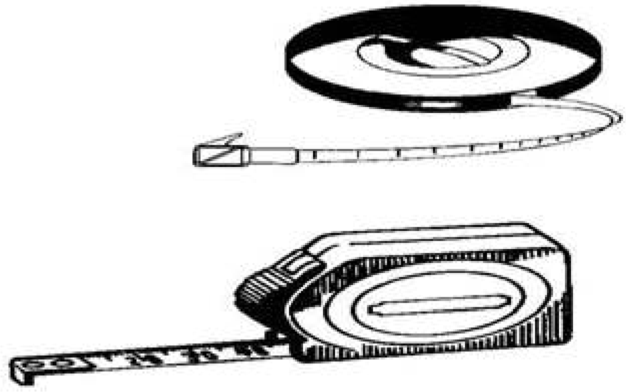


Figure 2.3.The different types of tapes

2.2.4. Pen or Pencil

To record your measurements you will need to use a pen or a pencil.Make a rough sketch of what you are measuring and write the dimensions on this. Label your sketch so you know what it refers to.

2.2.5. Calculator

These days most people use a calculator to help them measure. It can be used to work out complex calculations or just simple daily addition and subtraction. Calculators vary from simple to complex. Some even have more than one line of information. If you decide to use a calculator, we suggest that you use a standard calculator rather than one in your clipboard or mobile phone.

Standard calculators are easier to use. They are generally bigger, the numbers are easier to view and all the keys are available all the time!

Figure 2.4.The different features of capacitor as measuring Equipment

2.3. Fractions, percentages, ratio and mixed numbers

Continue exploring rational numbers, working with an area model for multiplication and division with fractions, and examining operations with decimals. Explore percent's and the relationships among representations using fractions, decimals, and percent's. Examine benchmarks for understanding percent's, especially percent's less than 10 and greater than 100. Consider ways to use an elastic model, an area model, and other models to discuss percent's. Explore some ratios that occur in nature.

- **Fraction**

If there are 2 oranges and 3 apples, the ratio of oranges to apples is 2:3, whereas the fraction of oranges to the total fruit is 2/5.

If orange juice concentrate is to be diluted with water in the ratio 1:4, then one part of concentrate is mixed with four parts of water, giving five parts total; the fraction of concentrate is 1/5 and the fraction of water is 4/5.

- **Number of Terms**

In general, when comparing the quantities of a two-quantity ratio, this can be expressed as a fraction derived from the ratio. For example, in a ratio of 2:3, the amount/size/volume/number of the first quantity will be $\frac{2}{3}$ that of the second quantity. This pattern also works with ratios with more than two terms. However, a ratio with more than two terms cannot be completely converted into a single fraction; a single fraction represents only one part of the ratio since a fraction can only compare two numbers. If the ratio deals with objects or amounts of objects, this is often expressed as "for every two parts of the first quantity there are three parts of the second quantity".

- **Percentages**

What is percentage?

Percent (%) means out of 100. For example, 10% means 10 out of 100.

Finding a percentage

To find a percentage of a number, multiply the number by the percent and divide by 100.

For example:

20% of $300.00= $300.00 x 20 □□100

= $60.00

Using a percentage

To add on GST

GST of 10% needs to be added to the cost of all goods and services.

For example:

How to do it Direct labor costs for 4 hours work @ $30.00/hour = $120.00

GST on these labor costs = 10% of $120.00 = $120.00 x 10 ÷□100 = $12.00

So direct labor costs including GST = $120.00 + $12.00 = $132.00

To add on additional costs

Profit might be charged at 15% of labor and material costs.

For example:

How to do it Labor and material costs = $370.00

Profit = 15% of $370.00

= $370.00 x 15 □□100

= $55.50

Now add this to the labor and material costs:

= $370.00 + $55.50

= $425.50

To take off a discount

Discount of 5% might be offered to a client for prompt payment.

Work out the amount of the discount, then subtract it from the price.

For example: How to do it

Cost to client = $425.50

5% discount = $425.50 x 5 □□100 = $21.28

So cost after discount = $425.50 - $21.28 = $404.2

2.4. Numerical computation

<u>Numbers and symbols</u>

The expression of numerical quantities is something we tend to take for granted. This is both a good and a bad thing in the study of electrical/electronics. It is good, in that we're accustomed to the use and manipulation of numbers for the many calculations used in analyzing electrical/electronic circuits. On the other hand, the particular system of notation we've been taught from grade school onward is *not* the system used internally in modern electronic computing devices, and learning any different system of notation requires some re-examination of deeply ingrained assumptions.

First, we have to distinguish the difference between numbers and the symbols we use to represent numbers. A *number* is a mathematical quantity, usually correlated in electrical/electronics to a physical quantity such as voltage, current, or resistance. There are many different types of numbers. Here are just a few types, for example:

WHOLE NUMBERS:

1, 2, 3, 4, 5, 6, 7, 8, 9 . . .

INTEGERS:

-4, -3, -2, -1, 0, 1, 2, 3, 4 . . .

IRRATIONAL NUMBERS:

Π (approx. 3.1415927), *e* (approx. 2.718281828),

Square root of any prime number.

REAL NUMBERS:

(All one-dimensional numerical values, negative and positive,

Including zero, whole, integer, and irrational numbers)

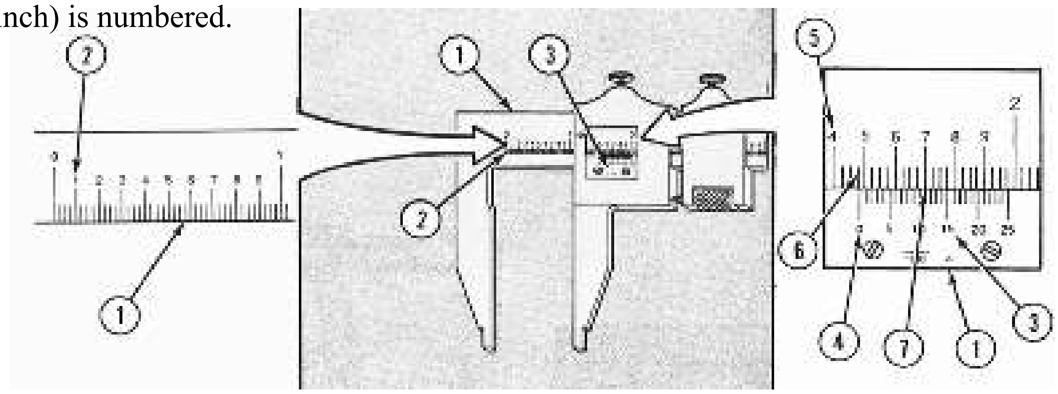
COMPLEX NUMBERS:

3 - J4, 34.5 ∠ 2

2.5. Reading instruments

2.5.1. READING A METRIC CALIPER

To read a veneer caliper, you must be able to understand both the steel rule and veneer scales. The steel rule (1) is graduated in 0.025 of an inch. Every fourth division (2) (representing a tenth of an inch) is numbered.



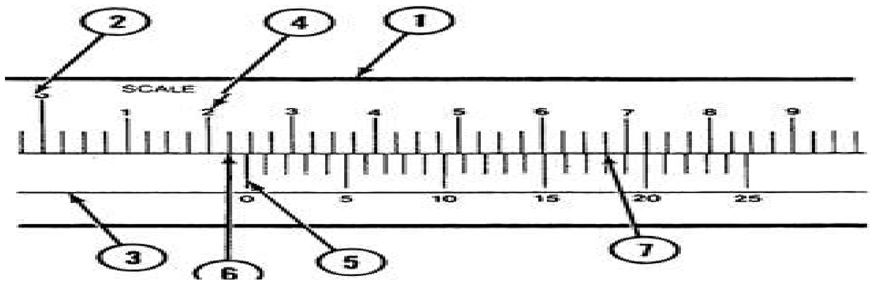
The veneer scale (3) is divided into 25 parts and numbered 0, 5, 10, 15, 20, and 25. These 25 parts are equal to 24 parts on the steel rule (1). The difference between the width of one of the 25 spaces on the veneer scale (3) and one of the 24 spaces on the steel rule (1) is 1/1000 of an inch.

2.5.2. Read the measurement as shown above.

1) Read the number of whole inches on the top scale (1) to the left of the veneer zero index (4) and record. …. 1.000 inch Read the number of tenths (5) to the left of the veneer zero index (4) and record. ……. .0.400 inch
2) Read the number of twenty-fifths (6) between the tenths mark (5) and the zero index (4) and record. .3 X .025 = .075 inch
3) Read the highest line on the veneer scale (3) which lines up with the lines on the top scale (7) and record. (Remember1/25 = .001 inches) . . . . 11/25 or 0.011 inch TOTAL 1.486 inches

Most veneer calipers read OUTSIDE on one side and INSIDE on the other side. If a scale isn't marked, and you want to take an inside measurement, read the scale as you would for an outside diameter. Then add the measuring point allowance by referring to manufacturer's instructions or the following table.

Size of Caliper	English Measure	Metric Measure
6 inch or 150 mm	Add 0.250 inch	Add 6.35 mm
12 inch or 300 mm	.300 inch	7.62 mm
24 inch or 600 mm	.300 inch	7.62 mm
36 inch or 600 mm	.500 inch	12.70 mm



The steel rule (1) is divided into centimeters (cm) (2) and the longest lines represent 10 millimeters each. Each millimeter is divided into quarters.

The veneer scale (3) is divided into 25 parts and is numbered 0, 5, 10, 15, 20 and 25.

1) Read the total number of millimeters (4) to the left of the veneer zero index (5) and record .32.00 mm

2) Read the number of quarters (6) between the millimeter mark and the zero indexes and record . . . 25 mm = (1 quarter)

3) Read the highest line on the veneer scale (3) which lines up with the line on the scale (7) and record............................18 mm TOTAL 32.43 mm

2.5.3. CARE OF CALIPERS

1. Store calipers in separate containers provided.
2. Keep graduations and markings on all calipers clean and legible.
3. Do not drop any caliper. Small nicks or scratches can cause inaccurate measurements.
4. Protect caliper points from damage

2.5.4. Measurement and reading with ruler or tape

Taking accurate measurements does not stop with following the correct procedures for weighing or measuring an infant or child. One of the greatest sources of error in taking anthropometric measurements takes place during the reading and recording of a measurement. If the height or

Weight is read incorrectly or an error is made when recording the measurement, the result will be inaccurate. Therefore, it is important to use care in reading and recording measurements.

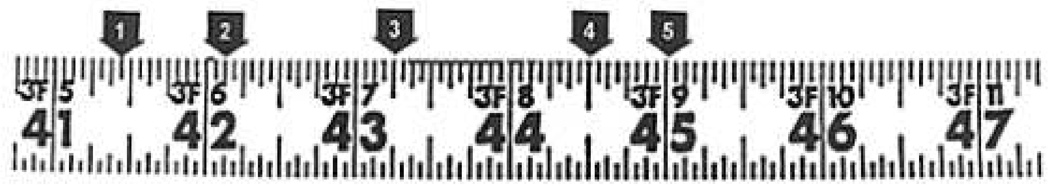


Figure 2.4 Consideration while measuring with tape

Measurements can be difficult to read. The reading area of the measuring tape on most height measuring boards is usually in English units (inches and feet). Some measuring instruments may have both English and metric units. Read the English units only. Be sure to read the measurement in the correct area on your board. Find out where measurements should be read on your board.

If you need to measure using a ruler, you will place the 0cm measurement at the start of the line and read the measurement at the end of the line on the comparative point on the ruler.

In engineering, we use millimeters as the common measurement. Centimeters are more often used for domestic purposes.

- Take care when reading measurements:
- ensure that you have placed the 0mm exactly on the pre-determined point
- ensure that you have a square view of the measurement

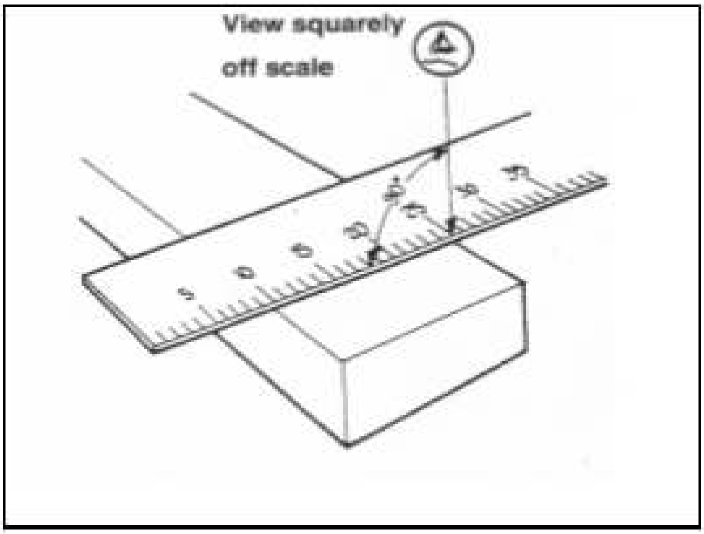


Figure 2.5Rurle common measurement tool for measuring short length

2.6. Measurement systems

Identifying and converting Systems of measurement

THE METRIC SYSTEM

The metric system or SI (International System) is the most common system of measurements in the world, and the easiest to use. The base units for the metric system are the units of:

- length, measured in meters (m);
- time, measured in seconds (s);
- mass, measured in grams (g); and
- Temperature, measured in Celsius (°C).

In the metric system, prefixes are used to describe multiples or fractions of the base units. The most common metric system prefixes are:

- nano (n) .... / 100,000,000
- micro (µ) .... / 1,000,000
- milli (m) .... / 1,000
- centi, (c) .... / 100
- deci (d) .... / 10

- deca (da).....................................x 10
- hecto (h) ....x 100
- kilo (k)...................................x 1,000
- mega (M)........................x 1,000,000
- giga (G) ....x 1,000,000,000

Using the base unit for length:

- 1 nanometer (nm) = 1 m / 100,000,000 = 0.000 000 001 m
- 1 micrometer (µm) = 1 m / 1,000,000 = 0.000 001 m
- 1 millimeter (mm) = 1 m / 1,000 = 0.001 m
- 1 centimeter (cm) = 1 m / 100 = 0.01 m
- 1 decimeter (dm) = 1 m / 10 = 0.1 m
- 1 decameter (dam) = 1 m x 10 = 10 m
- 1 hectometer (hm) = 1 m x 100 = 100 m
- 1 kilometer (km) = 1 m x 1,000 = 1,000 m
- 1 mega meter (Mm) = 1 m x 1,000,000 = 1,000,000 m
- 1 gig meter (Gm.) = 1 m x 1,000,000,000 = 1,000,000,000 m

Similarly for mass, you will often see the following units:

- 1 milligram (mg) = 1 g / 1,000 = 0.001 g
- 1 kilogram (kg) = 1 g x 1,000 = 1,000 g

The Imperial System

The Imperial system is more complicated than the metric system, as it does not work in multiples of 10 as the metric system does. The Imperial system is used in England and the United States, and you will probably recognize many of the units used.

In the Imperial system the base units are:

- length, commonly measured in inches (in), feet (ft.), yards and miles;
- time, commonly measured in seconds (s), hours (hr.), days (d), weeks and years (yr.);
- weight, commonly measured pounds (lb.); and
- Temperature, measured in Fahrenheit (°F).

Note that the Imperial system commonly uses weight, rather than mass. Weight refers to the gravitational pull on an object, whereas mass refers to the amount of matter in the object. An object would have the same mass on the moon as it does on the earth, but it would weigh less on the moon as the gravitational pull of the moon is less than the gravitational pull of the earth. Astronauts have the same mass on the moon as they do on the earth, but they can jump higher on the moon because they weigh less there! This difference does not affect us much as all the problems we will be solving assume we are on the earth, but you should be aware of it.

Converting Systems of measurement

Conversions between the common units of length used in the Imperial system are listed below

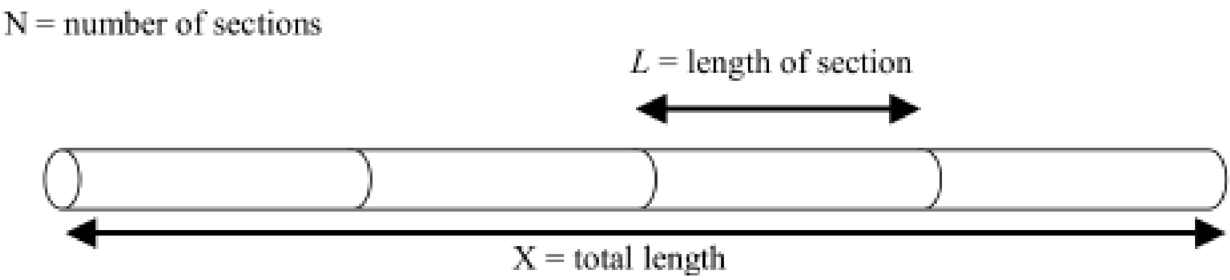
- 12 in = 1 ft.
- 3 ft. = 1 yard
- 1760 yards = 1 mile

The units of time are generally accepted for use with the metric system, as well as the Imperial system. Conversions between the common units of time are listed below:

- 60 s = 1 min
- 24 hrs. = 1 day
- 7 days = 1 week
- 52 weeks = 1 yr.

Conversion between Metric and Imperial

LENGTH



Units of Measurement:

Metric (SI):

Mm = millimeters

cm = centimeters

m = meters

Km = kilometers

Imperial:

in. = inches

ft. = feet

yards

miles

Conversion:

Metric (SI):

1 cm = 10 mm

cm x 10 = mm

Mm x 0.1 = cm

1 m = 100 cm

m x 100 = cm

cm x 0.01 = m

Metric to Imperial (and back):

1 in = 2.54 cm

cm x 0.393 7 = inches

inches x .54 = cm

1 ft = 30.48 cm

cm x 0.032 8 = feet

feet x 30.48 = cm

1 m = 1 000 mm
m x 1 000 = mm
Mm x 0.001 = m
1 km = 1 000 m
Km x 1 000 = m
m x 0.001 = km

1 m = 3.281 ft
m x 3.281 = feet
feet x 0.304 8 = m
1 mile = 1.609 km
km x 0.621 4 = miles
miles x 1.609 = km

Units of Measurement for Area:

Metric (SI):

m2= square meters
Ha = hectares

Imperial:

ft2= square feet = ft. sq.
square yards
Acres

Conversion:

Metric (SI):

1 m^2= 10 000 cm^2
M2 x 10 000 = cm^2
Cm2 x 0.000 1 = m^2
1 ha = 10 000 m^2
Ha x 10 000 = m^2
M2 x 0.000 1 = m^2

Metric to Imperial (and back):

1 m^2= 10.763 9 square feet
m^2 x 10.763 9 = square feet
feet square x 0.0929 = m^2
1 ha = 2.471 acres
ha x 2.471 = acres
acres x 0.404 69 = ha

Units of Measurement for volume:

Metric (SI):

cm^3 = cubic centimeters
m^3= cubic meters = cu m
L= liters
ML= milliliters

Imperial:

ft^3= cubic feet = ft. cu.
gallons (Imperial) = Imp. gal. = ig
US gallons

2.7. Measuring work pieces according to job requirement

All construction requires the use of accurate measurement and calculation of quantities. On big projects a quantity surveyor is often employed to do this work. For house construction, it is often the job of the builder or contractor to carry out this work.

2.7.1. The principles of measurement

When measuring, either materials or labor or both can be taken into account. For example, when a brick wall is measured, it is measured in terms of its area and not the number of bricks, weight of sand, cement and the number of bricklayers necessary to complete the wall.

Performing Measurements and Calculations

Making Measurements

When using a measuring device (such as a tape measure or rule) you should start measuring from the zero mark. The zero mark may not be at the end of the measuring tool. The zero mark of your measuring instrument should be aligned with one end of the object being measured.

Accuracy of measurement can be affected by the angle at which you look at the measuring device. Always try to have your eyes directly above the measuring point when taking measurements. If this is not possible, mark the point carefully with a pencil, scriber or even your fingernail so you can view the measuring point accurately when you remove the ruler or tape.

Make sure you use all measuring and calculating tools and equipment safely and effectively when carrying out operations.

Checking measurements more than once will help reduce the possibility of errors. Make a record of all measurements taken. Record the units you have measured in (e.g. millimeters, meters).

Factors and Methods of Measurement

When measuring objects and spaces there is a range of factors to consider such as:

Factor	Description
Length	The longest horizontal dimension of an object.
Width	The distance across an object at right angles to the length.
Height	The vertical distance from the base to the top of an object.
Area	The surface of a two-dimensional shape or plane
Depth	The vertical distance below a surface or behind.
Weight	The heaviness of an object (i.e. the force placed on it by gravity).
Volume	The measure of the 3-dimensional space of an object calculated from its length, width and height.
Mass	The quantity of matter an object contains
Scale	The ratio between a distance shown (e.g. on a map or building plan) and an actual distance.
Perimeter	The total of all the lengths of the sides of an object.

Quantity	The amount or number of something.
Number	An amount or total.
Grade	A degree or level of something.
Percentage	A fraction expressed compared to 100. A part of a whole expressed in hundredths
Ratio	A quantity of one value (e.g. weight, distance, and angle) in relation to another.

Calculation Methods

Calculations used in construction work use different methods and formulas. There are a number of ways to determine the needed results. Using plans or blueprints is a good way to get initial figures for calculations, but for accuracy the worksite needs to be measured up and calculations made from the real world figures.

Once measurements have been made and recorded the methods below are used to produce quantities or figures needed for other sections of the work.

Measurements may be required when you are calculating:

- Length - Area - circumference
- Volume - Angle - percentage
- Perimeter - Ratio

Making Calculations

The calculations that need to be completed depend on the type of work.

- Is there an area that requires paving?
- Is there a trench to be dug?
- A pipe that has to be laid? Or
- A length of fencing to be constructed around a site?

The type of work will determine what you are calculating and which formula or method you use. To determine the requirements for the job to be done, take your measurements from the actual worksite and record them. For each of the calculations you will need to apply the correct formula.

Be sure to use the appropriate unit of measure to correctly calculate the material quantities required for the work you are to perform.

Determine Material Requirements

When carrying out measurements and calculations in civil construction you may need to determine material requirements. This includes:

- The length of a trench, structure or distance being worked on.
- The area of a surface that is to be cleared filled or covered.
- The amount of filler material needed to backfill an excavation.
- The weight of material, beams or columns.
- It is important to make sure that the material quantities you calculate are within project and/or site tolerances. Tolerances are allowable variations from a specified value or measurement.
- For instance, you may have calculated the volume of a trench that needs to be filled. Remember that loose soil takes up more space than compacted soil. Your calculation of the volume of the trench should therefore allow for this and 15% more soil may have to be ordered.

You will need to determine the tolerances for the job you are doing and factor them into your calculations. It's better to have a small amount of wastage than to have to send the truck back for a tiny bit extra. Make sure the amount of tolerance is recorded along with the measurements originally made and the calculations you used to work out the quantities of material required.

Estimating Material Quantities

When calculating quantity requirements or giving quotes, you may need to give an approximation of how much material will be needed. When estimating quantities you should round off numbers to the nearest 0.5 of the last digit of a number.

For example

3.2m + 2.8m + 5.3m = 11.3m

This would round off to: -

3m + 3m + 5.5m = 11.5m

Sometimes it is better to round up (e.g. when estimating material requirements) or round down (e.g. when removing an area such as road surface). This will ensure errors are made on the side of caution, reducing unnecessary expense and/or delays in projects.

Note that estimating does not mean taking a glance at a job and guessing at the needs. Instead it is a skilled task based on calculations made from measurements to find the required amounts of material to ensure the job can be completed.

Estimating is performed by measuring the site, calculating the required amounts, then adding in the tolerance factors and producing a final figure

Self-check-2

Test-I Write True or False

Instruction: Write True or False for the question given below. You have given 1 Minute for each question. Each question carries 2 Point.

1. Calculator is a drawing materials?
2. Volumes are calculated by multiplying a base area (m2) with a third dimension?
3. The inverse trigonometric functions can be used to calculate the internal angles for a right angled triangle with the length of any two sides?

Test II: short Answer Writing

Instruction: write short answer and show brief stapes if necessary for the given question. You are provided 3 minute for each question and each question has 5 Points.

1. Write the following in descending order.

   0.4 0.04 0.004 0.44 40.00 04.40

2. Write the decimal number between 0.30 and 0.50.

3. Convert the following units

   a. 12kg to grams
   b. 120cm to meter
   c. 1150 ml to liters
   d. 1050 kg to to kilogram
   e. 13m to millimeter
   f. 5.58 liter to milliliter
   g. 20^0C to degree ferahenit

2. If right angle triangle side a is 3m and side b is 30cm. What is the length of the diagonal side c that need to be cut.

3. If diameter of a circle is 9cm.what are the area, circumference and radius of the circle.

4. If vertical difference is 50cm and horizontal difference 10000mm.calculate the slope and in percent slope.

6. Calculate the heat energy and power required to raise 1000cm^3 of water from 10^{0}C to 60^{0}C.

7. If the material cost is 2000Birr and the labour cost is 30% of material cost and overhead cost is 10% of material cost. Calculate total cost.

8. If side a is 1m and side b and c are 4and 3m respectively. What is the perimeter of the triangle

9.

Question 6.

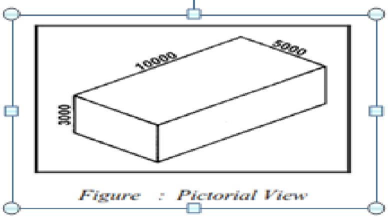


Figure : Pictorial View

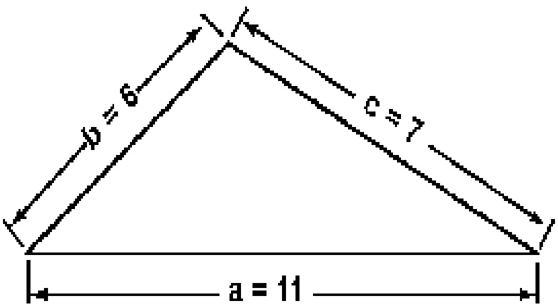
Calculate the amount of air space occupied by a building or part thereof and is found by multiplying the length by the breadth by the height of the building or object. Example on Figure

Volume = 10.0 x 5.0 x 3.0

Volume = 150m^3

.

10. Calculate the area of the triangle given below.



11. If income is 24000 Birr and Profit before tax is 4000Birr. Calculate the expense cost and Net profit including 10% income tax.

Note: Satisfactory rating – above 60%   Unsatisfactory - below 60%

You can ask you teacher for the copy of the correct answers

የሥራ እና ክህሎት ሚኒስቴር
MINISTRY OF LABOR
AND SKILLS