Ethiopian TVET-System

BASIC ELECTRICAL/ELECTRONIC EQUIPMENT SERVICING Level I

Based on May 2011 Occupational standards

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Module Title: Performing Measurement and Calculation

TTLM Code: EELBEE1 TTLM 0919v1

This module includes the following Learning Guides

LG28: Plan and prepare tasks

LG Code: EEL BEE1 M08 LO1-LG-28

LG29: Select measuring instrument

LG Code: EEL BEE1 M08 LO1-LG-29

LG30: Carry Out Measurement and Calculation

LG Code: EEL BEE1 M08 LO1-LG-30

LG31: Maintain measuring instrument

LG Code: EEL BEE1 M08 LO1-LG-31

Instruction Sheet	LG28: Plan and prepare tasks

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

- Identifying object or component to be measured
- Obtaining correct specifications from relevant source
- Selecting measuring tools
- Making workstation ready in accordance with job specifications

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to –

- Identify object or component to be measured in according to procedures
- Obtain correct specifications from relevant source.
- Select measuring tools in line with job requirements
- Make workstation ready in accordance with job specifications

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the "Information Sheets". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the "Self-checks" in each information sheets.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to "Operation sheets and LAP Tests if any". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After you accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result;
8. Then proceed to the next learning guide.

Information Sheet-1	Identifying object or component to be measured.

1.1. Introduction to planning measurement

Planning for measurement means preparing the workstation (tools, objects, specification of objects to be measured) so that measurement can be undertaken easily and safely. Before undertaking measurement, the object to be measured should be identified and check its specification. There are many tools used for measurement. The right measuring tool should be used to perform accurate measurement. Take time to plan your work, by yourself and with others. Safety planning is an important part of any task. It takes effort to recognize, evaluate, and control hazards. If you are thinking about your work tasks or about what others think of you, it is hard to take the time to plan for safety. But, YOU MUST PLAN! Planning with others is especially helpful. It allows you to coordinate your work and take advantage of what others know about identifying and controlling hazards. While planning your work, what steps you are going to follow, how it is done, the time taken & the materials, tools, instruments needed to finish the work should be clearly indicated.

1.2 Concepts and measurement principles

Measurement: is the assignment of numbers to material things to represent the relations among them with respect to particular properties. The process of assigning numbers is defined as the “measurement process”. The measurement process is the set of operations to determine the value of a quantity.

Precess: is an integrated set of activities that uses resources to transform inputs into outputs. In the case of measurement, the requirement or the objective of measurement is the input, while the method employed is the activity that uses the measuring instrument and operator as the resources, to give the output. The value assigned is defined as the “measurement value”. It is also known as the measure and or the result of a measurement value attributed to a measure and, obtained by measurement.

standard : is a material measure or physical property that defines or reproduces the unit of measurement of a base or derived quantity.

Aaccuracy: The closeness of the agreement between the result of a measurement and a true value of the measure and.

Precision : The closeness of the agreement between the results of successive measurements of the same measure and carried out under the same conditions of measurement. Precision is also called repeatability.

- **Reproducibility:** The closeness of the agreement between the results of measurements of the same measure and carried out under changed conditions of measurement. The changed conditions of measurement may include:

  - ✓ Different measurement principle
  - ✓ Different method of measurement
  - ✓ Different operator or appraiser
  - ✓ Different measuring instrument
  - ✓ Different reference standard
  - ✓ Different location
  - ✓ Different conditions of use at a different time

- **Calibration:** is the set of operations that establish, under specified conditions, the relationship between values indicated by a measuring instrument, a measuring system or values represented by a material measure, and the corresponding known values of a measure and. Whenever measurements are made, it is with the objective of generating data. The data is then analyzed and compared with requirements so that an appropriate decision can be taken, such as to accept, rework or reject the product. However, unless the measurement data is reliable, decisions based on such data cannot be reliable either. Consequently, these actions contribute enormously to the cost of quality a manufacturer has to bear.

1.3. Units of measurements.

The solution to any practical mathematics problem entails a two-part answer. The first part represents the how many, or the amount, and is always a number. This amount or magnitude is physically meaningless without the second part, which is the what, or unit of the solution. In general, a unit is fixed by definition and is independent of physical conditions. Some examples of units are the foot, pound, degree, ohm, meter, and so on. Each of these is physical unit, which means that it is a subject of observation and measurement.

The early establishment of standards for the measurement of physical quantities proceeded in several countries at broadly parallel times, and in consequence, several sets of units emerged

for measuring the same physical variable. For instance, length can be measured in yards, meters, or several other units. Apart from the major units of length,
subdivisions of standard units exist such as feet, inches, centimeters and millimeters, with a fixed relationship between each fundamental unit and its subdivisions.

1.4. Fundamental and derived units and their definition

At the time of measuring a physical quantity, we must express the magnitude of that quantity in terms of a unit and a numerical multiplier,

i.e., Magnitude of a physical quantity = (Numerical ratio) × (Unit)

The numerical ratio is the number of times the unit occurs in any given amount of the same quantity and, therefore, is called the number of measures. The numerical ratio may be called numerical multiplier. However, in measurements, we are concerned with a large number of quantities which are related to each other, through established physical equations, and therefore the choice of size of units of these quantities cannot be done arbitrarily and independently. In this way, we can avoid the use of awkward numerical constants when we express a quantity of one kind which has been derived from measurement of another quantity. In science and engineering, two kinds of units are used:

Fundamental Units are the units of the fundamental quantities, as defined by the International System of Units. They are not dependent upon any other units, and all other units are derived from them. In the International System of Units, the fundamental

- **Table 1.1. table of fundamental units**

Physical quantity	SI unit	Symbol	Definition
Length	Meter	M	The length of path travelled by light in an interval of 1/299 792 458 seconds
Mass	Kilogram	Kg	The mass of a platinum– iridium cylinder kept in the International Bureau of Weights and Measures.
Time	Second	Sec	9.192631770 x 10^9cycles of radiation from vaporized caesium-133 (an accuracy of 1 in 10^{12}or1 second in 36 000 years)
Temperature	Kelvin	K	The temperature difference between absolute zero and the triple point of water is defined as 273.16kelvin
Current	Ampere	**A**	One ampere is the current following through two infinitely long parallel conductors of negligible cross-section placed 1 meter apart in a vacuum and producing a force of 2 x 10^{-7}newtons per meter length of conductor
Luminous intensity	Candela	Cd	One candela is the luminous intensity in a given direction from a source emitting mono chromatic radiation at a frequency of 540 tera-hertz (Hz X10^{12})and with a radiant density in that direction of 1.4641mW/ steradian. (1 steradian is the solid angle which, having its vertex at the centre of a sphere, cuts off an area of the sphere surface equal to that of a square with sides of length equal to the sphere radius)
Matter	Mole	Mol	The number of atoms in a 0.012 kg mass of carbon-12

- **Derived Units** Other quantities, called derived quantities, are defined in terms of the seven base quantities via a system of quantity equations. The SI derived units for these derived quantities are obtained from these equations and the seven SI base units. Examples of such SI derived units are given in Table ,

➢ **Table 1.2. table of derived units**

Quantity	Standard unit	Symbol
Area	square metre	m^2
Volume	cubic metre	m^3
Velocity	metre per second	m/s
Acceleration	metre per second squared	m/s^2
Angular velocity	radian per second	rad/s
Angular acceleration	radian per second squared	rad/s^2
Density	kilogram per cubic metre	kg/m^3
Specific volume	cubic metre per kilogram	m^3/kg
Mass flow rate	kilogram per second	kg/s
Volume flow rate	cubic metre per second	m^3/s
Force	newton	N
Pressure	newton per square metre	N/m^2
Torque	newton metre	N m
Momentum	kilogram metre per second	kg m/s
Moment of inertia	kilogram metre squared	$kg\ m^2$
Kinematic viscosity	square metre per second	m^2/s
Dynamic viscosity	newton second per square metre	$N\ s/m^2$
Work, energy, heat	joule	J
Specific energy	joule per cubic metre	J/m^3
Power	watt	W
Thermal conductivity	watt per metre kelvin	W/m K
Electric charge	coulomb	C
Voltage, e.m.f., pot. diff.	volt	V
Electric field strength	volt per metre	V/m
Electric resistance	ohm	Ω
Electric capacitance	farad	F
Electric inductance	henry	H
Electric conductance	siemen	S
Resistivity	ohm metre	Ωm
Permittivity	farad per metre	F/m
Permeability	henry per metre	H/m
Current density	ampere per square metre	A/m^2

1.6. Electrical /electronic units

Units that can be measured in Electrical /electronic include, current, voltage, power, resistance, conductance, charge, and frequency.

- **Ampere**

✓ Ampere (amp or A) is the name given to the transfer of certain number of electrons through a material over a certain elapse time as a result of an electrical pressure. A movement of 6.25 X 10 18 electrons (one coulomb) past a point in 1 second is defined to be 1 ampere of current

Electron Volt

Electron volt is used to state the energy of charged particles, such as electrons, and must not be confused with the volt unit. An electron which is accelerated through a potential difference of one volt gains one electron volt (v) of energy.

- **Ohm**

Ohm (Ω) is the physical unit of resistance of a material. One ohm is the amount of electrical opposition that forces an electron movement through a material. One volt across one ohm will result in a current of one ampere.

- **Siemens**

Conductivity of a material is the ease with which it passes electrons. Conductivity and resistivity of a material are inversely related by the formula (G=1/R). The unit of conductance is the Siemens. The symbol used for the Siemens is (S).

- **Watt**

Watt is the unit of power or the rate of doing work in an electrical circuit. The power converted in an electrical circuit is 1 watt when energy is converted at the rate of 1 joule-per-second.

- **Coulomb**

Coulomb (Q) is the unit of electrical charge. One coulomb is a charge of 6.25 X 1018 electrons. A flow of one coulomb past a point in one second is one ampere.

- **Hertz**

Frequency is the number of times an event occurs in a given period. In electrical circuits, frequency is usually given in cycle-per-second. By international agreement, the term Hertz (Hz)has been adopted to mean cycle-per-second.

- **Second**

The standard unit of time is second.

In electronics, measurements may be specified in either the English system or the metric system, and for this reason we must convert from one system to the other system of measurement. However, the metric system is preferred and should be used in all scientific writing. However, since both systems are in current usage we must learn to convert from one to the other.

1.7. Ranges of Electrical Units

As we noted earlier, electronics is a science which uses very large and very small units, such as a thousand-ohm resistor, a millionth-farad capacitor, a thousand million-cycles-per-

second, and soon. To save time in writing and speaking these terms, symbols have been universally adopted to replace those most commonly used terms.

table1.3. **Table of the most Common prefixes used in Electronics**

Prefix	Symbol	Value

Pico	P	10^{-12}
Nano	N	10^{-9}
Micro	µ	10^{-6}
Milli	M	10^{-3}
Kilo	K	10^{3}
Mega	M	10^{6}
Giga	G	10^{9}
Tera	T	10^{12}

Example I

2, 000 ohms = 2

× 103Ω = 2 kΩ Or, as it is spoken, 2 kilo ohms or 2 "k" ohms.

Again ,0.000,000,01 farads = 0.01 × 10-6F = 0.01µF = 10 nF or 10,000 pF

Self-Check 1.	**Written Test**

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Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Part I : Match the following question column A to column B

Column A	Column B
_______1. Resistor	A. Area
_______2. Current	B. Ampere
_______3. Siemens	C. Length
_______4. Derived unit	D. Ohms
_______5. Fundamental unit	E. Conductivity

Part II. Say true and false for the following question below

_________ 1. Accuracy is not the closeness of the agreement between the result of a Measurement.

__________ 2. The right measuring tool should be used to perform accurate measurement.

__________ 3. The measurement process is the set of operations to determine the value of a quantity.

Part III. Choose the best answer from the question below

1. ________________ is used to state the energy of charged particles, such as electrons, and must not be confused with the volt unit

A. Current C. Ohm's

B. Electric volt D. Power

2. _______________is a material measure or physical property that defines or reproduces the unit of measurement of a base or derived quantity.

A. **Accuracy** **C. Standard**

B. **Precision** **D. All**

3. ________________is an integrated set of activities that uses resources to transform inputs into outputs.

A. Process C. Calibration

B. Measurement D. none

Satisfactory rating: 6 and above **unsatisfactory rating: Below 6**

Information Sheet 2	Obtaining correct specifications from relevant source

1.2 Definitions of specification.

It is an exact statement of the particular needs to be satisfied, or essential characteristics that a customer requires (in a good, material, method, process, service, system, or work) and which a vendor must deliver.

Specifications are written usually in a manner that enables both parties (and/or an independent certifier) to measure the degree of conformance. They are, however, not the same as control limits (which allow fluctuations within a range), and conformance to them does not necessarily mean quality (which is a predictable degree of dependability and uniformity). Specifications are divided generally into two main categories:

- **Performance specifications:** conform to known customer requirements such as keeping a room's temperature within a specified range
- **Technical specifications**: express the level of performance of the individual units, and are subdivided into(a) individual unit specifications which state boundaries (parameters) of the unit's performance consisting of a nominal (desired or mandated) value and tolerance (allowable departure from the nominal value, (b)acceptable quality level which states limits that are to be satisfied by most of the units, but a certain percentage of the units is allowed to exceed those limits, and (c) distribution specifications which define an acceptable statistical distribution (in terms of mean deviation and standard Deviation) for each unit, and are used by a producer to monitor its production processes. When completing a job for someone else you should always try and follow every specification so you can get future work from them. You may have to make sure that you follow every specification when you are trying to set up a new factory.

2.2. Sources used to obtain correct specifications.

Published literature is of considerable help in the choice of a suitable instrument for a particular measurement situation. Many books are available that give valuable assistance in the necessary evaluation by providing lists and data about all the instruments available for measuring a range of physical quantities.

However, new techniques and instruments are being developed all the time, and therefore a good instrumentation technician must keep **up-to-date** of the latest developments by reading the appropriate technical journals regularly.

2.3. Datasheet

- **A data-sheet, or spec sheet** is a document that summarizes the performance and other characteristics of a product, machine, component (e.g., an electronic component),material, a subsystem (e.g., a power supply) or software insufficient detail that allows a buyer to understand what the product and a design engineer to understand the role of the component in the overall system. Typically, a datasheet is created by the manufacturer and begins with an introductory page describing the rest of the document, followed by listings of specific characteristics, with further information on the connectivity of the devices. In cases where there is relevant source code to include, it is usually attached near the end of the document or separated into another file. Data-sheets are created, stored and distributed via Product information management or Product data management systems. Depending on the specific purpose, a datasheet may offer an average value, a topics value, a typical range, engineering tolerances, or a nominal value. The type and source of data are usually stated on the data sheet. A datasheet is usually used for the commercial or technical communication to describe the characteristics of an item or product. It can be published by the manufacturer to help people choose products or to help use the products. By contrast, a technical specification is an explicit set of requirements to be satisfied by a material, product, or service.

✓ **Product data-sheet information**

A product data-sheet (PDS), like any data-sheet, has a different data model per category. It typically contains:

- Identifiers like manufacturer & manufacturer product code
- Classification data,
- Descriptions such as marketing texts
- Specifications
- Product images
- Feature logos

✓ **Material or Product Safety Data Sheet (PSDS)**

It is an important component of product stewardship and occupational safety and health. These are required by agencies such as OSHA in its Hazard Communication Standard.

It provides workers with ways to allow them to work in a safe manner and gives them physical data(melting point, boiling point, flash point, etc.), toxicity, health effects, first aid, reactivity, storage, disposal, protective equipment, and spill-handling procedures. There is a need to have an internationally recognized symbol when describing hazardous substances.

Self-Check 2	**Written Test**

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Part I : **<u>Say true and false for the following question below</u>**

____1. A product data-sheet like any data-sheet, has a different data model per Category.
____ 2. Specification is an exact statement of the particular needs to be satisfied, or essential characteristics that a customer requires T
____3. **spec sheet** a document that summarizes the performance and other characteristics of a product, machine, component. T

Part II. Choose the best answer from the question below

1. ____________is usually used for the commercial to describe the characteristics of an item or product.

A. information C. Data sheet
B. Product image D. logos

2. ____________is express the level of performance of the individual units

A. **Technical specifications** **C. datasheets**
B. **Performance specifications** **D. all**

3. ____________are written usually in a manner that enables both parties to measure the degree of conformance.

A. Data sheet C. specification
B. Description D. all

Answer Sheet

Name: _________________________ Date: _______________

Satisfactory rating: 3 and above **unsatisfactory rating: Below 3**

Information Sheet-3	Selecting measuring tools

3.1. Introduction to Measuring tools

When performing maintenance and repair tasks on projects and arresting gear equipment, you will use many different types of measuring tools in the daily performance of your duties. you must take accurate measurements during inspection, to determine the amount of wear or service life remaining on a particular item or to make sure replacement parts used to repair equipment meet established specifications. The accuracy of these measurements, often affecting the performance and failure rates of the concerned equipment, depends on the measuring tool you use and your ability to use it correctly.

3.2. Methods for selection of measuring instruments (tools)

The selection of measuring instruments (tools) for linear measurements, takes the following main factors into account: manufacturing program, the construction features of the details and manufacturing accuracy – the tolerance zone (IT), measuring instrument error and the measuring costs.

In the single production companies, the special measurement instruments are inapplicable, so it is recommended the dimension's control of manufacturing products to be made using universal measuring equipment (calipers, micrometers, indicating internal gages i.e.). In the serial production the main measurement testing and control instruments are limit gauges, measurement templates and semiautomatic measurement instruments. For the selection of measurement instruments the set of metrological, exploitation and economical indices are reviewed. The metrological indices are: scale interval, measurement method, accuracy, measurement range (interval).

The exploitation and the economic indices are the cost and the reliability of measurement instruments, running time before repair is needed, inspection intervals, easy to use, inspection and repair costs including the measurement instrument delivery costs to the place for inspection and back .

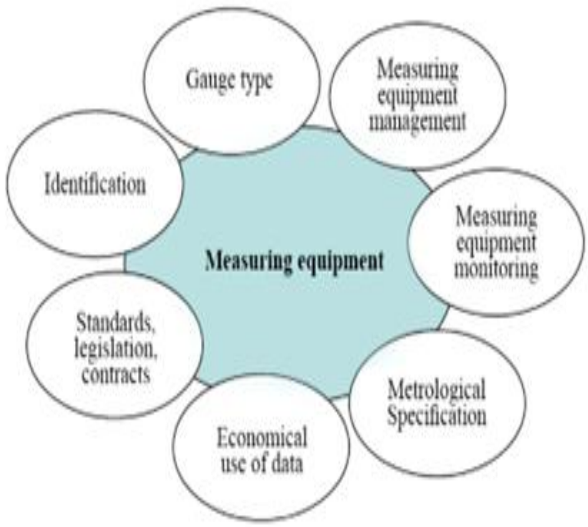


Fig. 3.1. measuring cycle

Fig. 3.1. shows the required information for the preliminary selection of measurement instruments. The purpose of preliminary selection of measurement instruments is to

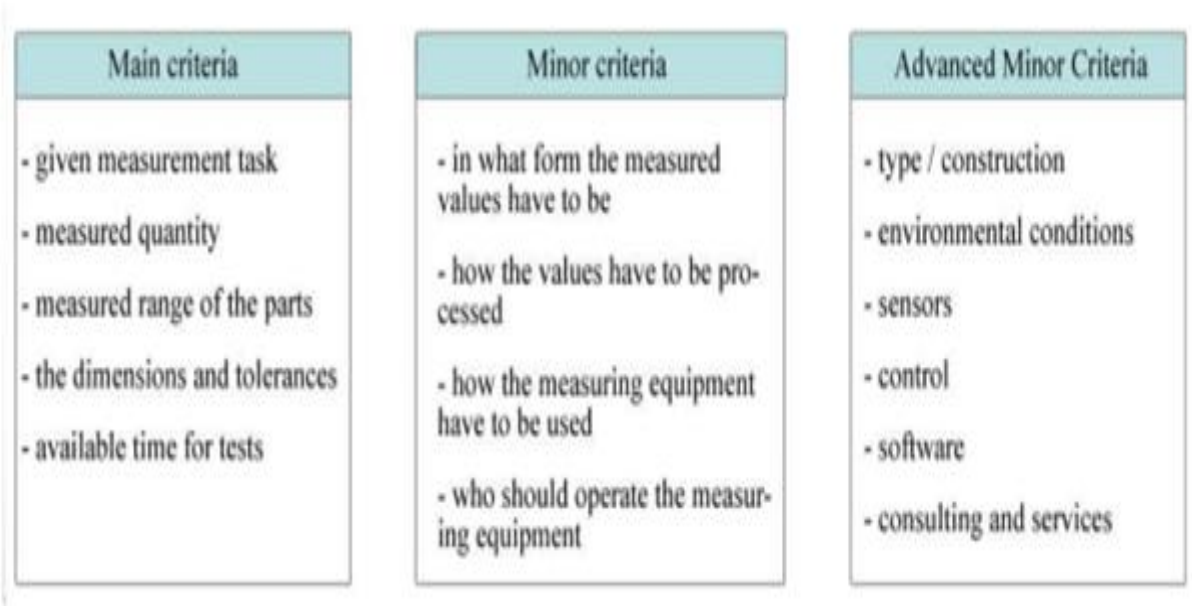


Fig. 3.2. criteria for selection of measuring equipment

The starting point in choosing the most suitable instrument to use for measurement of a particular quantity in a manufacturing plant or other system is the specification of the instrument characteristics required, especially parameters like the desired measurement accuracy, resolution, sensitivity and dynamic performance).

It is also essential to know the environmental conditions that the instrument will be subjected to, as some conditions will immediately either eliminate the possibility of using certain types of instrument or else will create a requirement for expensive protection of the instrument. Provision of this type of information usually requires the expert knowledge of personnel who are intimately acquainted with the operation of the manufacturing plant or system in question.

Then, a skilled instrument technician, having knowledge of all the instruments that are available for measuring the quantity in question, will be able to evaluate the possible list of instruments in terms of their accuracy, cost and suitability for the environmental conditions and thus choose the most appropriate instrument. As far as possible, measurement systems and instruments should be chosen that are as insensitive as possible to the operating environment, although this requirement is often difficult to meet because of cost and other performance considerations. The extent to which the measured system will be disturbed during the measuring process is another important factor in instrument choice.

3.3. Types and Uses of measuring tools.

As a technician must be able to identify the types and use of basic measuring and repair instruments (tools) and the basic components of these instruments. The following measuring and repair instruments (tools) are discussed these are rule, straight edge, try square, protractor, combination gauge and torque gauge.

Measuring tools are instruments used to determine lengths and angles. They follow two systems, these are the US customary system and the International System (SI), commonly referred to as metric. US customary rulers and scales measure feet and inches. Smaller units are measured in fractions of an inch (See Fig. 3.3A).To find the fractional distance you need, count the spaces across the board. This becomes the numerator (top number). Count the spaces in one inch on the rule. This is the denominator (bottom number).

Metric rulers and scales measure in millimeters. They are typically numbered every 10 mm. See the metric rule in Fig .3.3B. A metric rule may be further divided into 0.5 mm. Both systems may appear on the same measuring tool, as shown in Fig. 3.3. C.

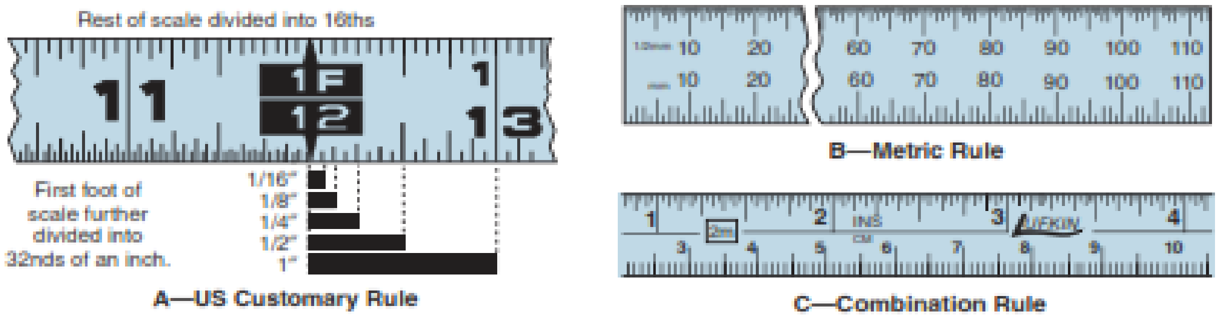


Fig . 3.3 . A) US system, B) Metric systems and C) Both systems

The measuring system you choose depends on the working drawings. The title block will indicate what system is used. It will also provide the scale of the drawing. If the scale reads 1″ = 1′-0″, then each inch on the drawing will be 1′ on the layout. Special purpose rules include a centering rule, with the measuring units extending both directions from the center zero point. This reduces the chances for error with many centering tasks.

3.3. Rules:

The rule is a basic measuring tool used to measure actual sizes and from which many other tools have been developed. Rules range in size from as small as one-quarter inch in length for measuring in grooves, recesses and key-ways to as much as twelve feet in length for large work.

Rules are graduated to agree with standards calibrated by the National Institute of Standards and Technology (NIST). There are two basic types of rule: steel rule & tape rule. Both start at zero and have millimeter graduations.

- **Steel rules**

Steel rules are precision measuring instruments used for measuring dimensions, drawing, straight line and scribing. It is graduated in the English (Inch) or Metric system and sometimes scales for both systems are provided on a single rule. They can be graduated on each edge of both sides and even on the ends. English graduations are commonly as fine as one-hundredth (.010) inch in decimals or one sixty-fourth (1/64) inch in fractions. Metric graduations are usually as fine as one-half millimeter (0.50mm).

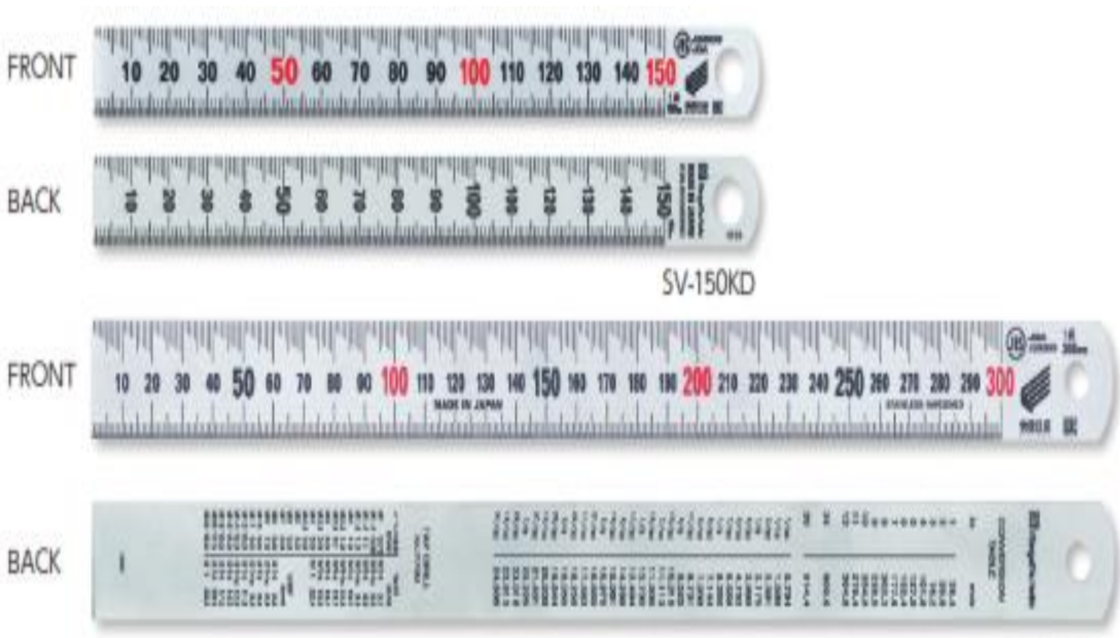


Fig. 3.4. Rigid Steel rules

Steel rules come in many sizes and formats. Basic 6" and 12" steel rules come inflexible and rigid forms. Flexible rules are usually ½" wide and 1/64" thick. Rigid rules are usually ¾" wide and3/64" thick.

- **Flexible Steel rules**

This rule is used for measuring spherical or hemispherical objects. These are 6≤ to 12≤ in size. These are made from spring steel sheet of 1/64≤ thickness so that it attains elasticity. This rule contains measurement both in inches and millimeters. First two inches are divided into 32 equal parts and the third inch is divided into 64 equal parts. On rest of the rule each inch is divided into 8 equal parts. In the same way, other side of the rule markings indicate centimeters. Each centimeter is divided into ten equal parts, i.e., one millimeter. This part is further divided into two equal parts.

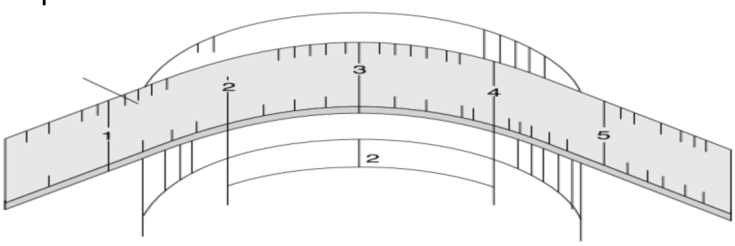


Fig. 3.5. Flexible Steel rules

- **Tape rules**

Tape rules are a logical extension of a graduated measuring tool beyond the practical limits of a steel rule. Long line tapes are available in lengths up to 100 feet and are still accurate.

- **Steel Tape Rule**

It is often difficult or rather impractical to carry long foot rules. For the purpose of convenience steel tape rules are available. This is made of spring steel and is elastic. It can be rolled and packed in a round tiny box (case). Its breadth is 1≤ and length is 6≤. It contains inch as well as millimeter graduation.

Fig. 3.6. Steel Tape Rule

- **Canvas Tape**

This rule is used for measuring greater lengths. This is made of a long canvas tape which can be rolled and packed in a small leather or steel box. A ring is attached to the one end. By pulling this ring we can pull out the tape. For folding it a small handle is provided. These taperules are generally of 50 to 100 feet in length.

Fig. 3.7. Canvas tape rule

- **Folding Rule**

This rule is made by joining four pieces of 6 inches. These pieces are either wooden or of steel. It is generally used by the carpenters and masons, by unfolding this rule we can take measurement up to2 feet. When we fold it, it is reduced to 6≤. Graduation in inches and millimeters is indicated on it.

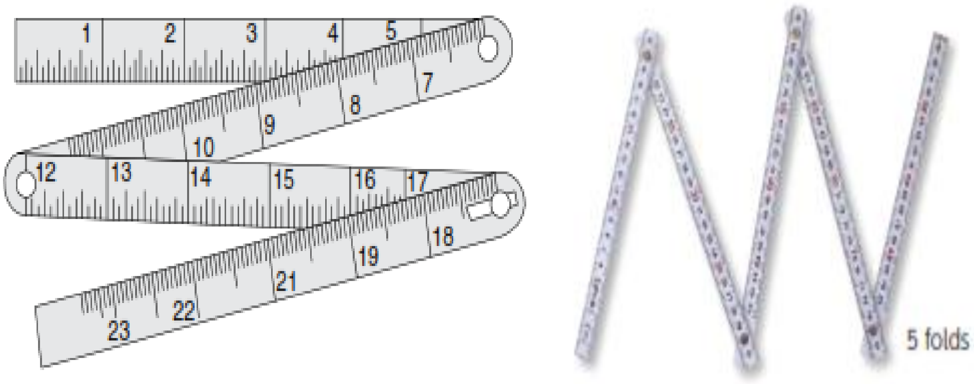


Fig. 3.8. Folding Rule

- **Triangular scale rule:** It is used for drafting reading scaled drawing.

Fig. 3.9. Triangular scale rule

- **Try square**

The try square is used to set or check lines which is at right angles (90 degrees) to each other. The try square is made of a steel or wood stock (1) and a blade (2). The blade is from2 to 12 inches long and is graduated in eighths. Some have a 45° angle cut into the handle. Try squares are the most reliable of all squares for accuracy. Use them for making layouts, checking square ness, or setting up machinery. See Fig. 3.9.

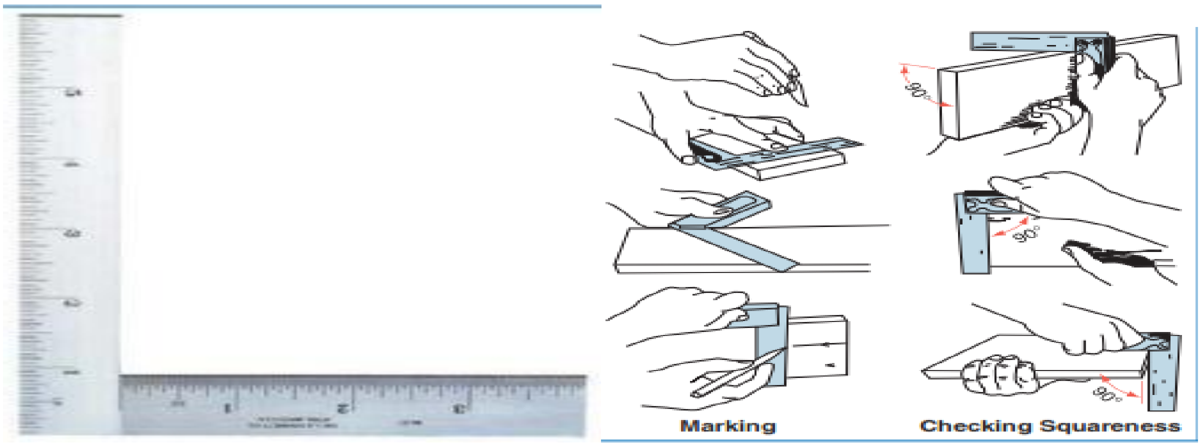


Fig. 3.10. Try square

- **Protractor**

Protractors: Measuring the angular relationship of two or more lines or surfaces can be performed with a variety of tools depending upon the degree of precision required and the job in hand. For simple angles, a common protractor will serve, with a half circle (180°) graduated in degrees so that angles can be measured or laid out. The rectangular shape has the advantage that anyone of four edges can be used as a vertical or horizontal line of reference.

Fig. 3.11. Protractor

- **Bevel Protractors**

A protractor and bevel are combined for greater convenience in the universal bevel protractor. It consists of a graduated disk with a fixed blade and an adjustable stock. With this tool, any angle may be laid out or measured by reading the angle of stock and blades as shown on the protractor scale in degrees. By means of a Venire and ultra-fine adjustment, it is possible to accurately read angles to 5 minutes or 1/12 of a degree. Extremely close angular measurements to accuracies as close as ¼ second can be accomplished by means of angle gage blocks.

Fig. 3.12. Bevel Protractor

- **Combination square**

A combination square is more versatile than a try square. It consists of a grooved blade that slides through the handle. It can also be equipped with a protractor and a center head (See Fig11).

You can use a combination square for a number of purposes:

- Measure distances and depths.
- Lay out 45° and 90° angles.
- Draw parallel lines and
- Locate centers.

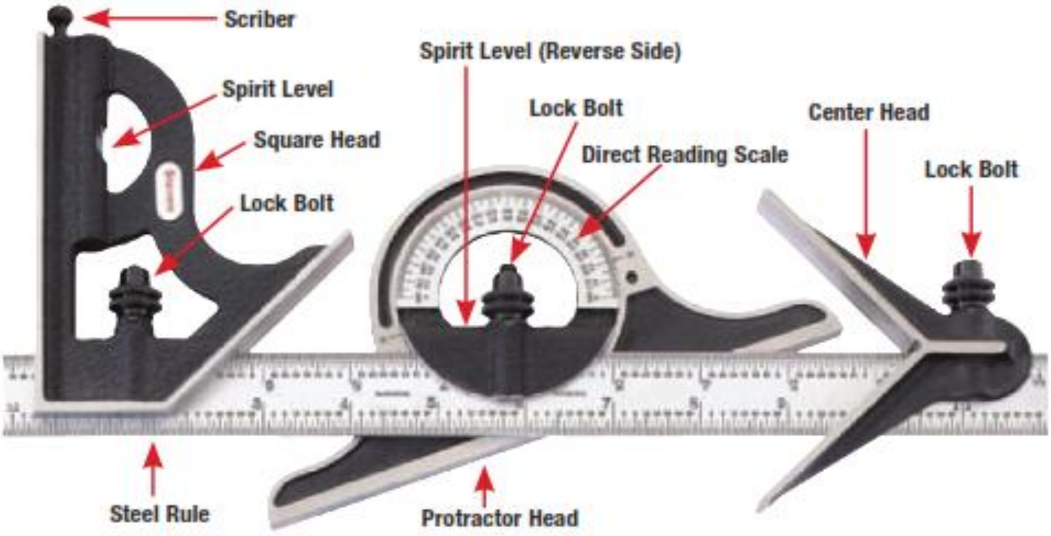


Fig. 3.13. Parts of combination square

Fig. 3.14. Application a combination square.

- **Layout tools**

Layout tools transfer distances, angles, and contours. Most lack scales for measuring distances and angles. These are set with a measuring tool. The following descriptions cover common layout tools with a protractor. Loosen the locking device on the handle to move the blade. After setting the proper angle, tighten the locking device.

3.8. Calipers

Calipers are used to transfer dimensions. The three types of calipers are outside, inside, and hermaphrodite. See Figure 12-20. Some are assembled with a firm (friction) joint. Others have bow spring with an adjusting screw and nut. Firm-joint calipers are quicker to adjust, but bow spring calipers maintain greater accuracy during use.

Fig. 3.15. Different calipers

Calipers are used most often when wood turning. When the lathe is stopped, you can check or transfer thicknesses and distances.

- **An outside caliper** checks outside diameters on turnings. See Figure 14a. First, set the caliper with a rule. Then turn the material until the caliper slips over it. When making duplicate parts, set the caliper by the work piece being copied.

- **An inside caliper** checks inside diameters. Preset the caliper with a scale. Then turn the work until the diameter is reached, Figure 14b.

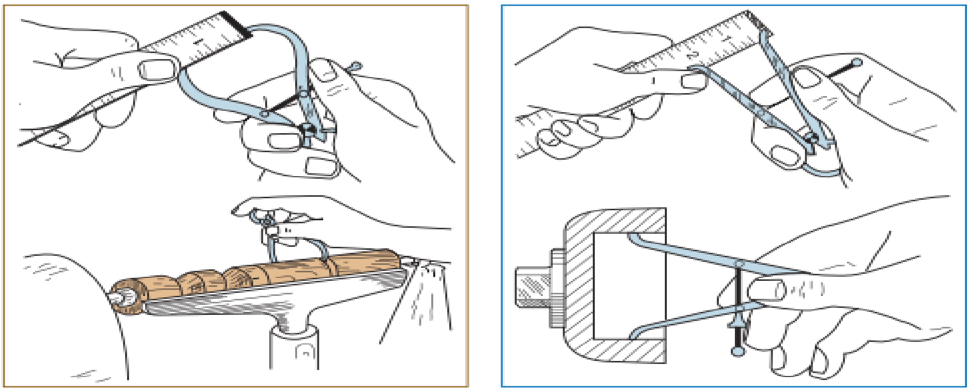


Fig. 3.16. a)Outside caliper and b).Inside caliper

- **The hermaphrodite caliper** is a firm-joint tool that has one caliper-like leg and one needle-like point. The hermaphrodite caliper is used to:

✓ Locate outside and inside centers by scribing three or four arcs, Figure 15A.
✓ Mark a parallel line on flat or round stock, Figure 15B.
✓ Copy a contour, which is often called coping, Figure 15C.

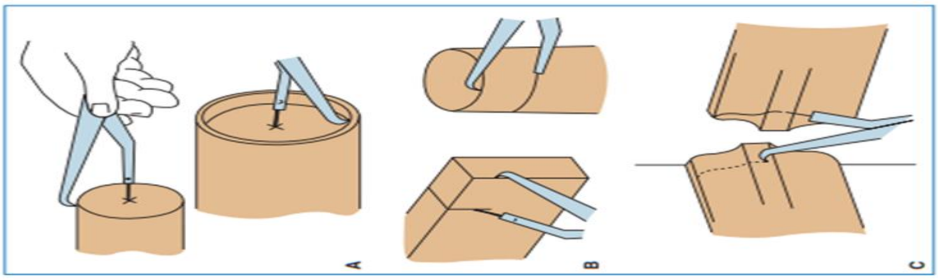


Fig. 3.17. The hermaphrodite caliper

- **Divider caliper**

In the metalworking field, a divider caliper, popularly called a compass, is used in the process of marking out locations. The points are sharpened so that they act as scribers, one leg can then be placed in the dimple created by a center or prick punch and the other leg pivoted so that it scribes a line on the work piece's surface, thus forming an arc or circle.

- **A divider caliper** is also used to measure a distance between two points on a map. The two caliper's ends are brought to the two points whose distance is being measured. The caliper's opening is then either measured on a separate ruler and then converted to the actual distance, or it is measured directly on a scale drawn on the map

Fig. 3.18. . Dividers caliper

- **Odd leg calipers,** Hermaphrodite calipers, or Odd leg jenny's, as pictured on the above, are generally used to scribe a line a set distance from the edge of a work piece. The bent leg is used to run along the work piece edge while the scriber makes its mark at a predetermined distance; this ensures a line parallel to the edge. In the diagram at left, the uppermost caliper has a slight shoulder in the bent leg allowing it to sit on the edge more securely; the lower caliper lacks this feature but has a renewable scriber that can be adjusted for wear, as well as being replaced when excessively worn.

Fig. 3.19. Odd leg calipers

- **The Vernier caliper** is an instrument that allows you measure lengths much more accurate than the metric ruler. The smallest increment in the Vernier caliper you will be using is (1/50) mm = 0.02mm = 0.002cm. Thus, the uncertainty is Δx = (1/2)0.002 cm = 0.001 cm.

✓ **Use of Vernier Calipers**

- measure diameter of a small spherical/cylindrical body,
- measure the dimensions of a given regular body of known mass and hence to determine its density; and
- measure the internal diameter and depth of a given cylindrical object like beaker/glass/calorimeter and hence to calculate its volume.

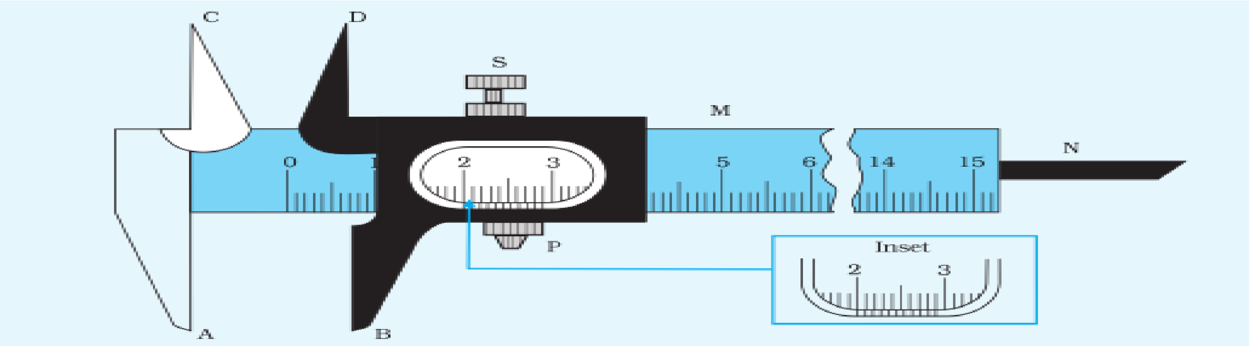


Fig. 3.19. The Vernier caliper and its parts.

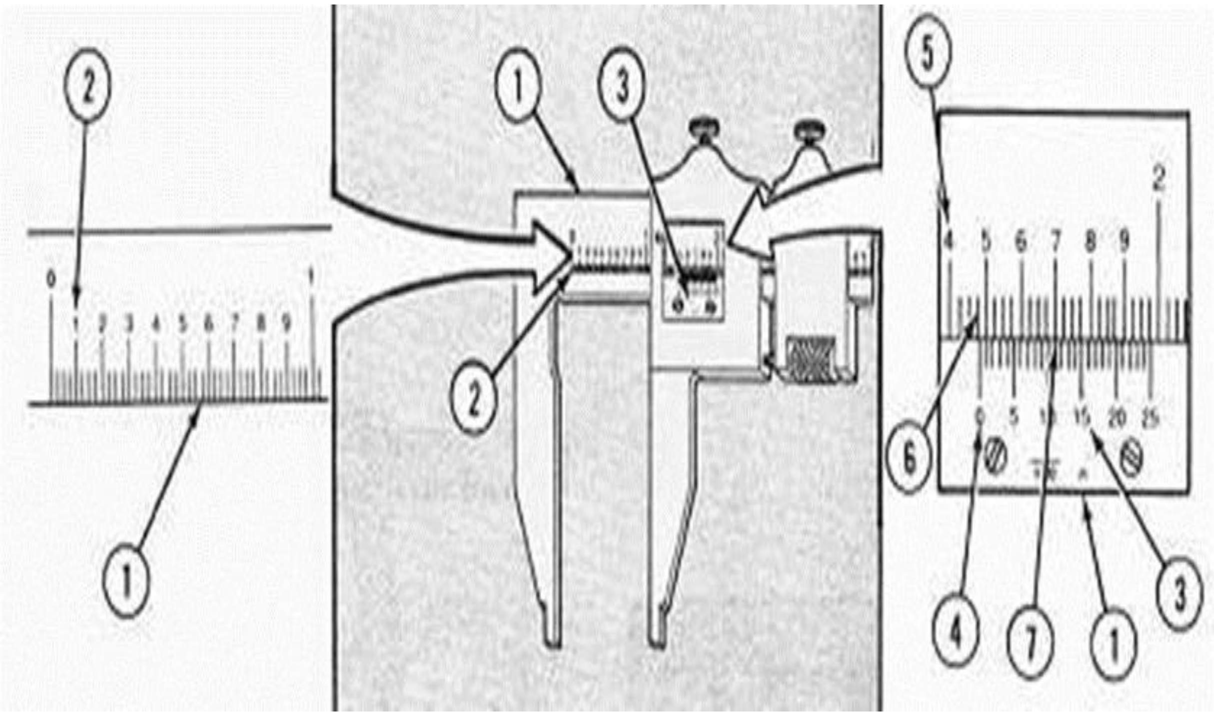
✓ A Vernier Caliper has two scales–one main scale and a Vernier scale, which slides along the main scale. The main scale and Vernier scale are divided into small divisions though of different magnitudes.

- The main scale is graduated in cm and mm. It has two fixed jaws, A and C, projected at right angles to the scale.
- The sliding Vernier scale has jaws (B, D) projecting at right angles to it and also the main scale and a metallic strip (N).
- The zero of main scale and Vernier scale coincide when the jaws are made to touch each other. The jaws and metallic strip are designed to measure the distance/diameter of objects.
- Knob P is used to slide the Vernier scale on the main scale. Screw S is used to fix the Vernier scale at a desired position.

The least count of a common scale is 1mm. It is difficult to further subdivide it to improve the least count of the scale. A Vernier scale enables this to be achieved.

- **Parts of a Vernier caliper:**
  - ✓ Outside large jaws: used to measure external diameter or width of an object
  - ✓ Inside small jaws: used to measure internal diameter of an object

- ✓ Depth probe: used to measure depths of an object or a hole
- ✓ Main scale: scale marked every mm
- ✓ Main scale: scale marked in inches and fractions
- ✓ Vernier scale gives interpolated measurements to 0.1 mm or better
- ✓ Vernier scale gives interpolated measurements in fractions of an inch
- ✓ Retainer: used to block movable part to allow the easy transferring of a measurement



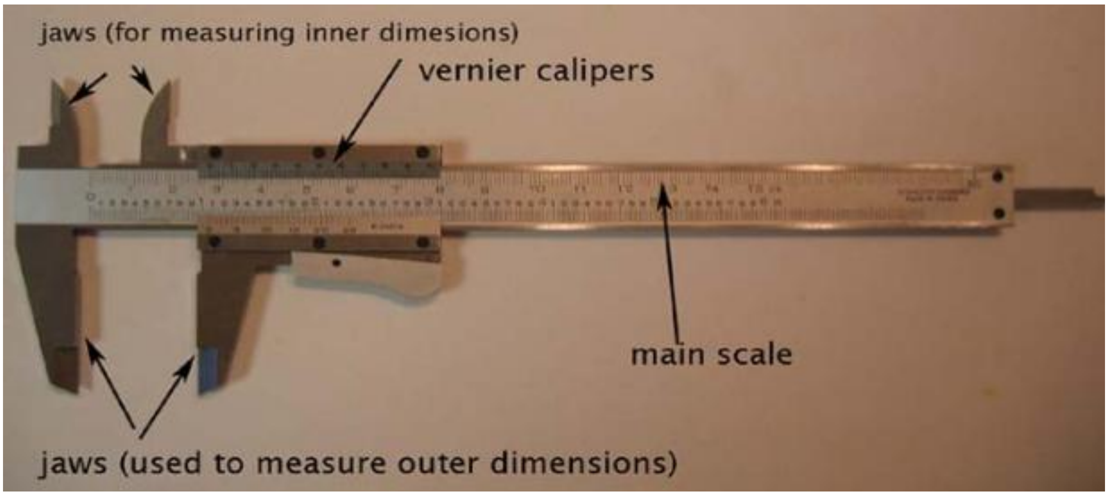


Fig. 3.20. Parts The Vernier caliper

The difference in the magnitude of one main scale division (M.S.D.) and one Vernier scale division (V.S.D.) is called the least count of the instrument, as it is the smallest distance that can be measured using the instrument. V.S.D. = (n – 1) M.S.D.

- **Dial/Vernier Caliper**

The dial/Vernier caliper is used to measure the inside or outside diameter of an object. Figure 20 shows a typical dial/Vernier caliper. Most dial/Vernier calipers have a slide, slide locks crew, thumb button, scale, dial with measured increments of 0.001 inch, and a bezel.

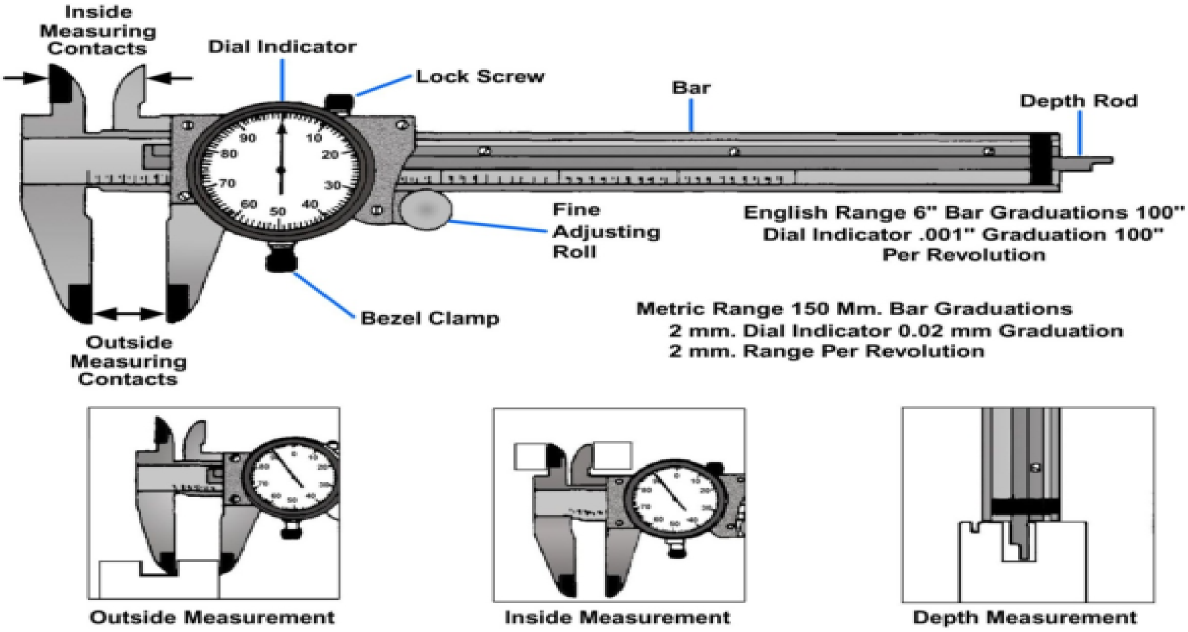


Fig. 3.21. Dial caliper part

The slide of a dial caliper can usually be locked at a setting using a small lever or screw; this allows simple go/no-go checks of part sizes.

- **Digital Caliper**

Fig. 3.22. Digital caliper

A refinement now popular is the replacement of the analog dial with an electronic digital on which the reading is displayed as a single value. Rather than a rack and pinion, they have a linear encoder. Some digital calipers can be switched between centimeters or millimeters, and inches. All provide for zeroing the display at any point along the slide, allowing the same sort of differential measurements as with the dial caliper.

Digital calipers may contain some sort of "reading hold" feature, allowing the reading of dimensions even in awkward locations where the display cannot be seen. Ordinary 6-in/150-mm digital calipers are made of stainless steel, have a rated accuracy of 0.001 in (0.02mm) and resolution of 0.0005 in (0.01 mm). The same technology is used to make longer 8-in and 12-in calipers; the accuracy for bigger measurements declines to 0.001 in (0.03 mm) for 100–200 mm and 0.0015 in (0.04 mm) for 200–300 mm.

3.9. Micrometers

A micrometer is a specialized instrument used to take very accurate measurements. The thimble, which rotates as the micrometer is tightened, has 50 equal divisions around its diameter, giving an accuracy of 0.01 mm. A reading is taken by adding all the visible whole numbers to the nearest 0.5 mm. The reading from the thimble, which will be between 0 and 0.49 mm, is added to the main reading to get the exact measurement.
There are four types of micrometer calipers, each designed for a specific use: outside micrometer, inside micrometer, depth micrometer, and thread micrometer. It may be used to measure the outside dimensions of shafts, thickness of sheet metal stock, the diameter of drills, and for many other applications.

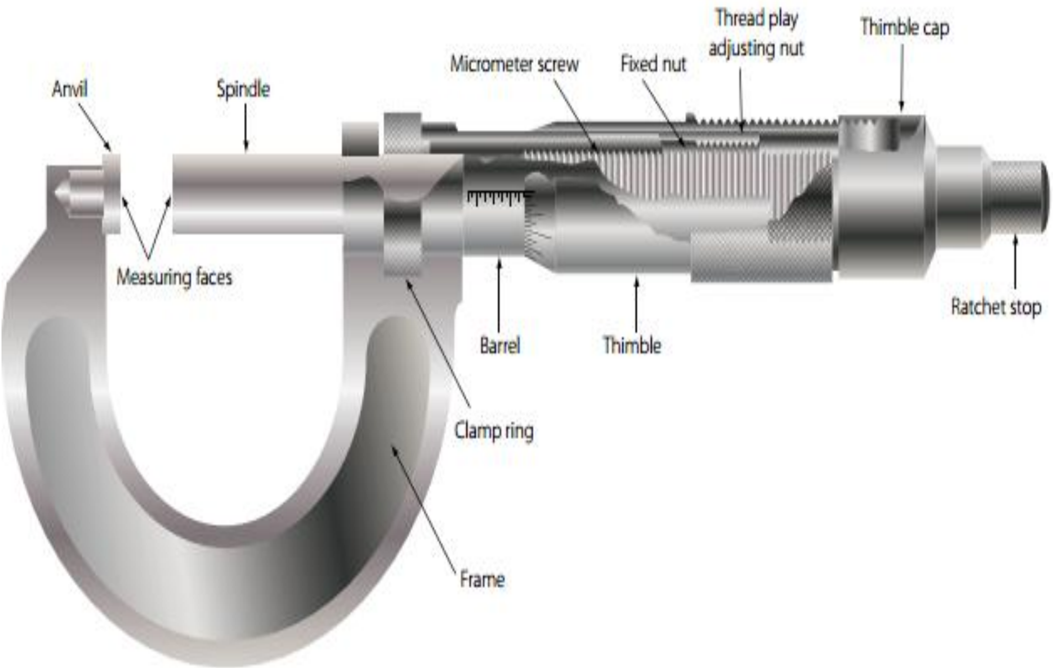


Fig. 3.23. Parts of outside micrometer

Self-Check -3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

___________ 1. is an instrument that allows you measure lengths much more accurate than the metric ruler.

A. Combination square C. Calipers

B. Vernier scale D. Services

_____________2. are instruments used to determine lengths and angles. Measuring tools

A. Equipment C. Measuring tools

B. Device D. All

_____________3. is a specialized instrument used to take very accurate measurements.

A. **Micrometer** **C.** Vernier scale,

B. Digital Caliper **D. All**

___________ 4. are precision measuring instruments used for measuring dimensions, drawing, straight line and scribing.

A. Steel rules C. Combination square

B. Protractor D. try square

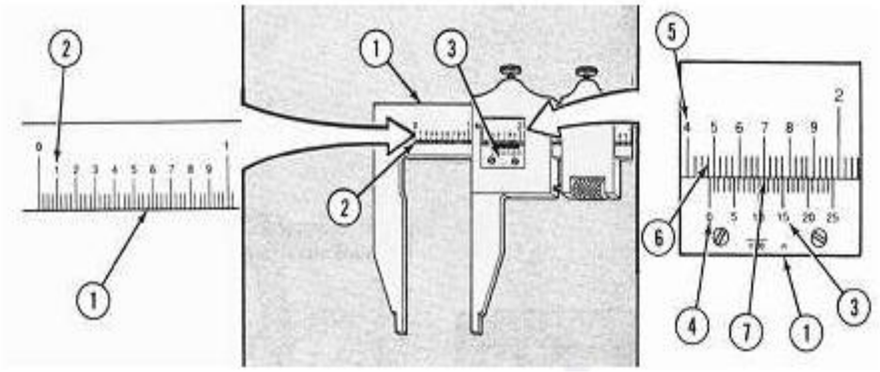
___________5. The rule is a basic measuring tool used to measure actual sizes and from which many other tools have been developed.

A.True B. False

Answer Sheet

Name: ________________________ Date: ______________

Operation Sheet -1	READING A VERNER CALIPER



To read a vernier caliper, you must be able to understand both the steel rule and vernier 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 vernier 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 vernier scale (3) and one of the 24 spaces on the steel rule (1) is 1/1000 of an inch.

Read the measurement as shown above. Read the number of whole nches on the top scale (1) to the left of the vernier zero index (4) and record . . 1.000 inch

Read the number of tenths (5) to the left of the vernier zero index (4) and record 0.400inch

Read the number of twenty-fifths (6) between the tenths mark(5) and the zero index (4)

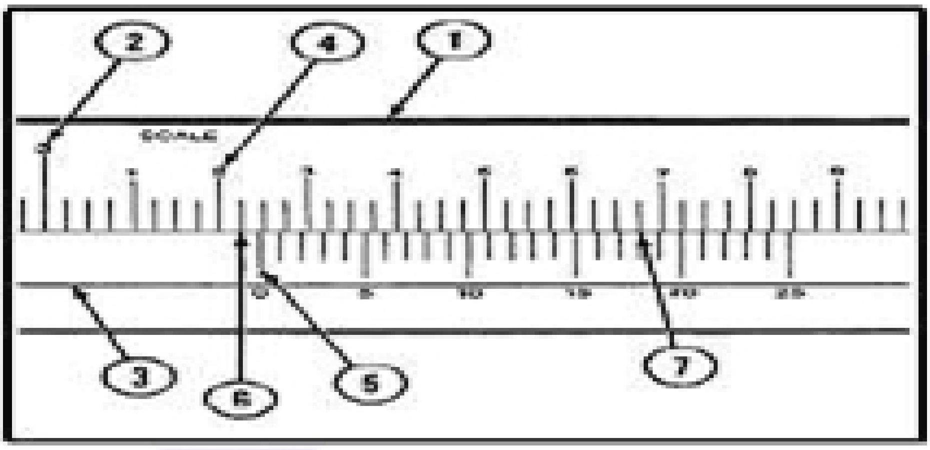
and record . .3 x .025 = .075 inch

Read the highest line on the vernier scale (3) which lines up with the lines on the top scale (7) and record. (Remember 1/25 = .001 inch) . .11/25 or 0.011 inch TOTAL 1.486 inches

Most vernier 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 is divided into centimeters (cm) and the longest lines represent 10 Millimeters each. Each millimeter is divided into quarters. The venire scale is divided into 25 parts and is numbered 0, 5, 10, 15, 20 and 25. Read the total number of millimeters to the left of the vernier zero index and record.32.00 mm Read the number of quarters between the millimeter mark and the zero index and record Read the highest line on the vernier scale (3) which lines up with the line on the scaleand record .... .18 mm

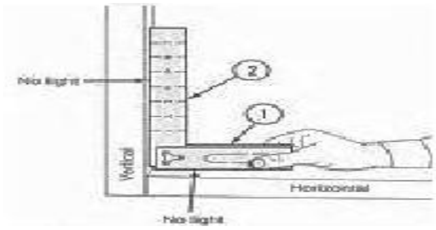
TOTAL 32.43mm

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.

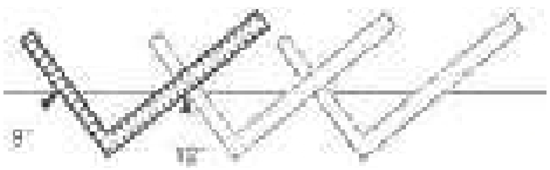
Operation Sheet – 2	USING A TRY SQUARE

TO MARK A SQUARE LINE



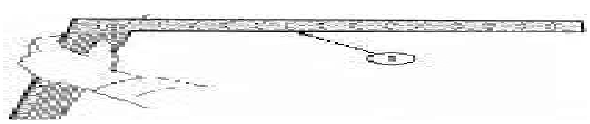
1. To mark a square line, place the blade or tongue (1) of the square against the side of the material with
the square tilted slightly so the blade or tongue of the square extends across the work. 2. Mark a line across the work using a pencil or marking crayon.

USING A CARPENTER'S SQUARE TO LAY OUT STEPS



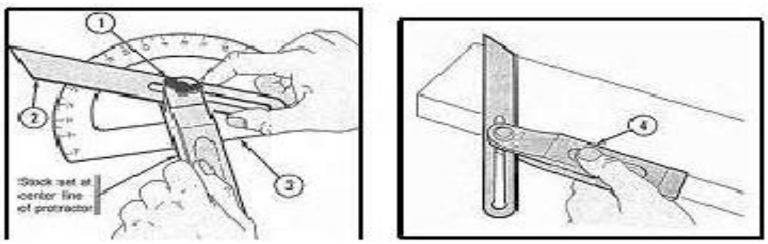
1. The following example shows proper square position when marking cut lines for a series of steps 9" x 12."
2. Continue the process until desired number of steps has been lay out.

USING A TRY SQUARE



1. To check a square joint, place the stock (I') against a horizontal section and the blade (2) against a vertical section. Light must not be seen around blade edge. If light is seen, the work is not square.

USING A SLIDING T-BEVEL SQUARE



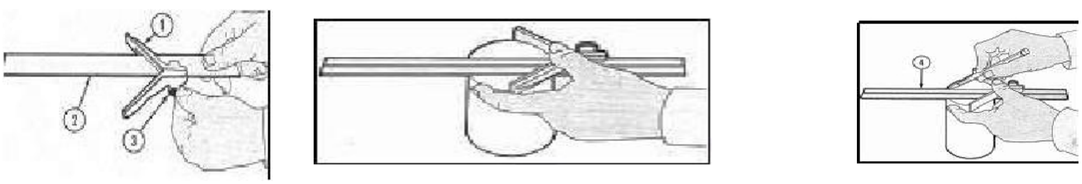
1 .Loosen locking nut (1) and adjust blade

(2) To measure a desired angle using protractor

(3). Tighten locking nut(1). And 2. The angle may now be laid out by extending the blade across the board with the stock

(4) held firmly against the edge

USING A COMBINATION SQUARE



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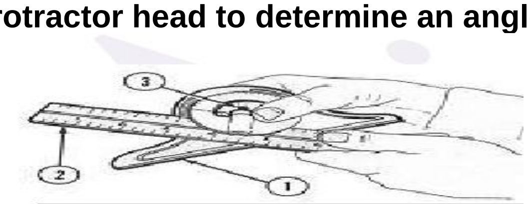
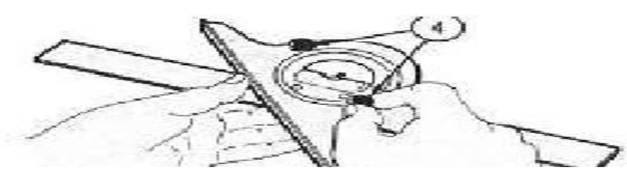
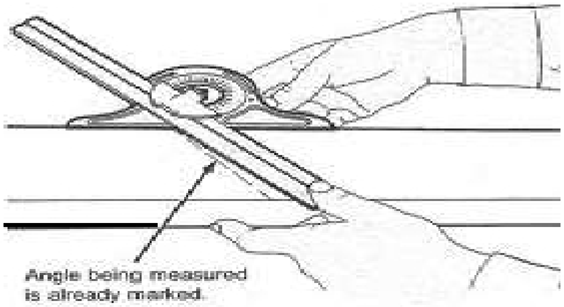
1. Slide center head (1) on rule (2) and fasten by tightening setscrew (3).
2. Put the center head flush against the cylinder.
3. Mark the diameter on the cylinder using a pencil or marking crayon by drawing a straight line along the inside edge (4). Make sure the square does not slip while marking.

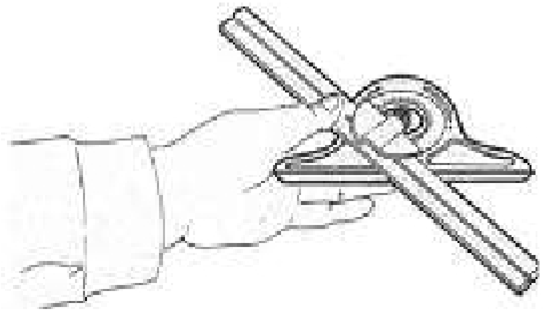
Using as a protractor head to determine an angle



Using as a protractor head to determine an angle







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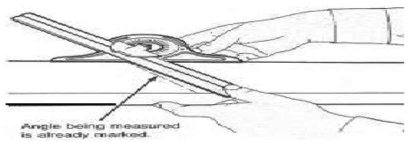
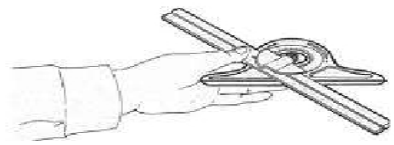
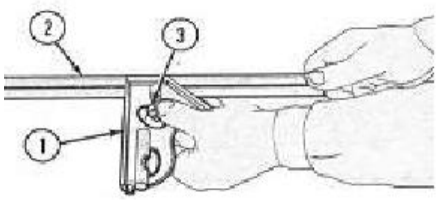
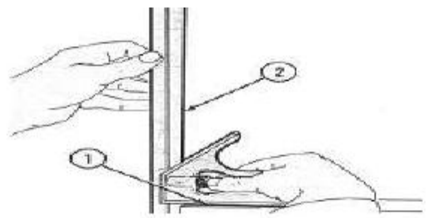


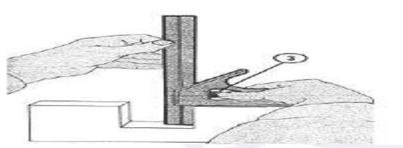


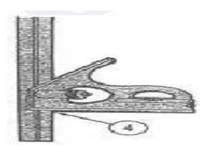
Place the rule on the angle being measured and pivot the protractor head against the edge. Tighten adjustment screws Remove and read measured angle on a protractor scale. Using as a combination square to determine depth





1. Side square head (1) on rule (2) and fasten by tighten setscrew (3)
2. loosen setscrew Set the flat surface of the square head (1) above the hole and adjust the rule (2) until it hits the bottom





Tighten setscrew (3) Re the intersection of the rule and the square head (4)move the combination square and read the depth at

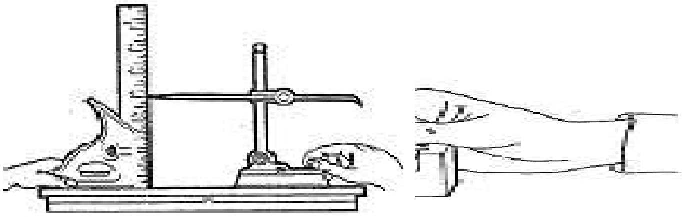
CARE OF SQUARES

1. Make sure squares are kept clean
2. apply a light of oil to all metal surfaces after using.
3. A square with a loose stock is no good. Replace the square

Operation Sheet – 3	USING THE SURFACE, DEPTH, AND HEIGHTGAGES

USING A SURFACE GAGE

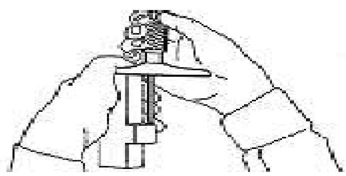
Setting gage for transfer of 4-inch vertical measurement



USING A RULE DEPTH GAGE

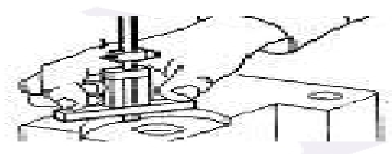
Measuring the distance from a surface to a recessed point

USING A MICROMETER DEPTH GAGE



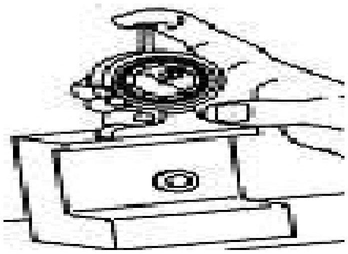
Measuring projection depth with micrometer precision

USING A VERNIER DEPTH GAGE



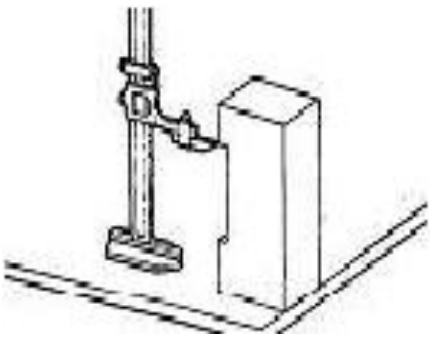
Measuring hole a depth of die from a given surface

USING A DIAL DEPTH GAGE



Measuring depths of holes, recesses, slots, scratches and paint thicknesses.

USING A HEIGHT GAGE



Measuring vertical distance from a plane surface

CARE OF SURFACE, HEIGHT, AND DEPTH GAGES

1. Coat all metal parts of gages with a light coat of oil to prevent rust.
2. Carefully store gages when not in use. Use separate containers if provided by manufacturer.
3. Keep graduations and markings clean and legible.
4. Do not drop any gage. Small nicks and scratches can cause inaccurate measurements.
5. Protect all pointed gage parts from damage.

Information Sheet-4	Making workstation ready in accordance with job specifications

4.1. Introduction To Work Station Of Electrical Hand Tools

The floor and interior of the operator's station/work station should be made of fire-resistant materials. Machines with an engine performance exceeding 30 kW should have a built-in fire extinguisher system or a location for installing a fire extinguisher that is easily reached by the operator. Also your practical work shop tool preparation must be ready for any electrical work activates at any time .

4.2. SAFE WORK PRACTICES

A safe work environment is not enough to control all electric hazards. You must also work safely. Safe work practices help you control your risk of death from workplace hazards. If you are working on electrical circuits or with electrical tools and equipment, you need to use safe work practices.

- Before you begin a task, ask yourself:
- What could go wrong?
- Do I have the knowledge, tools, and experience to do this work safely?

All workers should be very familiar with the safety procedures for their jobs. You must know how to use specific controls that help keep you safe. You must also use good judgment and common sense.

4.3. Cleaning

- Clean the tools immediately after use.
- Wash the tools using water. A wire brush may be useful to loosen the soil stuck to the blades.
- Avoid the risk of spreading pathogens while the tools are being cleaned.
- Coat the blades with light oil like WD-40 on areas prone to rust.

4.4. **Lubrication** is the process or technique employed to reduce friction between, and wear of one or both, surfaces in proximity and moving relative to each other, by interposing a substance called a lubricant in between them. The lubricant can be a solid, (e.g. Molybdenum disulfide MoS_2)a solid/liquid dispersion, a liquid such as oil or water, a liquid-liquid dispersion (a grease) or a gas.

- ✓ With fluid lubricants the applied load is either carried by pressure generated within the liquid due to the frictional viscous resistance to motion of the lubricating fluid between the surfaces, or by the liquid being pumped under pressure between the surfaces.
- ✓ Lubrication can also describe the phenomenon where reduction of friction occurs unintentionally, which can be hazardous such as hydroplaning on a road.

Self-Check 4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Part Ⅰ: Say true and false for the following question below

_____________1. A safe work environment is enough to control all electric hazards.
_____________2. Lubrication is the process or technique employed to reduce friction .
_____________3. Portable tool boxes are not used for carrying and storing a variety of hand tools

Part Ⅱ . Choose the best answer from the question below

1. Which one of the following used for storing tools
   - **A. Tool box**
   - **B. Lubrication**
   - **C. Cleaning**
   - **D. none**

Answer Sheet

Name: ___________________________ Date____________

References

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Instruction Sheet	LG29: Select measuring instrument

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

- Types of measuring instruments and their uses(UK)
- Selecting appropriate measuring instrument
- Obtaining accurate measurement
- Performing calculation to complete work tasks.
- Using calculation to complete workplace tasks.
- Checking and correcting numerical computation for accuracy
- Reading instruments to the limit accuracy of the tool.

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

- Select appropriate ***measuring instrument*** to achieve required outcome
- Obtain accurate measurements are for job.
- Types of measuring instruments and their uses(UK)
- Perform ***calculation*** needed to complete work tasks using the four basic process of addition (+), subtraction (-), multiplication (x), and division (/)
- Use calculation involving fractions, percentages and mixed numbers to complete workplace tasks.
- Check and correct numerical computation for accuracy
- Read Instruments to the limit of accuracy of the tool.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” in each information sheets.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets and LAP Tests if any”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After you accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; Then proceed to the next learning guide.

Information Sheet-1	Types of measuring instruments and their uses(UK)

1.1. Introduction

The instrument used for measuring the physical and electrical quantities is known as the measuring instrument. The term measurement means the comparison between the two quantities of the same unit. The magnitude of one of the quantity is unknown, and it is compared with the predefined value. The result of the comparison obtained regarding numerical value.

The measuring instrument categorized into three types;

- Electrical Instrument
- Electronic Instrument
- Mechanical Instrument

The mechanical instrument uses for measuring the physical quantities . This instrument is suitable for measuring the static and stable condition because the instrument is unable to give the response to the dynamic condition. The electronic instrument has quick response time. The instrument provides the quick response as compared to the electrical and mechanical instrument. The electrical instrument is used for measuring electrical quantities likes current, voltage, power, etc. The ammeter , voltmeter , wattmeter are the examples of the electrical measuring instrument. The ammeter measures the current in amps; voltmeter measures voltage and Wattmeter are used for measuring the power. The classification of the electric instruments depends on the methods of representing the output reading.

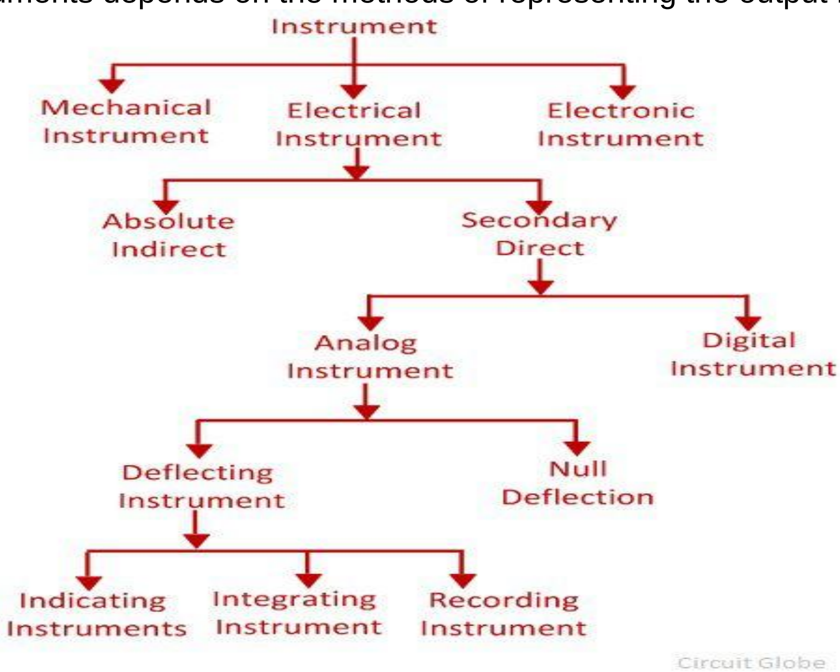


Fig. 1.1. types of measuring instrument.

1.2. Absolute Instrument

The absolute instrument gives the value of measures quantities regarding the physical constant. The physical constant means the angle of deflection, degree and meter constant. The mathematical calculation requires for knowing the value of a physical constant. The tangent galvanometer is the examples of the absolute instruments. In tangent galvanometer, the magnitude of current passes through the coil determines by the tangent of the angle of deflection of their coil, the horizontal component of the earth magnetic field, radius and the number of turns of wire used. The most common applications of this type of instrument are found in laboratories.

1.3. Secondary Instrument

In the secondary instrument, the deflection shows the magnitude of the measurable quantities . The calibration of the instruments with the standard instrument is essential for the measurement. The output of this type of device is directly obtained, and no mathematical calculation requires for knowing their value.

1.4. Digital Instrument

The digital instrument gives the output in the numeric form . The instrument is more accurate as compared to the analogue instrument because no human error occurs in the reading.

1.5. Analog instrument

The instrument whose output varies continuously is known as the analogue instrument. The analogue instrument has the pointer which shows the magnitude of the measurable quantities. The analogue device classifies into two types.

1.6. Null Type Instrument

In this instrument, the zero or null deflection indicates the magnitude of the measured quantity. The instrument has high accuracy and sensitivity. In null deflection instrument, the one known and one unknown quantity use. When the value of the known and the unknown measuring quantities are equal, the pointer shows the zero or null deflection. The null deflection instrument is used in the potentiometer and in galvanometer for obtaining the null point.

1.7. Deflection Type Instrument

The instrument in which the value of measuring quantity is determined through the deflection of the pointer is known as the deflection type instrument. The measuring quantity deflects the pointer of the moving system of the instrument which is fixed on the calibrated scale. Thus, the magnitude of the measured quantity is known.

The deflection type instrument is further sub-classified into three types.

- **Indicating Instrument –** The instrument which indicates the magnitude of the measured quantity is known as the indicating instrument . The indicating instrument has the dial which moves on the graduated dial. The voltmeter, ammeter, power factor meter are the examples of the indicating instrument.

- **Integrating Instrument –** The instrument which measures the total energy supplied at a particular interval of time is known as the integrating instrument. The total energy measured by the instrument is the product of the time and the measures electrical quantities. The energy meter , watt-hour meter and the energy meter are the examples of integrating instrument.

- **Recording Instrument –** The instrument records the circuit condition at a particular interval of time is known as the recording instrument . The moving system of the recording instrument carries a pen which lightly touches on the paper sheet. The movement of the coil is traced on the paper sheet. The curve drawn on the paper shows the variation in the measurement of the electrical quantities.

1.8. Use of measuring instrument.

- **Advantages of Mechanical Instruments**
  - ✓ Relatively cheaper in cost
  - ✓ More durable due to rugged construction
  - ✓ Simple in design and easy to use
  - ✓ No external power supply required for operation
  - ✓ Reliable and accurate for measurement of stable and time invariant quantity
- **Disadvantages of Mechanical Instruments**
  - ✓ Poor frequency response to transient and dynamic measurements
  - ✓ Large force required to overcome mechanical friction
  - ✓ Incompatible when remote indication and control needed
  - ✓ Cause noise pollution
- **Uses of Electrical Measuring Instruments**:

These measuring instruments are helping to determine the electrical quantities 0r the numerical values for the electrical appliances. In the daily routine, instruments used in the lab, commercial, industrial, many more place. In Generating Station and Substation, the most important purpose of the instruments is the data recording.

Apart from that, the following are some of the major use cases of electrical measuring instruments.

- ✓ To find out the unknown numerical values of the electrical quantities and for comparison with the standard values.

- ✓ To find out the error in the measuring values in the circuit or system.
- ✓ It helps to find out fault condition and to protect the electrical appliances.
- ✓ Measuring instruments are used for recording the data with respect to the time.
- ✓ It is essential for displaying numerical values of the electrical quantities as per the time.
- ✓ Electrical measuring instruments give the accurate and efficient reading for electrical equipment. Mostly, the digital meter is used for accurate reading.
- ✓ It is also used for the safety purpose while electrical circuit development and testing in the

Self-Check 1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Choose the best answer from the question below

1. Which one of the following instrument does not need mathematical calculation for knowing their value.
   A. Secondary instrument
   B. Absolute instrument
   C. Analog instrument
   D. Digital instrument
2. which instrument indicates the magnitude of the measured quantity
   A. Direct instrument
   B. Indirect instrument
   C. Digital instrument
   D. All
3. One of the following is not Advantages of Mechanical Instruments
   A. Relatively cheaper in cost
   B. More durable due to rugged construction
   C. Simple in design and easy to use
   D. None

Note: **Satisfactory rating - 2 points** **Unsatisfactory - below 2 points**.

Score = ___________
Rating: ____________

Name: _________________________ Date: _______________

Information Sheet-2	Selecting appropriate measuring instrument

2.1. Introduction

A measuring instrument is a device for measuring a physical quantity. In the physical sciences, quality assurance, and engineering, measurement is the activity of obtaining and comparing physical quantities of real-world objects and events. Established standard objects and events are used as units, and the process of measurement gives a number relating the item under study and the referenced unit of measurement. Measuring instruments, and formal test methods 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. Scientists, engineers and other humans use a vast range of instruments to perform their measurements. These instruments may range from simple objects such as rulers and stopwatches to electron microscopes and particle accelerators. Virtual instrumentation is widely used in the development of modern measuring instruments.

2.2. Measuring instrument selection criteria

One of the tasks at planning of quality inspection is selection of measuring instruments. The measuring instruments are the most important part of the measuring process so their selection have to be done carefully. The selection of measuring instruments is a complex task, which depend on the size, the character and the value of measured magnitude. The purpose of this paper is to analyze the existing methods for selection of measuring equipment. In the paper are presented the advantages and disadvantages of existing methods and recommendation for their implementation, according to the metrological tasks given. There are results obtained, using the Measurement System Analysis (MSA), for: selection of the correct measuring instrument and method; assessment the capabilities of measuring instruments; assessment of the procedures and operators; assessment of any measuring interactions, calculating the uncertainty of measuring of individual measuring instrument and/or measuring systems.

- **The selection of measuring instruments** depends on the measurement to be performed. Generally, three characteristics are considered; these are:
  - ✓ The range and magnitude of the parameter to be measured and the accuracy of the measurement (the instrument should have the range to cover effectively the range of the parameter).
  - ✓ The resolution of the measuring instrument should be smaller than the minimum unit of measurement of the parameter.

- ✓ Lastly, and most importantly, the accuracy or uncertainty of the measuring instrument should comply with the accuracy requirement of the parameter to be measured.

➢ Table. 2.1. accuracy of measurement

Parameter to be measured	Accuracy of measurement
100° ± 10°C	± 3°C
100° ± 1ºC	± 0.3°C

In order to select the correct measuring instrument, the implications of instrument accuracy on the measurement data and the effect it has on decisions taken based on the data must be clearly understood. If the accuracy of a measuring instrument is ± 1, this means that the value displayed on the instrument would be considered the correct value so long as the actual value of the measurement is within ± 1 of the actual value. In other words, if 10 is the reading displayed on a measuring instrument while making a measurement and if ± 1 is the accuracy of that instrument, then the actual value could be anywhere between 9and 11, including either 9 or 11. Thus, the expanded value of the measurement can be considered as 11. Instead of direct algebraic addition, however, a better projectionist that instead of 11, the expanded value is $\sqrt{10^2+1^2}$ = (101) = 10.05. Thus, the original value of 10 has now been expanded to 10.05. This is based on the statistical theory of root sum squares. So now, instead of 11, the original value becomes 10.05 based on the accuracy of the measuring instrument.

Selection criteria, as mentioned above, should generally be followed when procuring new instruments. However, in many cases the measuring instruments are already available. In such situations, action as described below should be taken.

- First, the parameter being measured should be examined to check whether the tolerance and the accuracy have been stated. Next, the measuring instrument should be checked to see whether the range and the resolution are appropriate for the measurement. Lastly, the accuracy of the instrument should be checked to see whether it satisfies the specified requirement. In cases where the accuracy of the measurement is not specified, the instrument's accuracy should be examined to see if it is better than one third of the tolerance. If it is, then the instrument selection was appropriate.

- If, however, the measuring instrument's accuracy is more than one third of the tolerance of the parameter, then either of the following actions should be taken:
  - ✓ Replace the instrument with an appropriate one, if the present system of measurement is affecting the quality of the product resulting in rejection or rework at the subsequent stage of production;
  - ✓ Review the specified tolerance if the existing measurement system does not affect the product quality. This means that perhaps the close tolerance specified is not needed and hence the tolerance could be increased to accommodate the accuracy of the instrument.
- For measurement data to be reliable, measurement should be:
  - ✓ Accurate
  - ✓ Precise
  - ✓ Reproducible

Handling and storage of measuring instruments is very important for the measurement process. If handling and storage of such instruments is not appropriate, even a robust one may malfunction or may give erroneous output. To ensure proper handling and storage, a system approach is the most suitable.

Self-Check 2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Part I : <u>Say true and false for the following question below</u>

_________ 1. The range and magnitude of the parameter to be measured.

__________ 2. Handling and storage of measuring instruments is not very important for the measurement process.

Part II. Choose the best answer from the question below

1. Which one of the following Measuring instrument?
   - A. Multi range meter
   - B. Screw driver
   - C. Electrical knife
   - D. Side cutter
2. Which one of the following characteristics of Measuring instrument**?**
   - A. Range and magnitude
   - B. Resolution
   - C. Accuracy
   - D. All
3. Which one of the following is **selection** criteria for measuring instrument?
   - A. Resolution
   - B. Accuracy
   - C. Precise
   - D. All

Answer Sheet

Name: _________________________ Date: _______________

Score = ___________
Rating: ____________

Satisfactory rating: above 2 **unsatisfactory rating: Below 2**

Information Sheet-3	Obtaining accurate measurement

3.1. Measurements and calculation

- **RATIO AND PROPORTION**
  - ✓ **RATIO:-**is a comparison of two or more quantities. The ratio of two quantities is the quotient of two quantities that tells the numerical relationship of the two quantities usually written as fractions. Ratios are expressed by the symbol (:) placed between the two numbers being compared or in the forms of fractions.Eg.2/4,2:4,1:2. This means If the total quantity (student) is 90,30students are girls and 60 students are boys.

Example

1. State the ratio between 40cm and 2m.

   2mx100=200cm

   40cm/200cm=1/5cmor 1:5

Calculate the followings

1. Two speeds are in the ratio 2:5 if the first speed is 60km/hr, what is the second speed? IF360 birr is divided among three people in the ratio of 3:4:5, find the share of each people.The height of chaltu to chala is in the ratio of 5:7.If chala's height is 1.75m ,

what is chaltu's height?

- **PROPORTION:-**is an equality of two quantities or ratios. When two ratios are equal the four terms taken in order are called proportional's and the ratios are said to be in proportion.eg a/b: c/d, ratio a:b is proportional to c:d.That means ad(extremes)=bc (means).

Example.

1.Find the unknown terms in each of the following proportions.

a).5:15=Y:6

b).2:Z=4:12

15xY=5x6

Zx4=2x12

Y=5x6/15=2,Y=2 Z= 2x12/4=6, Z=6

EX. Are the following numbers taken in order of proportion?

a)3,6,7,12 b).2,5,8.20 c)6,12,12.24

- **DIRECT PROPORTIONALITY**

Y is said to be directly proportional to X (Y∞X) if their is a constant k , such that Y=kX .k is called the constant of proportionality.

EXAMPLE
If the connected load/resistance/ in the circuit is constant 5o ohm with 1A , see the following table

Current in amps (X)	1A	2A	3A	4A
Voltage in volts (Y)	50v	100v	150v	200v

Y is directly proportional to X because as X increases Y also increase as a factor of 50 x .Observe the table carefully that 50=50/1=100/2=150/3=200/4 is the constant of proportionality is k=50 ohm.

- **INVERSE PROPORTIONALITY**

Y is said to be inversely proportional to X (Y ∞ 1/X) if there is a constant k such that Y=K.1/X or Y.X=K
Compare the proportionality of current and resistance in a simple dc circuit of constant voltage 200v per one ampere

Current in Amps (X)	1A	2A	3A	4A
Resistance in ohms(Y)	200	100	66.67	50

Remember that as the current (X) increase, the resistance of the circuit(Y) decrease but Y.X is constant=200

- **PERCENT**

The word percent means “for every hundred”. When we speak of a certain percent of something, we mean that it is that portion of 100 units. Percent is designated by %.
For example, 20% is read as 20 percent, it means 20 out of every hundred and is equivalent to 20/100.

To express a given decimal fraction or common fraction as a percent , we multiply the decimal fractions or the common fraction by 100/100.

Eg. a).0.05=0.05 x 100/100=5/100=5%
b). ½ =1/2 x100/100=50/100=50%

To express a percent as a common fraction, omit the percent sign and write the percent as the numerator of a fraction whose denominator is 100 then reduce this fraction to its lowest term.

Example

a).35%=35/100=7/20=0.35

Self-Check 3	Written Test

Direction: choose the best answer for all the questions listed below. Illustrations may be necessary to aid some explanations/answers.

Part. I Choose the best answer from the question below

1. The area of a square below is 18 square units. What is the perimeter of the rectangle?
   A. 34 units
   B. 36 units
   C. 20 units
   D. 22 units
4. **Which one of the following is the SI unit of length? (2Points)**
   A. Kilo gram
   B. Meter
   C. Second
   D. Square meter

Part II. Match

Column A	**Column B**
_______1. Volume.	A. equality of two quantities or ratios.
_______2. Area.	B. comparison of two or more quantities.
_______3. Proportional .	C. surface of an object
_______4. Ratio	D. meter cube

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Satisfactory rating: above 2 unsatisfactory rating: Below 2

Operation Sheet -1	Techniques of measuring perimeter of a polygon/a circle

Step 1: Select measuring tools and equipments

Step 2: Select polygon or circle that you are going to measure its perimeter.

Step 3: On the board, draw a rectangle labeled with a length of 4 feet and width of 3 feet. Then draw a **right triangle** with a base of 4 feet, height of 3 feet, and *hypotenuse* (the side opposite the right angle) of 5 feet.

Step 4: Measure the perimeter of any polygon, you add together the lengths of each side. *P* = side a + side b + side c. The perimeter is 3 + 4 + 5, or 12 feet.

Step 5: Record and report the measurements

Information Sheet-4	Performing **calculation** to complete work tasks using

4.1. The four basic mathematical operations

Introduction

- **CALCULATION:** Is a deliberate process that transforms one or more inputs into one or more results, with variable change. The term is used in a variety of senses, from the very definite arithmetical calculation of using an algorithm, to the vague heuristics of calculating a strategy in a competition, or calculating the chance of a successful relationship b/n two people. To calculate means to ascertain by computing.
  - ✓ Area,
  - ✓ Volume,
  - ✓ Triangle
  - ✓ Perimeter
  - ✓ Circle and
  - ✓ Circumference)

The four basic mathematical operations: Addition, subtraction, multiplication, and division have application even in the most advanced mathematical theories. Thus mastering them is one of the keys to progressing in an understanding of math and, specifically, of algebra.

- **Addition, Subtraction, Division and Multiplication**

- **Addition and subtraction**: are two complementary operations. We can actually define subtraction in terms of addition. Addition is simply the combination of distinct sets of like entities (and we must stress the word like). Thus, if we add one set of four squares to another set of five squares, we get a total of nine squares or simply 4+5=9.

If two numbers are added, it does not matter in which order they are added. (Forexample,5+3=8 and 3+5=8, or 5+3=3+5) this statement generalized and accepted as being correct for all Possible combinations of numbers being added, is called **the commutative law for addition.** It states that the sum of two numbers is the same, regardless of the order in which they are added. We make no attempt to prove this law in general, but accept that it is true.

In the same way, we have **the associative law for addition**, which states that the sum of three or more numbers is the same, regardless of the way in which they are grouped for addition.
For-example, 3 + (5 + 6) = (3 + 5) + 6.

- **Subtraction**: is the opposite of addition. Instead of adding two quantities (numbers), we are removing one from another. Thus, if we have nine squares and take away (subtract) five, we are left with four squares. Using just the numbers, where the minus sign (-) represents the subtraction operation, 9-5=4

  Here, 9 and 5 are the terms of the operation, and 4 is the difference. Unlike addition, ***subtraction is not commutative.*** That is to say, 9-5 and 5-9 are not the same.

- **Multiplication:** The two numbers to be multiplied are called factors, and the result is called the product. The laws just stated for addition are also true for multiplication. Therefore, the product of two numbers is the same, regardless of the order in which they are multiplied, and the product of three or more numbers is the same, regardless of the way in which they are grouped for multiplication.

For example, 2 * 5 = 5 * 2, and 5 * (4 * 2) = (5 * 4) * 2.

Another very important law is the distributive law. It states that the product of one number and the sum of two or more other numbers is equal to the sum of the products of the first number and each of the other numbers of the sum.
For example, 5(4+2) =5*4+5*2

- **Division**: is the inverse of multiplication. The number being divided is called dividend, the number by which it is divided is called the divisor, and the result is called quotient. Unlike multiplication, ***division is not commutative.***

- **Fundamental laws of algebra**
  - Commutative law of addition: a + b =b + a
  - Associative law of addition: a + (b + c) = (a + b) + c
  - Commutative law of multiplication: a (b*c) =(a*b) c
  - Associative law of multiplication: a (b*c) = (a*b) c
  - Distributive law: a (b + c) = a*b + a*c

4.2. Calculating perimeter, area and volume of a shape.

- **Calculating perimeter of a shape.**

The perimeter of a shape is the sum of the lengths of its sides. Since the two lengths (l) are equal to each other and the two widths (w) are equal to each other in a rectangle, the formula for perimeter, P, of a rectangle is:

$P = 2(l + w)$ or $P = 2l + 2w$

The perimeter of a shape is defined as the distance around the shape. Since we usually discuss the perimeter of polygons (closed plane figures whose sides are straight line segment), we are able to calculate perimeter by just adding up the lengths of each of the sides.

- **The perimeter of a circle**

When we talk about the perimeter of a circle, we call it by the special name of circumference. Since we don't have straight sides to add up for the circumference (perimeter) of a circle, we have a formula for calculating this.

- **Calculating Area of a shape.**

The area of a shape is defined as the number of square units that cover a closed figure. For most of the shape that we will be dealing with there is a formula for calculating the area. In some cases, our shapes will be made up of more than a single shape. In calculating the area of such shapes, we can just add the area of each of the single shapes together.

- **Area of a rectangle**

A rectangle is a quadrilateral with opposite side's parallel and right interior angles**.** The formula is given by:

- ***REMEMBER:*** In the process of calculating the area, we multiply unit's times units. This will produce a final reading of square units (or units squared). This

fits well with the definition of area which is the number of square units that will cover a closed figure.

- **Area of a triangle**

The height of a triangle is the perpendicular distance from any vertex of a triangle to the side opposite that vertex. In other words, the height of triangle is a segment that goes from the vertex of the triangle opposite the base to the base (or an extension of the base) that is perpendicular to the base (or an extension of the base). Notice that in this description of the height of a triangle, we had to include the words "or an extension of the base".

This is required because the height of a triangle does not always fall within the sides of the triangle. Another thing to note is that any side of the triangle can be a base. You want to pick the base so that you will have the length of the base and also the length of the height to that base. The base does not need to be the bottom of the triangle. You will notice that we can still find the area of a triangle if we don't have its height. This can be done in the case where we have the lengths of all the sides of the triangle. In this case, we would use Heron's formula.

- **Area of a parallelogram**

A parallelogram is a quadrilateral with opposite sides parallel. You will notice that this is the same as the formula for the area of a rectangle. A rectangle is just a special type of parallelogram. The height of a parallelogram is a segment that connects the top of the parallelogram and the base of the parallelogram and is perpendicular to both the top and the base. In the case of a rectangle, this is the same as one of the sides of the rectangle that is perpendicular to the base.

- **Area of a trapezoid**

A trapezoid is a quadrilateral that has one pair of sides which are parallel. These two sides are called the bases of the trapezoid. The height of a trapezoid is a segment that connects the one base of the trapezoid and the other base of the trapezoid and is perpendicular to both of the bases.

- **Volume:**is the quantity of three-dimensional space enclosed by a closed surface, for example, the space that a substance (solid, liquid, gas, or plasma) or shape occupies or contains. Volume is often quantified numerically using the SI derived unit, the cubic meter. The volume of a container is generally understood to be the capacity of the container, i. e. the amount of fluid (gas or liquid) that the container could hold, rather than the amount of space the container itself displaces.
  - Three dimensional mathematical shapes are also assigned volumes. Volumes of some simple shapes, such as regular, straight-edged, and circular shapes can be easily calculated using arithmetic formulas.
  - The volume of a solid (whether regularly or irregularly shaped) can be determined by fluid displacement. Displacement of liquid can also be used to determine the volume of a gas. The combined volume of two substances is usually greater than the volume of one of the substances. However, sometimes one substance dissolves in the other and the combined volume is not additive.

Volume is the measure of the space inside of a three-dimensional solid. In the

4.3. Calculation of Areas and Volume

- Calculation of area

Definition: - The unit of measurement for an area is in square meter (m2). This term is mostly encountered in determining the area to be: Excavated, Compacted, Surfaced and Grassed areas.

Table 4.1. (A): Relationship between various units of areas

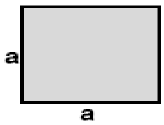
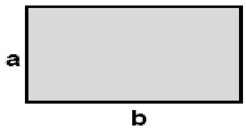
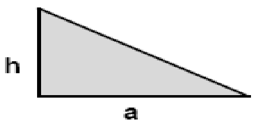
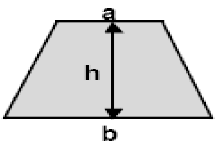
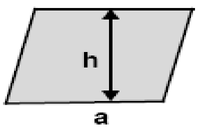
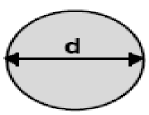
	mm^2	cm^2	m^2	hectare	km^2
$1mm^2$	1	0.01	0.0000001		
$1cm^2$	100	1	0.0001		
$1m^2$	1,000,000	10,000	1	0.0001	0.000001
hectare			10,000	1	0.10
$1km^2$			1,000,000	100	1

Table 4.2. (B): Calculation of areas

mm x mm = mm^2	cm x cm = cm^2	m x m = m^2	km x km = km^2

Other special units are:

10m x 10m = $100m^2$ = 1are	100m x 100m = $10,000m^2$ = 1hectare

	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

- **Calculation of Volume**

Volume is the amount of space taken up by a three dimensional shape or object. Volume is related to capacity, which is the amount of liquid that a container can hold. This type of measurement is used when measuring liquids such as water. Volume is measured in cubic meters. One cubic meter is the volume of a cube with sides of one meter.

The volume of objects with a regular, geometric shape such as a cube or a cylinder can be determined by applying the appropriate formula. For example, the volume of a block can be calculated by multiplying the length times the width times the height. The volume of a cylinder is equal to π (3.14) times the height times the radius squared.

$$V \text{ (of cube)} = lwh$$

$$V \text{ (of cylinder)} = \pi * r^2 h$$

- ✓ The most frequently used unit of measurement for volume is the cubic meter (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
  - Volume of liquids
  - Volume of liquid thanks

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

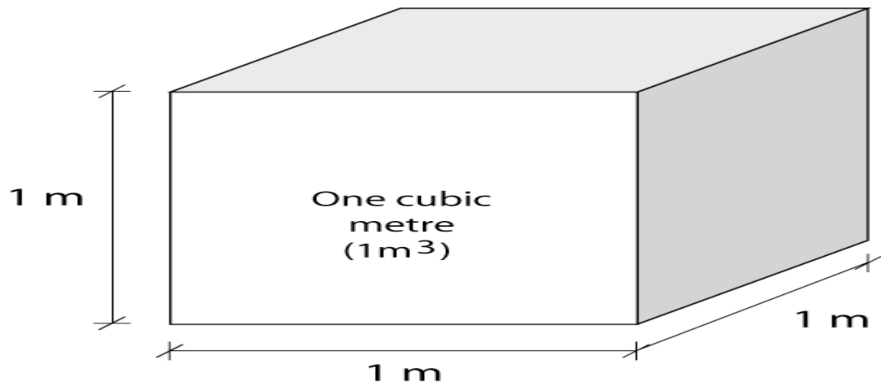


Fig. 4.1. cube dimension

Capacity, which is measured in liters. For instance, one cubic meter holds 1,000 liters. And, 0.001 m3 (one thousandth of a cubic meter) holds 1 liter.

To calculate the volume of a rectangular block, multiply the height by the width by the thickness.

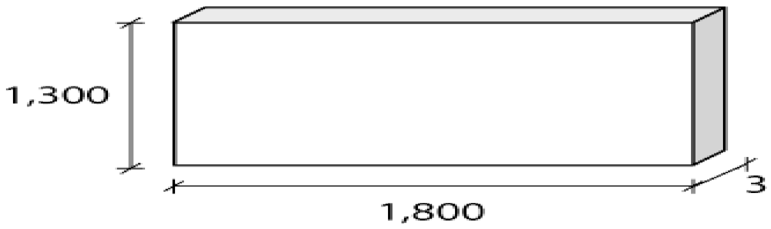


Fig.4.2. cube

For example

Volume = H x W x T

= 1,800 mm x 1,300 mm x 3 mm

= 1.8 m x 1.3 m x .003 m

= 0.00702 m

To calculate the capacity of a rectangular space, find its volume in cubic meters, then multiply by 1,000. This will give you the capacity in liters.

For example – how many liters of water would a fish tank like the one shown below hold?

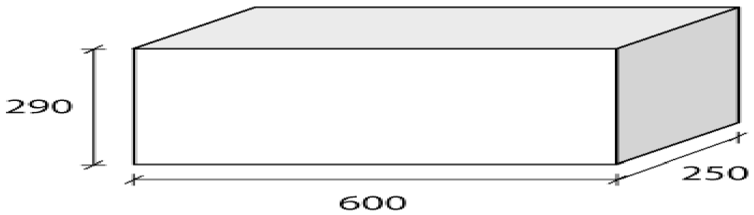


Fig.4.3 volume in cubic

Volume = H x W x T

= 290 mm x 600 mm x 250 mm

= 0.29 m x 0.6 m x 0.25 m

= 0.0435 m3

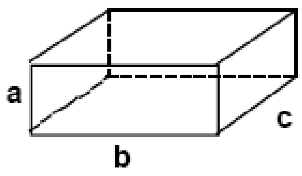
Capacity = 0.0435 x 1,000

= 43.5 Litres

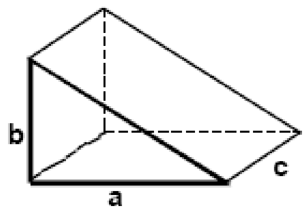
Table 4.3. : basic mathematical relation for calculation of volume

$mm^2 \times mm = mm^3$	$cm^2 \times cm = cm^3$	$m^2 \times m = m^3$	$km^2 \times km = km^3$

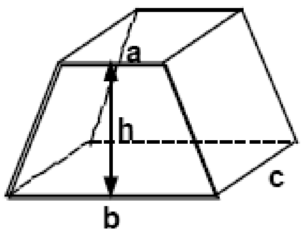
Calculations for volumes:



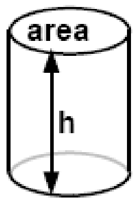
rectangular prism: $a \times b \times c = v$



triangular prism: $\frac{a \times b}{2} \times c = v$



quadrilateral prism: $\frac{a + b}{2} \times h \times c = v$



cylinder: area x h

$\frac{d^2 \times \pi}{4} \times h = v$

Table 4.3. (B): Relationships between various types 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

Example:

If a trench is excavated 20m long which is 600mm deep and 550mm wide, how much soil is removed from the trench?

Answer: The volume is 20m x .600mm x .550mm = 6.60 m3

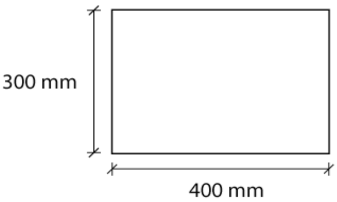
- **Calculation of Perimeters**

Perimeter: The perimeter is the distance around the edge of something. You will need to calculate perimeter so that you can work out the cost of edgework to be done.

To calculate the perimeter (P) of an object with straight sides, simply measure the lengths of each side and add them up.

For example:

a/



P = total of all side lengths

= (300 + 400 + 300 + 400) mm

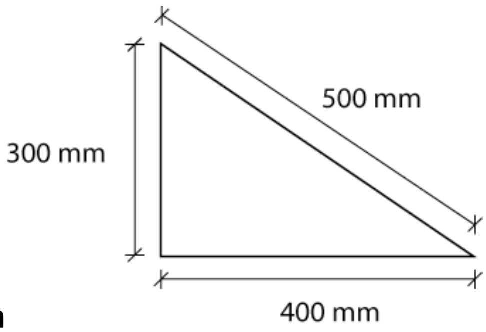
= 1,400 mm

= 1.4 Lm

b/

P = total of all side lengths

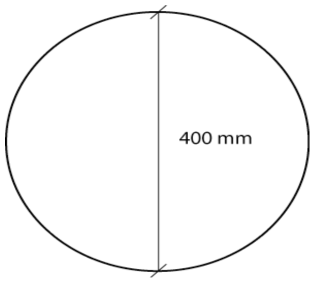
= (300 + 400 + 500) mm



= 1,200 mm = 1.2 Lm

Fig.4.4. A./ B show the perimeter of rectangle and triangle

The perimeter of a circle is also called the circumference (C). Its length is just over three times the length of the diameter. It can be worked out by multiplying π□(3.14) by the diameter (the width of the circle).



C = π x diameter

= 3.14 x 400 mm

= 1,256 mm

= 1.256 Lm

fig. 4.5. show the perimeter circle

If you need to work out the perimeter of a more complex shape, start by writing the length on all sides.

For example:

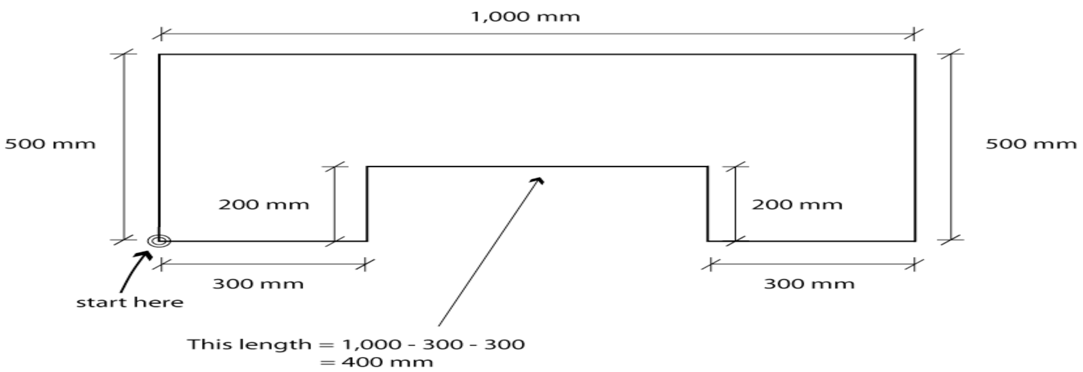


Fig. 4.6. perimeter of mixed figure

Then, add up the lengths of all the outer edges.

For example:

P = total of all side lengths

= (500 + 1,000 + 500 + 300 + 200 + 400 + 200 + 300) mm

= 3,400 mm

= 3.400 Lm

Start at one corner and work in a clockwise direction. This will make sure that you don't miss out any of the side lengths. If the shape has straight and curved sides you may need to do several calculations to get the perimeter.

For example, the shape below is made up of two semicircles and a rectangle.

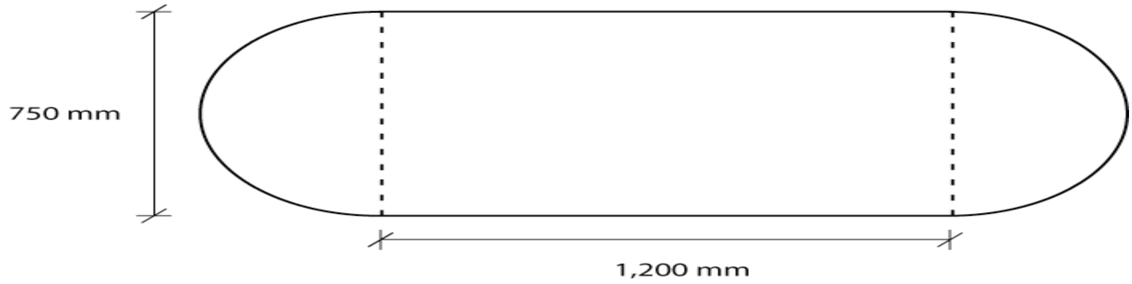


Fig.4.7. semicircles and a rectangle.

To work out the perimeter of this shape, you will need to work out the perimeter of each semicircle first then, add these measurements to the other sides.

For example:

Perimeter of each semicircle = $\pi d \div 2$

$= (3.14 \times 750\ mm) \div 2 \quad = 2{,}355\ mm \div 2 \quad = 1{,}177.5\ mm$

Total perimeter = total of all side lengths

$= (1{,}177.5 + 1{,}200 + 1{,}177.5 + 1{,}200)\ mm \quad = 4{,}755\ mm \quad = 4.755\ Lm$

Circumference : Circumference is the linear distance around the outside of a closed curve or circular object. The circumference of a circle is of special importance to geometric and trigonometric concepts. However circumference may also describe the outside of elliptical closed curves. **Circumference is a** special example of perimeter.

The circumference of a circle—the complete distance around a circle—can be found by using this formula: $C = \pi 2r$, in which π is about 3.1416 and r is the radius.

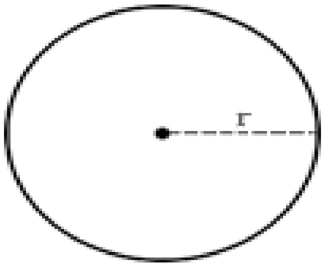


Fig.4.8. circle

What's the difference between perimeter and circumference when they mean the total length of the boundary of a two-dimensional geometric shape?Circumference is a special case of perimeter. Both describe the total length of the boundary of a two dimensional figure, but circumference specifically refers to the perimeter of a curved figure or arc. Therefore it only applies to circles, ovals, ellipses, arcs, etc.

- **Calculation of mass**

Multiply the volume and density together. Multiply your two numbers together, and you'll know the mass of your object. Keep track of the units as you do this, and you'll see that you end up with units of mass(kilograms or grams).

Mass means how much matter there is in something. Matter is something you can physically touch. Generally, mass is related to size but not always. A balloon might be bigger than something else but have less mass, for example. There are ways you can measure mass.

Density measures how tightly the matter in an object is packed together. Each material has its own density, which you can look up online or in a textbook. The scientific unit of density is kilograms per cubic meter (kg/m3), but you can use grams per cubic centimeter (g/cm3) for smaller objects

- Use this formula to convert between these units: 1,000 kg/m3 = 1 g/cm3
- The density of liquids is often measured in kilograms per liter (kg/L) or grams per milliliter (g/ml) instead. These units are equivalent: 1 kg/L = 1 g/ml.

Example: Diamond has a density of 3.52 g/cm3.

4.4. Losing Significant Figures

Sometimes significant figures are 'lost' while performing calculations. For example, if you find the mass of a beaker to be 53.110 g, add water to the beaker and find the mass of the beaker plus water to be 53.987 g, the mass of the water is 53.987-53.110 g = 0.877 g. The final value only has three significant figures, even though each mass measurement contained 5 significant figures.

4.5. Rounding and Truncating Numbers

There are different methods which may be used to round numbers. The usual method is to round numbers with digits less than 5 down and numbers with digits greater than 5 up (some people round exactly 5 up and some round it down).

Example: If you are subtracting 7.799 g - 6.25 g your calculation would yield 1.549 g. This number would be rounded to 1.55 g, because the digit '9' is greater than '5'.

In some instances numbers are truncated, or cut short, rather than rounded to obtain appropriate significant figures. In the example above, 1.549 g could have been truncated to 1.54 g.

4.6. Exact Numbers

Sometimes numbers used in a calculation are exact rather than approximate. This is true when using defined quantities, including many conversion factors, and when using pure numbers. Pure or defined numbers do not affect the accuracy of a calculation. You may think of them as having an infinite number of significant figures. Pure numbers are easy to spot because they have no units. Defined values or conversion factors, like measured values, may have units. Practice identifying them!

Example: You want to calculate the average height of three plants and measure the following heights: 30.1 cm, 25.2 cm, 31.3 cm; with an average height of (30.1 + 25.2 + 31.3)/3 = 86.6/3 = 28.87 = 28.9 cm. There are three significant figures in the heights. Even though you are dividing the sum by a single digit, the three significant figures should be retained in the calculation.

Self-Check 4	Written Test

- *Directions:* Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers.
- **Choose the best answer from the question below**

1. is the inverse of multiplication.
   A. Addition
   B. Subtraction
   C. Division
   D. All
2. is the opposite of addition.
   A. Addition
   B. Subtraction
   C. Division
   D. All
3. Is a deliberate process that transforms one or more inputs into one or more results, with variable change. The
   A. Calculation
   B. Addition
   C. Operation
   D. All
4. **Which one of the following is the area of circle_____**
   A. L*W
   B. L+W
   C. πr^2
   D. $2\pi r$
5. **Which one of the following is the perimeter of rectangle_____**
   A. L*W
   B. 2(L+W)
   C. πr^2
   D. $2\pi r$ **Answer Sheet**

Name: _____________________________ Date: _________________

Satisfactory rating: above 2 **unsatisfactory rating: Below 2**

Operation Sheet 1	Performing Calculations

QUALITY CRITERIA: The Mathematical operations should be performed to show the characteristics of the operations

PROCEDURE:

1. Arrange the provided paper, pen and if needed calculator, to perform calculation.
2. Add four consecutive numbers b/n 10 & 100 and record the answer.
3. Re-arrange their order and add them. Compare the result with that found instep 1.
4. Subtract the larger number from the smaller number and record their difference.
5. Subtract the smaller number from the larger number and record the difference.
6. Compare the result found in step 4 with that found in step 5.
7. Multiply three consecutive numbers b/n 10 & 20 and record their product.
8. Divide the larger number to the smaller number and record the quotient.
9. Write three different mixed fractions and convert them to percentage respectively.
10. Convert the result of step 9 to mixed fraction showing each step neatly.

PRECAUTIONS: Avoid interchanging positive numbers and negative numbers while performing the calculation.

Information Sheet 5	Using calculation in fraction, percentage and mixed number.

1.1. Calculation in fraction, percentage and mixed number

- **Converting a mixed fraction into percentage:**

Firstly, convert mixed fraction into improper fraction. (Mixed Fraction to Improper Fraction) then, multiply improper fraction by 100. Some example regarding to the Conversion of Mixed Fraction into Percentage are as follows:

Example 1: Convert a given mixed fractions 1 2/10 into percentage.

Answer = The procedure is: -

- ✓ Firstly, convert mixed fraction (1 2/10) into Improper Fraction and we get: = 1 2/10
- ✓ Now, Multiply the improper fraction (i.e. 12/10) by 100 and we get: = 12/10 × 100
- ✓ Multiply numerator of improper fraction (i.e. 12) by multiplier (i.e. 100) and denominator remains the same and we get: = 12×100/10 = 1200/10
- ✓ Divide numerator by denominator, and we get the required percentage: = 120 %

Example 2: Convert a given mixed fractions 2 3/5 into percentage.

Answer = The procedure is: -

- ✓ Firstly, convert Mixed Fraction (2 3/5) into Improper Fraction and we get: = 2 3/5 = 13/5
- ✓ Now, Multiply the improper fraction (i.e. 13/5) by 100 and we get: = 13/5 × 100
- ✓ Multiply numerator of improper fraction (i.e. 13) by multiplier (i.e. 100) and denominator remains the same and we get: = 13×100/5 = 1300/5
- ✓ Divide numerator by denominator, and we get the required percentage: = 260 %

- **Converting Percentage in to fractions**

To convert a percent to a fraction, follow these steps:

- ✓ Step 1: Write down the percent divided by 100 like this: percent/100
- ✓ Step 2: If the percent is not a whole number, then multiply both top and bottom by 10 for every number after the decimal point. (For example, if there is one number after the decimal, then use 10, if there are two then use 100, etc.)
- ✓ Step 3: Simplify (or reduce) the fraction

Example1: Convert 11% to a fraction

- ✓ Step 1: Write down: 11/100
- ✓ Step 2: The percent is a whole number, go straight to step 3.
- ✓ Step 3: The fraction cannot be simplified further.
- ✓ **Answer = 11/100**

Example2: Convert 75% to a fraction

- ✓ Step 1: Write down: 75/100
- ✓ Step 2: The percent is a whole number, go straight to step 3.
- ✓ Step 3: Simplify the fraction (this took me two steps; you may be able to do it one!):

1.2. unit Conversion

- **The most commonly used metric measurements of length are shown below.**
  - ✓ 1000 microns (μ) = 1 millimeter (mm)
  - ✓ 10 millimeters = 1 centimeter (cm)
  - ✓ 10 centimeters = 1 decimeter (dec)
  - ✓ 10 decimeters = 1 meter (m)
  - ✓ 10 hectometers = 1 kilometers (km)
- **The Most Common Metric of Weight (Mass) Measurements is presented below.**
  - ✓ 10 milligrams (mg) = 1 centigram (cg)
  - ✓ 10 centigram = 1 decigram (dg)
  - ✓ 10 decigram = 1 gram (g)
  - ✓ 10 hectograms = 1 kilogram (kg)
- **The Most Common Metric of time (second) Measurements is presented below.**
  - ✓ **1year = 12months**
  - ✓ **1months = 30days**
  - ✓ **1day= 24hrs**
  - ✓ **1hrs = 60min**
  - ✓ **1min = 60 sec**
- **English System of measurements and their relationships**
  - ✓ 1000 milli-inches = 1 inch
  - ✓ 1 foot = 12 inches
  - ✓ 1 yard =36 inches
  - ✓ 1 yard =3 feet

1.3. Relationships between the Metric and the English Systems

The most often used units of linear measurement in the metric system are the millimeter, centimeter, meter, and kilometer. The relationship between these units and the units of the English system are as follows:

- ✓ 25.4 millimeters = 1 inch (approximately)
- ✓ 2.54 centimeters = 1 inch (approximately)
- ✓ 1 meter = 39.37 inches (approximately)
- ✓ 1 kilometer = 0.62137 miles (approximately 5/8 mile)

The milligram, the gram, and the kilogram are the most often used units of mass (weight) in the metric system. The relationship between these measurements and those of the English system are as follows:

- ✓ 1 milligram = 0.0003527 ounces (approximately)
- ✓ 1 gram = 0.03527 ounces (approximately)
- ✓ 1 kilogram = 2.205 pounds (approximately)

Example 1 Light travels at a velocity of approximately 300,000 km per second. What is the approximate velocity of light in mi per sec?

- ✓ 1 km = 0.62137 mile = 186,000 mi/sec

Example 2. How many kilograms does an 80-pound television set weigh?

1 kg = 2.205lb.

Answer Weight in kg = 2.205 kg/lb × 80 lb = 176.4 kg (Answer)

Example 3 How many inches are there in an antenna that has a length of 30 cm?

Answer

2.54 cm = 1 in.

= 11.8 in.

Example 4 A football field measures 100 yards, what is the length in meters?

Answer

- ✓ (1 meter = one yard = 36 inches, therefore 1 meter = 1.0936 yards.)
- ✓ 100 yards' x 1.0936 meters/yard = 109.36 meters

Self-Check 5	Written Test

Direction: choose the best answer for all the questions listed below. Illustrations may be necessary to aid some explanations/answers.

Part. I Choose the best answer from the question below

1. 1kg is equal to__________ ?
   E. 1000mg
   F. 1000g
   G. 0.1 tone
   H. None
2. **1 meter is equal to ____________?**
   A. 100cm
   B. 10dcm
   C. 1000mm
   D. All

Answer Sheet

Score = ___________
Rating: ____________

Name: _________________________ Date: _______________

Satisfactory rating: above 2 **unsatisfactory rating: Below 2**

Operation Sheet 2	Measurement and calculation

Procedures for measurement and unit conversation of <u>wire size for socket outlet</u>

1. Identify the type of measuring instrument you use
2. Select wire size for socket outlet
3. Insert the measured wires inside the caliper/micrometer
4. . Read the caliper/micrometer and list the result.
5. Convert the measured unit in to centimeter and inch
6. Report your work and conclusion to your trainer

Information Sheet 6	Checking and correcting numerical computation for accuracy

6.1. Introduction to Numerical computation

Fundamentals of Numerical Computation is an advanced undergraduate-level introduction to the mathematics and use of algorithms for the fundamental problems of numerical computation: linear algebra, finding roots, approximating data and functions, and solving differential equations.

"If mathematical modeling is the process of turning real phenomena into mathematical abstractions, then numerical computation is largely about the transformation from abstract mathematics to concrete reality. Many science and engineering disciplines have long benefited
from the tremendous value of the correspondence between quantitative information and mathematical manipulation."

6.2. *Numbers and symbols*

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 numbers
- REAL NUMBERS: (All one-dimensional numerical values, negative and positive, including zero, whole, integer, and irrational numbers)
- COMPLEX NUMBERS: 3 - j4 , 34.5 ∠ 20

- **BINARY ARITHMETICS**

People and computers do not normally speak the same language. Methods of translating information in to forms that is understandable and useable to both are necessary. Humans generally speak in words and numbers expressed in the decimal number system, while computers understand coded electronic pulses that represent digital information. These pulses are defined in the simplest possible number system, which is the binary or base 2 system. The binary system uses only two symbols (0 & 1).

<table>
<tr><th>System:</th><th>Hash Marks</th><th>Roman</th><th>Decimal</th><th>Binary</th></tr>
<tr><td>-------</td><td>----------</td><td>-----</td><td>-------</td><td>------</td></tr>
<tr><td>Zero</td><td>n/a</td><td>n/a</td><td>0</td><td>0</td></tr>
<tr><td>One</td><td>|</td><td>I</td><td>1</td><td>1</td></tr>
<tr><td>Two</td><td>||</td><td>II</td><td>2</td><td>10</td></tr>
<tr><td>Three</td><td>|||</td><td>III</td><td>3</td><td>11</td></tr>
<tr><td>Four</td><td>||||</td><td>IV</td><td>4</td><td>100</td></tr>
<tr><td>Five</td><td>/|||/</td><td>V</td><td>5</td><td>101</td></tr>
<tr><td>Six</td><td>/|||/ |</td><td>VI</td><td>6</td><td>110</td></tr>
<tr><td>Seven</td><td>/|||/ ||</td><td>VII</td><td>7</td><td>111</td></tr>
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<tr><td>Nine</td><td>/|||/ ||||</td><td>IX</td><td>9</td><td>1001</td></tr>
<tr><td>Ten</td><td>/|||/ /|||/</td><td>X</td><td>10</td><td>1010</td></tr>
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<tr><td>Sixteen</td><td>/|||/ /|||/ /|||/ |</td><td>XVI</td><td>16</td><td>10000</td></tr>
<tr><td>Seventeen</td><td>/|||/ /|||/ /|||/ ||</td><td>XVII</td><td>17</td><td>10001</td></tr>
<tr><td>Eighteen</td><td>/|||/ /|||/ /|||/ |||</td><td>XVIII</td><td>18</td><td>10010</td></tr>
<tr><td>Nineteen</td><td>/|||/ /|||/ /|||/ ||||</td><td>XIX</td><td>19</td><td>10011</td></tr>
<tr><td>Twenty</td><td>/|||/ /|||/ /|||/ /|||/</td><td>XX</td><td>20</td><td>10100</td></tr>
</table>

Neither hash marks nor the Roman system are very practical for symbolizing large numbers. Obviously, place-weighted systems such as decimal and binary are more efficient for the task. Notice, though, how much shorter decimal notation is over binary notation, for the same number of quantities? What takes five bits in binary notation only takes two digits in decimal notation.

6.3. Fraction , decimal and percentage

Percentage can be converted to fraction because' percentage' simply means ' per hundred ' they can also be converted very easily to decimal, which can be useful when using a calculator. Fraction and decimal can also be converted back to percentages

Worked Example 1

Convert each of the following percentages to fractions.

(a) 50% (b) 40% (c) 8%

Solution

(a) $50\% = \frac{50}{100} = \frac{1}{2}$

(b) $40\% = \frac{40}{100} = \frac{2}{5}$

(c) $8\% = \frac{8}{100} = \frac{2}{25}$

Worked Example 2

Convert each of the following percentages to decimals.

(a) 60% (b) 72% (c) 6%

Solution

(a) $60\% = \frac{60}{100} = 0.6$

(b) $72\% = \frac{72}{100} = 0.72$

(c) $6\% = \frac{6}{100} = 0.06$

Worked Example 3

Convert each of the following decimals to percentages.

(a) 0.04 (b) 0.65 (c) 0.9

Solution

(a) $0.04 = \frac{4}{100} = 4\%$

(b) $0.65 = \frac{65}{100} = 65\%$

(c) $0.9 = \frac{9}{10} = \frac{90}{100} = 90\%$

Worked Example 4

Convert each of the following fractions to percentages.

(a) $\frac{3}{10}$ (b) $\frac{1}{4}$ (c) $\frac{1}{3}$

Solution

To convert fractions to percentages, multiply the fraction by 100%. This gives its value as a percentage.

(a) $\frac{3}{10} = \frac{3}{10} \times 100\% = 30\%$

(b) $\frac{1}{4} = \frac{1}{4} \times 100\% = 25\%$

(c) $\frac{1}{3} = \frac{1}{3} \times 100\% = 33\tfrac{1}{3}\%$

6.4. Addition and subtraction of fraction

The numerator is the top part of a fraction and the denominator is the bottom part of a fraction. When adding or substracting fraction they must have the same denominator:

Worked Example 1

$$\frac{4}{7} + \frac{5}{7} = ?$$

Solution

As both fractions have the same denominator (7), they can simply be added to give

$$\frac{4}{7} + \frac{5}{7} = \frac{9}{7}$$
$$= 1\frac{2}{7}.$$

Worked Example 2

$$\frac{3}{4} + \frac{2}{5} = ?$$

Solution

As these fractions have different denominators, it is necessary to find the *lowest common denominator*, that is, the smallest number into which both denominators will divide exactly. In this case it is 20, since both 4 and 5 divide into 20 exactly.

$$\frac{3}{4} + \frac{2}{5} = \frac{15}{20} + \frac{8}{20}$$
$$= \frac{15+8}{20}$$
$$= \frac{23}{20}$$
$$= 1\frac{3}{20}$$

Worked Example 3

$$\frac{2}{3} + \frac{7}{12} = ?$$

Solution

In this example, 12 is the lowest common denominator.

$$\frac{2}{3} + \frac{7}{12} = \frac{8}{12} + \frac{7}{12}$$
$$= \frac{8+7}{12}$$
$$= \frac{15}{12}$$
$$= 1\frac{\cancel{3}^{1}}{\cancel{12}_{4}}$$
$$= 1\frac{1}{4}$$

Worked Example 4

$$\frac{5}{8} - \frac{1}{3} = ?$$

Solution

Here 24 is the lowest common denominator.

$$\frac{5}{8} - \frac{1}{3} = \frac{15}{24} - \frac{8}{24}$$
$$= \frac{15-8}{24}$$
$$= \frac{7}{24}$$

Exercises

1. Give the answers to the following, simplifying them as far as possible.

(a) $\frac{1}{5} + \frac{1}{5}$ (b) $\frac{3}{8} + \frac{1}{8}$ (c) $\frac{5}{7} + \frac{1}{7}$

(d) $\frac{5}{7} - \frac{2}{7}$ (e) $\frac{8}{13} - \frac{5}{13}$ (f) $\frac{7}{9} - \frac{4}{9}$

(g) $\frac{7}{9} + \frac{8}{9}$ (h) $\frac{3}{5} + \frac{4}{5}$ (i) $\frac{6}{7} + \frac{5}{7}$

(j) $\frac{7}{10} - \frac{3}{10}$ (k) $\frac{8}{9} - \frac{5}{9}$ (l) $\frac{4}{15} - \frac{1}{15}$

6.5. Multiplication and division of fraction

- **Multiplication**

When multiplying two fraction, the numerators (top parts should be multiplied together to give the numerator of the result. Similarity, the two denominators should be multiplied together

In general terms,

$$\frac{a}{b} \times \frac{b}{d} = \frac{a \times c}{b \times d}$$

Worked Example 1

$$\frac{3}{4} \times \frac{5}{7} = ?$$

Solution

$$\frac{3}{4} \times \frac{5}{7} = \frac{3 \times 5}{4 \times 7}$$

$$= \frac{15}{28}$$

Worked Example 2

$$\frac{3}{5} \times \frac{7}{12} = ?$$

Solution

$$\frac{{}^{1}\cancel{3}}{5} \times \frac{7}{\cancel{12}_{4}} = \frac{1 \times 7}{5 \times 4}$$

$$= \frac{7}{20}$$

Worked Example 3

$$1\frac{1}{2} \times 3\frac{4}{5} = ?$$

Solution

$$1\frac{1}{2} \times 3\frac{4}{5} = \frac{3}{2} \times \frac{19}{5}$$

$$= \frac{57}{10}$$

$$= 5\frac{7}{10}$$

- **Division**

To understand how to divide with fractions, first consider how multiplication and division are related.

$$\frac{a}{b} \div \frac{c}{d} = \frac{a}{b} \times \frac{d}{c}$$

Take as an example,

$$3 \times 4 = 12.$$

Then it is also true that

$$12 \div 4 = 3.$$

So '$\times 4$' and '$\div 4$' are *inverse* operations.

Note that

$$12 \times \frac{1}{4} = 3,$$

so $\div 4$ is the same as $\times \frac{1}{4}$.

Similarly, because $\div \frac{1}{2}$ is the same as $\times 2$,

$$6 \div \frac{1}{2} = 12 \quad \left(\text{check: } 12 \times \frac{1}{2} = 6\right)$$

and, alternatively, $6 \times 2 = 12$.

So $\div \frac{1}{2}$ is the same as $\times 2$.

You can generalise these examples to give

$$\div a \quad \text{is the same as} \quad \times \frac{1}{a}$$

$$\div \frac{1}{b} \quad \text{is the same as} \quad \times b$$

and combining the two results gives

$$\div \frac{a}{b} \quad \text{is the same as} \quad \times \frac{b}{a}.$$

Worked Example 4

$$\frac{3}{4} \div \frac{7}{8} = ?$$

Solution

$$\frac{3}{4} \div \frac{7}{8} = \frac{3}{{}_1\not{4}} \times \frac{\not{8}^{\,2}}{7}$$

$$= \frac{3 \times 2}{1 \times 7}$$

$$= \frac{6}{7}$$

6.6. OPERATION ON POSITIVE AND NEGATIVE NUMBERS

When using the basic operations (addition, subtraction, multiplication, division) on positive and negative numbers, we determine the result to be either positive or negative according to the following rules.

I. ***Addition of two numbers of the same sign***.

- Add their absolute values and assign the sum their common sign.

EXAMPLE 1 Adding numbers of the same sign

(a) $2 + 6 = 8$ — the sum of two positive numbers is positive

(b) $-2 + (-6) = -(2 + 6) = -8$ — the sum of two negative numbers is negative

✓ The negative number -6 is placed in parentheses since it is also preceded by a plus sign showing addition. It is not necessary to place the -2 in parentheses.

II. ***Addition of two numbers of different signs***.

- Subtract the number of smaller absolute value from the number of larger absolute value and assign to the result the sign of the number of larger absolute value.

EXAMPLE 2 Adding numbers of different signs

(a) $2 + (-6) = -(6 - 2) = -4$

(b) $-6 + 2 = -(6 - 2) = -4$

the negative 6 has the larger absolute value

(c) $6 + (-2) = 6 - 2 = 4$

(d) $-2 + 6 = 6 - 2 = 4$

the positive 6 has the larger absolute value

the subtraction of absolute values

III. ***Subtraction of one number from another.***

- Change the sign of the number being subtracted and change the subtraction to addition. Perform the addition.

EXAMPLE 3 Subtracting positive and negative numbers

(a) $2 - 6 = 2 + (-6) = -(6 - 2) = -4$

Note that after changing the subtraction to addition, and changing the sign of 6 to make it -6, we have precisely the same illustration as Example 2(a).

(b) $-2 - 6 = -2 + (-6) = -(2 + 6) = -8$

Note that after changing the subtraction to addition, and changing the sign of 6 to make it -6, we have precisely the same illustration as Example 1(b).

(c) $-a - (-a) = -a + a = 0$

This shows that subtracting a number from itself results in zero, even if the number is negative. Therefore, *subtracting a negative number is equivalent to adding a positive number of the same absolute value.*

- **Multiplication and division of two numbers**

The product (or quotient) of two numbers of the same sign is positive. The product (or quotient) of two numbers of different signs is negative.

EXAMPLE 4 Multiplying and dividing positive and negative numbers

(a)	$3(12) = 3 \times 12 = 36$	$\frac{12}{3} = 4$	result is positive if both numbers are positive
(b)	$-3(-12) = 3 \times 12 = 36$	$\frac{-12}{-3} = 4$	result is positive if both numbers are negative
(c)	$3(-12) = -(3 \times 12) = -36$	$\frac{-12}{3} = -\frac{12}{3} = -4$	result is negative if one number is positive and the other is negative
(d)	$-3(12) = -(3 \times 12) = -36$	$\frac{12}{-3} = -\frac{12}{3} = -4$	

6.7. ORDER OF OPERATIONS

Often, how we are to combine numbers is clear by grouping the numbers using symbols such as parentheses (), the bar, ____, between the numerator and denominator of a fraction, and vertical lines for absolute value. Otherwise, for an expression in which there are several operations, we use the following order of operations.

Order of Operations

1. *Operations within specific groupings are done first.*
2. *Perform multiplications and divisions (from left to right).*
3. *Then perform additions and subtractions (from left to right).*

EXAMPLE 5 Order of operations

(a) $20 \div (2 + 3)$ is evaluated by first adding $2 + 3$ and then dividing. The grouping of $2 + 3$ is clearly shown by the parentheses. Therefore, $20 \div (2 + 3) = 20 \div 5 = 4$.

(b) $20 \div 2 + 3$ is evaluated by first dividing 20 by 2 and then adding. No specific grouping is shown, and therefore the division is done before the addition. This means $20 \div 2 + 3 = 10 + 3 = 13$.

(c) $16 - 2 \times 3$ is evaluated by ***first multiplying*** 2 ***by*** 3 and then subtracting. We *do* **not** *first subtract* 2 *from* 16. Therefore, $16 - 2 \times 3 = 16 - 6 = 10$.

(d) $16 \div 2 \times 4$ is evaluated by first dividing 16 by 2 and then multiplying. From left to right, the division occurs first. Therefore, $16 \div 2 \times 4 = 8 \times 4 = 32$.

(e) $|3 - 5| - |-3 - 6|$ is evaluated by first performing the subtractions within the absolute value vertical bars, then evaluating the absolute values, and then subtracting. This means that $|3 - 5| - |-3 - 6| = |-2| - |-9| = 2 - 9 = -7$.

When evaluating expressions, it is generally more convenient to change the operations and numbers so that the result is found by the addition and subtraction of positive numbers. When this is done, we must remember that

$$a + (-b) = a - b$$

$$a - (-b) = a + b$$

EXAMPLE 6 Evaluating numerical expressions

(a) $7 + (-3) - 6 = 7 - 3 - 6 = 4 - 6 = -2$

(b) $\frac{18}{-6} + 5 - (-2)(3) = -3 + 5 - (-6) = 2 + 6 = 8$

(c) $\frac{|3 - 15|}{-2} - \frac{8}{4 - 6} = \frac{12}{-2} - \frac{8}{-2} = -6 - (-4) = -6 + 4 = -2$

(d) $\frac{-12}{2 - 8} + \frac{5 - 1}{2(-1)} = \frac{-12}{-6} + \frac{4}{-2} = 2 + (-2) = 2 - 2 = 0$

In illustration (b), we see that the division and multiplication were done before the addition and subtraction. In (c) and (d), we see that the groupings were evaluated first. Then we did the divisions, and finally the subtraction and addition.

EXAMPLE 7 Evaluating in an application

A 1500-kg van going at 40 km/h run head-on into a 1000-kg car going at 20 km/h. An insurance investigator determined the velocity of the vehicles immediately after the collision from the following calculation. See Fig. 1.5.

$$\frac{1500(40) + (1000)(-20)}{1500 + 1000} = \frac{60\,000 + (-20\,000)}{1500 + 1000} = \frac{60\,000 - 20\,000}{2500}$$

$$= \frac{40\,000}{2500} = 16 \text{ km/h}$$

The numerator and denominator must be evaluated before the division is performed. The multiplication in the numerator are performed first, followed by the addition in the denominator.

3.4. OPERATION WITH ZERO

Since operations with zero tend to cause some difficulty, we will show them here.

If a is a real number, the operations of addition, subtraction, multiplication, and division with zero are as follows:

$$a + 0 = a$$

$$a - 0 = a \qquad 0 - a = -a$$

$$a \times 0 = 0$$

$$0 \div a = \frac{0}{a} = 0 \qquad (\text{if } a \neq 0)$$

(≠ means "is not equal to")

EXAMPLE 8 Operations with zero

(a) $5 + 0 = 5$ (b) $-6 - 0 = -6$ (c) $0 - 4 = -4$

(d) $\frac{0}{6} = 0$ (e) $\frac{0}{-3} = 0$ (f) $\frac{5 \times 0}{7} = \frac{0}{7} = 0$

Note that there is no result defined for division by zero. To understand the reason for this, consider the results for 6/2 and 6/0.

$$\frac{6}{2} = 3 \quad \text{since} \quad 2 \times 3 = 6$$

If $\frac{6}{0} = b$, then $0 \times b = 6$. This cannot be true because $0 \times b = 0$ for any value of b. Thus,

division by zero is undefined

(The special case of $\frac{0}{0}$ is termed *indeterminate*. If $\frac{0}{0} = b$, then $0 = 0 \times b$, which is true for any value of b. Therefore, no specific value of b can be determined.)

EXAMPLE 9 Division by zero is undefined

$\frac{2}{5} \div 0$ is undefined $\qquad \frac{8}{0}$ is undefined $\qquad \frac{7 \times 0}{0 \times 6}$ is indeterminate

The operations with zero will not cause any difficulty if we remember to

never divide by zero

Division by zero is the only undefined basic operation. All the other operations with zero may be performed as for any other number.

Self-Check -6	Written Test

Direction: **choose the best answer for all the questions listed below. Illustrations may be necessary to aid some explanations/answers.**

Choose the best answer from the question below

1. Convert the following fraction to percentage $\frac{4}{10}$ __________ ?
   - A. 20%
   - B. 40%
   - C. 35%
   - D. 30%

- Convert the following percentage to fraction 45% ____________**?**
  - **A.** $\frac{4}{10}$
  - **B.** $\frac{4.5}{10}$
  - **C.** $\frac{6}{10}$
  - **D. All**
- **Which one of the following is whole number _____**
  - **A. 2/3**
  - **B. -4**
  - **C. 4**
  - **D. All**

Answer Sheet

Score = ___________

Rating: ____________

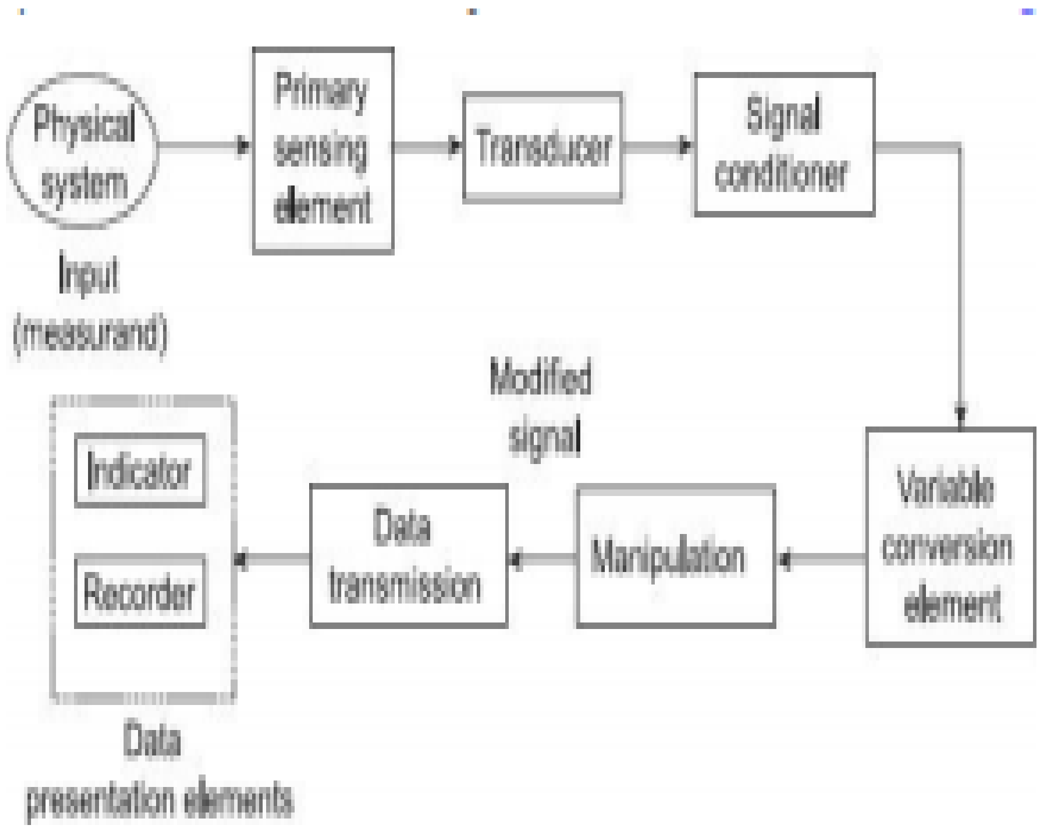
Name: _________________________ Date: _______________

Satisfactory rating: above 2 unsatisfactory rating: Below 2

Information Sheet 7	Reading instruments to the limit of accuracy of the tool.

7.1 .Introduction of reading instrument

A measurement system may be defined as a systematic arrangement for the measurement or determination of an unknown quantity and analysis of instrumentation. The generalized measurement system and its different components/elements are shown in



The operation of a measurement system can be explained in terms of functional elements of the system. Every instrument and measurement system is composed of one or more of these functional elements and each functional element is made of distinct components or groups of components which performs required and definite steps in measurement.

7.2. DEFINITIONS OF SOME STATIC CHARACTERISTICS

- **Accuracy**

  Accuracy is the closeness with which the instrument reading approaches the true value of the variable under measurement. Accuracy is determined as the maximum amount by which the result differs from the true value. It is almost impossible to determine experimentally the true value. The true value is not indicated by any measurement system due to the loading effect, lags and mechanical problems (e.g., wear, hysteresis, noise, etc.). Accuracy of the measured signal depends upon the following factors: • Intrinsic accuracy of the instrument itself; • Accuracy of the observer; • Variation of the signal to be measured; and • Whether or not the quantity is being truly impressed upon the instrument.

- **Precision**

  Precision is a measure of the reproducibility of the measurements, i.e., precision is a measure of the degree to which successive measurements differ from one another. Precision is indicated from the number of significant figures in which it is expressed. Significant figures actually convey the information regarding the magnitude and the measurement precision of a quantity. More significant figures imply greater precision of the measurement.

- **Resolution**

  If the input is slowly increased from some arbitrary value it will be noticed that the output does not change at all until the increment exceeds a certain value called the resolution or discrimination of the instrument. Thus, the resolution or discrimination of any instrument is the smallest change in the input signal (quantity under measurement) which can be detected by the instrument. It may be expressed as an accrual value or as a fraction or percentage of the full scale value. Resolution is sometimes referred as sensitivity. The largest change of input quantity for which there is no output of the instrument is called the dead zone of that instrument.

  The sensitivity gives the relation between the input signal to an instrument or a part of the instrument system and the output. Thus, the sensitivity is defined as the ratio of output signal or response of the instrument to a change of input signal or the quantity under measurement.

7.3. MEASUREMENT OF ERRORS

In practice, it is impossible to measure the exact value of the measured. There is always some difference between the measured value and the absolute or true value of the unknown quantity (measured), which may be very small or may be large. The difference between the true or exact value and the measured value of the unknown quantity is known as the absolute error of the measurement.

Self-Check 7	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Say true and false for the following question below

1. Accuracy is not determined as the maximum amount by which the result differs from the true value.

2. The difference between the true or exact value and the measured value of the unknown quantity is known as error.

Note: **Satisfactory rating - 2 points** **Unsatisfactory - below 2 points**.

Answer Sheet

Score = ____________

Rating: _____________

Name: ____________________________ Date: ________________

Answer

LAP Test. 1	Practical Demonstration

Instructions: Given necessary instrument and materials you are required to perform the following tasks within 1hour.

Task 1: Perform the four mathematical operations of four numbers and show the properties of each operation

Task2: Convert mixed fraction numbers to percentage and vice versa

LAP Test . 2	**Practical Demonstration**

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 30 min.

Task 1. Measure the size of wire for socket outlet

Task 2. Convert the result in to cm and m

References

1) "Introduction to the Measurement of Roundness" (PDF). Taylor-Hobson Precision. The separation of two concentric circles that just enclose the circular section of interest.
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BASIC ELECTRICAL/ELECTRONIC

Instruction Sheet	LG30: Carry Out Measurement and Calculation

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

- Handling measuring instruments without damage
- Cleaning measuring instruments before and after using.
- Undertaking Proper storage of instruments
  - ✓ manufacturer's specifications and
  - ✓ standard operating procedures

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to –

- Handle measuring instruments without damage
- Clean measuring instruments before and after using.
- Undertake Proper storage of instruments
  - ✓ manufacturer's specifications and
  - ✓ standard operating procedures

Learning Instructions:

2. Read the specific objectives of this Learning Guide.
3. Follow the instructions described below
4. Read the information written in the "Information Sheets". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
5. Accomplish the "Self-checks" in each information sheets.
6. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
7. If you earned a satisfactory evaluation proceed to "Operation sheets and LAP Tests if any". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
8. After you accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result;

Then proceed to the next learning guide.

Information Sheet-1	Handling measuring instruments without damage

1.1. Operational maintenance is the care and minor maintenance of equipment using procedures that do not require detailed technical knowledge of the equipment's or system's function and design. This category of operational maintenance normally consists of inspecting, cleaning, servicing, preserving, lubricating, and adjusting, as required. Such maintenance may also include minor parts replacement that does not require the person performing the work to have highly technical skills or to perform internal alignment.

As the term implies, operational maintenance, is performed by the operator of the equipment. Its purpose is threefold: (1) to make the operator aware of the state of readiness of the equipment; (2) to reduce the delays that would occur if a qualified technician had to be called every time a simple adjustment were needed; and (3) to release technicians for more complicated work

One of the major problems with the use of bolted joints is the precision, with regard to achieving an accurate preload, of the bolt tightening method selected. Insufficient preload, caused by an inaccurate tightening method, is a frequent cause of bolted joint failure. It is important for the Designer to appreciate the features and characteristics of the main methods employed to tighten bolts. Note however that whatever method is used to tighten a bolt, a degree of bolt preload scatter is to be expected.

1.2. Cleaning

- Clean the tools immediately after use.
- A wire brush may be useful to loosen the soil stuck to the blades.
- Avoid the risk of spreading pathogens while the tools are being cleaned.
- Coat the blades with light oil like WD-40 on areas prone to rust.

1.3. Corrective maintenance is a maintenance task performed to identify, isolate, and rectify a fault so that the failed equipment, machine, or system can be restored to an operational condition within the tolerances or limits established for in-service operations.

Corrective maintenance can be subdivided into "immediate corrective maintenance" (in which work starts immediately after a failure) and "deferred corrective maintenance" (in which work is delayed in conformance to a given set of maintenance rules).

1.4. Repair and overhaul tools

Fig.1.1. measuring tools

1. *Torque wrench (small and mid-ranges)*
2. *Conventional, plastic or soft-faced hammers*
3. *Impact driver set*
4. *Vernier gauges*
5. *Circlip pliers*
6. *Set of cold chisels riveting tool set and punches*
7. *Selection of pullers*
8. *Breaker bars external, or combination)*
9. *Chain breaking/*
10. *Wire stripper and crimper tool*
11. *Multi meter (measures amps, volts and ohms)*
12. *Stroboscope (for dynamic timing checks)*
13. *Hose clamp (wingnut type shown)*
14. *Clutch holding tool*
15. *One-man brake/clutch bleeder kit*

Self-Check 3	**Written Test**

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

<u>Say true and false for the following question below</u>

Directions: Give short answer for the following questions.

1. operational maintenance is performed by the operator of the equipment.
2. Cleaning Clean the tools immediately after use.
3. maintenance is not a task performed to identify, isolate, and rectify a fault

Note: **Satisfactory rating - 2 points** **Unsatisfactory - below 2 points**.

Answer Sheet

Score = ____________
Rating: _____________

Name: ___________________________ Date: ________________

Information Sheet-2	Cleaning measuring instruments before and after using.

2.1. Introduction

Fig.2.1. high-quality handheld measuring device.

High-quality handheld measuring devices are among the most important instruments – both in shop floor surroundings as well as in laboratories and quality management departments. They are simple to operate and deliver precise and easy to read results.

Although they boast robust design – some models even an IP class – and long life expectancy they require proper treatment and care.

This information sheet is explains the correct care and maintenance necessary to ensure reliable results and a long lifetime of your handheld length measuring instruments.

- **Before use**
  - ✓ Make sure type, measuring range, graduation – respectively digital step – and other specifications of the measuring instrument are appropriate for your application.

Fig. 2.2. Application of a point jaw caliper

  - ✓ According to EN ISO 1, the reference temperature for length measurement is 20°C. At other temperatures, according to temperature requirements, countermeasures such as compensation become necessary.

- ✓ Remove dust or dirt from the measuring instrument, especially from the measuring surfaces.
- ✓ To clean the instrument, use a soft cloth soaked in a diluted neutral detergent. Do not use any organic solvent (thinner, benzene etc.). These might damage the instrument.
- ✓ To prevent rust, wipe the moveable parts with a cloth moistened with anti-corrosion oil.

Fig.2.3. Remove dust or dirt from the measuring instrument

- ✓ Check to see whether the moveable parts move smoothly without any jamming or unevenness by moving it all the way through its range.
- ✓ Do not disassemble or modify the measuring instrument unless you have a profound knowledge.
- ✓ Set the zero point or reference point before starting measurement. That means bring the measuring surfaces close together (e.g. outside micrometer 0-25 mm) or use an appropriate calibrated master gauge.

Fig.2.4. Reference point setting with a gauge block

- Reference setting and measuring should be carried out under as similar conditions as possible in order to minimize measurement errors.

fig.2.5. Zero setting with a 10 mm ceramic gauge block if the work piece nominal is 10 mm

- **During Use**
  - ✓ Do not apply excessive force to the measuring instrument.
  - ✓ Make sure to apply constant measuring force during measurement e.g. by using the constant force device of an outside micrometer.

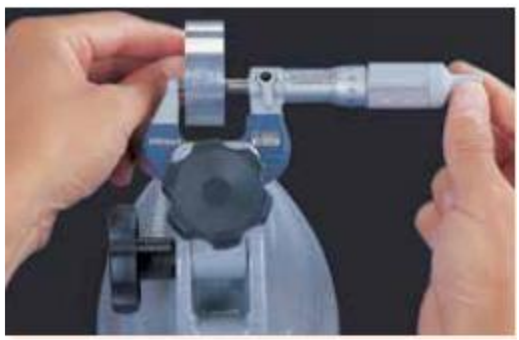


Fig. 2.6. micrometers ensure constant and reliable measuring force of 5-10 N.

- ✓ Do not use the measuring instrument for other applications than indicated by the specification (e.g. only perform measurement within the measuring range).
- ✓ Perform the measurement in a stable and comfortable measuring position.

Fig.2.7. perform measurement within the measuring range).

- ✓ Leave the measuring instrument and the work piece in the ambient room temperature long enough to adapt to the environment temperature. The ability of a material to conduct heat is specified by the thermal conductivity l [W/(m · K)]. Thermal conductivity is a matter constant. The higher the value, the higher the thermal transfer in relation to time

	Steel	Aluminium	Cast Iron	Copper	Ceramic	Brass
Thermal Conductivity λ [W/(m · K)]	47-58	appr. 200	appr. 58	appr. 384	appr. 2,9	appr. 113

Table.2.1. specified by the thermal conductivity l

- ✓ The temperature of measuring tools rises when held in a bare hand. Perform the measurement as fast as possible or protect the instrument against body heat e.g. by using heat-insulating plates or wearing gloves.

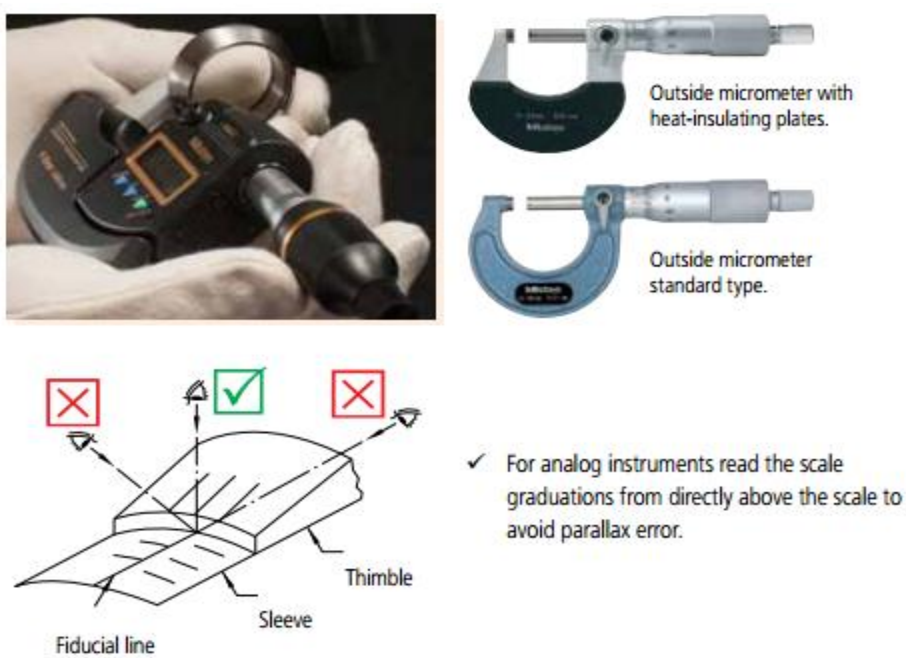


Fig.2.8. using heat-insulating plates or wearing gloves.

- ✓ If using the instrument in long measuring sessions, regularly check (and if necessary adjust) the zero point or reference point.

- ✓ If the instrument is damaged due to being dropped or struck hard do not use it before checking its function and accuracy.
- ✓ Whenever changing the instrument's configuration, like replacing exchangeable contact points, extension rods or any other parts, repeat reference setting.

Fig.2.9.safe handle equipment

3-point internal micrometers with exchangeable measuring heads require new reference setting after an exchange of the measuring head.

- **After Use**
  - ✓ Check the measuring instrument for damage. Repair or replace if necessary. Clean the instrument.
  - ✓ If the instrument was used at places contaminated by soluble cutting oil, perform rust prevention treatment after cleaning.
  - ✓ Store the instrument in a room free of excessive heat and moisture. Protect it from dust and oil mist.
  - ✓ Before storing the instrument for a long time, apply anti-corrosive coating for rust prevention

Fig.2.10. apply anti-corrosive coating for rust prevention

✓ Do not expose measuring instruments to direct sunlight.

✓ Store measuring instruments in a case

Fig.1.11. Store measuring instruments in a case

2.2. Digital Instruments

- **Before Use**
  - ✓ When the battery symbol appears, replace the battery.

Fig. 2.12.calipers battery

✓ The supplied batteries (standard) are used only for the purpose of checking the functions and performance of the caliper, therefore they may not reach the specified battery life.

✓

✓ Install battery with the positive side up. Use SR44 respectively CR2032 battery type only.

Fig. 2.13. battery with the positive side up

- ✓ After the battery is replaced, clean the measuring faces and bring them into contact. Then press the ORIGIN/PRESET button to perform the zero point setting or reference point setting

.

Fig. 2.14. checking the functions and performance of the caliper, there

- ✓ When tightening the output connector cover and battery cap screws, make sure not to squeeze the rubber seal with the cap or cover.

Fig. 2.15. Rubber seal to protect the battery housing respectively output connector against ingress.

- ✓ Do not use electric pens to mark the measuring instrument. These may damage the internal circuitry. Any other types of voltage loads should also be avoided.

- **During Use**
  - ✓ If any error occurs or the count is displayed abnormally, remove and reinstall the battery.
  - ✓ The operating temperature is between 5°C and 40°C. The electronic components of digital tools are designed to ensure operation within this temperature range. However, reference temperature for accuracy specification is 20°C, conforming to EN ISO1.
  - ✓ The maximum temperature gradient is 1,5 °C/min. Significant changes in the ambient temperature not only affect the measuring accuracy. The resulting condensation can damage digital tools, compromise sensor detection and cause corrosion.
  - ✓ The relative air humidity must be below 80%. To avoid condensation do not use measuring tools in high relative humidity at length in order to avoid condensation (which compromises sensor detection). It can also cause the parts made from organic materials to swell and have adverse effects to the electric circuits. However, if the ambient air is too dry, static electricity may cause malfunctions.
  - ✓ Magnetic or electromagnetic fields generated by a magnetic chuck or a demagnetizer do not state a problem. A demagnetizer can be used on measuring tools. Remove the battery and use the lowest level of the demagnetization instrument for a short time only.
  - ✓ Low pressure (< 1,33322 Pa) can damage the LCD and cause the battery to leak.
  - ✓ Radioactive radiation will cause deterioration of the ICs and other components.
  - ✓ The digital instruments have no explosion prevention and protection.
  - ✓ High IP grades (e.g. IP67) should not be misunderstood as a license to careless or even negligent treatment of the equipment. Coolant fluid will eventually cause damage if the instruments are not treated with the proper care throughout their service life.

Fig. 2.16. to check the dimension of gear

- ✓ If the data output and a dedicated cable is used, avoid tensile stress, excessive bending and buckling of the connected cable.

Fig.2.17. Avoid abnormal cable guidance and tensile stress

- ✓ A foot switch eases data transfer from a Dogmatic handheld measuring instrument to a PC or a data collecting device, minimizes operator fatigue and extends the data switch's lifetime.

Fig.2.18 foot switch

- **After Use**

- ✓ The storage temperature must be between -10°C and 60°C. Parts made of different materials are bonded in digital instruments. Under excessively severe temperature conditions, they may be damaged due to the difference in thermal expansion coefficient between them.
- ✓ Do not expose digital measuring instruments to ultraviolet radiation at length. They deteriorate the plastic parts and the LCD (liquid crystal display).
- ✓ If the measuring instrument is not in use for more than 3 months, remove the battery from the instrument. The battery might leak and cause damage.

2.3. Micrometer

- **Outside Micrometer**

Fig. 2.19. parts of out side micro meter

- **Before Use**
  - ✓ Clamp a sheet of lint-free paper between anvil and spindle, as if measuring its thickness. Slowly draw it away to remove dust or dirt from the measuring faces.

Fig. 2.20. how to use micro meter

- ✓ Especially when the measuring range exceeds 300 mm, adjust reference point (preset value). In this process – due to frame deflection – the micrometer should be in the same position it will be in when measuring.

- **During Use**
  - ✓ Do not retract the spindle too far past the upper limit of the measuring range. This can damage some types of digital micrometer.

Fig.2.21. Outside micrometer 0-25 mm.

- **Outside Micrometer**

- ✓ Slowly bring the measuring faces into contact and rotate the ratchet stop several times (1.5 to 2 turns) to apply constant pressure. Excessive force may affect the measurement accuracy.

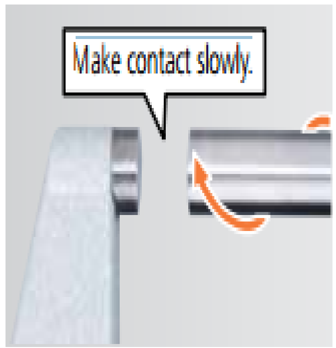


Fig.2.22. make contact slowly

- ✓ The spindle of the outside micrometer advances 2 mm in one rotation. Its spindle feeds rapidly, so be careful not to feed the spindle too fast during measurement or zero point adjustment, to prevent the spindle from touching the measurement surface.
- ✓ When mounting the micrometer on a stand, ensure that the micrometer frame is clamped at the center. Do not clamp it too tightly.

Fig.2.23. spindle pitch Micrometer stand

- **After Use**

✓ Release the spindle clamp, separate the measuring faces by approximately 0.2 to 2 mm, and then store the instrument in a appropriate case. Unlocked ü Always use the ratchet stop, ratchet thimble or friction thimble when measuring.

- **3-Point (line) Internal Micrometer**

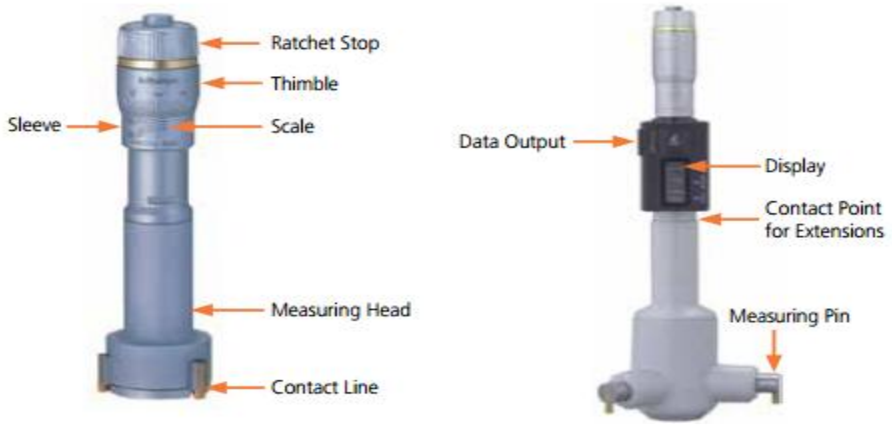


Fig. 2.24. 3-Point (line) Internal Micrometer

- **Before Use**

✓ Perform the initial setting using the calibrated master gauge.

Fig.2.25. calibration of master gauge

✓ If measuring using only a part of the measuring surface (contact line), make sure to set the reference point at the same position of the surface. Follow the general guideline: Adjust in the same manner you measure.

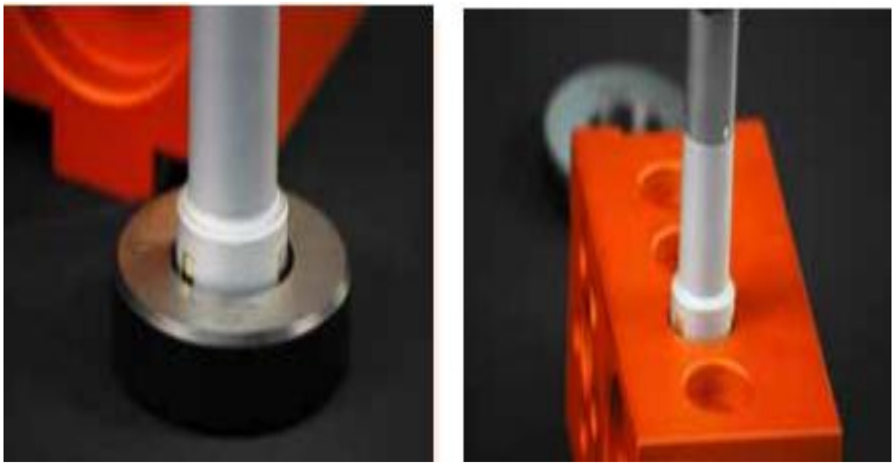


Fig.2.26. A. Setup B. Measuring

✓ Note that if the measuring head is replaced or an extension is used, the accuracy specification is no longer guaranteed unless the initial setting is repeated.

- **During Use**

✓ Retracting the spindle of a digital 3-point internal micrometer too far past the upper limit of the measuring range will damage the internal micrometer. If resistance is felt do not retract the spindle any further.

✓ To apply measuring force, bring the measuring face into light contact with the work piece and hold there. Then operate the ratchet 5 or 6 times (2 to 3 turns) to apply constant force.

Fig.2.27. Retracting the spindle of a digital 3-point internal micrometer

- **After Use**
  - ✓ See all instruments, respectively digital instruments.
- **2-Point Internal Measuring Instruments**

Fig.2.29. 2. parts of -Point Internal Measuring Instruments

- **Before Use**
  - ✓ Securely tighten the clamping device to lock the gauge in position. If the gauge still moves, clean the gauge stem and the clamping device.
  - ✓ To perform reference setting, a calibrated setting ring, respectively a bore gauge checker with gauge blocks, is recommended.

Fig. 2.30. bore gauge checker with gauge blocks

✓ Set the zero point (midpoint of the measuring range) of the bore gauge, in 0,5 mm increments, to the appropriate median of the bore diameter range. Example: Nominal value of the hole: 54 mm

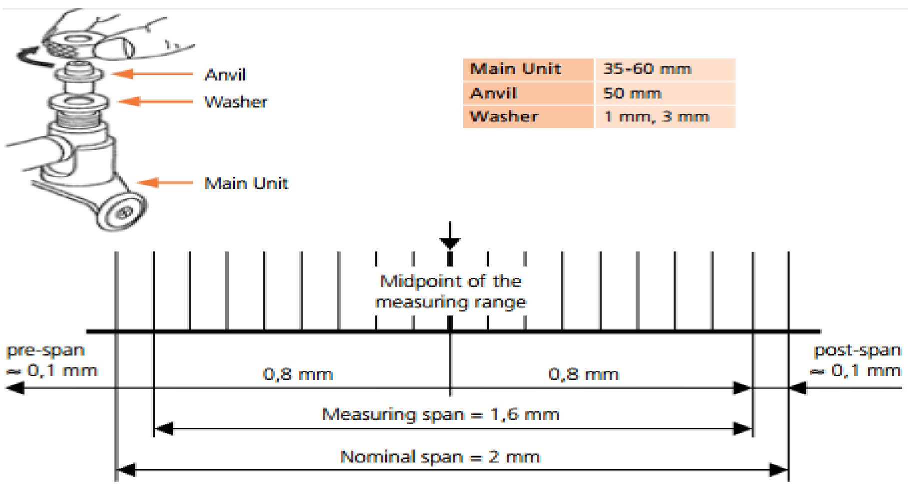


Fig. 2.31. measuring range and parts of gauge

- **During Use**

✓ To insert the bore gauge into the hole to be measured or a setting ring (for reference point setting), tilt the handle so that the guides enter first, followed by the anvil, as shown below.

Fig. 2.32. bore gauge into the hole to be measured

- **2-PointInsideMeasuringInstruments**

✓ Note the correlation between the directions of the contact point displacement and indicator's pointer rotation. The clockwise rotation of the pointer from the reference point indicates that the measured dimension is smaller than the set value. Counter-clockwise pointer rotation from 20 the reference point indicates that the measured dimension is larger than the set value

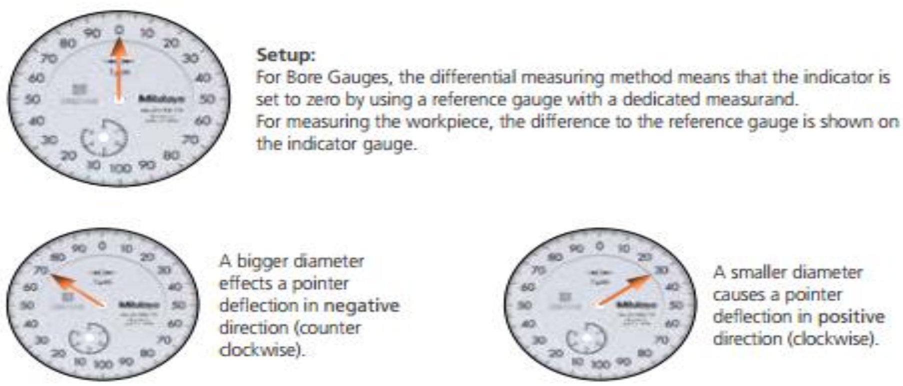


Fig.2.33. **2-Point Inside Measuring Instruments**

- **After Use**

✓ Store the bore gauge with the indicator removed.

✓ If contamination is suspected inside the measuring or the sliding section, clean the inside of the head with a diluted neutral detergent after disassembling using snap-ring pliers.

After cleaning, dry completely and apply a film of micrometer oil to the contact point and the driver pin.

Fig.2.34. film of micrometer oil to the contact point and the driver pin.

2.3. Calipers

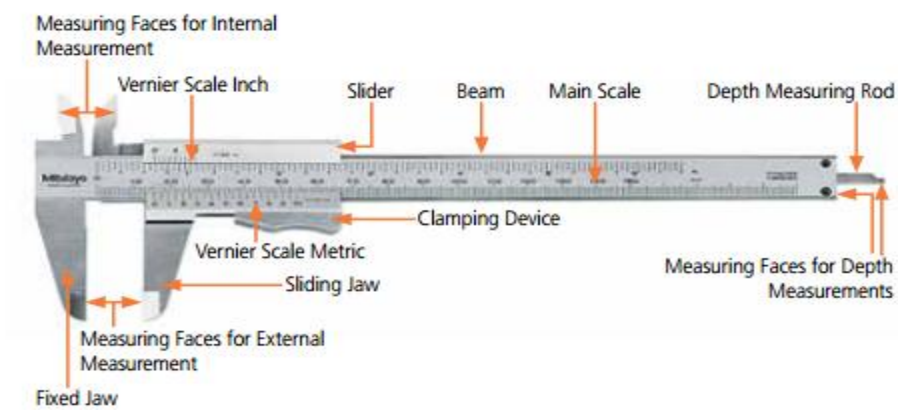


Fig.2.36. parts of calipers

- **Before Use**
  - ✓ Close the measuring faces after cleaning and check the following: Outside measuring faces are in good condition if no light can be seen between them when they are held against a light source. If the faces show contamination or burrs they will not close properly on their full length and light will be seen between them. Inside measuring faces are in good condition if only little light can be seen between them when they are held against a light source.

- **During Use**

✓ Make sure to apply constant force during measurement and measure the workpiece as close to the scale as possible.

Fig.2.37. correct use of calipers

✓ Do not measure an object with the measuring faces tilted.

✓ The knife edges for hole measurement should not be used for holes smaller than appr. 3 mm in diameter. Otherwise a relatively big measurement error caused by the inside measuring jaws will occur and have to be compensated.

- **After Use**

✓ Open the outside measuring jaws by approximately 0.2 to 2 mm, leave the locking screw enlightened, and then store the instrument in a proper case.

Fig. 2.38. proper store of calipers

2.5. Height Gauges

fig 2.39. detail parts of height gauge

- **Before Use**
  - ✓ Set the stylus as close to the main beam as possible. ü Clean beams, instrument reference base, stylus mounting surface as well as the granite surface plate on which the height gauge will be used.
  - ✓ When carrying the instrument, hold it with one hand on the top and the other on the base.

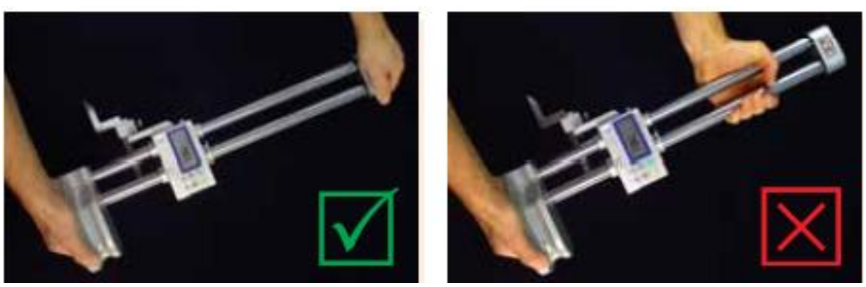


Fig.2. 40. Proper usage of gauge.

- **During Use**
  - ✓ Rotate the feed wheel slowly when applying a constant measuring force. Coarse feed or fine feed (if available) can be selected by pulling or pushing the handle of the slider feed wheel.

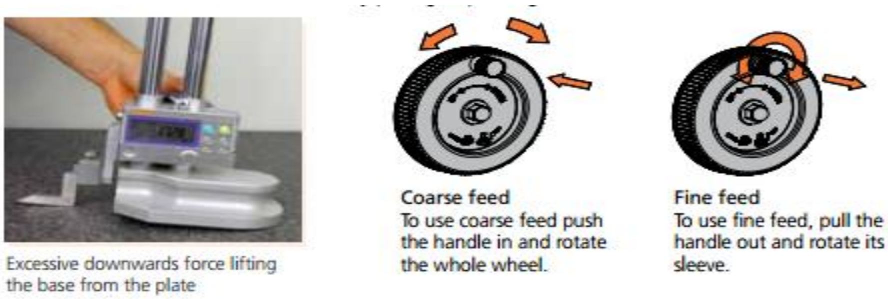


fig.2.41. pulling or pushing the handle of the slider feed wheel

- **After Use**
  - ✓ When the height gauge will not be used for some time leave the scriber unclamped and just above, but not touching, the surface plate. This is to avoid injury by accidental contact with the scriber tip.
  - ✓ Be especially careful not to let the scriber protrude over the edge of the surface plate at any time.

Fig. 2.42. correct use gauge

✓ If the instrument will not be used for a long time, cover the unit with the supplied dust cover.

Fig. 2.43. cover the gauge after use

2.6. Indicators

Fig.2.44. parts of indicator

- **Before Use**

✓ When setting the zero point, retract the plunger by at least 0.2 mm from the rest position.
✓ To avoid measuring error due to non-perpendicular positioning (plunger to table), ensure that the plunger is accurately aligned with the intended direction of measurement. Also note that unevenness of the reference surface may cause measuring errors.

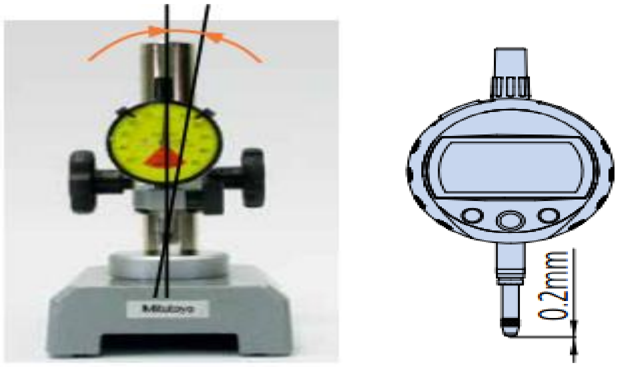


Fig. 2.45. Positioning error

✓ Use the contact point that fits the application best.

Fig.2.46. pin of indicator

✓ Use a holding fixture that will not deflect significantly during normal use.
✓ If the pointer and revolution counter are significantly out of position at the rest point (where the spindle is fully extended), the device may suffer mechanical demage.
✓

- **During Use**
  - ✓ Do not move the plunger rapidly or apply force in transverse direction, otherwise operation and accuracy may be adversely affected.
  - ✓ Use a lifting lever, a spindle lifting cable or any other appropriate device to release the plunger from the work piece.

Fig . 2.47. Application with spindle lifting cable.

- **After Use**

✓ See all instruments, respectively digital instruments

2.7. Dial Test Indicators

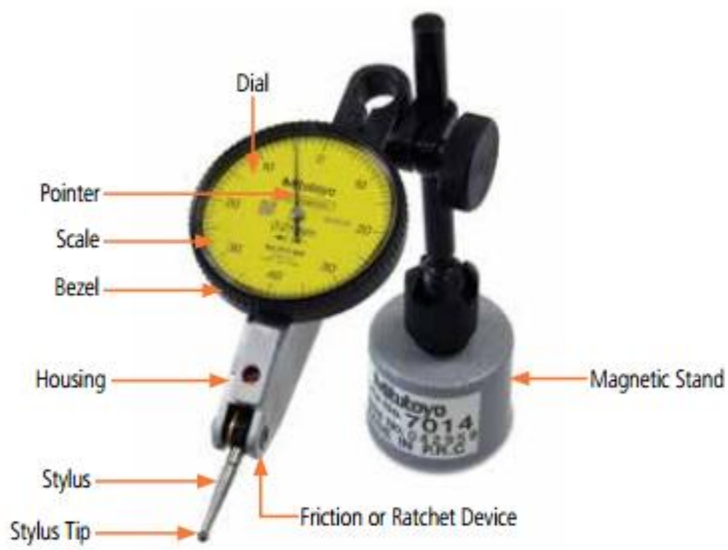


Fig. 2.48. parts of dial test indicator.

- **Before Use**

✓ Be sure to use the stylus with standard length matching the indicator model, otherwise a large measuring error may be the result.

Fig.2.49. correct use of dial test indicator

- ✓ Use a holding fixture that will not deflect significantly during normal use.
- ✓ A Dial Test Indicator's scale factor depends on the angle between the directions of movement of stylus and work piece. In practice, to avoid significant error, if the angle θ is kept less than 10° during measurement, then the effect can be ignored. If this angle cannot be kept small, the dial reading has to be multiplied by a factor to compensate this so-called cosine effect.

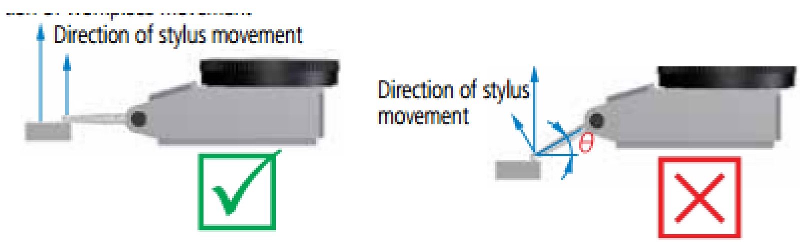


Fig. 2.50. Direction of workpiece movement

- ✓ When measuring a rotating or moving workpiece or when moving the dial test indicator, ensure that it rotates or moves away from the contact point.

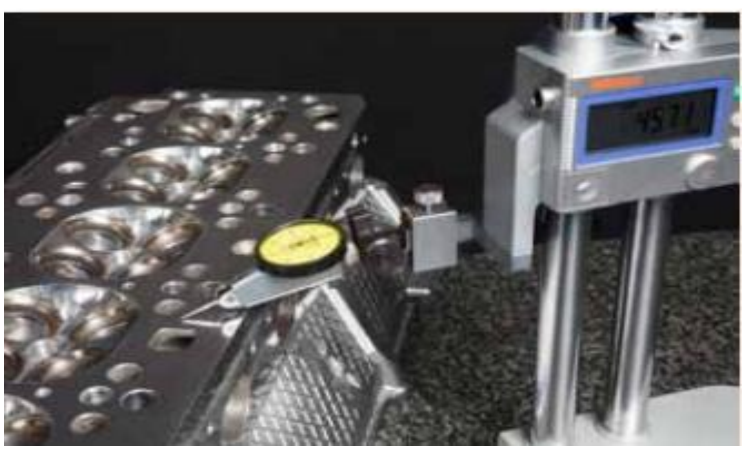


Fig. 2.51. Measurement direction

- **After Use**

✓ See all instruments, respectively digital instruments.

2.8. Depth Measuring Instruments

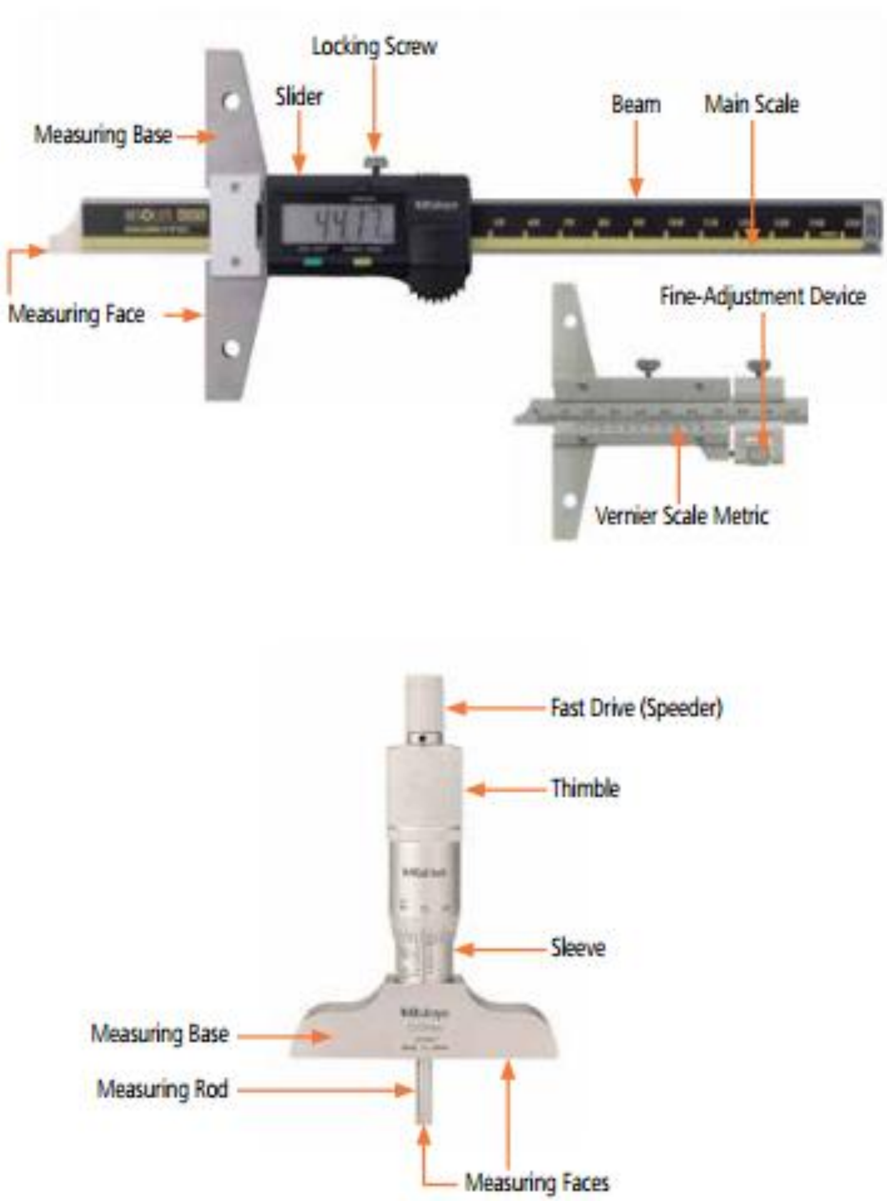


Fig. 2.52. parts of depth measurement.

- **Before Use**
  - ✓ Slowly bring the movable measuring face (rod/beam) into contact while pressing the fixed measuring face (base) against a flatness-assured surface such as a precision

surface plate. Then setup the reference point, if necessary. Use gauge blocks to check the setting of depth micrometers if the reference point is over 25 mm and of indicator depth gauges with extension rods.

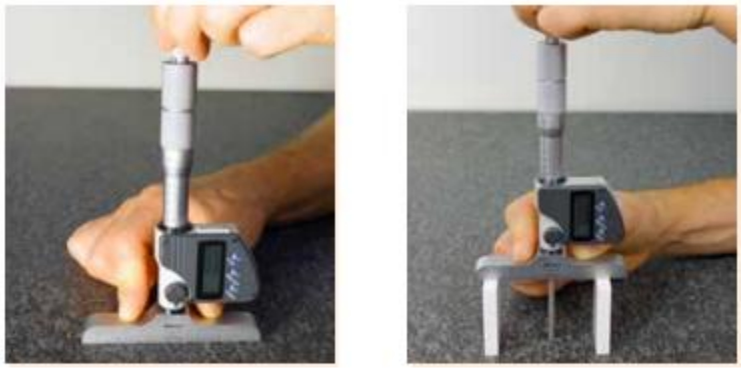


Fig. 2.52. Use gauge blocks to check the setting of depth micrometers

- ✓ When changing the rods of depth micrometers, remove dust or dirt from the contacting surfaces on the rod collar and spindle end.

Fig.2.53. contacting surfaces on the rod collar and spindle end.

- **During Use**
  - ✓ Perform measurement while the reference surface (base surface and measuring surface) is fully in contact with the workpiece.
  - ✓ Take care, that the base is always sufficiently pressed down against the workpiece to avoid tilting due to measurement force

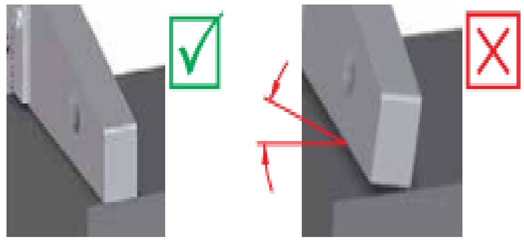


Fig. 2.54. correct usage of depth measurement.

✓ If the total length of extension rods used with an indicator depth gauge exceeds 110 mm use the gauge in vertical orientation only.

Fig. 2.55. use the gauge in vertical orientation only.

- **After Use**

✓ See all instruments, respectively digital instruments.

2.9. Auxiliary Equipment Comparator Stands

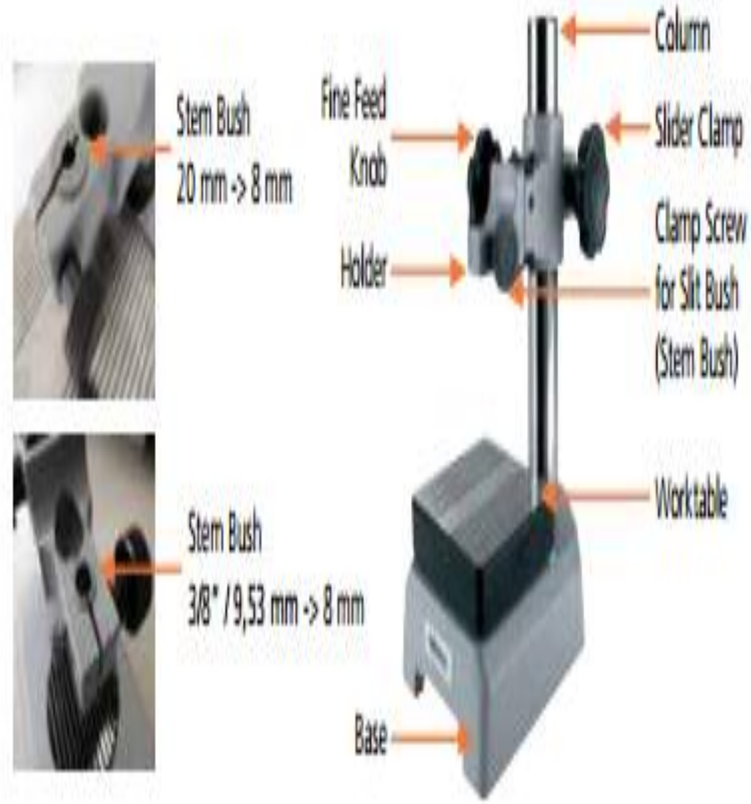


Fig.2.56. parts of Auxiliary Equipment Comparator Stands

- **Before Use**

✓ Clean the worktable using a dry cloth or a cloth moistened with alcohol.

✓ Make sure to hold the bracket firmly when moving it up or down. ü Mount the indicator in the stem mounting hole and tighten the clamp screw. Clamp the indicator firmly. However, the plunger of the indicator must still move smoothly.

✓ After adjusting the measuring position, tighten the slider clamp before starting measurement.

✓ For reference point adjustment, it is recommended to use a gauge block or a master work piece.

Fig.2.57. Reference point setting with a 50 mm Gauge Block.

- **During Use**
  - ✓ Especially for high-accuracy measurements move the plunger of the indicator upwards and downwards using any spindle lifting device such as a spindle lifting cable or a spindle lifting lever to avoid excessive force when changing the measurement equipment.

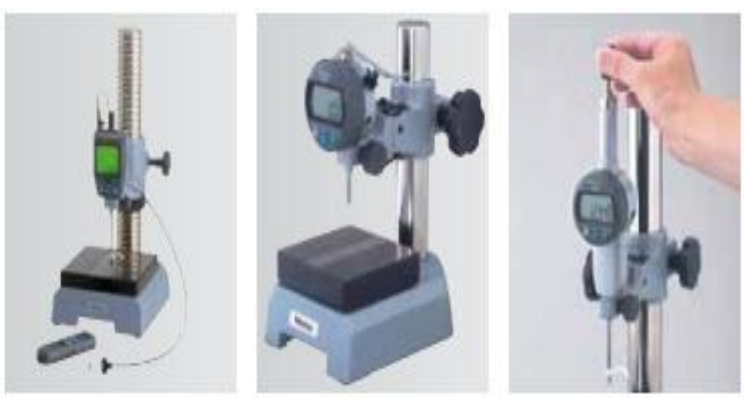


Fig. 2.58. high-accuracy measurement.

- **After Use**
  - ✓ See all instruments, respectively digital instruments.

2.10. Gauge Blocks

Fig. 2.59. parts of gauge block

- **Before Use**
  - ✓ To obtain maximum benefit from the extreme accuracy of gauge blocks, use them in a thermally stable environment.
  - ✓ Wipe off the oil film from the gauge blocks using a soft cloth and petroleum ether.
  - ✓ After wiping, the surfaces are cleaned with a cosmetic brush rinsed with petroleum ether and then blown clean with bellows.
  - ✓ Never use alcohol or benzene for cleaning; benzene contains impurities and alcohol always contains aqueous components which may cause corrosion.
  - ✓ Best-suited for wiping gauge blocks are micro fiber cloths.
  - ✓ Check the cleaned gauge blocks for rust and scratches.
  - ✓ If there are burrs on the measuring surface remove them carefully using a special Cranston for gauge blocks. Move the dry gauge block over the Cranston with very little pressure.

Fig.2.60. Accessories for Gauge Block preparation

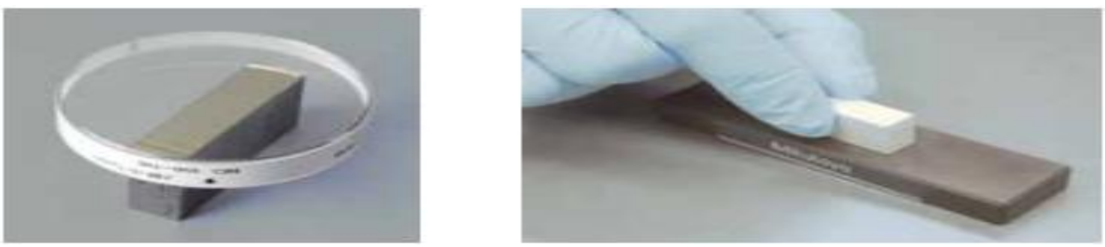


Fig. 2.61. A. Optical flat to check the measuring face **B**. Ceraston

- **During Use**
  - ✓ Wringing should always be performed in a clean place on a soft pad – if gauge blocks slip out of your hand, they will not be damaged.
- In case the measuring surfaces are in good condition, but wringing is still difficult, you may wipe them with medical cotton wool – its oily components will provide a fine film, thus improving the grip of the measuring surfaces.

- **After Use**
  - ✓ Check for damage to the blocks and, if found, recondition them by the method described above. If this is ineffective, replace.
  - ✓ After using steel gauge blocks, clean and apply rust prevention treatment using a cloth moistened with anti-corrosion oil.

Fig. 2.62. After using steel gauge blocks, clean and apply rust prevention treatment

2.11. WEEE Disposal of Batteries and Measuring Instruments

- **Disposal of batteries**
  - ✓ Batteries contain materials that can harm the environment when treated as conventional waste. On the other hand, most of these materials can be recycled, saving valuable resources. Therefore, for disposing of old batteries you are obliged to hand them to a certified battery collecting point.
- **Disposal of measuring equipment**
  - ✓ Disposal of measuring equipment ü Disposal of Old Electrical & Electronic Equipment (applicable in the European Union and other European countries with separate collection systems)
  - ✓ This symbol on the product or on its packaging indicates that this product shall not be treated as household waste. To reduce the environmental impact of WEEE (Waste Electrical and Electronic Equipment) and minimize the volume of WEEE entering landfills, please reuse and recycle.

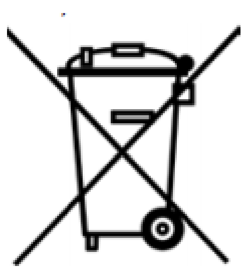


Fig. 2.63. Disposal of Old Electrical & Electronic Equipment

Self-Check 2.	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Say true and false for the following question below

1.Any measuring instruments does not affect expose to direct sunlight..
2. Any error occurs or the count is displayed abnormally, remove and reinstall the battery
3. Batteries contain materials that can harm the environment when treated as conventional waste.

Note: **Satisfactory rating - 2 points** **Unsatisfactory - below 2 points**.

Answer Sheet

Score = ____________
Rating: _____________

Name: ___________________________ Date: ________________

Answer

Information Sheet-3	Undertaking Proper storage of instruments based on ✓ manufacturer's specifications and

	✓ standard operating procedures

1.1. Introduction

Proper way of storing material should be considered in schoolwork shops and training area and this has to be adopted in the real work of electrical work shop. It is use full to keep materials in a proper manner, to preserve materials long lasting, to secure chemical character of the material, for easy access and handling etc. In general proper way of storing material saves time and money. Accordingly methods of storing for some materials and hand tools are described and illustrated below. Storing materials and tools depend up on the type, size, and product character, etc.

1.2. Storage

Store tools in a dry, sheltered environment. Place tools on a rack for easy safety and easy access. Place similar tools close together so that workers can see easily the available tools.

1.3. Storing tools safely in appropriate locations in accordance with manufacturers

- **Tools Habits**

"A place for everything and everything in its place" is just common sense. You cannot do an efficient, fast repair job if you have to stop and look around for each tool that you need. The following rules, if applied, will make your job easier.

- ✓ **Keep Each Tool In Its Proper Storage Place**. A tool is useless if you cannot find it. If you return each tool to its proper place, you will know where it is when you need it.

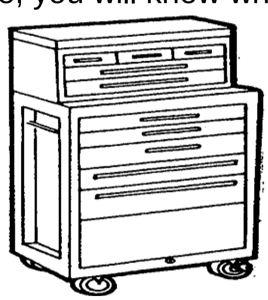


Fig. 4.1. tools storage

- ✓ **Keep Your Tools In Good Condition**. Keep them free of rust, nicks, burrs, and breaks.

✓ **Keep Your Tool Set complete.** If you are issued a tool box, each tool should be placed in it when not in use. If possible, the box should be locked and stored in a designated area. Keep an inventory list in the box and check it after each job. This will help you to keep track of your tools.

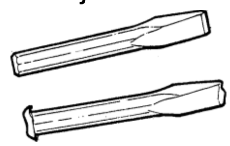


Fig. 4.2. chisel

- **Use Each Tool Only On The Job For Which It Was Designed.** If you use the wrong tool to make an adjustment, the result will probably be unsatisfactory. For example, if you use a socket wrench that is too big, you will round off the corners of the wrench or nut. If this rounded wrench or nut is not replaced immediately, the safety of your equipment may be endangered in an emergency.

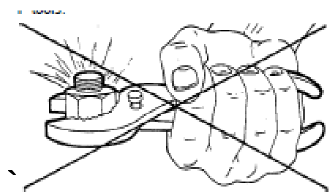


Fig.4.3. unpropre use of tools

- **Keep Your Tools Within Easy Reach And Where They Cannot Fall On The Floor Or On Machinery**. Avoid placing tools anywhere above machinery or electrical apparatus. Serious damage will result if the tool falls into the machinery after the equipment is turned on or running.

NOTE: Return broken tools to section chief.

- **Never Use Damaged Tools**. Notify your supervisor of broken or damaged tools. A battered screwdriver may slip and spoil the screw slot or cause painful injury to the user. A gage strained out of shape will result in inaccurate measurements.

1.4. Storage Items

- **Toolboxes**

Steel toolboxes are most popular. Their prices vary according to gauge of steel used, number of trays and whether the box is reinforced in the corners.

Some precision tool users use hardwood chests because the wood absorbs rust-producing condensation. Carpenters' toolboxes are specially designed so carpenters can carry hand saws and framing squares in the same box with other tools. The word "carpenter" differentiates this box from a regular toolbox because of the extra tools it will carry.

Plastic toolboxes are available in a number of styles. Some are suited for light-duty use, while others are comparable to steel in quality.
The highest quality plastic boxes are constructed of polypropylene, and some models can hold up to 75 lbs. of tools. The high quality plastic boxes feature interlocking pinned hinges, tongue-in-groove closure and positive locking latches, as well as padlock eyes and lift-out trays.

- **Tool Chests**

Utility chests store parts, screws, nuts, bolts and other small pieces. These chests are made of either plastic or steel with removable plastic dividers.

- **Tool Caddies**

Plastic revolving tool caddies hold tools and items such as nails, bolts, screws, glue and wire in tiers of circular trays.
The caddies are made of a high-impact plastic and feature a ball bearing base plate, allowing the unit to revolve easily.

- **Modular Workshops**

Modular, mobile workshops are increasing in popularity, as users like their adaptability and functionality. Some models feature adjustable leveling feet, adjustable height, detachable casters, latching doors, drawers, hooks for hanging tools, dust collection ports, quick-change tool set-up, lock-down hardware and corner tops. They can hold large and small tools, and can be designed to serve as a shop bench, router station or clamping station.

- **How to Choose and Use Tool Boxes**

The "Types and Uses" section provides you with a list of some of the types of tool boxes. These pages should help you select the right tool box to do the job.

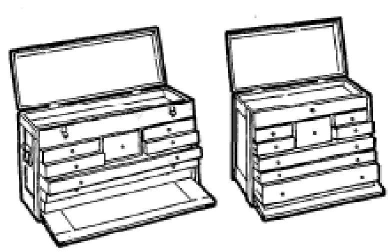


Fig.4.4. tools box

1.5. Types and Uses

Tool boxes are used for storing tools. They are usually made of steel, but wood and plastics are also used. Portable tool boxes are used for carrying and storing a variety of hand tools. Both special and common tools, such as mechanic's, electrician, and carpentry tools can be found in tool boxes. Chest-type tool boxes generally contain larger tools, such as specialized automotive tools or machinist's tools, requiring a more permanent location. Some larger tool boxes are mounted on wheels so they can be moved easily from place to place. Tool bags are usually made of canvas. Like the boxes, they are available in a variety of sizes and serve similar functions.
Examples of tool boxes are illustrated below.

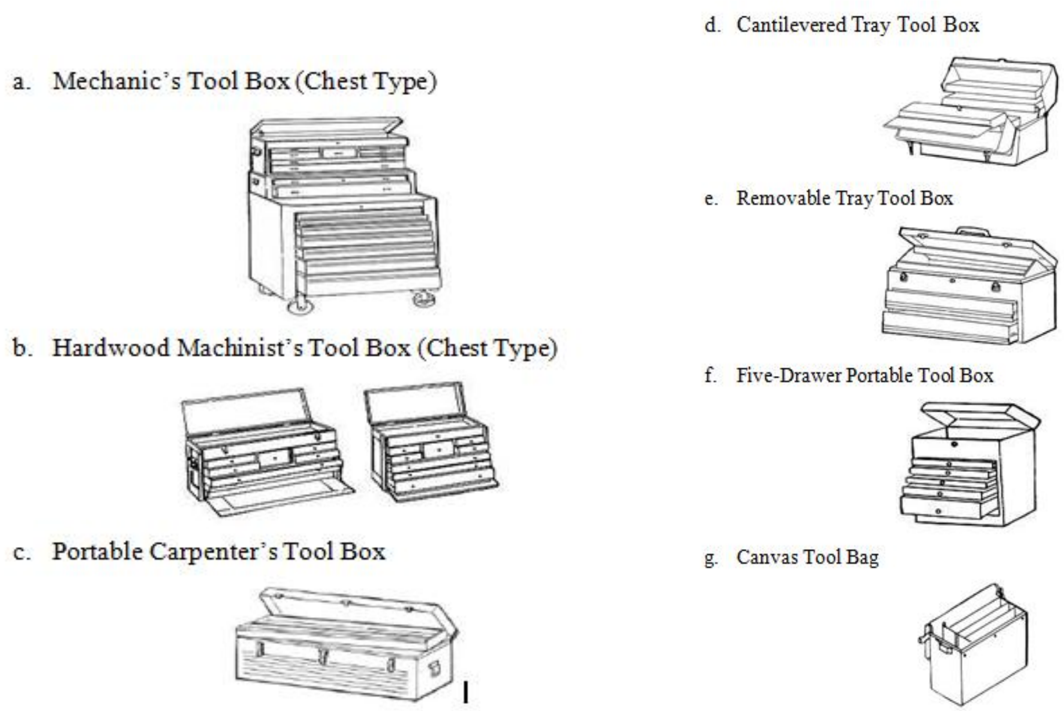


Fig. 4.5. different tools box

Self-Check 3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

<u>Say true and false for the following question below</u>

1. proper way of storing material saves time and money.
2. Modular workshops are increasing in popularity, as users like their adaptability
3. A tool is useless if you cannot find it.

Note: **Satisfactory rating - 2 points** **Unsatisfactory - below 2 points**.

Answer Sheet

Score = ___________
Rating: ____________

Name: _________________________ Date: _______________

Answer

Instruction Sheet	LG31: Maintain measuring instrument

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

- Identifying object or component to be measured
- Obtaining correct specifications from relevant source
- Selecting measuring tools

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to –

- Identify object or component to be measured
- Obtain correct specifications from relevant source
- Select measuring tools

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” in each information sheets.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets and LAP Tests if any”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After you accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result;

Then proceed to the next learning guide.

1.1. **A straightedge is** : a tool used for drawing straight lines, or checking their straightness. If it has equally spaced markings along its length, it is usually called a ruler . Straightedges are used in the automotive service and machining industry to check the flatness of machined mating surfaces. True straightness can in some cases be checked by using a laser line level as an optical straightedge: it can illuminate an accurately straight line on a flat surface such as the edge of a plank or shelf.

Fig.1.1. Straight edge

A pair of straightedges called winding sticks are used in woodworking to amplify twist (wind) in pieces of wood.
An idealized straightedge is used in compass-and-straightedge constructions in plane geometry . It may be used:

- Given two points, to draw the line connecting them.
- Given a point and a circle, to draw either tangent.
- Given two circles, to draw any of their common tangents.

It may not be marked or used together with the compass so as to transfer the length of one segment to another. It is possible to do all compass and straightedge constructions without the straightedge . It is not, however, possible to do all constructions using only a straightedge. It is possible to do them with straightedge alone given one circle and its center

1.2. TORQUE MEASURING TOOLS

The Torque Measurement tool is used in the manufacturing and engineering industries to check, determine or apply the correct level of torque. It monitors by detecting loosening torque and the tightening of screws therefore it performs a critical role in the audit, inspection, production, quality control, research, development and servicing environments.
A torque wrench is a tool used to apply a specific torque to a fastener such as a nut or bolt . It is usually in the form of a socket wrench with special internal mechanisms.

- A t**orque wrench** is used where the tightness of screws and bolts is crucial. It allows the operator to set the torque applied to the fastener so it can be matched to the specifications for a particular application. This permits proper tension and loading of all parts. A torque wrench uses torque as a proxy for bolt tension. The technique suffers from inaccuracy due to inconsistent or un calibrated friction between the fastener and its mating hole. Measuring bolt tension (indirectly via bolt stretch) is actually what is desired, but often torque is the only practical measurement which can be made.

Fig. 1.2. torque wrench

- **Torque gauges with wrench sensor**

Ideal to measure torque on bolt and using the Centor technology, the digital torque gauge Centor TW with wrench sensor has a very large graphic display and shows a maximum amount of information for more efficient torque measurement.

Fig. 1.3. torque gauge

- .**Torque gauges with handle sensor**

The torque tester Centor TH, with its handle torque sensor, is an instrument designed to measure manually torque on screws, bolts, tools... directly in production.

Fig. 1.4. torque gauge with handle sensor.

1.3. **A try square** is a woodworking tool used for marking and measuring a piece of wood. The square refers to the tool's primary use of measuring the accuracy of a right angle (90 degrees); to try a surface is to check its straightness or correspondence to an adjoining surface. "Try square" is so called because it is used to "try" the squareness.

Fig.1.5. Try square.

A piece of wood that is rectangular, flat, and has all edges (faces, sides, and ends) 90 degrees is called four square. A board is often milled four square in preparation for using it in building furniture. A traditional try square has a broad blade made of steel that is riveted to a wooden handle or "stock". The inside of the wooden stock usually has a brass strip fixed to it to reduce wear. Some blades also have graduations for measurement. Modern try squares may be all-metal, with stocks that are either die-cast or extruded.

1.4. **A protractor** is a measuring instrument , typically made of transparent plastic or glass, for measuring angles . Most protractors measure angles in degrees (°). Radian-scale protractors measure angles in radians . Most protractors are divided into 180 equal parts. Some precision protractors further divide degrees into arc minutes. They are used for a variety of mechanical and engineering-related applications. One common use is in geometry lessons in schools. Some protractors are simple half-discs. More advanced protractors, such as the bevel protractor, have one or two swinging arms, which can be used to help measure the angle.

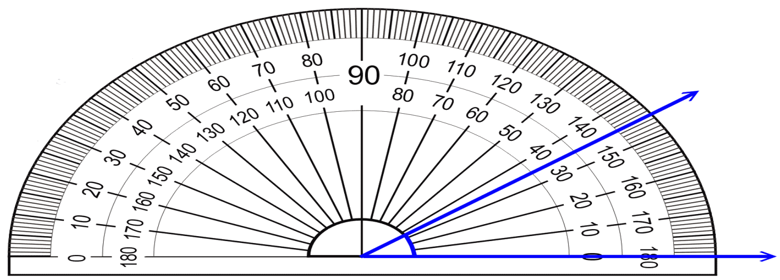


Fig. 1.6. protractor

1.5. **A combination square**: consisting of the rule, 45° holder, protractor and center square A combination square is a tool used for multiple purposes in woodworking , stonemasonry and metalworking . It is composed of a ruler and one or more interchangeable heads that may be affixed to it. The most common head is the standard or square head which is used to lay out or check right and 45° angles. the combination square continues to be a commonplace tool in home workshops, construction jobsites and metalworking.

Fig. 1.7. combination square Uses

- Measuring angles — A combination square can reliably measure 90° and 45° angles. The 45° angle is used commonly in creating miter joints .

- Determining flatness — When working with wood the first step is to designate reference surface on a board which is known as the face side.

The rest of the work piece is measured from the face side. Measuring the center of a circular bar or dowel . The rule is assembled through the center of the center square, the two cast iron legs of the center square are then placed against the outside of the bar (dowel) allowing a center line to be scribed alongside the ruler. Perform this action at two locations and the intersecting lines will approximate the center of the bar (dowel).

Protractor head allows angles to be set and measured between the base and ruler.
A rudimentary level for approximating level surfaces is incorporated in the protractor and also the 45° holder.
By moving and setting the head, it can be used as a depth gauge or to transfer dimensions.
Marking the work surface; with the included Scribe Point storedin a drilled hole in the Square Base.
It is used to find the center of the round jobs.

In woodworking, the starting raw material is neither flat nor square, however, the end product such as a table must be flat and have corners and legs which are square.
In metalworking, it is useful for a wide variety of layout and setup tasks. When used correctly, a fairly high degree of precision can be achieved. One use would be setting large items at the required angle in machine vises, where the long reach of the rule and firm, heavy base aid the process
.
1.6. **A ruler** sometimes called a rule or line gauge , is a device used in geometry and technical drawing, as well as the engineering and construction industries, to measure or draw straight lines. Rulers have long been made from different materials and in multiple sizes. Some are wooden. Plastics have also been used since they were invented; they can be molded with length markings instead of being scribed . Metal is used for more durable rulers for use in the workshop; sometimes a metal edge is embedded into a wooden desk ruler to preserve the edge when used for straight-line cutting. 12 in or 30 cm in length is useful for a ruler to be kept on a desk to help in drawing. Shorter rulers are convenient for keeping in a pocket. Longer rulers, e.g., 18 in (46 cm) are necessary in some cases. Rigid wooden or plastic yardsticks , 1 yard long, and meter sticks , 1 meter long, are also used. Classically, long measuring rods were used for larger projects, now superseded by tape measure , surveyor's wheel or laser rangefinders .

- **Desk rulers** are used for three main purposes: to measure, to aid in drawing straight lines and as a straight guide for cutting and scoring with a blade. Practical rulers have distance markings along their edges.

A line gauge is a type of ruler used in the printing industry. These may be made from a variety of materials, typically metal or clear plastic. Units of measurement on a basic line gauge usually include inches, agate , picas , and points . More detailed line gauges may contain sample widths of lines, samples of common type in several point sizes , etc.

Fig. 1.8. Steel ruler or line gauges

Measuring instruments similar in function to rulers are made portable by folding (carpenter's folding rule) or retracting into a coil (metal tape measure) when not in use. When extended for use, they are straight, like a ruler. The illustrations on this page show a 2 m (6 ft 7 in) carpenter's rule, which folds down to a length of 25 cm (10 in) to easily fit in a pocket, and a 5 m (16 ft) tape, which retracts into a small housing.

Fig.1.9. carpenter’s ruler

A flexible length measuring instrument which is not necessarily straight in use is the tailor's fabric tape measure, a length of tape calibrated in inches and centimeters. It is used to measure around a solid body, e.g., a person's waist measurement, as well as linear measurement, e.g., inside leg. It is rolled up when not in use, taking up little space.

Fig. 1.10

self check	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Choose the best answer from the question below

_____________1. Which one of the following to check the flatness of machined mating surfaces.

A. Micrometer
B. Straight edge
C. Steel ruler
D. All

____________2. Which one of the following is apply the correct level of torque.

A. Steel ruler
B. Plastic ruler
C. Torque wrench
D. micrometer

____________3. Which one of the following is simple half-discs instrument.

A. Protractor
B. Ruler
C. Torque gauge
D. None

____________4. Which one of the following is marking and measuring a piece of wood.

A. Steel ruler
B. Multi meter
C. Try square
D. micrometer

Answer Sheet

Name: _____________________ Date: ________________

Answer

***Note:* Satisfactory rating – 2 points** **Unsatisfactory - below 2 points**.

information sheet 2	Obtaining correct specifications from relevant source

2.1. Obtaining correct specifications

"Specifications" is a general term applying to all directions, provisions, and requirement pertaining to the performance of the work and payment for the work. Technician 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. 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.

2.2. Well-written specifications:

- are clear, concise, and technically correct.
- do not use ambiguous words that could lead to misinterpretation.
- are written using simple words in short, easy to understand sentences.
- use technically correct terms, not slang or "field" words.
- avoid conflicting requirements.
- do not repeat requirements stated elsewhere in the Contract.

do not explain or provide reasons for a requirement.

- state construction requirements sequentially.
- avoid the use of awkward phrases such as "and/or" and "him/her." Rewriting the sentence can eliminate such phrases.

Furthermore, the phrases "approved by the Engineer" or "accepted by the Engineer" should be avoided. These should be used only when the Engineer will actually accept or approve the work. In such phrases, "approved" and "accepted" are synonymous; there is no difference in the responsibility taken by the Engineer

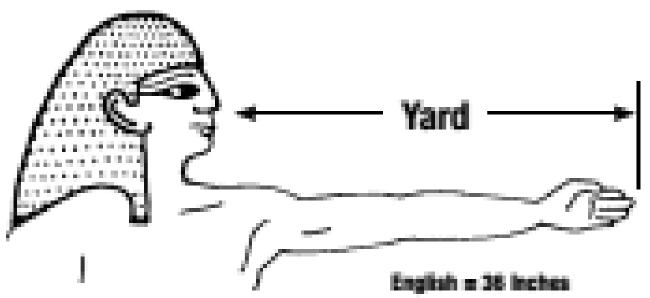
A. A **requirement specification** is a documented requirement, or set of documented requirements, to be satisfied by a given material, design, product, service,

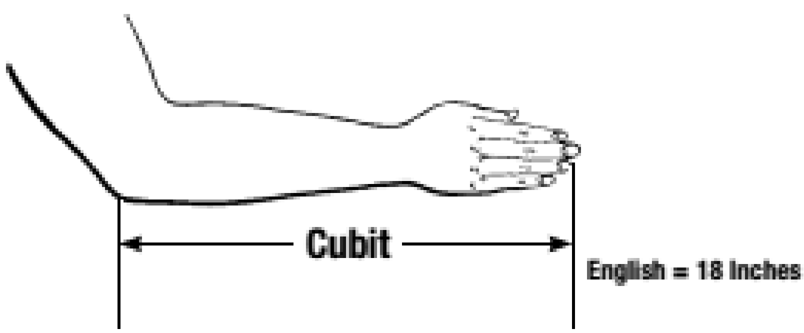
B. etc..In engineering, manufacturing, and business, it is vital for suppliers, purchasers, and users of materials, products, or services to understand and agree upon all requirements.

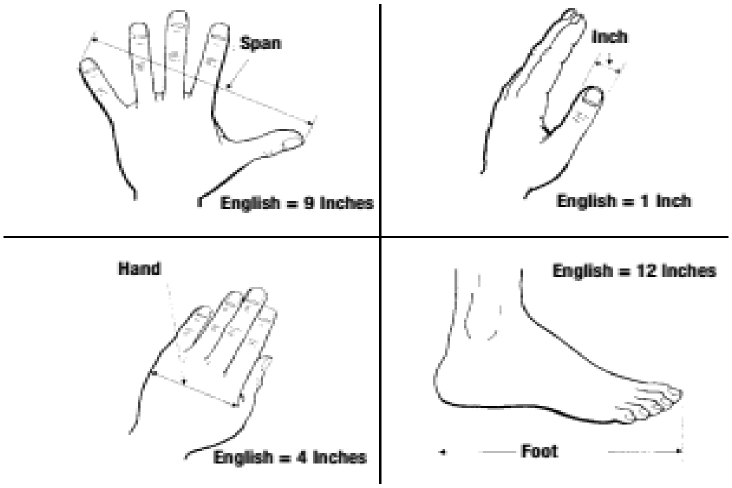
The reading of the measured value of instruments vary in accordance with type and correctness of that instrument. The measuring instrument can be chosen by the following criteria's.

1. Using alternative measuring instruments

Precision has not always been associated with measurement. At the dawn of civilization, man began to use parts of the body to estimate dimensions , from such measurements, there evolved the first standards of measurement: the inch, hand, span, foot, cubit, yard and fathom. The tools of the past did not demand great accuracy. Most products were custom made by hand and a fraction of an inch one way or the other made little difference to satisfactory operation.







. **Using alternative measuring instruments**

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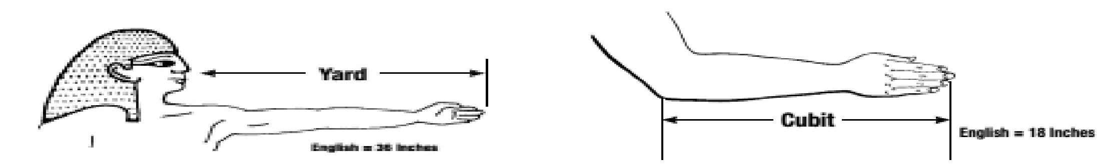
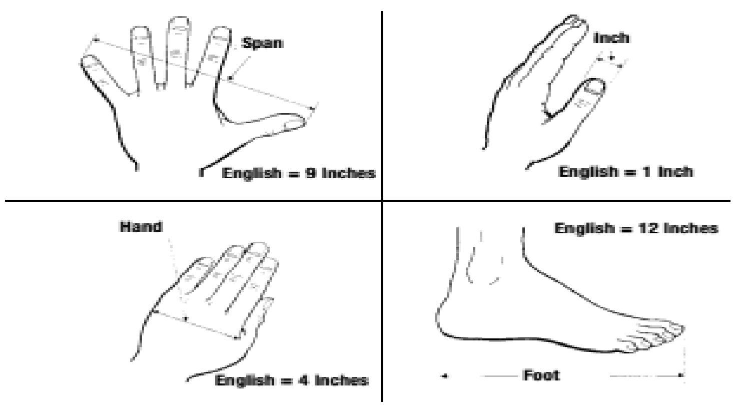




Self-Check -2	Written Test

Matching

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

Answer Sheet

Name: ____________________________ Date: ________________

Answer Questions

Note: **Satisfactory rating - 2 points** **Unsatisfactory - below 2 points**.

Operation Sheet 1	Obtaining correct specifications

Techniques of measuring length

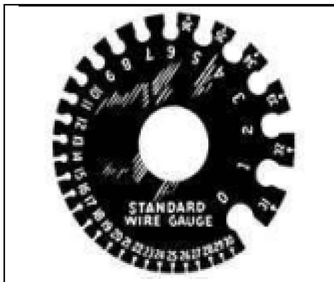
1. Select/identify/ the type of measuring instrument you use
2. Prepare different size of steel and/or conduits.
3. Measure 0.25m of conduit
4. Convert the measured unit in to cm
5. Mark the measured size.
6. Report your work and conclusion to your trainer

information sheet 3	selecting measuring Instruments

.1. MEASURING INSTRUMENTS Measurement is the process or the result of determining the ratio of a physical quantity, such as a length, time, temperature, etc., to a unit of measurement, such as the meter, second or degree Celsius. The science of measurement is called metrology. The English word measurement originates from the Latin mēnsūra and the verb metiri through the Middle French measure.

Electrical measuring tools and instruments are sensitive and delicate so extra care is necessary in handling them. These are used to measure currents, voltages, resistances, wattages and other important elements in electrical works. This topic, will tackle the function/use of each measuring tool and instrument used in doing a electrical task. Different kinds of measuring tools and precision measuring instruments are as follows:

Measuring tool/instrument	Description
	Test Light is a pocket size tool used to test the line wire or circuit if there is current in it.
	Micrometer is used to measure the diameter of wires/conductors in circular mils. It can measure small and big sizes of wires and cables

	Wire Gauge is used in determining the size of wires/conductors. The gauge ranges from 0 to 60 awg (American wire gauge).
	Ruler/foot rule is a measuring tool used to measure length, width and thickness of short flat object and in sketching straight lines
	*A ruler/rule is a tool used in, for example, geometry, technical drawing, engineering, and carpentry, to measure lengths or distances or to draw straight lines. Strictly speaking, the ruler is the instrument used to rule straight lines and the calibrated instrument used for determining length called a measure. However, common usage calls both instruments rulers and the special name straight edge is used for an unmarked rule.
 	Pull-Push Rule is a measuring tool used to measure the length of an object in centimeter and inches

	Ammeter is an instrument used to measure the amount of electrical current intensity in a circuit. The unit of measure is ampere (a). It is connected along or series to the circuit.
	Voltmeter is an instrument used to measure electrical pressure or voltage of a circuit. The unit of measure is volt (v). This is connected across or parallel to the circuit.
	Clamp Ammeter is also called tong-tester. It is used to measure current flowing in a conductor. It is clamped or hanged in a conductor.
	Volt-Ohmmeter (VOM) otherwise called as Multi-tester; is used to measure the voltage, resistance and current of a circuit. It is connected in parallel or series with the circuit depending on what to measure.

Table 3.1. Description of Measuring tool/instrument

Self-Check 3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Part 1: Say true and false for the following question below

Directions: Give short answer for the following questions.

1. Micrometer is used to measure the diameter of wires/conductors in circular mils.
2. Test Light is not a pocket size tool used to test the line wire
3. Measurement is the process or the result of determining the ratio of a physical quantity.
4. Wire Gauge is not used in determining the size of wires/conductors.

Part 2 : Match the electrical measuring tools and instruments in Column A to their descriptions in Column B. Write the letter of your answer in the space provided before each number.

Answer Sheet

Name: ___________________________ Date: _________

***Note:* Satisfactory rating - 2 points** **Unsatisfactory - below 2 points**.

LAP Test. 1.	**Maintain measuring instruments**

Instructions: Given necessary instrument and materials you are required to perform the following tasks within 1hour.

Task 1: The operator aware of the state of readiness of the equipment

Task2: Use appropriate tools for appropriate material maintenance and righs measuring instrument for right measurement.

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