Electrical/Electronic Equipment

Servicing Level-II

Based on April, 2022 Curriculum Version I

Module Title: - Perform Electrical/Electronic Measurement and Calculation

Module code: EIS EEES2 01 0322

Nominal duration: 90 Hour

Prepared by: Ministry of Labor and Skill

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Addis Ababa, Ethiopia

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Acknowledgement

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

Acronym

LAP -- Laboratory Activity performance

Si--- System of International

LCD-- Liquid Crystal Display

Dc-- Direct Current

AC--- Alternating Current

KWh -- Killo Watt hour

Hz-- Hertz

AG--- Automotive Glass

RCM --- Reliability and centered Maintenance

SOP--- Standard Operation Procedure

FMECA--- Failure Mode Effects and Critically analysis

HSE--- Health and safety environment

MRO-- Maintenance repair and Operation

OD-- Outside Diameter

ID-- Inside Diameter

Introduction to the unit

In Electrical/electronic equipment servicing filed; the performing Electrical/Electronic measurement and calculation; helps to know ; identify object or component according to procedures to be measured , Obtain Correct specifications from relevant source, Select Measuring tools in line with job requirements, Obtain accurate measurements for job, Perform Calculation needed to complete work tasks using the four basic process of addition (+), subtraction (-), multiplication (x), and division (/), Check and correct Numerical computation for accuracy, handle Measuring instruments without damage according to procedures,.

This module is designed to meet the industry requirement under the performing of Electrical/Electron measurement and calculation.

This unit covers the topics :

- Plan and prepare tasks
- Select measuring instruments
- Carry out measurements and calculation
- Maintain measuring instruments

Learning Objective of the unit

- Identify Object or component according to procedures to be measured
- Select Measuring tools in line with job requirements
- Obtain accurate measurements for job
- Perform ***Calculation*** needed to complete work tasks using the four basic process of addition (+), subtraction (-), multiplication (x), and division (/)
- Check and correct Numerical computation for accuracy
- Undertake Proper storage of instruments according to manufacturer's specifications and standard operating procedures.

unit Instruction

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

1. Read the specific objectives of this unit.
2. Follow the instructions described below
3. Read the information written in the "unit". 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 units.

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 unit.

unit one Plan and prepare tasks

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

- Identifying component or object to be measured
- Obtaining correct specifications
- Selecting Measuring instruments with job requirements
- Making workstation ready with job specifications.

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

- Identify Object or component according to procedures to be measured
- Obtain Correct specifications from relevant source
- Select Measuring tools in line with job requirements
- Make ready Workstation in accordance with job specifications
- Obtain accurate measurements for job

1. Plan and prepare tasks

1.1Identify object or component to be measured

Measuring is the science of finding size or amount of something by comparing it with a standard unit. Knowledge of measuring and its practice is of ever-increasing importance in industry. The development of engineering production in the past has been inseparable from that of measurement. It is certain that the more exacting demands of industry of mechanisms and assemblies, which must meet stringent design requirements, have resulted in even closer attention being paid to the science of **Measurement**. Highly accurate and standard measurement systems are very important for interchangeable manufacture, world trade, and the need for high precision.

1.2 Obtain correct Specification

Presently there are two major systems of measurement used in the world. These are the inch systems often called the English system of measurement and the metric system. The metric system of measurement is being utilized by about 90percent of the world's Populations these days because of its ease of use and better accuracy over the inch system. In the metric system of measurement, the amount of measurement (measured value) of certain property is related to the basic unit of measurement by factors of 10.

If for instance, length with the basic unit meter is taken, all length measurement values are expressed as multiples of 10 as mm (10^{-3} m), cm (10^{-2} m), Km (10^{3} m) etc.

This in other words means that all measuring tools of the metric system come with graduations that are positive or negative powers of 10. And this makes conversion of the measured value to the base unit very easy.

On the contrary, measured values (amount of measurement) in the inch system are related to the basic unit of measure by unusual factors. For example, the unit of length inch is divided in to 2, 4, 8,16,32,64 and some other fractions that are of no regular pattern when compared to the metric system.

Besides this inch system uses more than one unit for same property unlike the metric system. For instance, foot, yard, and Mile are other units for length measurement and this could be some good reason to create confusion.

Considering all this irregularity in the English systems, the metric system of measurement is the one which all countries are likely to adopt in time. The basic units of measurement of the metric system are standardized by the international system of units (SI).Due to this they interchangeably are called SI unit.

1.3 Select measuring instruments

Electrical measurements are the methods, devices and calculations used to measure electrical quantities. Measurement of electrical quantities may be done to measure electrical parameters of a system. Using transducers, physical properties such as temperature, pressure, flow, force, and many others can be converted into electrical signals, which can then be conveniently measured and recorded. Electrical measurements are a branch of the science of metrology.

Measurable independent and semi-independent electrical quantities comprise:

- Voltage by the means of voltmeter
- Electric current by the means of Ammeter
- Electrical resistance by the means of Ohmmeter
- Electrical charge by the means of electrometer
- Electrical power by the means of watt meter

Measurable dependent electrical quantities comprise:

- Inductance by the means of Inductance meter
- Capacitance by the means of Capacitance meter
- Electrical impedance defined as vector sum of electrical resistance and electrical reactance by the means of Ohmmeter
- Frequency by the means of Frequency meter

1.4 Making workstation ready with job specification

Electrical Units of Measure

The standard SI units used for the measurement of voltage, current and resistance are the Volt [V], Ampere [A] and Ohms [Ω] respectively. Sometimes in electrical or electronic circuits and systems it is necessary to use multiples or sub-multiples (fractions) of these standard units when the quantities being measured are very large or very small. The following table gives a list of some of the standard units used in electrical formulas and component values.

Standard Electrical Units

Parameter	Symbol	Measuring Unit	Description
Voltage	V or E	Volt	Unit of Electrical Potential $V = I \times R$
Current	I or i	Ampere	Unit of Electrical Current $I = V \div R$
Resistance	R	Ohm	Unit of DC Resistance $\mathbf{R = V \div I}$
Conductance	G	Siemen	Reciprocal of Resistance $\mathbf{G = 1 \div R}$
Capacitance	C	Farad	Unit of Capacitance $\mathbf{C = Q \div V}$
Charge	Q	Coulomb	Unit of Electrical Charge $\mathbf{Q = C \times V}$
Inductance	L	Henry	Unit of Inductance $\mathbf{V_L = -L(di/dt)}$
Power	P	Watts	Unit of Power $\mathbf{P = V \times I}$ or $\mathbf{I^2 \times R}$
Impedance	Z	Ohm	Unit of AC Resistance $\mathbf{Z^2 = R^2 + X^2}$
Frequency	F	Hertz	Unit of Frequency $\boldsymbol{f} \mathbf{= 1 \div T}$

Multiples and Sub-multiples

There is a huge range of values encountered in electrical and electronic engineering between a maximum value and a minimum value of a standard electrical unit. For example, resistance can be lower than 0.01Ω's or higher than 1,000,000Ω's. By using multiples and sub-multiples of the standard unit we can avoid having to write too many zero's to define the position of the decimal point. The table below gives their names and abbreviations

. Prefix	Symbol	Multiplier	Power of Ten
Terra	T	1,000,000,000,000	10^{12}
Giga	G	1,000,000,000	10^{9}
Mega	M	1,000,000	10^{6}
Kilo	K	1,000	10^{3}
None	None	1	10^{0}
Centi	C	1/100	10^{-2}
Milli	M	1/1,000	10^{-3}
Micro	µ	1/1,000,000	10^{-6}
Nano	N	1/1,000,000,000	10^{-9}
Pico	P	1/1,000,000,000,000	10^{-12}

example:

- 1kV = 1 kilo-volt - which is equal to 1,000 Volts.
- 47kΩ = 47 kilo-ohms - which is equal to 47 thousand Ohms.
- 1kW = 1 kilo-watt - which is equal to 1,000 Watts.
- 1MHz = 1 mega-hertz - which is equal to one million Hertz.
- 1mA = 1 milli-amp - which is equal to one thousandths (1/1000) of an Ampere.
- 100uF = 100 micro-farads - which is equal to 100 millionths (1/1,000,000) of a Farad.

To convert from one prefix to another it is necessary to either multiply or divide by the difference between the two values. For example, convert 1MHz into kHz.

Well we know from above that 1MHz is equal to one million (1,000,000) hertz and that 1kHz is equal to one thousand (1,000) hertz, so one 1MHz is one thousand times bigger than 1kHz. Then to convert Mega-hertz into Kilo-hertz we need to multiply kilo-hertz by
one thousand, as 1MHz is equal to 1000 kHz. Likewise, if we needed to convert kilo- hertz into mega-hertz we would need to divide by one thousand. A much simpler and quicker method would be to move the decimal point either left or right depending upon whether you need to multiply or divide.

Calculation

A 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 between two people.

For example, multiplying 7 by 6 is a simple algorithmic calculation. Statistical estimations of the likely election results from opinion polls also involve algorithmic calculations, but produces ranges of possibilities rather than exact answers. Some other examples of calculation in a sentence:

i. According to experts' *calculations*, that star will explode within two billion years.
ii. The computer can do millions of *calculations* each second.
iii. Careful *calculation* is required to determine the required amount of fuel.
iv. His positions are based on political *calculation* of what voters want to hear.

DIMENSION:

Dimension can have different meaning based on the context as follows;

- ✓ **measurement of size of something**: a measurement of something in one or more directions such as length, width, or height

  example the dimensions of the room

- ✓ **size:** the size or extent of something (usually used in the plural)

  example: discussed the dimensions of the problem
- ✓ **coordinate for space and time** (mathematics) : a coordinate used with others to locate a point in space and time
- ✓ **property defining physical quantity** (physics): one of a group of properties or magnitudes such as mass or time that collectively define a physical quantity

Self-Check 1	Written Test

I. Say true or false for the following questions

1. The two types of measurement systems are inch system and metric system
2. Electrical measurements are the methods, devices and calculations used to measure electrical quantities
3. Electric current is measured by the means of Ammeter

II. Choose the correct answer

1. The measuring unit of capacitance is;

   A. Siemen B. watt C. Ohm D. Farad

2. Electrical power is measured by means of

   A. Watt meter B. Ammeter C. Volt meter D. Inductance mete

III. Give the necessary answers for the following questions

1. What is measurement? (3 points)
2. Convert the following prefixes into its power of ten.

A. Terra B. Giga C. Mega D. Pico E. Micro F. Micro

Unit two Measurement Instruments

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

- Selecting suitable measuring instrument
- Obtaining accurate measurements.
- Performing four basic process of mathematical calculation
- Performing mathematical calculations of parallel circuit, series circuit and series parallel circuit.
- Checking and correcting numerical computation
- Reading the limitation of accuracy of instruments tool

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

- Selecting suitable measuring instrument
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- Reading the limitation of accuracy of instruments tool

2. Select measuring instruments

2.1 Select suitable measuring instrument

Measuring instruments are of two types .These are mechanical and Electrical measuring instruments Mechanical measuring instruments are designed either for line measurements (for measuring distance between two edges, like steel rule), or end measurement (for measuring distance between two surfaces like micrometer, Screw gauges, etc). It is Very difficult that instruments designed for one system to be used for other system. The Measuring instruments may be classified depends up on the accuracy that can be attained. The two categories are non- precision instruments and precision instruments. Electrical measuring instruments are designed to measure voltage, resistance and current in electronics & electrical equipment

A. Mechanical measuring Instruments

I. The Steel Rule

Steel rules are the most common linear measuring tools and are available in the metric or inch system. Metric rules are graduated in both millimeters and half-millimeters. Some rules are available with both inch and millimeter graduation.

It is the simplest and most common measuring instruments used in inspection. Scale is available in different Sizes, Styles and accuracy. Scale is graduated either on both edges or on only one side. Metric steel rules can be 150 mm long, 300mm, 600 mm or 1000mm long with Accuracy of 1mm and 1/2 mm. Certain rules have some attachments and special features with them to make use more versatile e.g., Very small rules may be providing a handle to use it easily. They may be made in folder form so that they can be kept in pocket, also certain rule take in to accounts the shrinkage of-materials after cooling and are called shrink rules.

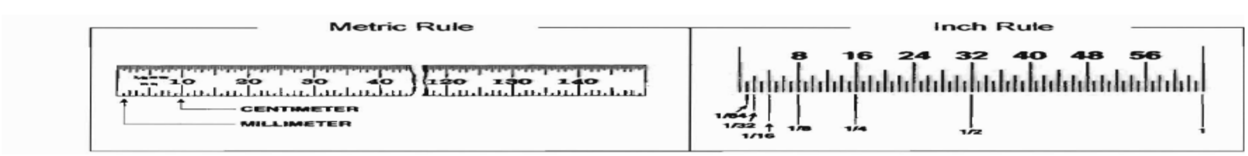


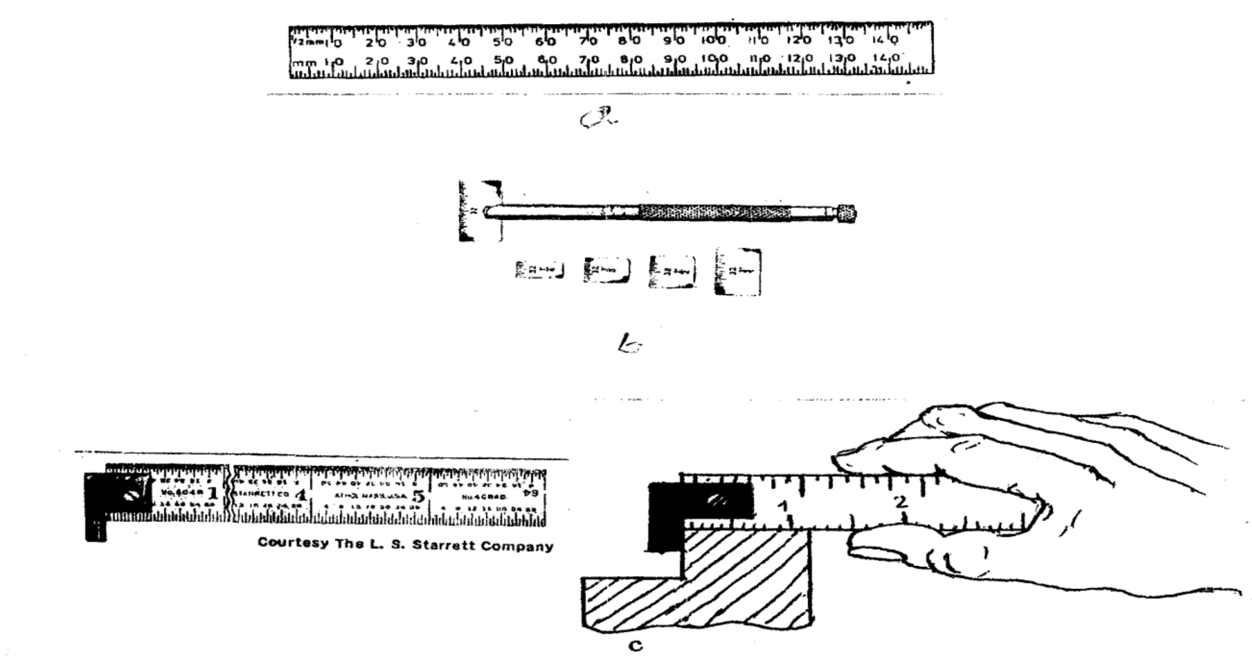
fig. 2.1 Graduations of steel, rule

Graduations rule accessories.

For direct line measurement, the reliability of measurement is directly related with the proper positioning of the rule in relations to the work piece. To improve the accuracy of the rule positioning several accessories are used.

i. **Hooks**: Used to provide good alignment of the zero point on the borderline of an object surface and keep the rule in a position substantially normal to the edge of that surface. These may be fixed length or extendable type.
ii. **Clamping shafts:** used to hold short rule sections to permit direct measurement in cramped locations since, confined spaces does not provide access for regular steel rules.
iii. **Parallel clamps**: used for aligning steel rules with the axis of cylindrical shafts.
iv. **Square heads and center finder**: used in layout work. Center finders are used on steel rule to permit scribing centerline on the face of round objects. Square heads aligns rule normal to the edge of straight sided object.

Fig.2.2 A. Graduation rule accessories (b. Clamping shaft, c. Hook



How to Use Rules

Using a steel rules requires three important considerations.

- First, which particular style of rule will best do the Job?
- Second, which scale should be used?
- Third, What Method of holding the rule and the part provides the most reliable measurement.

The purpose of all three is to establish the most precise relationship between the reference point and measured point on the part with the scale graduations of the rules.

To get good results, certain techniques must be followed in the use of scale.

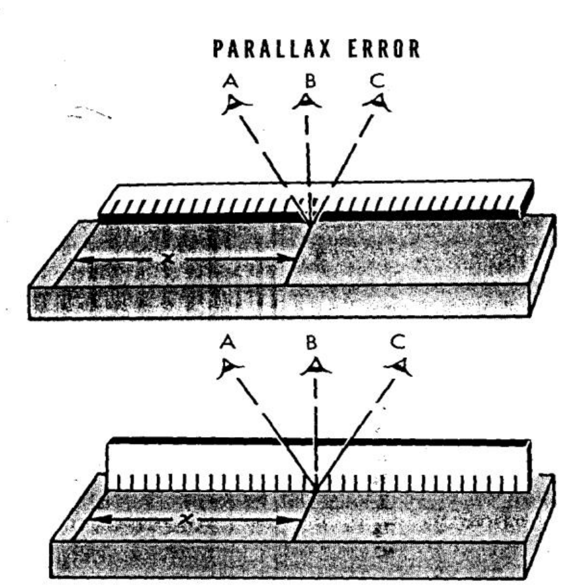


Fig.2.3 Parallax error

1. The rule is worn at ends; therefore, the end of the rule must never be set of the edge of the part to be measured. Not only is the end of the rule worn out but also it difficult to line up accurately the end of rule to the edge of the part to be measured.
2. The Scale should never be laid flat on the part to be measured. Because by doing so the graduations of the scale are not direct contact with the surface of the part and it is difficult to read the correct dimension.
   - The degree of accuracy, when measurements are made by a steel rule of depends up on the quality of the rule, and the skill of the user in estimating part of a millimeter.
   - The engineers rule used for making direct measurements depends up on visual alignments of a mark or surface on the work to be measured against the nearest division on its scale.

- Various errors in measurements can be minimized by using a rule whose thickness is as small as possible.
- It is important when making measurement to have the eye directly opposite and at 90 to the work. Otherwise there will be 'parallax' error, (which is the result of any sideways positioning of the direction of sighting.

II. Gauging Tools

Gauging Tools, special devices used for making accurate measurements. Gauging tools include calipers, depth gauges, taper and thickness gauges, dial and surface gauges, spirit levels and plumb bobs, and straightedges and squares.

i. **Straightedges and squares**: measure dimensions and check angles. They are used in such tasks as marking and making a straight cut across a board. Straightedges are basically heavy-duty rules, usually made of metal, while squares consist of two arms that are at right angles, or 90°, to each other. Miter squares have 45° angles. A combination square is shaped so that it can check both inside and outside 90° and 45° angles; it usually includes a small bubble level for quickly checking level and plumb positions as well. Bevels or bevel protractors are used to measure other angles; in these devices, the angle of the square is adjustable.

ii. **Try Square**: a wood working tool used to test and mark out right angles, consisting of a rectangular handle with a thin flat rectangular metal blade fitted perpendicular to it

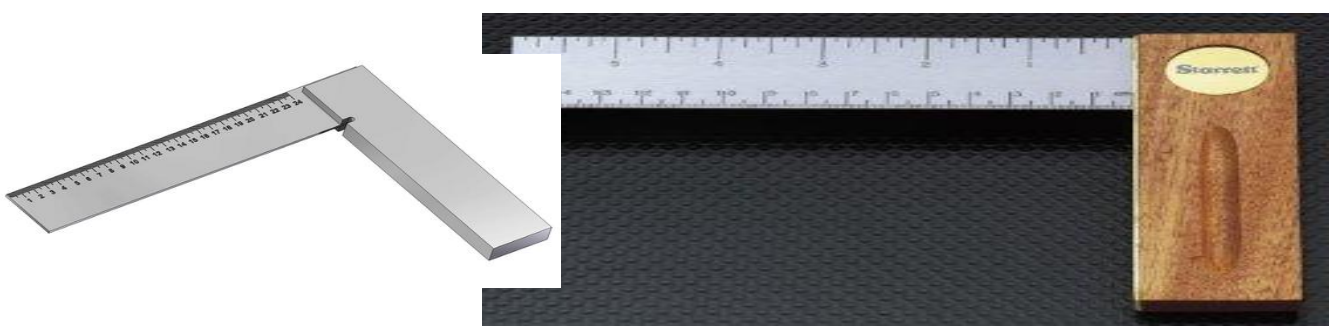


fig 2.4 Angle Measuring Instruments

With a simple Protractor the measuring arm can be set against a circular degree scale from 0 degree to 180 degree. The measuring error is around 1 degree. With a more precise Universal Bevel Protractor angular measurements can be carried out with an accuracy of 5 minutes.

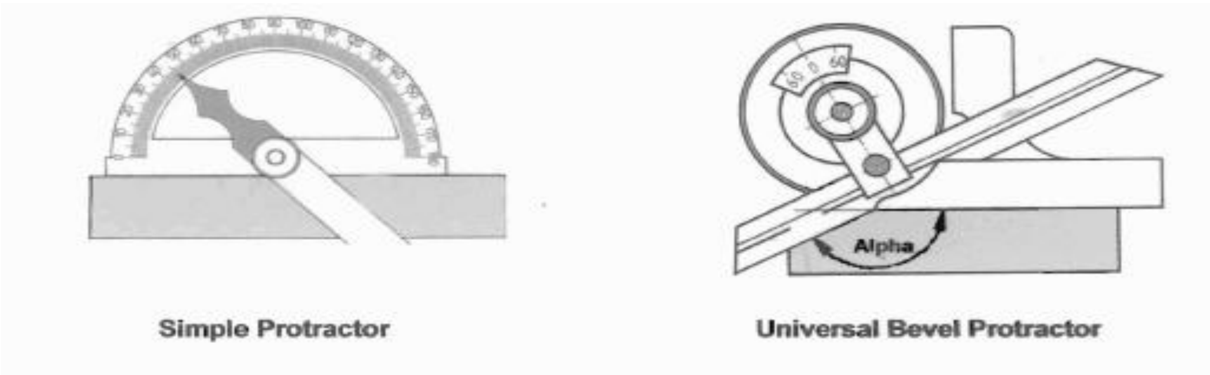


fig. 2.5 types of protractor

iii. Indirect Reading Instruments

Inside and Outside Calipers are comparison tools used to make approximate measurements of the outside diameter of round work pieces. The caliper cannot be read directly and its setting must be checked with a rule or a vernier caliper.

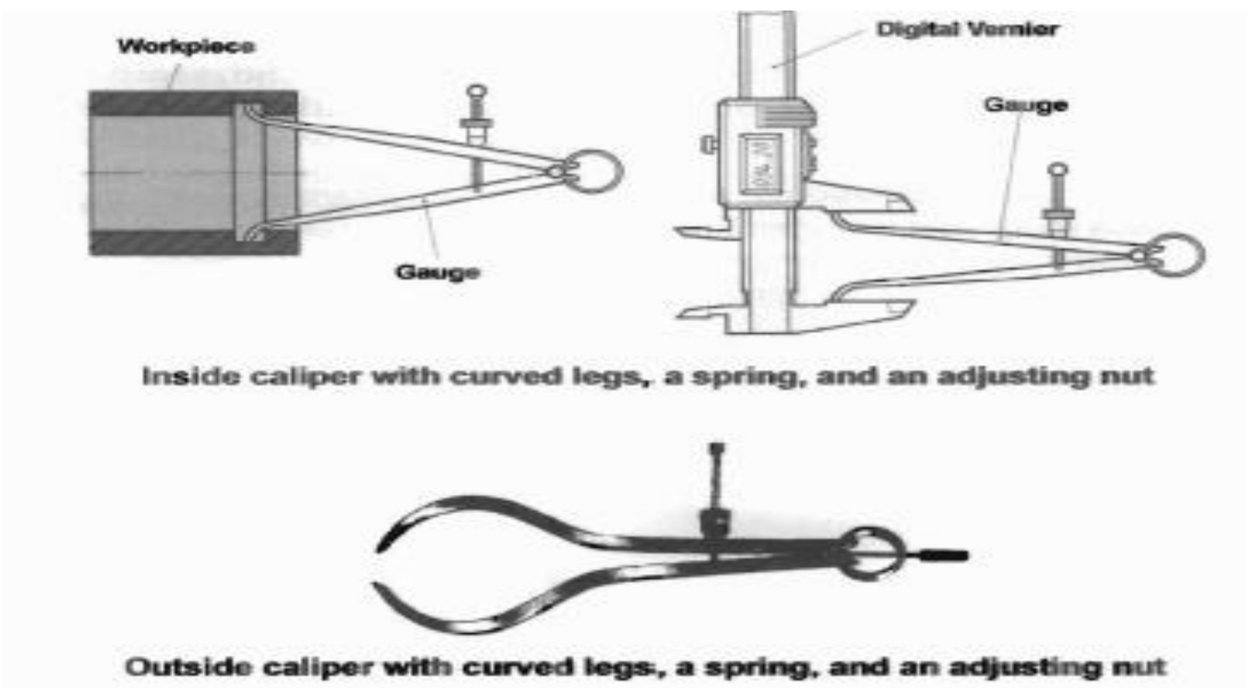


fig.2.6 Calipers (A . inside caliper B. outside caliper)

IV. Vernier Calipers

Vernier calipers are precision measuring instruments used to make internal, exter al and depth measurements. Both systems metric and inch are available, and some styles of vernier caliper provide metric readings on one side and inch readings on the other side. The common ssize of verniers for machine shops are 200 mm, 250 mm and 300 mm. The precision depends on the vernier scale. Common types provid an accuracy of either 0.05 mm or 0.02 mm. The example below shows an accuracy of0.05 mm.

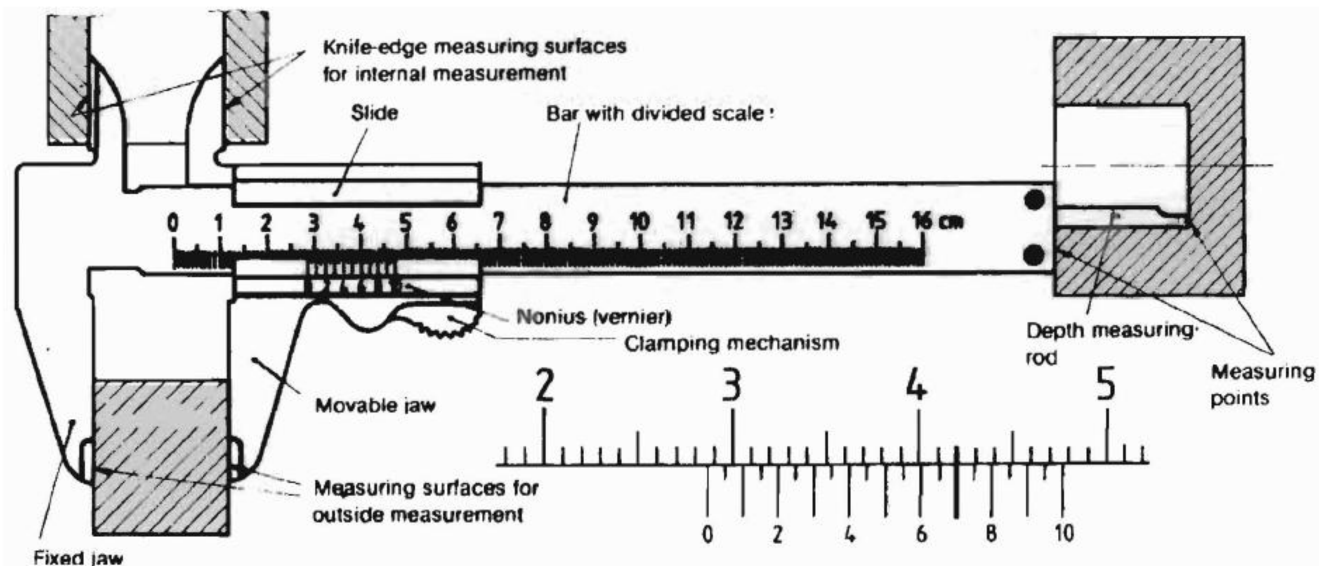


Fig.2.7 vernier caliper

V. Torque gauge: Torque gauges are used to measure turning force and twisting force (torsion).(A torque sensor or torque transducer or torquemeter) is a device for measuring and recording the torque on a rotating system, such as an engine, crankshaft, gearbox, transmission, rotor, a bicyclecrank or Cap Torque Tester. Static torque is relatively easy to measure. Dynamic torque, on the other hand, is not easy to measure, since it generally requires transfer of some effect (electric or magnetic) from the shaft being measured to a static system.

fig.2.8 torque gauge

V. Taper and thickness gauges

To measure very small distances—such as the depth of a screw hole or the thickness of a few sheets of paper—taper and thickness gauges are often used. The taper gauge is a tapered metal rod with a measurement scale marked on it. It is slipped into the gap to be measured. The depth of the opening may be determined by reading the number on the taper gauge at the point where it just enters the gap.

VI. 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.

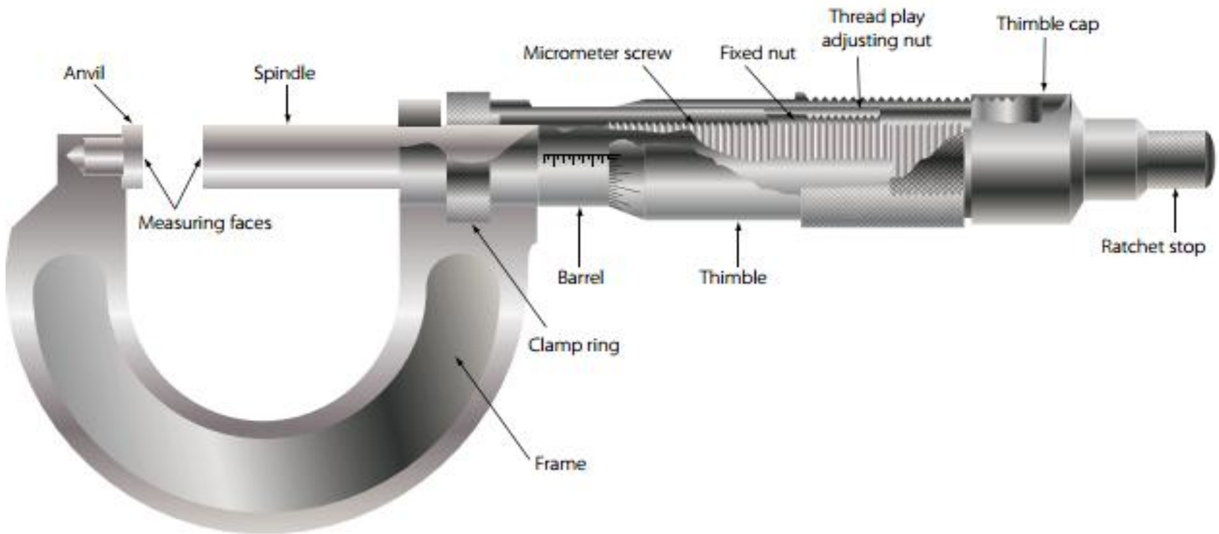


Fig. 2.9 Parts of outside micrometer

B. Electrical Measuring Instruments

Electrical Measuring instruments are used to measure voltage, resistance and current in electronics & electrical equipment. It is also used to test continuity b/n two points to verify if there is any break in circuit or line. There are two types of multi meter: analogue and digital ..Analogue style gauge Digital has LCD display

Test equipment is necessary for determining proper set-up, adjustment, operation, and maintenance of electrical systems and control panels.

I. Voltmeter

For measuring differences of potential (voltage) between two points in an electrical circuit. The instrument is connected in parallel with the circuit being measured. Ranges vary from a few tenths volt to a few thousand volts. Instruments are capable of measuring both A.C. and DC voltage.

Volt meters can be classified into two . these are analog and digital volt meters. Analog voltmeters measure voltage or voltage drop in a circuit. They display readings using a needle rather than a digital display.

Analog voltmeters move a pointer across a scale in proportion to the voltage measured and can be built from a galvanometer and series resistor. Meters using amplifiers can measure tiny voltages of micro volts or less. Digital voltmeters give a numerical display of voltage by use of an analog-to-digital converter

fig.2.10 analog voltmeter

fig. 2.11 digital volt meter

. **II. OHMETERS:**

For measuring the electrical D.C. and AC ohm resistance of a circuit, circuit part, or component. Calibrated from zero ohms to infinite. Measures either series or parallel resistance.

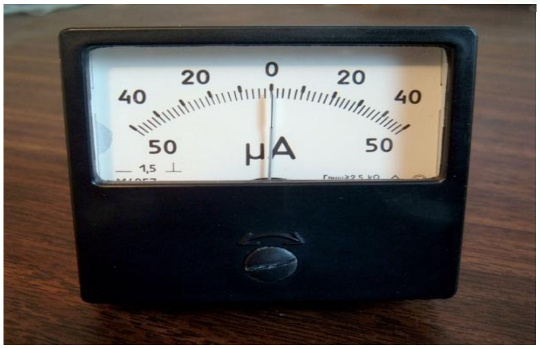
fig.2.12 analog and digital ohm meter

III. AMMETERS

Measure magnitude of electrical current flow in an electrical circuit. When measuring DC. currents, some types must be inserted in series with the circuit. A.C. ammeters are of two types. One requires that it be connected in series with the circuit; the other needs only to be clamped around the current carrying conductor. There are two types of ammeters. these are:

i. A digital ammeter is an instrument that measures the flow of an electrical current in a circuit. The measurements are given in amperes, the unit for measuring electrical current. Power Distribution Units (PDUs) distribute power to multiple devices through a single electrical source.

ii. Analog ammeters, also known as current meters, are metered instruments that measure current flow in amperes. Current levels are displayed on a dial, usually with a moving pointer or needle made of a soft What is analog ammeter?



(A) **(B)**

fig. 2.13 A. analog ammeter and B. Digital ammeter

IV. Wattmeter:

Is used for measuring powers in AC circuits. For DC circuits, powers can be found simply from multiplying voltage by current.

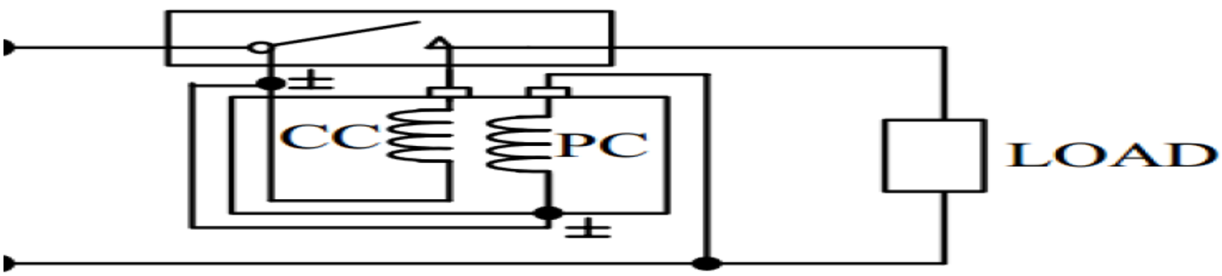


fig. 2.14 connection of watt meter

A wattmeter consists of a current coil, connected in series with the line like an ammeter, and a potential coil, connected in parallel with the line like a voltmeter. The connection is shown in the Figure 2.14. There is a shunt switch for the current coil similar to an ammeter, while the potential coil has no shunt switch.

fig.2.15 Watt meter

V. KWh meter

KWh meter is the electric meter that measures the amount of electrical energy in kWh that was consumed in the house. The kWh meter has a counter display that counts units of kilowatt-hour (kWh). The energy consumption is calculated by calculating the difference of the counter's reading in the specified period. The most common unit of measurement on the electricity measurement is the kilowatt hour [kWh], which is equal to the amount of energy used by a load of one kilowatt hour over a period of one hour. equal to the amount of energy used by a load of one kilowatt hour over a period of one hour.

Major applications

The vast application of energy meters can be categorized into four major parts of the power system network: Generation, transmission, distribution, and utilization

fig. 2.16 energy meter

fig. 2.17 the symbol of energy meter

VI. Frequency meter

A frequency meter is an instrument that displays the frequency of a periodic electrical signal. Various types of frequency meters are used. Many are instruments of the deflection type, ordinarily used for measuring low frequencies but capable of being used for frequencies as high as 900 Hz. These operate by balancing two opposing forces. Changes in the frequency to be measured cause a change in this balance that

can be measured by the deflection of a pointer on a scale. Deflection-type meters are of two types, electrically resonant circuits and radiometers.

An example of a simple electrically resonant circuit is a moving-coil meter. In one version, this device has two coils tuned to different frequencies and connected at right angles to one another in such a way that the

whole element, with attached pointer, can move. Frequencies in the middle of the meter's range cause the currents in the two coils to be approximately equal and the pointer to indicate the midpoint of a scale. Changes in frequency cause an imbalance in the currents in the two coils, causing them, and the pointer, to move.

fig. 2.18 frequency counter

VII. OSCILOSCOPE

The oscilloscope is basically a graph-displaying device - it draws a graph of an electrical signal. in most applications the graph shows how signals change over time; the vertical (y) axis represents voltage and the horizontal (x) axis represents time. the intensity of brightness of the display is sometimes called the z-axis. this simple graph can tell you many things about the signal. here are a few;

i. you can determine the time and voltage values of a signal.

ii. you can calculate the frequency of an oscillating signal

iii. you can see the moving parts of a circuit represented by the signal

iv. you can tell if a malfunctioning component is distorting the signal.

v. you can find out how much of a signal is direct current (dc) or alternating current(ac).

vi. you can tell how much of the signal is noise and whether the noise is changing with time.

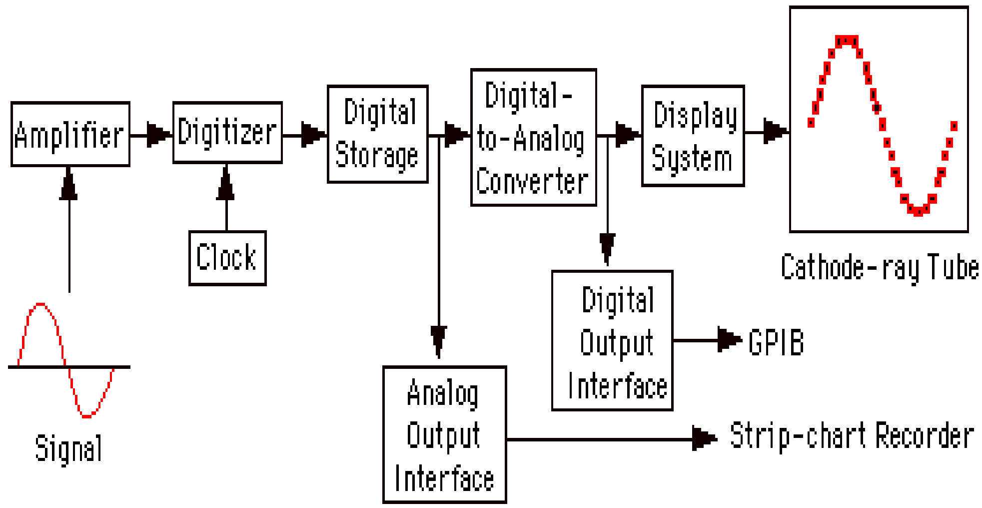


fig. 2.19 block diagram of an oscilloscope

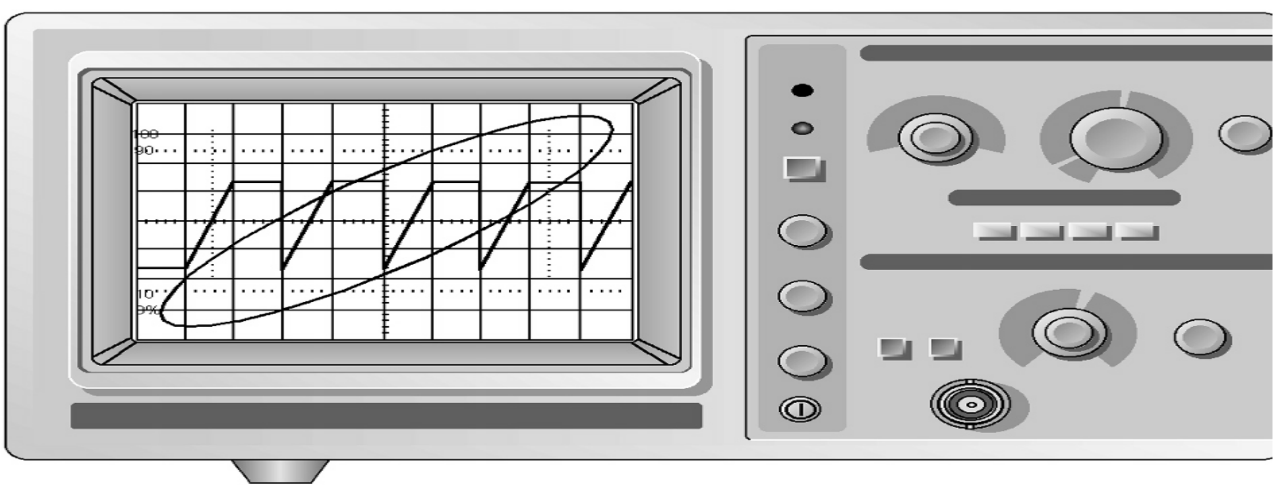


fig.2.20 Oscilloscope

VIII. Function generator

The Function Generator outputs waveforms that include DC (direct current) as well as sine, square, triangle, positive ramp, and negative ramp with a frequency range of 0.001 Hz (hertz) to 100 kHz (kilohertz). The sine wave worm retains its form up to a frequency of 150 kHz, but the other waveforms will show some distortion above 100 kHz. Its 10 watt power output (up to 10 volts and up to 1 amp) makes it useful for driving speakers, string vibrators, and circuits.

Features ;

i. Liquid Crystal Display (LCD):

ii. Frequency/Range Selection:

iii. Output Standby:

iv. Output Current/Voltage Maximum:

v. Offset Voltage: .

vi. Frequency Sweep:

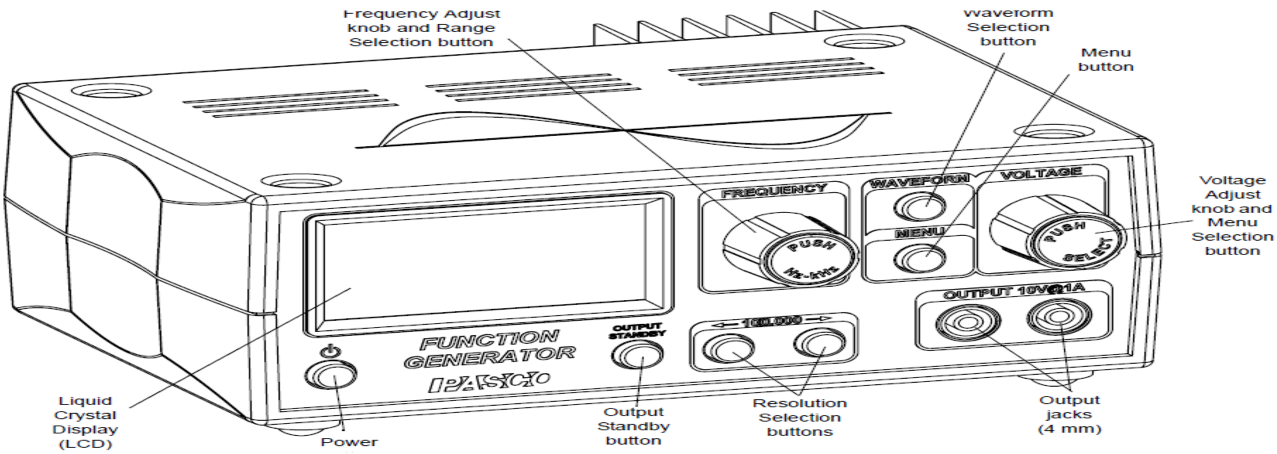


fig.2.21 Function generator

2.2 Obtain Accurate measurements

Simple Electric Circuit

An Electric Circuit: A fundamental relationship exists between current, voltage, and resistance. A simple **electric circuit** consists of a voltage source, some type of load, and a conductor to allow electrons to flow between the voltage source and the load. In the following circuit a battery provides the voltage source, electrical wire is used for the conductor, and a light provides the resistance. An additional component has been added to this circuit, a switch. There must be a complete path for current to flow. If the switch is open, the path is incomplete and the light will not illuminate. Closing the switch completes the path, allowing electrons to leave the negative terminal and flow through the light to the positive terminal.

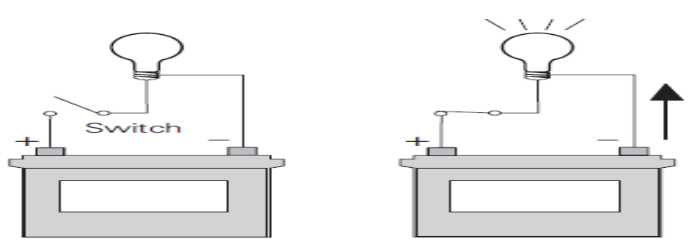


fig. 2.22 An electric circuit

The following schematic diagram is a representation of an electrical circuit, consisting of a battery, a resistor, a voltmeter and an ammeter. The ammeter, connected in series with the circuit, will show how much current flow in the circuit. The voltmeter, connected across the voltage source, will show the value of voltage supplied from the battery. Before an analysis can be made of a circuit, we need to understand Ohm's Law

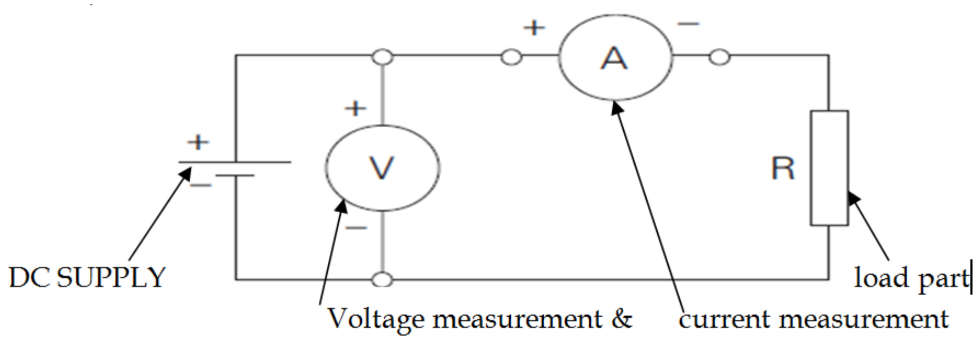


fig. 2.23 schematic diagram of an electric circuit

A Simple circuit contains the minimum things needed to have a functioning electric circuit. A simple circuit requires the following:

- AC/DC source
- Equipment that will operate on either an AC or DC power source
- Battery: A dc voltage source containing two or more cells that convert chemical energy to electrical energy.
- Cell- Single unit used to convert chemical energy into a DC electrical voltage.

FUSE

Once you design a simple circuit on electronics, it is important to include a fuse in the primary or secondary of a transformer.

fig.2.24 fuse

➢ Fuse is a safety device used to protect an electrical circuit from the effect of excessive current It's essential component is usually a strip of metal that will melt at a given temperature. A fuse is so designed that the strip of metal can easily be placed in the electric circuit. If the current in the circuit exceed a predetermined value, the fusible metal will melt and thus break, or open the circuit.

➢ A fuse is usually rated in Amperes, which represent the maximum continuous current it could handle without blowing.

- The most popular type of fuse in Electronics is 3AG type. This code describes the case size and material where “G” indicates a glass materials and “A” indicates that intended for automotive application. A 3AG fuse measures approximately 32mm x 6mm.

Switch and its function

fig 2.25types of switches

- Switch is a device used to break an electric current or transfer it to another conductor. Switches are commonly used to open or close a circuit. Closed is the ON position, while open is OFF position. Normally, switch is installed in series with the line carrying current from the power source to the load.
- A switch is a mechanical device used to connect and disconnect a circuit. Switches cover a wide range of types, from subminiature up to industrial plant switching megawatts of power on high voltage distribution lines.
- When the switch is closed, the electron finds uninterrupted path in the circuit.
- Open is the OFF position of the switch, while closed is the ON position.
- When the switch is opened, the current delivered by the power supply is normally insufficient to jump the switch gap in the form of an arc and the electron flow in the circuit is blocked.

Load

a source drives a load. Whatever component or piece of equipment is connected to a source and draws current from a source is a load on that source. The following are examples:

- Bulb

- Appliances (i.e: washing machine, stove, fridge…)
- Motors
- Any electrical or electronic devices

Direct Current and Alternating Current circuits

Direct Current or DC:

Direct current is the first type of current because it was easy to produce. This type of current always flows in one direction. One of the disadvantages of using DC is the excessive voltage drop and power loss in the power lines in a long distance. transmission. Batteries are common sources of direct current.

Alternating Current or AC:

Is the solution to the problem of DC. AC allows the flow of current in two directions. Today, it is possible to step-up electricity, a power station, transmit it to any distant place and step it down to for consumption. A transformer is the device used for stepping-up or stepping-down AC voltage. Common sources of AC are found in our AC outlet (Typically, 220 volts, in our country Ethiopia).

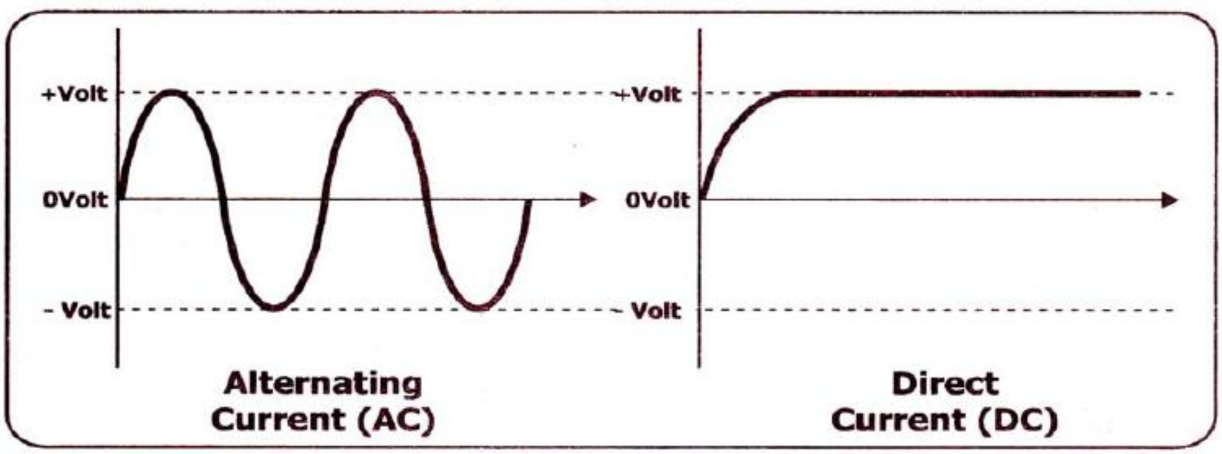


Fig: 2.26 AC and DC Wave Form

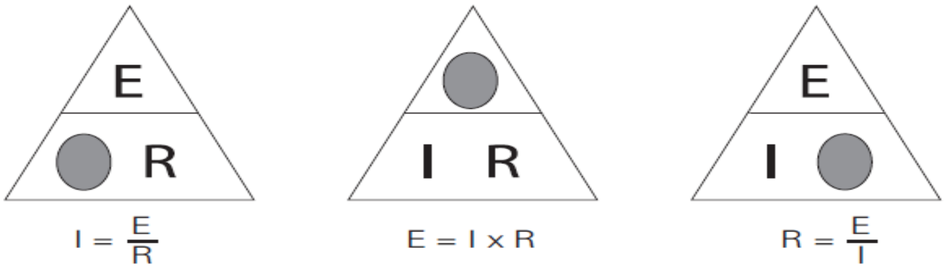
Ohm's Law and Power Law

Ohm's law states that, for a constant resistance, the current in a circuit is **directly proportional** to the total voltage acting in the circuit and for a constant voltage the current in the circuit is **inversely proportional** to the total resistance of the circuit. law may be expressed by the following equation if the current I is in amperes, EMF E is in volts, and the resistance R is in ohms. The relationship of the foregoing three variables was discovered by **Georg Simon Ohm,** who theorized that current is in direct proportion to resistance. The relationship

is explained algebraically, using this formula:

$R = E/I$ | $E = I \times R$ | $I = E/R$

E – EMF in Volts
R – Resistance
I – Current in Amperes



Dc circuit

There are basically three types of electrical circuits. They are:

- Series circuits
- Parallel circuits
- Combinational circuit

DC Series Circuit

Resistance in a series circuit: A series circuit is formed when any numbers of resistors are connected end-to-end so that there is only one path for current to flow. The resistors can be actual resistors or other devices that have resistance. The following illustration shows four resistors connected end-to-end. There is one path of current flow from the negative terminal of the battery through R4, R3, R2, R1 returning to the positive terminal.

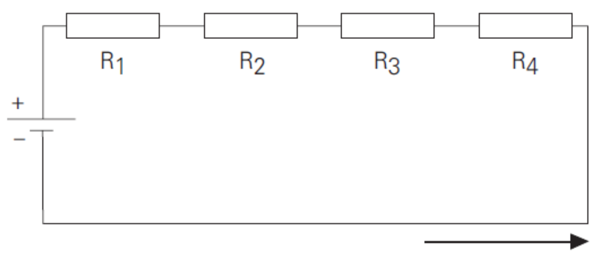


fig. 2.27 DC series circuit

Formula for Series Resistance

The total resistance or equivalent resistance of resistors connected in series is calculated using the following mathematical formula:

$$R_t = R_1 + R_2 + R_3 + R_4 + R_5 \cdots + R_n$$

Current in a Series Circuit

The equation for total resistance in a series circuit allows us to simplify a circuit. Using Ohm's Law, the value of current can be calculated. Current is the same anywhere when we measured in a series circuit.

$$I = \frac{E}{R}$$

Voltage in a Series Circuit

Voltage can be measured across each of the resistors in a circuit. The voltage across a resistor is referred to as a voltage drop. A German physicist, Gustav Kirchhoff, formulated a law which states the sum of the voltage drops across the resistances of a closed circuit equals the total voltage applied to the circuit. The highest resistance value will have the highest voltage drop and the smallest resistance value will have small voltage

Voltage Division in a Series Circuit

The battery represents E_{in} which in this case is 50 volts. The desired voltage is represented by Eout, which mathematically works out to be 40 volts. To calculate this voltage, first solve for total resistance.

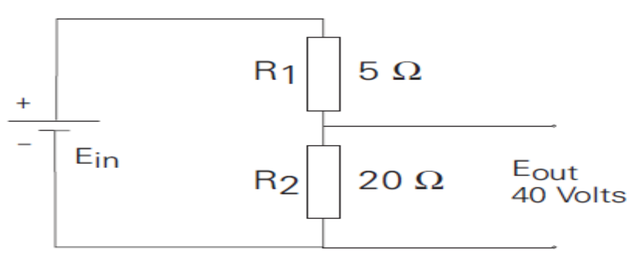
$$R_t = R_1 + R_2$$
$$R_t = 5 + 20$$
$$R_t = 25\ \Omega$$

Second, solve for current:

$$I = \frac{E_{in}}{R_t}$$
$$I = \frac{50}{25}$$
$$I = 2 \text{ Amps}$$

Finally, solve for voltage:

$$E_{out} = I \times R_2$$
$$E_{out} = 2 \times 20$$
$$E_{out} = 40 \text{ Volts}$$



DC Parallel Circuit

A **parallel circuit** is formed when two or more resistances are placed in a circuit side-by-side so that current can flow through more than one path. The illustration shows two resistors placed side-by-side. There are two paths of current flow. One path is from the negative terminal of the battery through R1 returning to the positive terminal. The second path is from the negative terminal of the battery through R2 returning to the positive terminal of the battery.

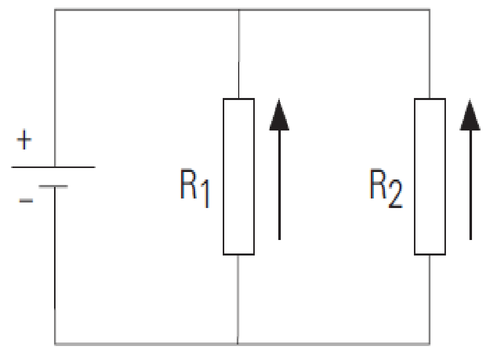


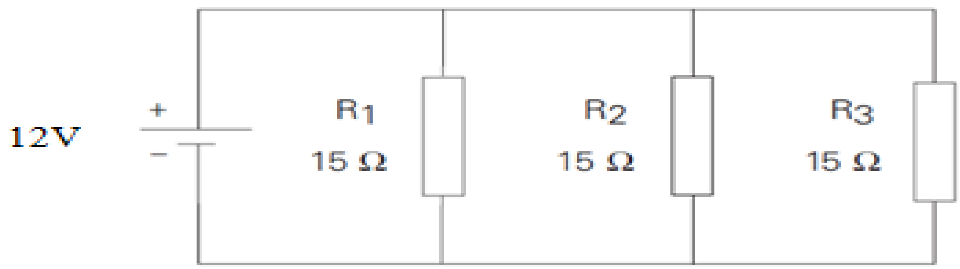
fig. 2.28 DC parallel circuit

Formula for Equal Value Resistors in a Parallel Circuit

To determine the total resistance when resistors are of equal value in a parallel circuit, use the following formula:

$$R_t = \frac{\text{Value of any one Resistor}}{\text{Number of Resistors}}$$

Example:



$$R_t = \frac{\text{Value of any one Resistor}}{\text{Number of Resistor}}$$

$$R_t = \frac{15}{3}$$

$$R_t = 5\ \Omega$$

Formula for Unequal Resistors in a Parallel Circuit

There are two formulas to determine total resistance for resistors of any value in a parallel circuit. The first formula is used when there are any numbers of resistors.

$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \cdots + \frac{1}{R_n}$$

The second formula is used when there are only two resistors.

$$R_t = \frac{R_1 \times R_2}{R_1 + R_2}$$

Voltage in a Parallel Circuit

When resistors are placed in parallel across a voltage source, the voltage is the same across each resistor. In the above illustration three resistors are placed in parallel across a 12 volt battery. Each resistor has 12 volts available to it.

Current Division in a Parallel Circuit

The current in a parallel circuit is divided among the loads connected to the source voltage. The largest load (resistance value) has small current passing through it as compared to the load (resistance) which has smaller value connected to the same voltage source.

Combination Circuits

A combination circuit is a circuit which has both series and parallel circuits in one circuit. It means some of the circuit components are connected in series and others are connected in parallel. In this case we apply both the principles of series circuits and parallel circuits.

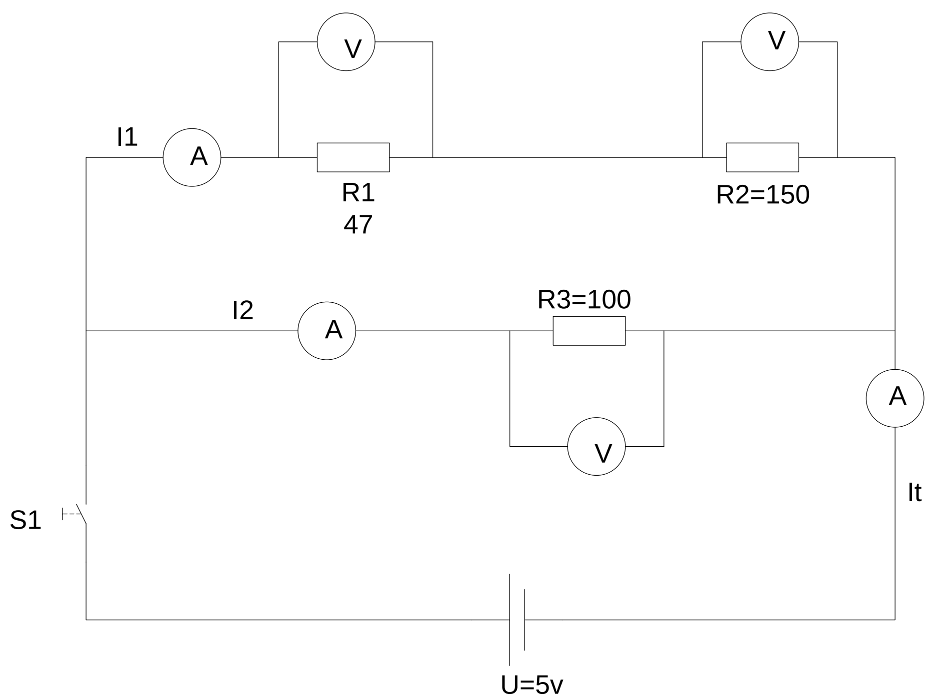


Fig: 2.29 Combination Circuit

AC Circuits

Alternating current

Direct current (DC) circuits involve current flowing in one direction. In alternating current (AC) circuits, instead of a constant voltage supplied by a battery, the voltage oscillates in a sine wave pattern, varying with time as:

$$V = V_0 \sin \omega t$$

In a household circuit, the frequency is 60 Hz. The angular frequency is related to the frequency, f, by:

$$\omega = 2 \pi f$$

Vo represents the maximum voltage, which in a household circuit in North America is about 170 volts. We talk of a household voltage of 220 volts, though; this number is a kind of average value of the voltage. The particular averaging method used is something called root mean square (square the voltage to make everything positive, find the average, take the square root), or rms. Voltages and currents for AC circuits are generally expressed as rms values. For a sine wave, the relationship between the peak and the rms average is:rms value = 0.707 peak value

Resistance in an AC circuit

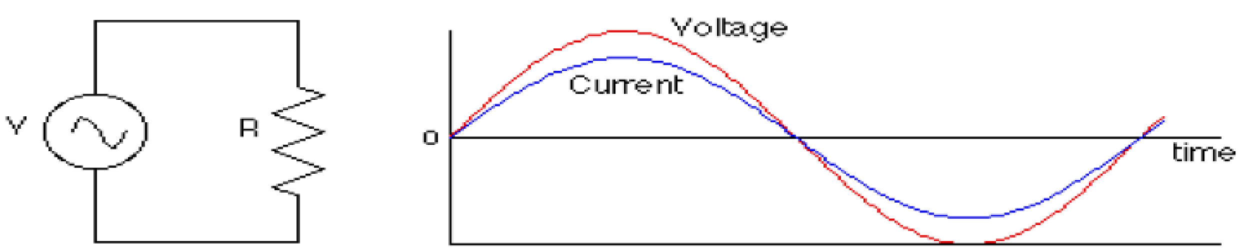


Fig. 2.30. **Resistance in an AC circuit**

The relationship V = IR applies for resistors in an AC circuit, so

$$I = V / R = (V_0 / R) \sin(\omega t) = I_0 \sin(\omega t)$$

In AC circuits we'll talk a lot about the phase of the current relative to the voltage. In a circuit which only involves resistors, the current and voltage are in phase with each other, which means that the peak voltage is reached at the same instant as peak current. In circuits which have capacitors and inductors (coils) the phase relationships will be quite different.

Capacitance in an AC circuit

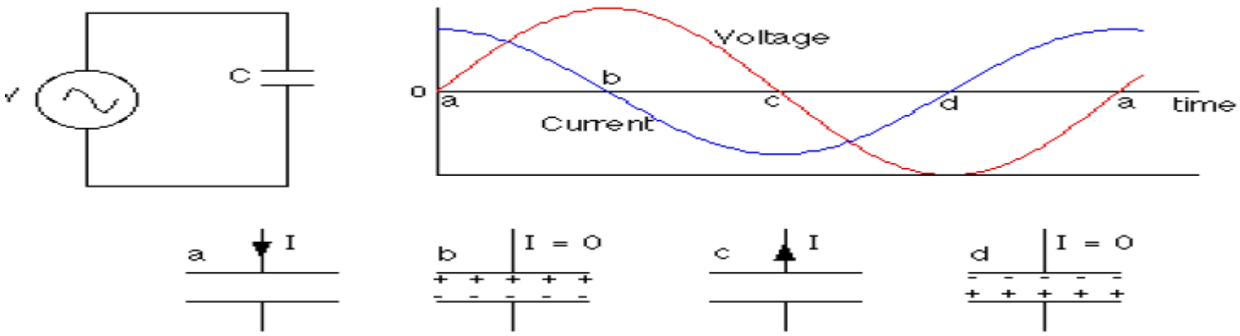


FIG.2.31 Capacitance in an AC circuit

Consider now a circuit which has only a capacitor and an AC power source (such as a wall outlet). A capacitor is a device for storing charging. It turns out that there is a 90° phase difference between the current and voltage, with the current reaching its peak 90° (1/4 cycle) before the voltage reaches its peak. Put another way, the current leads the voltage by 90° in a purely capacitive circuit.

To understand why this is, we should review some of the relevant equations, including: relationship between voltage and charge for a capacitor: $CV = Q$

relationship between current and the flow of charge : $I = \Delta Q / \Delta t$

The AC power supply produces an oscillating voltage. We should follow the circuit through one cycle of the voltage to figure out what happens to the current.

Step 1 - At point a (see diagram) the voltage is zero and the capacitor is uncharged. Initially, the voltage increases quickly. The voltage across the capacitor matches the power supply voltage, so the current is large to build up charge on the capacitor plates. The closer the voltage gets to its peak, the slower it changes, meaningless current has to flow. When the voltage reaches a peak at point b, the capacitor is fully charged and the current is momentarily zero.

Step 2 - After reaching a peak, the voltage starts dropping. The capacitor must discharge now, so the current reverses direction. When the voltage passes through zero at point c, it's changing quite rapidly; to match this voltage the current must be large and negative.

Step 3 - Between point's c and d, the voltage is negative. Charge builds up again on the capacitor plates, but the polarity is opposite to what it was in step one. Again the current is negative, and as the voltage reachesits negative peak at point d the current drops to zero.

Step 4 - After point d, the voltage heads toward zero and the capacitor must discharge. When the voltage reaches zero it's gone through a full cycle so it's back to point a again to repeat the cycle.The larger the capacitance of the capacitor, the more charge has to flow to build up a particular voltage on the plates, and the higher the current will be. The higher the frequency of the voltage, the shorter the time available to change the voltage, so the larger the current has to be. The current, then, increases as the capacitance increases and as the frequency increases.

Usually this is thought of in terms of the effective resistance of the capacitor, which is known as the capacitive reactance, measured in ohms. There is an inverse relationship between current and resistance, so the capacitive reactance is inversely proportional to the capacitance and the frequency:

A capacitor in an AC circuit exhibits a kind of resistance called capacitive reactance, measured in ohms. This depends on the frequency of the AC voltage, and is given by:

capacitive reactance: $X_C = 1 / \omega C = 1 / 2\pi f C$

We can use this like a resistance (because, really, it is a resistance) in an equation of the form V = IR to get the voltage across the capacitor:

$$V = I X_C$$

Note that V and I are generally the rms values of the voltage and current.

Inductance in an AC circuit

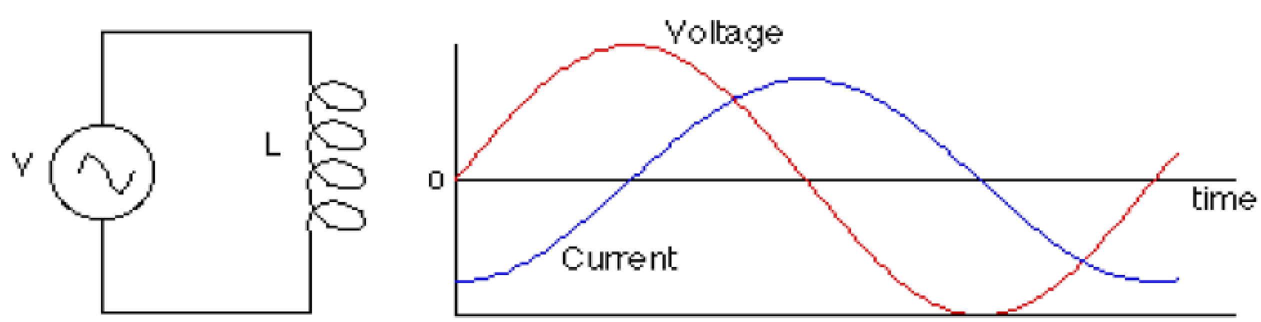


Fig2.32. ***Inductance in an AC circuit***

An inductor is simply a coil of wire (often wrapped around a piece of ferromagnet). If we now look at a circuit composed only of an inductor and an AC power source, we will again find that there is a 90° phase difference between the voltage and the current in the inductor. This time; however, the current lags the voltage by 90°, so it reaches its peak 1/4 cycle after the voltage peaks.

The reason for this has to do with the law of induction:

$$\varepsilon = -N\,\Delta\Phi / \Delta t \qquad \text{or} \qquad \varepsilon = -L\,\Delta I / \Delta t$$

Applying Kirchoff's loop rule to the circuit above gives:

$$V - L\,\Delta I / \Delta t = 0 \qquad \text{so} \qquad V = L\,\Delta I / \Delta t$$

As the voltage from the power source increases from zero, the voltage on the inductor matches it. With the capacitor, the voltage came from the charge stored on the capacitor plates (or, equivalently, from the electric field between the plates). With the inductor, the voltage comes from changing the flux through the coil, or, equivalently, changing the current through the coil, which changes the magnetic field in the coil.To produce a large positive voltage, a large increase in current is required. When the voltage passes through zero, the current should stop changing just for an instant. When the voltage is large and negative, the current should be decreasing quickly. These conditions can all be satisfied by having the current vary like a negative cosine wave, when the voltage follows a sine wave.

How does the current through the inductor depend on the frequency and the inductance? If the frequency is raised, there is less time to change the voltage. If the time interval is reduced, the change in current is also reduced, so the current is lower. The current is also reduced if the inductance is increased.

As with the capacitor, this is usually put in terms of the effective resistance of the inductor. This effective resistance is known as the inductive reactance. This is given by:

$$X_L = \omega L = 2\pi f L$$

Where L is the inductance of the coil (this depends on the geometry of the coil and whether it's got a ferromagnetic core). The unit of inductance is the henry.

As with capacitive reactance, the voltage across the inductor is given by:

$$V = I X_L$$

RLC Circuits

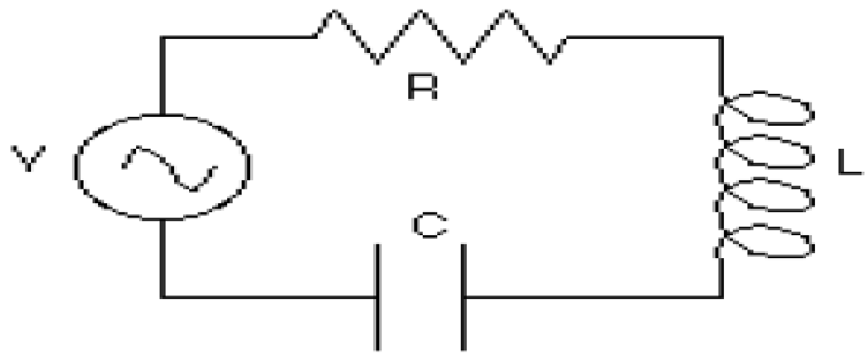


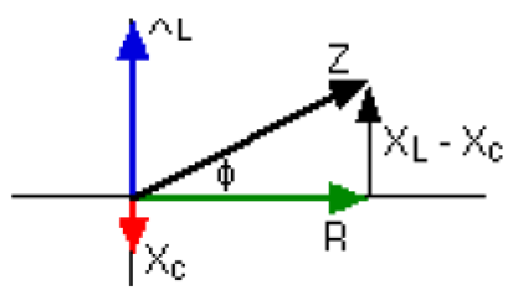
Fig.2.33 RLC circuit

Consider what happens when resistors, capacitors, and inductors are combined in one circuit. If all three components are present, the circuit is known as an RLC circuit (or LRC). If only two components are present, it's either an RC circuit, an RL circuit, or an LC circuit. The overall resistance to the flow of current in an RLC circuit is known as the impedance, symbolized by Z The impedance is found by combining the resistance, the capacitive reactance, and the inductive reactance.

Unlike a simple series circuit with resistors, however, where the resistances are directly added, in an RLC circuit the resistance and reactance are added as vectors. This is because of the phase relationships. In a circuit with just a resistor, voltage and current are in phase. With only a capacitor, current is 90° ahead of the voltage and with just an inductor the reverse is true, the voltage leads the current by 90°. When all three components are combined into one circuit, there has to be some compromise.

To figure out the overall effective resistance, as well as to determine the phase between the voltage and current, the impedance is calculated like this. The resistance R is drawn along the +x-axis of an x-y coordinate system. The inductive reactance is at 90° to this, and is drawn along the +y-axis. The capacitive reactance is also at 90° to the resistance, and is 180° different from the inductive reactance, so it's drawn along the -y axis. The impedance, Z, is the sum of these vectors, and is given by:

$$Z = [R^2 + (X_L - X_C)^2]^{1/2}$$



The current and voltage in an RLC circuit are related by V = IZ. The phase relationship between the current and voltage can be found from the vector diagram: its the angle between the impedance, Z, and the resistance, R. The angle can be found from:

$$\tan\phi = (X_L - X_C) / R$$

If the angle is positive, the voltage leads the current by that angle. If the angle is negative, the voltage lags the currents.

The power dissipated in an RLC circuit is given by:

$$P = VI\cos\phi$$ $\cos\phi$ is known as the power factor in the circuit

Note that all of this power is lost in the resistor; the capacitor and inductor alternately store energy in electric and magnetic fields and then give that energy back to the circuit.

The importance of accurate and precise measurements in the physical sciences cannot be overstated. Often times, even minute errors can render data unusable. For this reason, scientists must learn to use measuring devices in a manner that results in maximum accuracy and precision. The two most common sources of error include measurement errors and experimental technique. One of the basic skills that all scientists must possess is the ability to take accurate and detailed measurements. The cornerstone of making proper measurements is based on the idea that scientists want to collect as much meaningful and accurate data as possible.

2.3 Perform Calculation using the four basic process of addition (+), subtraction (-), multiplication (x), and division (/)

Perform calculation.

Arithmetic: refers to the simpler properties when using the traditional operations of addition, subtraction, multiplication and division with smaller values of numbers. Professional mathematicians sometimes use the term (higher) arithmetic when referring to more advanced results related to number theory, but this should not be confused with elementary arithmetic.

Arithmetic operations

The basic arithmetic operations are addition, subtraction, multiplication and division, although this subject also includes more advanced operations, such as manipulations of percentages, square roots, exponentiation, and logarithmic functions. Arithmetic is performed according to an order of operations. Any set of objects upon which all four arithmetic operations (except division by zero) can be performed, and where these four operations obey the usual laws, is called a field.

a) Addition (+)

Addition is the basic operation of arithmetic. In its simplest form, addition combines two numbers, the addends or terms, into a single number, the sum of the numbers.

Adding more than two numbers can be viewed as repeated addition; this procedure is known as summation and includes ways to add infinitely many numbers in an infinite series; repeated addition of the number one is the most basic form of counting. If a&b are the lengths of two sticks, then if we place the sticks one after the other, the length of the stick thus formed is $a + b$.

b) Subtraction (−)

Subtraction is the opposite of addition. Subtraction finds the difference between two numbers, the minuend minus the subtrahend. If the minuend is larger than the subtrahend, the difference is positive; if the minuend is smaller than the subtrahend, the difference is negative; if they are equal, the difference is zero.

Subtraction is neither commutative nor associative. For that reason, it is often helpful to look at subtraction as addition of the minuend and the opposite of the subtrahend, that is $a - b = a + (-b)$. When written as a sum, all the properties of addition hold.

c) Multiplication (×, ·)

Multiplication is the second basic operation of arithmetic. Multiplication also combines two numbers into a single number, the *product*. The two original numbers are called the *multiplier* and the *multiplicand*, sometimes both simply called *factors*.

Multiplication is best viewed as a scaling operation. If the real numbers are imagined as lying in a line, multiplication by a number, say x, greater than 1 is the same as stretching everything away from zero uniformly, in such a way that the number 1 itself is stretched to where x was. Similarly, multiplying by a number less than 1 can be imagined as squeezing towards zero. (Again, in such a way that 1 goes to the multiplicand.)

D) Division (÷ or /)

Division is essentially the opposite of multiplication. Division finds the *quotient* of two numbers, the *dividend* divided by the *divisor*. Any dividend divided by zero is undefined. For positive numbers, if the dividend is larger than the divisor, the quotient is greater than one, otherwise it is less than one (a similar rule applies for negative numbers). The quotient multiplied by the divisor always yields the dividend.

Division is neither commutative nor associative. As it is helpful to look at subtraction as addition, it is helpful to look at division as multiplication of the dividend times the reciprocal of the divisor, that is $a \div b = a \times {}^{1}/_{b}$. When written as a product, it obeys all the properties of multiplication.

Addition and subtraction are opposite operations. You can use related facts to help you add or subtract. Use addition to find how many in all. Use subtraction to find how many more or how many less. 9 +8 =17 i.e. 17 - 8 =9

Multiplication and division are opposite operations. You can use related facts to help you multiply or divide. Use multiplication to find the total in a number of equal groups. Use division to find how many in each group or the number of equal groups.

6 × 5 =30 i.e.30 ÷6 = 5

i. Properties of operations

A, **Commutative**: -

Addition and multiplication are commutative; switching the order of two numbers being added or multiplied does not change the result.

Example: - 100+8=8+100

- 100×8=8×100

B, **Associative**: -

Addition and multiplication are Associative, the order that numbers are grouped in addition and multiplication does not affect the result.

Example: - (a+b)+c=a+(b+c)

$(a\times b)\times c=a\times(b\times c)$

C, **Distributive**: -

The distributive property of multiplication over addition, multiplication may be distributed over addition. Example: - $a\times (b+c) = (a\times b) + (a\times c)$

D, **The zero property of addition**: -

Adding zero to any number the result leaves it unchanged. We call it zero is the additive identity

Example: - $a+0=a$

E, **The zero property of multiplication**: -

Multiply any number by zero gives zero. Example: -$a\times 0=0$

F, **The multiplicative identity**: -

Multiplying any number by one leaves the number unchanged. Example: - $a\times 1=1$

ii. Order of operations (Order of precedence and brackets)

When a particular arithmetic operation is to be performed first the numbers and the operator(s) are placed in brackets. Thus 3 times the result of 6 minus 2 is written as $3 \times (6 - 2)$. In arithmetic operations, the order in which operations are performed are:-

(i) To determine the values of operations contained in brackets;

(ii) Multiplication and division (the word 'of ' also means multiply); and

(iii) Addition and subtraction.

This order of precedence can be remembered by the word BODMAS, standing for Brackets, Of, Division, Multiplication, Addition and Subtraction, taken in that order. The basic laws governing the use of brackets and operators are shown by the following examples:

(i) $2 + 3 = 3 + 2$, i.e. the order of numbers when adding does not matter;

(ii) $2 \times 3 = 3 \times 2$, i.e. the order of numbers when multiplying does not matter;

(iii) $2 + (3 + 4) = (2 + 3) + 4$, i.e. the use of brackets when adding does not affect the result;

(iv) $2 \times (3 \times 4) = (2 \times 3) \times 4$, i.e. the use of brackets when multiplying does not affect the result;

(v) $2 \times (3 + 4) = 2(3 + 4) = 2 \times 3 + 2 \times 4$, i.e. a number placed outside of a bracket indicates that the whole contents of the bracket must be multiplied by that number;

(vi) $(2 + 3)(4 + 5) = (5)(9) = 45$, i.e. adjacent brackets indicate multiplication;

(vii) $2[3 + (4 \times 5)] =2[3 + 20] =2 \times 23 =46$, i.e. when an expression contains inner and outer brackets, the inner brackets are removed first.

iii. Whole Numbers

The whole numbers are the counting numbers and zero. i.e. 0, 1, 2…When writing large numbers it is common practices to separate them into groups of three using commas as the separator. When separating it into groups of three, start from the right and count towards the left.23,921,754

The following is a chart showing this separation and how the groups are labeled.

Billions	Millions	Thousands	Units
432	561	963	875

Each digit within each group of three has its own individual place value. Therefore, digits put in different places, as well as different groups, take on different values. Consider the assigned values to the group of three in the following example.

EXAMPLE 1: Write 234 in words.

Solution:- 2 hundreds 3 tens 4 ones

i.e. Two hundred thirty four

EXAMPLE 2: Write 527904 in words

Solution**:** First separate the number into groups of three counting from right to left: i.e. 527,904

Next evaluate the individual place values in each group and label each group with its group name:

Thousands	units
5 2 7	9 0 4

5 hundreds 2 tens 7 ones 9 hundreds 0 tens 4 ones

"Five hundred twenty seven thousand, nine hundred four"

Notice that when there is a zero digit in a particular place value or in an entire group, it is not read as "zero tens", as in our example, or "zero millions" it is simply not read or written.

When writing numbers in words, as in writing numbers using digits, the comma is not required. However, when reading and writing larger numbers in any form, using commas to group the digits can make reading them much easier.

Now look at an example where we write the numeral from words.

EXAMPLE 3: Write the following words in numerals

"Seventeen million, four hundred seventy thousand, nine hundred three"

Solution:-First separate the words, using the group names as the separators.

Seventeen million

1 ten = 10

7 ones = 7

Three hundred seventy **thousand**

4 hundreds = 400

7 tens = 70

Nine hundred three

9 hundreds = 900

3 ones = 3

Putting the groups together and placing our commas in the correct place gives us the following:

17,470,903

The following place value chart has been presented to show place values for very large numbers and can be used for study and reference.

hundred trillions	ten trillions	one trillion	hundred billions	ten billions	one billions	hundred millions	ten millions	one millions	hundred thousands	ten thousands	one thousands	hundreds	tens	ones
4	4	4	3	3	3	2	2	2	1	1	1	0	0	0

2.4 Calculation involving fractions, percentages and mixed numbers .

i. Fraction Number

When 2 is divided by 3, it may be written as $\frac{2}{3}$ or 2/3. $\frac{2}{3}$ is called a fraction. The number above the line, i.e. 2, is called the numerator and the number below the line, i.e. 3 is called the denominator. When the value of the numerator is less than the value of the denominator, the fraction is called a proper fraction; thus $\frac{2}{3}$ is a proper fraction. When the value of the numerator is greater than the denominator, the fraction is called an improper fraction. Thus $\frac{7}{3}$ is an improper fraction and can also be expressed as a mixed number, that is, an integer and a proper fraction. Thus the improper fraction $\frac{7}{3}$ is equal to the mixed number $2\frac{1}{3}$. When a fraction is simplified by dividing the numerator and denominator by the same number, the process is called cancelling. Cancelling by 0 is not permissible.

All fundamental operations are applied in this section also. Addition, subtraction, Multiplication, and division of fraction numbers are possible.

Example:-Simplify $\frac{1}{3}+\frac{2}{7}$

The LCM of the two denominators is 3x7=21

Expressing each fraction so that their denominators are 21.

Hence $\frac{1}{3}+\frac{2}{7} = \frac{1}{7}*\frac{7}{7} + \frac{2}{7}*\frac{3}{3}=\frac{7}{21}+\frac{6}{21}$

$=\frac{7+6}{21}$

$=\frac{13}{21}$

Step 1: The LCM of the two denominators;

Step 2: For the fraction1/3, 3 into 21 goes 7times, 7x the numerator is 7x1;

Step 2: For the fraction 2/7, 7into 21 goes 3times, 3x the numerator is 3x2;

Thus 1/3 + 2/7 $=\frac{7+3}{21}=\frac{13}{21}$

ii. Mixed Numbers

What is a mixed number?

A mixed number is a combination of a whole number and a fraction.

Example:-$1\frac{1}{2}$, $2\frac{3}{4}$, $4\frac{7}{10}$etc.

a. Changing Improper Fractions to Mixed Numbers

An improper fraction can be changed to a mixed number by dividing the numerator by the denominator and putting the remainder over the denominator.

Change the improper fractions to mixed numbers.

Step 1: Write the improper fraction.

$\frac{25}{6}$

Step 2: Divide the numerator by the denominator.

Step 3: The quotient becomes the whole number and the remainder is put over the denominator.

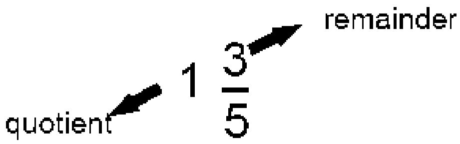
Example:- Write the improper fraction.

$\frac{8}{5}$ $\begin{array}{l} \rightarrow \text{numerator} \\ \rightarrow \text{denominator} \end{array}$

Divide the numerator by the denominator

$$\begin{array}{r|l} & 1 \text{ r } 3 \\ \hline 5 & 8 \\ & \underline{5} \\ & 3 \end{array}$$

The quotient becomes the whole number and the remainder is put over the denominator



b. Changing Mixed Numbers to Improper Fractions

A mixed number can be changed to an improper fraction by multiplying the denominator by the whole number and then adding the product to the numerator. The sum is then placed over the original denominator.

Step 1: Write the mixed number.

$2\frac{3}{4}$

Step 2: Multiply the denominator by the whole number and then add the numerator.

4x2+3=11

Denominator x Whole number + numerator

Step 3: Put the resulting number over the original denominator to produce the improper fraction.$\frac{11}{4}$

C. Operations with Mixed Numbers (Addition / Subtraction / Multiplication / Division)

To the already established methods for adding, subtracting, multiplying and dividing fractions, we need only add one more step at the beginning and one at the end.

At the beginning the mixed numbers are converted to improper fractions.

Sometimes the usual methods give an improper fraction answer, so the last step is to convert the improper fraction to a mixed number.

Addition

To add mixed numbers:

1. Convert each mixed number to an improper fraction.
2. Multiply the numerator and denominator of each improper fraction by a factor to obtain the lowest possible common denominator for the two fractions.
3. Add the numerators
4. Reduce the answer fraction if possible.
5. If the answer is an improper fraction **convert** it to a mixed number.

Example

$$3\frac{1}{2}+(-5\frac{1}{2})=-2$$

Subtraction

To subtract mixed numbers:

1. Convert each mixed number to an improper fraction.
2. Multiply the numerator and denominator of each improper fraction by a factor to obtain the lowest possible common denominator for the two fractions.
3. Subtract the numerators
4. Reduce the answer fraction if possible.
5. If the answer is an improper fraction convert it to a mixed number.

Example

$$3\frac{3}{4}-3\frac{1}{2}=\frac{1}{4}$$

Multiplication

To multiply mixed numbers:

1. **Convert** each mixed number to an improper fraction.
2. **Multiply** the numerators and **multiply** the denominators of the two fractions.
3. **Reduce** the answer fraction if possible.
4. If the answer is an improper fraction **convert** it to a mixed number.

Example

$$4\frac{1}{2} * 1\frac{2}{5} = \frac{63}{10} = 6\frac{3}{10}$$

Division

To divide mixed numbers:

1. Convert each mixed number to an improper fraction.
2. Change the division to a multiplication by the reciprocal of the divisor.
3. Multiply the numerators and multiply the denominators of the two fractions.
4. Reduce the answer fraction if possible.
5. If the answer is an improper fraction convert it to a mixed number.

Example

$$4\frac{4}{5} \div 1\frac{1}{5} = 4$$

iii. Percentage

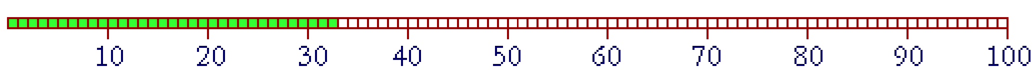
Percentages are used to give a common standard and are fractions having the number 100 as their denominators. For example, 25 percent means $\frac{25}{100}$ *ie.* $\frac{1}{4}$ and is written 25%.

Percentage means for each 100.

Thus, 100% means 100 for each 100, which is to say, all. 100% of 12 is 12.

50% is another way of saying half, because 50% means 50 for each 100, which is half. 50% of 12 is 6.

Example 1. Below are 100 small squares, and 32 have been shaded.



What percent of the squares have been shaded?

Answer. 32% -- 32 for each 100.

If we think of 100 being divided into one hundred equal parts, that is, into hundredths, then a perce
is a number of hundredths.

When the percent is less than or equal to 100%, then we can say "out of" 100. 32% is 32 out of 100. But to say that 200% is 200 out of 100 makes no sense. 200% is 200 for each 100, which is to say, twice as much.

Example 2. 100 people were surveyed, and 65 responded Yes. What percent responded Yes?

Answer. 65% -- 65 out of 100.

. How do we change a percent to a number?

24%=?

Divide by 100, and drop the % sign.

i.e. 24% = **.**24

How do we change a number to a percent?

.24 = ?%

Multiply it by 100, and add the % sign.

i.e. **.**24 = 24%

2.5 Checking Numerical computation

Area of plane figures (mensuration)

Mensuration is the mathematical name for calculating the areas, volumes, length of sides, and other geometric parts of standard geometric shapes such as circles, spheres, polygons, prisms, cylinders, cones, etc., through the use of mathematical equations or formulas. In this lesson the students will investigate the area formula for a circle and the theorems relating to the arcs of a circle, and learn formulae relating to arcs, Segments, sectors and area of a circle. Included here are the most frequently used and important mensuration formulas for the common geometric figures and symbols, both plane and solid.

Symbols

A	Area
a,b,c etc.	Sides
A,B,C	Angles
h	height perpendicular to base
L	Length of sides
R	Radius
n	Number of sides
C	Circumference
V	Volume
D	Diameter

i. Area of polygons

A polygon is a number of coplanar line segments, each connected end to end to form a closed shape. It is a closed plane figure bounded by straight lines.

A polygon which has:

(i) 3 sides is called a **triangle**
(ii) 4 sides is called a **quadrilateral**
(iii)5 sides is called a **pentagon**
(iv)6 sides is called a **hexagon**
(v) 7 sides is called a **heptagon**
(vi)8 sides is called an **octagon**

There are five types of **quadrilateral**, these being:

(i) rectangle (ii) square

(iii) parallelogram (iv) rhombus (v) trapezium

Area: is the measurement of the amount of space occupied by a closed flat surface and is measured in **square units**. The most widely used units of area are mm^2, cm^2 and m^2. Land areas are often given in hectares (ha). 1 ha = 10 000 m^2

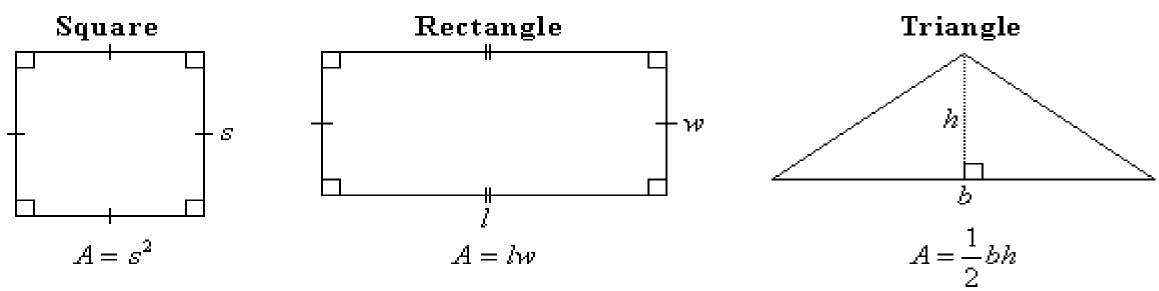
Knowledge of calculating the area of simple figures or shapes is an essential skill for tradesmen such as carpenters, painters, machinist, metalworker and builders.

The following are applications of area:

- To calculate the number of tiles to be ordered to tile a kitchen floor, the area of the kitchen floor must be taken into consideration.
- It is known that 5 liters of paint is needed to cover 50 square meters. To calculate the amount of paint needed to paint a room, we need to take into consideration the area of the walls, ceiling and windows.
- To calculate the amount of glass required for a window, we need to know the area of the window.
- To the carpenter or carpet layer, who is concerned with the amount of material to be used, measurement of area is very important.

ii. Calculating the Area of polygons

You learned the following formulas for calculating the area of plane figures such as squares, rectangles and triangles.

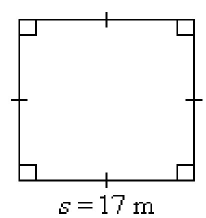


Example:- 1 Find the area of:

a. a square flower-bed of side 17 m

b. a rectangular field 45 m long and 40 m wide

c. a triangle of base length 30 m and height 25 m



Solution:

a. $A = s^2$

$= 17^2$

$= 289$

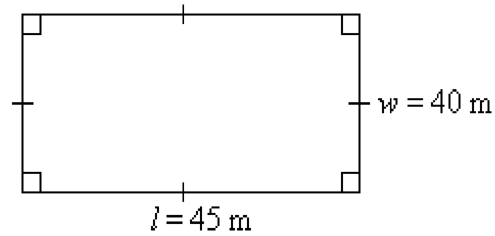
So, the area of the flower-bed is 289 m^2.

b. $A = lw$

$= 45 \times 40$

$= 1800$

So, the area of the rectangular field is $1800\ \text{m}^2$.

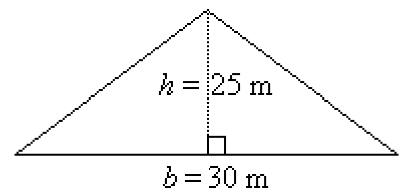


c. $A = \frac{1}{2}bh$

$= \frac{1}{2} \times 30 \times 25$

$= 375$

So, the area of the triangle is $375\ \text{m}^2$.



Note:

To find the area of a region enclosed within a plane figure, draw a diagram and write an appropriate formula. Then substitute the given values and use a calculator, if necessary, to obtain the required area.

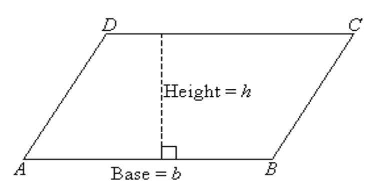
ii. Area of Other Figures

Knowledge of finding the area of rectangles and triangles enables us to find the area of other plane figures. For example, we can find the area of plane figures such as a parallelogram, trapezium, rhombus and kite.

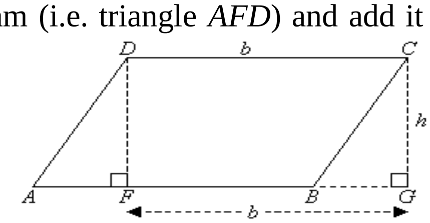
iii. Area of a Parallelogram

A parallelogram is a quadrilateral that has two pairs of parallel sides of equal length.

Consider the area of the following parallelogram.



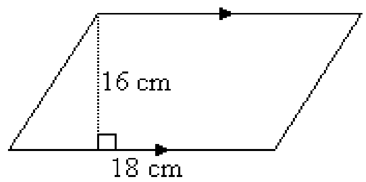
To calculate the C divide it into two parts that can form a rectangle. This is possible if we cut off one end of the parallelogram (i.e. triangle *AFD*) and add it to the other end to form the rectangle *FGCD*, as shown below.



It is clear from the diagram that the area of the shape has not changed.

$$\therefore \text{Area of the parallelogram} = \text{Area of the rectangle}$$
$$= \text{length} \times \text{width}$$
$$= bh$$

Example 2 Find the area of the following parallelogram.



Solution:

A =bh

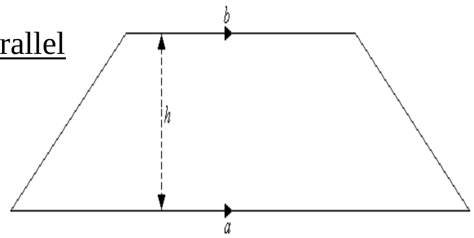
=18cmx16cm

=288cm^2

So, the area of the parallelogram is 288 cm^2.

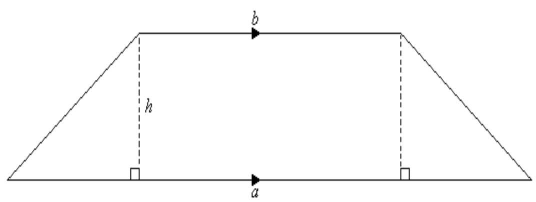
iv. Area of a Trapezium

A trapezium is a quadrilateral that has only one pair of parallel sides.

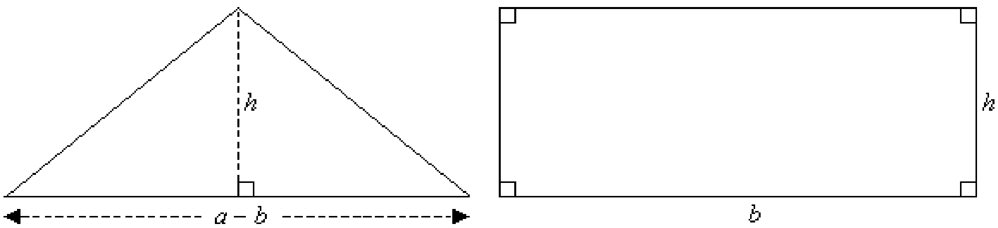


Consider the area of the following trapezium

To calculate the area of a trapezium, divide it into a rectangle and two triangles as shown below.



Now, piece together the triangular ends so that the trapezium is divided into a triangle and rectangle. The base of the triangle is the difference between the lengths of two parallel sides. That is, $a - b$.

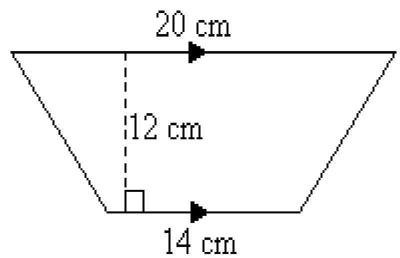


$\therefore$ Area of the trapezium = Area of the rectangle + Area of the triangle

$$= bh + \frac{1}{2}(a-b)h$$
$$= h\left[b + \frac{1}{2}(a-b)\right]$$
$$= h\left[\frac{2b}{2} + \frac{a-b}{2}\right]$$
$$= h\left[\frac{2b+a-b}{2}\right]$$
$$= h\left(\frac{a+b}{2}\right)$$
$$= \begin{pmatrix}\text{Half the sum of} \\ \text{parallel sides}\end{pmatrix} \times \begin{pmatrix}\text{Perpendicular distance} \\ \text{between the parallel sides}\end{pmatrix}$$

Example 3:Find the area of the following trapezium.

Solution:



$a = 20$ cm, $b = 14$ cm, $h = 12$ cm

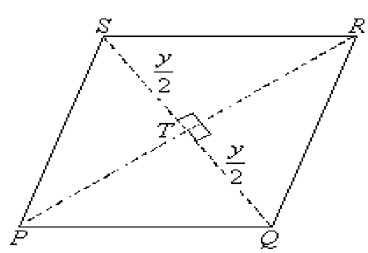
$$A = \frac{1}{2}(a+b)h$$
$$= \frac{1}{2}(20+14)\times 12$$
$$= \frac{1}{2}\times 34\times 12$$
$$= 204$$

So, the area of the trapezium is 204 m^2.

v. Area of a Rhombus

rhombus has four equal sides & its diagonals bisect each other at right angles.

Consider the area of the following rhombus.



The diagonals of a rhombus bisect each other at right angles.

$$\therefore TQ = TS = \frac{y}{2}$$

$\therefore$ Area of the rhombus = Area of triangle PQR + Area of triangle PRS

$$= \frac{1}{2}x \times \frac{y}{2} + \frac{1}{2}x \times \frac{y}{2} \qquad \left\{ \because \text{Area of triangles} = \frac{1}{2}bh,\ b = x \text{ and } h = TQ = \right.$$

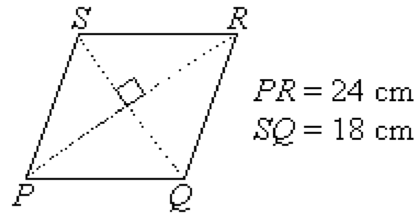
$$= \frac{xy}{4} + \frac{xy}{4}$$

$$= \frac{2xy}{4}$$

$$= \frac{1}{2}xy$$

$$= \text{Half of the product of the diagonals}$$

Example 4 Find the area of the following rhombus.



Solution: x = 24 cm, Y = 18 cm

A = (1/2)XY = ½.24.18

= 216

So, the area of the rhombus is 216 cm^2.

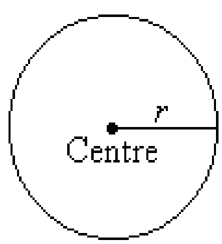
vi. Area of a circle

The area, *A*, of a circle is given by the following formula where *r* is the radius of the circle:

$A=\pi r^2$

Example 1Find the area of a circle whose radius is 14m using an approximate value for π of $\frac{22}{7}$

Solution:



R=14mA=πr^2

=3.14x(14m)^2

=616m^2

So, the area is 616 m^2.

Measurement of Volume

Volume is how much three-dimensional space a substance (solid, liquid, or gas) or shape occupies or contains, 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 volumes of more complicated shapes can be calculated by integral calculus if a formula exists for the shape's boundary. One-dimensional figures (such as lines) and two-dimensional shapes (such as squares) are assigned zero volume in the three-dimensional space.

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.

In this section, you will learn how to calculate the volume of common solids to include definition of volume, prisms, cylinders, pyramids, cones, and spheres.

A measuring cup can be used to measure volumes of liquids. This cup measures volume in units of cups, fluid ounces, and milliliters.

i. Volume of cylinder

A cylinder has a round base and a given height. The area of the base must be found first, and then it can be multiplied by the height to give the volume of the cylinder.

The area of the base is given by taking the radius (r) of the circular base and squaring it and then multiplying it by π.

Area base = πr^2 ,

Then multiply that by the height (h) of the cylinder to get the volume.

Volume of cylinder = $\pi r^2 h$

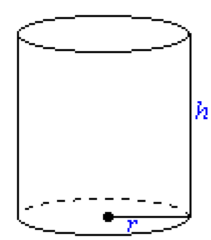


Fig. i cylinder

Ex. Find the volume of a cylindrical canister with radius 7 cm and height 12 cm.

Solution:

Volume of cylinder = π x r x r x h

= π x 7cm x 7cm x 12cm

= $\underline{\underline{1847.5\ cm^3}}$

ii. Volume of prism

Prisms are three-dimensional objects having end faces that are:

- polygons;
- parallel to each other; and
- have the same shape and size.

Prisms have identical cross-sections if a plane cuts them parallel to the ends.

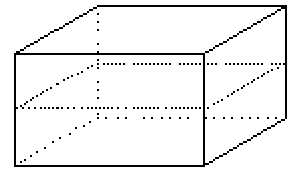


Fig. ii Prism

For example, a **cuboi**d is a rectangular prism. The ends of a cuboid are rectangular and it has identical rectangular cross-sections when cut by a plane parallel to the ends. Prisms are named according to the shape of their base (or cross-section). The volume, *V*, of a prism is given by

V=Area of base x Height

V=Ah

Where *A* is the area of the base (or cross-section) of the prism and *h* is the height.

The volume *V* of any right prism is the product of *B*, the area of the base, and the height *h* of the prism.

Formula: $V = Bh$

$B=lw$

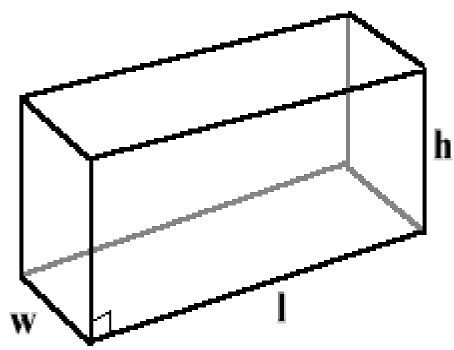


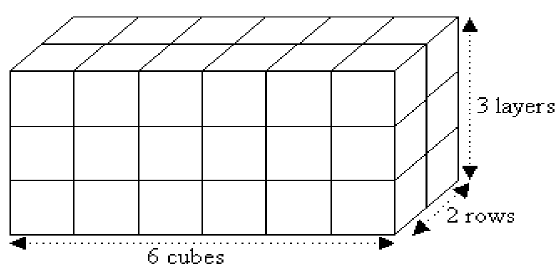
Fig.iii prism

Example 1

If the rectangular box were filled with 1 cm cubes, there would be:

6×2 cubes in the bottom layer

As there are 3 layers,



$$\begin{aligned} \text{Volume} &= (6 \times 2) \times 3 \\ &= 12 \times 3 \\ &= 36 \text{ cm}^3 \end{aligned}$$

Now note that the area of the box's base is given by:

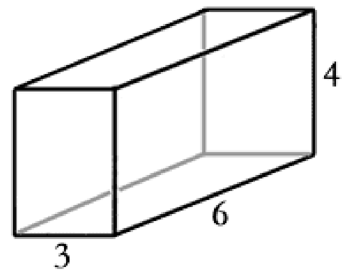
$$\begin{aligned} \text{Area} &= lw \\ &= 6 \times 2 \\ &= 12 \text{ cm}^2 \end{aligned}$$

From the above discussion, we can derive a formula for the volume of arectangular box as follows:

$$\begin{aligned}\text{Volume} &= 6 \times 2 \times 3 \\ &= (6 \times 2) \times 3 \\ &= \text{Area of the base} \times \text{Height}\end{aligned}$$

Example 2

A prism that has a length of 3 units, a width of 6 units, and a height of 4 units for the fig. below. Find the volume of prism.



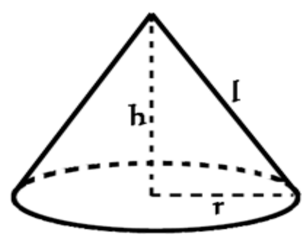
V=lwh

=3x6x4

=72unit^3

iii. Volume of cone

What is Cone**?**A cone is a space figure having a circular base and a single vertex. If *r* is the radius of the circular base, and *h* is the height of the cone, then the volume of the cone is $1/3 \times \pi \times r^2 \times h$. The volume of a cone is based on the height and the radius of the base. A **cone** is a space figure with one circular base and a vertex that is directly above the center of the base. This is the equation to find the volume of a cone.



Volume = $^1/_3\, \pi\, r^2\, h$

Fig. iv Cone

Example: What is the volume in cubic cm of a cone whose base has a radius of 3 cm, and whose height is 6 cm, to the nearest tenth?

We will use an estimate of 3.14 for π.

The volume is $1/3 \times \pi \times 3^2 \times 6 = \pi \times 18 = 56.52$, which equals 56.5 cubic cm when rounded to the nearest tenth.

iv. Volume of pyramids

What is a pyramid?

A pyramid is a space figure with a square base and 4 triangle-shaped sides. It isA 3-dimensional solid in which the base is a polygon and the sides are triangles which meet in one point called the

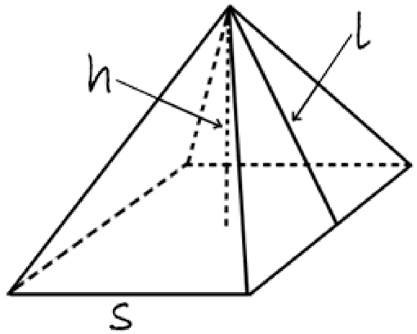


Fig. v pyramid

vertex. We shall examine **regular pyramids** in which the base is a regular polygon and the sides are congruent triangles**.**

A pyramid is a polyhedron with a single base and lateral faces that are all triangular. All lateral edges of a pyramid meet at a single point, or vertex**.**

To find the volume of a square based pyramid, we will start with a cube, which is a prismthat has edges of equal length, which have been labeled with the traditional letter s. So the volume of pyramid in fig below is:

V=Bh/3 Where B=base area, h=height**=s^2h/3**

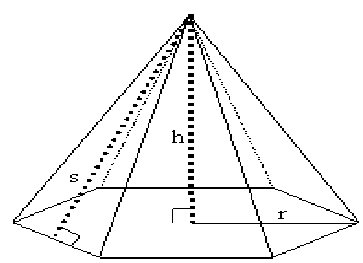


Fig.vi pyramid

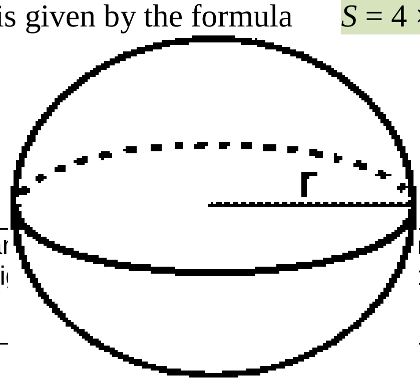
v. Volume of Sphere

A sphere is a space figure having all of its points the same distance from its center. The distance from the center to the surface of the sphere is called its radius. Any cross-section of a sphere is a circle.

If r is the radius of a sphere, the volume V of the sphere is given by the formula $V = 4/3 \times \pi \times r^3$.

The surface area S of the sphere is given by the formula $S = 4 \times \pi \times r^2$.

A sphere is the locus of all points in a region that are equidistant



from a point. The two-dimensional rendition of the solid is represented below.

Fig. vii Sphere

To calculate the surface area of a sphere, we must imagine the sphere as an infinite number of pyramids whose bases rest on the surface of the sphere and extend to the sphere's center. Therefore, the radius of the sphere would be the height of each pyramid.

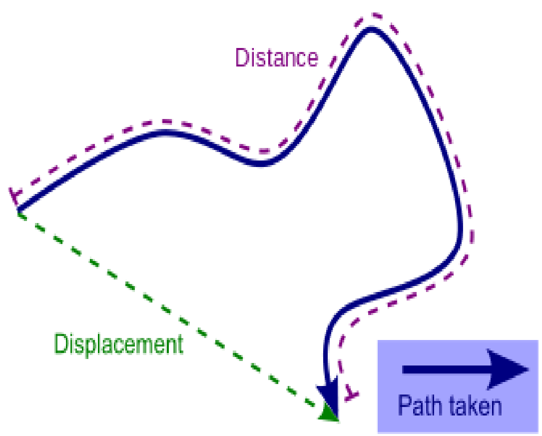
Example:-Find the volume and surface area of a sphere of diameter 8 cm.

Since D=8cm,then , radius , r=4cm.

$V=4/3\pi r^3$ $=4/3x\pi x(4cm)^3$ $=\underline{268.1cm^3}$

Displacement

Displacement (vector), the difference between the final and initial position of a point (for instance, the center of mass of a moving object). It can simply be defined as the shortest path between the final point and initial point of a body.



- Particle displacement, a measurement of distance of the movement of a particle in a medium as it transmits a wave (represented in mathematics by the lower-case Greek letter ξ)

- Displacement field (mechanics), an assignment of displacement vectors for all points in a body that is displaced from one state to another.
- Displacement (fluid), an object immersed in a fluid pushes the fluid out of the way

A displacement is the shortest distance from the initial to the final position of a point P. Thus, it is the length of an imaginary straight path, typically distinct from the path actually travelled by P. A 'displacement vector' represents the length and direction of that imaginary straight path.

Displacement versus distance traveled along a path.

A position vector expresses the position of a point P in space in terms of a displacement from an arbitrary reference point O (typically the origin of a coordinate system). Namely, it indicates both the distance and direction of an imaginary motion along a straight line from the reference position to the actual position of the point.

A displacement may be also described as a 'relative position': the final position of a point ($\boldsymbol{R_f}$) relative to its initial position ($\boldsymbol{R_i}$), and a displacement vector can be mathematically defined as the difference between the final and initial position vectors: $\boldsymbol{s} = \boldsymbol{R_f} - \boldsymbol{R_i} = \Delta \boldsymbol{R}$

In considering motions of objects over time the instantaneous velocity of the object is the rate of change of the displacement as a function of time. The velocity then is distinct from the instantaneous speed which is the time rate of change of the distance traveled along a specific path. The velocity may be equivalently defined as the time rate of change of the position vector.

Diameter

In geometry, the **diameter** of a circle is any straight line segment that passes through the center of the circle and whose endpoints lie on the circle. It can be also defined as the longest chord of the circle. Both definitions are also valid for the diameter of a sphere. All diameters of a circle or sphere have the same length, this being twice the radius.

All diameters of a circle or sphere have the same length, this being twice the radius.

$$d = 2r.$$

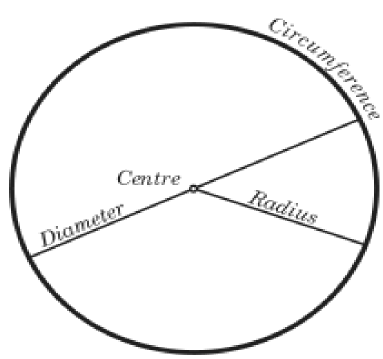


fig. 2.34 Diameter, radius and circumference of a circle

The diameter is defined to be the largest distance that can be formed between two opposite parallel lines tangent to its boundary, and the *width* is defined to be the smallest such distance. Both quantities can be calculated efficiently using rotating calipers.

i. Inside diameter: is the diameter of the inside of a tube, pipe or other object. The length of a line which passes through the center of a hollow cylindrical or spherical object and whose end points lie on the inner surface of the object. Abbreviated ID.

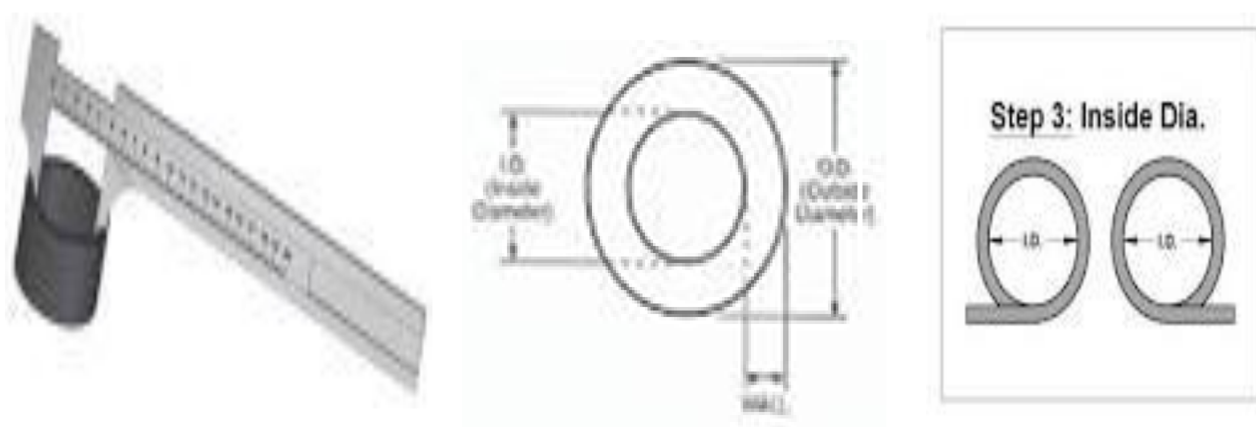
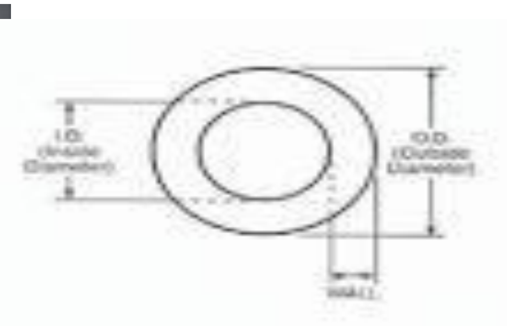


Figure.2.35 showing inside diameter

ii. Outside diameter: The outer diameter of a pipe, including the wall thickness; usually measured with calipers. Abbreviated OD.



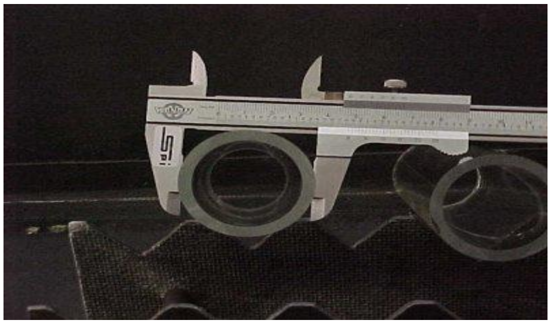


Figure 2.36 showing outside diameter

1. 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.

Circumference = twice the pi times the radius ($C = 2\pi r$ OR $C = \pi d$),

where C = circumference ,r = radius and d = diameter

2. Length: In geometric measurements, length is the longest dimension of an object. In other contexts "length" is the measured dimension of an object. For example it is possible to cut a length of a wire which is shorter than wire thickness.

Length may be distinguished from height, which is vertical extent, and width or breadth, which is the distance from side to side, measuring across the object at right angles to the length. Length is a measure of one dimension. The unit of length is a fundamental unit, from which other units are defined.

In the International System of Units (SI), the basic unit of length is the meter. The centimeter and the kilometer, derived from the meter, are also commonly used units. English or Imperial system of units, commonly used units of length are the inch, the foot, the yard, and the mile.

3. Thickness:

- ✓ is the quality or condition of being thick.
- ✓ is the dimension between two surfaces of an object, usually the dimension of smallest measure. A layer, sheet, stratum, or ply: Each floor is a single thickness of concrete.
- ✓ is the measure of the smallest dimension of a solid figure: a board of two-inch thickness.

4. Taper: means

i. get or make narrower: to become narrower at one end, especially gradually, or make something do this

ii. reduce gradually: to become smaller in size or amount, or less important, especially gradually, or make something do this

The taper gauge is a tapered metal rod with a measurement scale marked on it. It is slipped into the gap to be measured. The depth of the opening may be determined by reading the number on the taper gauge at the point where it just enters the gap.

5. Out of roundness Cylinder wear caused by piston thrust. This results in wear to front and back of cylinder. Cylinder wears oval shaped rather than round.

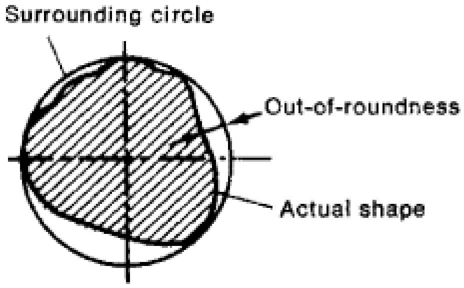


Figure 2.37 out of roundness

Out of roundness a measuring instrument for determining out-of-roundness—that is, the greatest distance from a surrounding circle of points on the actual cross-sectional profile of a cylindrical surface

Out-of-roundness gauges are used to check internal and external cylindrical surfaces 3-1,000 mm in diameter and 100-1,600 mm long. The results of measurement are recorded by an automatic device with magnifications of 2 × to 20,000 × on a disk or strip chart; the smallest measuring error is 0.05-0.8 micron.

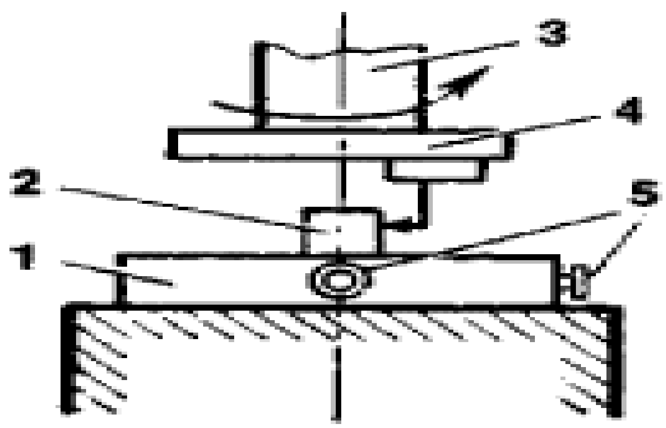


Figure 2.38. Diagram of determination of out-of-roundness for a cylindrical part by means of an out-of-roundness gauge: (1) instrument table, (2) part, (3) precision arbor, (4) primary transducer (sensor), (5) screws of centering device

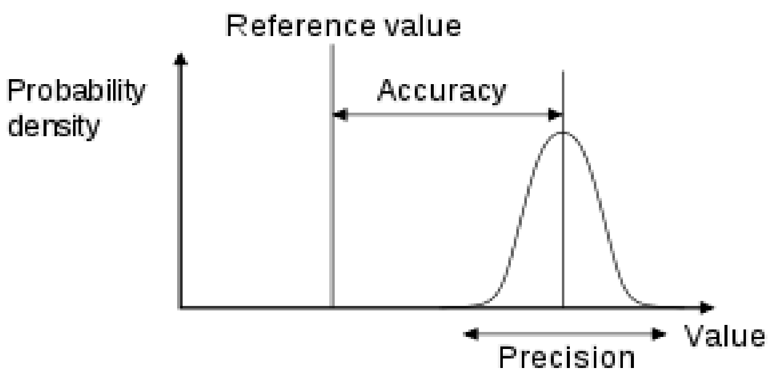
An out-of-roundness gauge with a tip that moves along the axis of the part is used to detect deviations from a cylindrical shape (the greatest distance of points on the actual surface from the surface of the surrounding cylinder). In this case the out-of-roundness and the deviations of the cylindrical profile in a longitudinal section of the part are determined simultaneously.

2.6 Reading of Instruments to the limit of accuracy .

Precision and Accuracy

Accuracy is the proximity of measurement results to the true value; precision, the repeatability, or reproducibility of the measurement

The accuracy of a measurement system is the degree of closeness of measurements of a quantity to that quantity's actual (true) value. The precision of a measurement system, also called reproducibility or repeatability, is the degree to which repeated measurements under unchanged conditions show the same results.



A measurement system can be accurate but not precise, precise but not accurate, neither, or both. For example, if an experiment contains a systematic error, then increasing the sample size generally increases precision but does not improve accuracy. The result would be a consistent yet inaccurate string of results from the flawed experiment. Eliminating the systematic error improves accuracy but does not change precision.A measurement system is considered *valid* if it is both *accurate* and *precise*.

Self-Check 2	**Written Test**

I. Say true or false for the following questions

1. Parallel clamps are used for aligning steel rules with the axis of cylindrical shafts
2. micrometer is a wood working tool used to test and mark out right angles,
3. Accuracy is the proximity of measurement results to the true value; precision, the repeatability, or reproducibility of the measurement

II. Choose the correct answer

1. Two resistors with $R_1= 3\Omega$ and $R_2 = 6\Omega$ are connected in parallel. The total resistance of the two resistors is A. 9 Ω B. 6 Ω C. 2 Ω D. 18 Ω
2. A resistor of 10Ω is connected across a supply voltage of 4v. The amount of current that flows the circuit is; A. 14A B. 40A C.6A D. 2.5A
3. The electric meter that measures the amount of electrical energy is;

   A. Watt meter B. KWh meter C. Volt meter D. All

III. Give the necessary answers for the following questions.

1. Write the types of micrometer?
2. List at least 5 parts of caliper.
3. Explain the fundamentals of algebra.
4. Write the application of protractor?
5. List the types of caliper.

Operation sheet 2. Perform measurement

JOB TITLE: perform measurements using

i. Steel rules and transfer it into work places (sheet metal or board)

ii. Vernier caliper the thickness of electrical wires, coils, cores etc

iii. Protractors and try square angles

UNIT OF COMPETENCY: perform measurement and calculation

READING: read carefully the information sheet 2 and related information from reference book and internet

OBJECTIVES: At the end of this practice the trainees will be able to:

- ❖ Measure either in metric or inch system dimension of objects
- ❖ Perform accurate measurements
- ❖ Thickness of materials with vernier caliper
- ❖ Check angles different figures

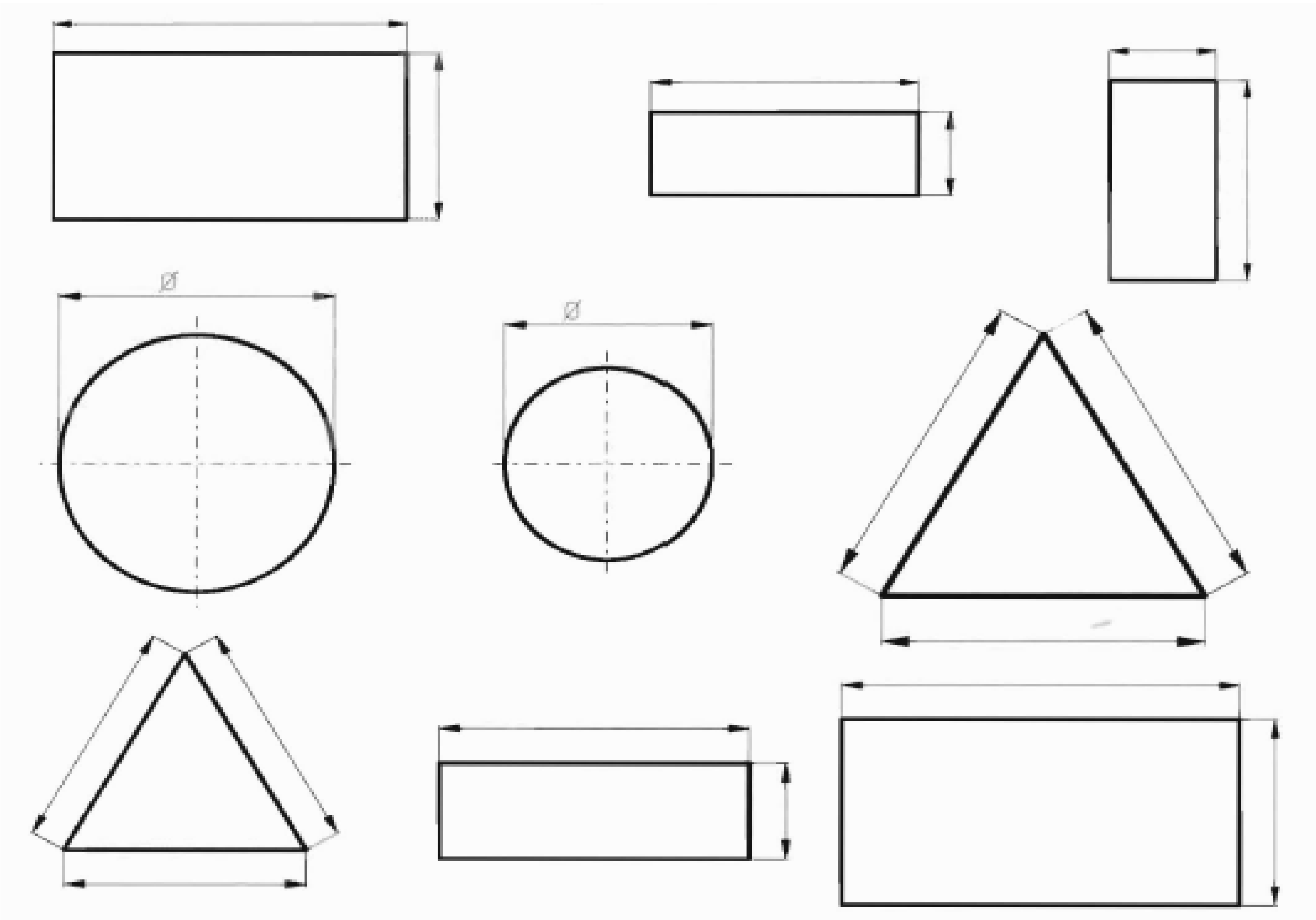
LABORATORY WORK:

1. Choose the proper measuring instruments and the proper scale for the measurement.
2. At all possible, have either the part or the **steel** rule resting in a stable conditions.
3. Align scale edge of the **steel** rule and the line of measurement of the part as closely as possible.
4. Align the reference Point to the steel rule so that sharp edges on either will not interfere.
5. Read the measured Point from a point directly opposite.

6. Repeat sufficient times for the needed reliability based on your skill
7. Read and calculate to get the results (for vernier caliper)
8. Have both the part and the measuring instruments clean.
9. Handle properly the measuring instrument

Supplies and Materials	Tools and Instruments	Equipment
Sheet metal, Board	Steel rule, Try Square,	
Different size wires andcoils	Protractor	
Different size cores	vernier caliper	

Measure these shapes by a steel rule both by metric and inch system



EVALUATION: Each lab exercise should be checked in accordance to the procedure

Comment is given immediately, then they try to correct their work based on the comments

Unit Three Carry out Measurement and Calculation
This unit is developed to provide you the necessary information regarding the following topics. • Handling measuring instruments without damage. • Cleaning before and after using measuring instruments. • Undertaking proper storage of instruments This unit will also assist you to attain the assessment criteria of the module title stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to –

- Handling measuring instruments without damage.
- Cleaning before and after using measuring instruments.
- Undertaking proper storage of instruments

3. Carry out measurement and calculation

3.1 Handle Measuring instruments without damage

Measuring instrument should always be in a good condition in order to maintain its accuracy of results.

Every measuring tools and devices have their own proper maintenance and handling guidelines as provided in their user manual. The content of measuring equipment guidelines should always be followed to have an accurate result.

The following items are the basic safe handling methods for measuring instruments:

- Always clean the measuring equipment before and after its usage.
- Perform calibration regularly to confirm if its result is still within the international standard.
- Provide designated area for all measuring equipments wherein visual control is observed.
- Always follow the guidelines on how to use measuring equipment properly.
- Provide working instruction on how to check it on a daily basis. Use check sheets.
- Use only appropriate measuring equipment for the specific parts to be measured.
- Segregate and dispose defective measuring instruments to avoid wrong usage.
- Contact the maker of measuring equipment if major problem was occurred on the said instrument.
- Always follow and implement 5S in the working area.
- It is very important to maintain the accuracy of measuring instrument in order to obtain reliable results and avoid possible rejects as well as to prevent accidents.

Safety

Safety is the state of being "safe", the condition of being protected against consequences of failure, damage, error, accidents, harm or any other event which could be considered non-desirable. Safety can also be defined to be the control of recognized hazards to achieve an acceptable level of risk. This can take the form of being protected from the event or from exposure to something that causes health or economical losses. It can include protection of people or of possessions.

Instruments should be stored properly to prevent occurrence of any damage on it.

When you store measuring instruments:

- ✓ clean them properly before storing.
- ✓ put them on the shelf based on their types, that should be accessible for the user easily.
- ✓ do not store instruments randomly.

The critical element of precision instrument care is handling measuring instruments correctly during use. Taking care to avoid accidental damage and use your tools correctly can help to extend their life and ensure accurate readings.

When using a measuring tool, it doesn't have the protection of its case or storage space, so it's especially crucial to handle it carefully. Take care to avoid sudden shocks or rough treatment such as dropping, throwing or banging the device against hard surfaces. Placing rubber mats in workspaces can help protect tools from damage should someone accidentally drop them.

It's also essential that you only use your instruments for their intended purposes. Never use measuring tools as hammers or to pry open other objects. Calipers, for instance, have ID jaws that come to sharp points. They appear to be ideal for cutting open boxes, but using calipers in this way cause burrs to form on the jaws. Even though these burrs may be too small to see with the naked eye, they can still affect the accuracy of the instrument.

As mentioned earlier, you may also want to avoid touching instruments that are especially sensitive with your bare hands, as the oils on your skin can cause corrosion. For some tools, minimizing the time you spend holding it or only touching it at certain points may be enough. For the most sensitive instruments or those you need to handle more frequently, you can use lint-free gloves or accessories, such as tweezers, lifters and forks, made specifically to handle sensitive instruments.

Another reason to avoid handling measuring tools for long periods is the heat your body produces. Holding an instrument for an extended period can cause it to heat up, potentially throwing off the accuracy of the unit. You should also avoid setting it on hot or cold sources and keep it away from sources of cold air or heat. Throughout the entire process of using the instrument, be careful to keep it at the proper temperature.

Training is vital for ensuring the proper handling of measuring equipment at all times. Employees should receive sufficient training for each type of instrument they will use, so they know how to take accurate measurements without damaging the tools.

Maintenance

You will also need to periodically conduct preventive gage maintenance, including regular lubrication and calibration. It's helpful to create a schedule for when you will perform maintenance so you can ensure the necessary tasks get done. You may also want to create a system for keeping track of what maintenance tasks you complete at which times and the conditions of your various instruments. You may want to do some upkeep yourself and outsource other assignments to third parties.

One essential aspect of gage maintenance is lubrication, as it will prevent damage caused by corrosion and oxidation. It's crucial that you lubricate each device as frequently as is recommended for each device and that you use the right lubricants in the right amounts. For many types of precision measuring tools, lightly oil them after each use. Be sure to remove any excess oil from the surfaces of the instrument using a clean, dry cloth. If a device is visibly wet with oil, it may attract particles that can cause internal wear of certain parts.

Be sure to use the right types of oils, and don't use penetrating oils or other substances made for purposes besides light lubrication. WD-40, for example, may leave a film on your instrument that can affect its calibration. Even a thin layer can throw off the accuracy of some sensitive instruments.

Calibration is another crucial part of proper gage maintenance. Many types of measuring devices require regular calibration to ensure they perform correctly and take accurate measurements. Calibration involves comparing a measurement made by your instrument with the value of the same measurement, as defined by an accepted standard. This comparison serves to check the accuracy of the tool. If the device's measurement differs from the standard to a significant degree, you will need to repair the instrument so it is accurate. For some devices, you may want to work with a professional calibration company that can ensure your devices have the correct calibration.

You should calibrate your instruments according to the schedule recommended for each device. All measurement devices drift out of calibration over time, so it's vital to recalibrate them regularly. In addition to your scheduled recalibrations, you may also need to recalibrate your instruments in certain other situations, such as:

- When it's undergone a shock such as a fall
- When it's experienced harsh conditions
- When it's producing readings that seem incorrect

Handling and storing materials involve diverse operations such as hoisting tons of steel with a crane; driving a truck loaded with concrete blocks; carrying bags or materials manually; and stacking palletized bricks or other materials such as drums, barrels, kegs, and lumber. The efficient handling and storing of materials are vital to industry. In addition to raw materials, these operations provide a continuous flow of parts and assemblies through the workplace and ensure that materials are available when needed. Unfortunately, the improper handling and storing of materials often result in costly injuries.

What is the Importance of Measuring Tool Maintenance

Why is the proper care of measuring tools so important? Some of the benefits include the following.

- **Increase accuracy:** If measuring tools don't receive proper care and maintenance, they're more likely to take inaccurate readings. Some of these tools take exact measurements, so even small changes can impact the accuracy of measurements. Damaged instruments may also be off by relatively large amounts. If you don't realize your measurements are off, these inaccuracies could get in the way of the success of a job. A wide variety of factors can impact the accuracy of a measuring tool, from improper storage temperature to excessive vibrations to physical damage due to dropping it. Because damage or improper maintenance can affect accuracy, it's crucial that you're careful to maintain them properly. A measuring instrument can also fall out of calibration naturally over time, so regular gage calibration is essential.
- **Extend life:** Caring for precision tools properly also helps extend their life. With proper care, many measuring instruments can serve you well for a long time. Without adequate maintenance, however, your tools will break sooner, and you'll have to replace them earlier. Improper care increases the risk of a tool failing in the middle of a job or gradually becoming less effective, reducing the efficiency and accuracy of your work.
- **Lower costs:** Following the right care and maintenance procedures can help you reduce your costs over the long term. It can help you avoid costly breakdowns, more extensive repairs and downtime. It also means you'll have to replace your tools less often, meaning you get more out of your investments in quality instruments.

Tips for Maintaining Precision Tools

Every measuring tool has different maintenance needs, and you should receive guidelines in the user manual for each device you purchase. It's crucial to follow these recommendations to keep your tools in optimal condition. In the following sections, we'll look at some overarching recommendations for the care of measuring tools, as well as some more specific examples..

3.2 Clean measuring instruments

Another essential aspect of gage maintenance is keeping your instruments clean. Like with measuring tool storage, there are different cleaning recommendations for different types of gages and materials. Be sure to follow the guidelines for your specific tools to ensure you thoroughly clean them and avoid damaging them. Conscientiously cleaning your devices is crucial, as any residue that remains on your device may impact the accuracy of your measurements.

The material your device is made of plays a significant role in the cleaning method you should use. If an instrument is mostly aluminum, for example, avoid using alcohol, as it can cause aluminum to deteriorate. For brass, it's best not to use anything except for a clean cloth that you've dampened with distilled water. Some general cleaning tips include:

- Not leaving your instruments in contact with dirt or oil for long periods, as oils can cause corrosion
- Avoiding touching gages with your bare hands, as skin oils can be damaging
- Using a soft, non-abrasive cloth to clean your instruments and ensuring the cloth is clean before using it

Scheduled Cleaning

As part of your routine gage maintenance, you should have a regular cleaning schedule in place for your devices. Various factors influence how often you should plan to clean your instruments.

- **The environment in which you use it:** Some situations may cause measuring tools to require cleaning more often. If you use your tools in a dusty manufacturing environment, for example, you may need to clean them more often than if you work in a relatively controlled lab environment.
- **The task for which you use it:** The job you use the tool for can also impact how often it requires cleaning. For example, pressure gage maintenance may involve cleaning it more often if you use it with liquids, as opposed to solid items. Also, if the measurements are so precise that small amounts of dirt or residue could throw them off, you'll need to clean your instruments more frequently.
- **Legal requirements:** In certain industries, rules and regulations may require you to clean tools more often. For example, food-related businesses must adhere to higher cleanliness standards than many other industries.

It's a smart rule of thumb to inspect and, if needed, clean instruments before each use. Before using a device, look for foreign matter on it, as this material could affect the readings.

Spot Cleaning

At times, you may need to do some maintenance beyond your typical scheduled gage cleaning. This type of upkeep is spot cleaning, and is a more vigorous method you use when your routine maintenance doesn't remove all foreign matter. Spot cleaning may involve using stronger cleaners, repeating cleaning processes until you remove all contaminants or other techniques

Important Safety Measures

To reduce the number of accidents associated with workplace equipment, employers must train employees in the proper use and limitations of the equipment they operate. In addition to powered industrial trucks, this includes knowing how to safely and effectively use equipment such as
conveyors, cranes, and slings.

Basic Safety and Health Principles

Employers can reduce injuries resulting from handling and storing materials by using some basic safety procedures such as adopting sound ergonomics practices, taking general fire safety precautions, and keeping aisles and passageways clear.

3.3 proper storage of instruments

Storage is a critical element of measuring tool care, as these devices can spend significant amounts of time in cupboards or cabinets where they may get damaged. Be sure to follow the recommendations for how to store each tool you use. Different types of gages and tools made of different materials often have different storage requirements.

Many measurement devices come in cases, and it's often a best practice to store your tools in these cases. If your tool didn't come with a case, purchase one that meets the storage requirements of your instrument. Make sure it's the right material, size and shape and that it has the right features. Often, these containers will have padding. For some types of gages, you may want to place them on a clean, dry cloth inside a case. Keeping your tools in a case helps to protect them from airborne contaminants and accidental physical damage.

Another crucial measure to take to prevent physical damage is to separate your devices so that they don't bump into and damage each other. You can separate them using dividers or cases. Don't stack devices on top of each other unless they're in cases that will protect them from damaging each other.

It can also be helpful to take time to organize your devices in a cart, tray, inspection station or other location. Doing so can help make it easier to follow proper storage procedures and enable you to access your tools more efficiently.

You also need to ensure that you store your devices in the proper temperature and humidity and that other conditions are suitable for your tools as well. In general, you want to keep gages in a cool, dry place, but some devices may also come with more specific recommendations.

Be sure to keep the storage area at an appropriate temperature and keep your devices away from sources of heat, including sunlight. If your gages get exposed to sunlight or other sources that produce too much heat, they may expand as they heat up and then contract as they cool, potentially damaging them and decreasing their accuracy.

You also need to take steps to keep the humidity of the storage space at a suitable level and to take care of any moisture issues that may arise. Doing so is crucial, since excessive moisture can lead to corrosion. Air conditioning or a dehumidifier can help you control humidity and reduce ambient moisture. Placing silica gel packets in the drawers where you store your tools can help take care of any other excess moisture.

Over time, vibration can cause measuring tools to fall out of calibration, so store your instruments away from any equipment that may cause vibration or movement

Self-Check 3	Written Test

I. Give the necessary answers for the following questions

1. explain how to handle measuring instruments safely

2. list down the different types of cleaning mechanisms

3. what are the methods applied to avoid storage hazards

Unit 4 maintain measuring instruments
This unit is developed to provide you the necessary information regarding the following learning outcomes: • Object or component to be measured is identified according to procedures • Correct specifications are obtained from relevant source • Measuring tools are selected in line with **job requirements** This unit also assist you to attain the assessment criteria of the unit stated in the cover page. Specifically, upon completion of this unit, you will be able to – • Identify object or component to be measured • Obtain correct specifications • Select measuring tools in line with job requirements

Unit Four Maintain measuring Instruments

4.1. Identifying object or component

Measuring instrument should always be in a good condition in order to maintain its accuracy of results.

Every measuring tools and devices have their own proper maintenance and handling guidelines as provided in their user manual. The content of measuring equipment guidelines should always be followed to have an accurate result.

The following items are the basic safe handling methods for measuring instruments:

- Always clean the measuring equipment before and after its usage.
- Perform calibration regularly to confirm if its result is still within the international standard.
- Provide designated area for all measuring equipments wherein visual control is observed.
- Always follow the guidelines on how to use measuring equipment properly.
- Provide working instruction on how to check it on a daily basis. Use check sheets.
- Use only appropriate measuring equipment for the specific parts to be measured.
- Segregate and dispose defective measuring instruments to avoid wrong usage.
- Contact the maker of measuring equipment if major problem was occurred on the said instrument.
- Always follow and implement 5S in the working area.
- It is very important to maintain the accuracy of measuring instrument in order to obtain reliable results and avoid possible rejects as well as to prevent accidents.

Safety

Safety is the state of being "safe", the condition of being protected against consequences of failure, damage, error, accidents, harm or any other event which could be considered non-desirable. Safety can also be defined to be the control of recognized hazards to achieve an acceptable level of risk. This can take the form of being protected from the event or from exposure to something that causes health or economical losses. It can include protection of people or of possessions.

4.2 Obtain correct Specification (SPEC)

Exact statement of the particular needs to be satisfied or essential characteristics that a customer requires 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. Specifications are divided generally into two main categories:

(1) Performance specifications: conform to known customer requirements such as keeping a room's temperature within a specified range.

(2) 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.

(3). Manufacturer's specifications:
The written installation and/or maintenance instructions which are developed by the manufacturer of a product and which may have to be followed in order to maintain the product warrantee.

Standard operation procedures (SOP)
Standard Operating Procedures (SOP) help maximum safety and operational efficiency. SOPs are detailed written instructions to achieve uniformity of the performance of a specific function. A well-written SOP can be used to satisfy compliance requirements. SOPs are recommended for all procedures that pose a potential risk to the health and safety of personnel.

Standard Operating Procedures **(**SOPs**)** lets you operationalize documents such as plans, regulation, compliance, and policies. SOPs distil requirements contained in these documents into a format that can be used by staff members in their work environment.

Standard Operating Procedures (SOPs) should be transferred without every modification to insure the expected results. Every modification or divergence of a given standard, the Procedure should being served, while an investigation and results of the investigation documented according to the internal divergence procedure. All high-class processes and procedures should be put on in a Standard Operating Procedure.
This Standard Operating Procedure should be the base for the everyday training program of every employee. The Standard Operating Procedure should be often updated to insure of obedience to the realization conditions and the working practice.

A minimum review list of 3 years is recommended. Changes of the Standard Operating Procedure are activated generally by the process or the procedure changes or the adaptations. These changes should be led by the internal site controlling procedure. A part of the activity list of such changes should be to update the coherent standard operating procedure. Standard operating procedure should be in the place for all high-class systems plus the specific operational activities on the side.

The structure of the Procedure System and the sum of all SOPs should be considered carefully. Too many standard operating procedure could lead to a breakdown of the SOP System

Maintain and Repair

Maintenance, repair, and operations(MRO) or maintenance, repair, and overhaul involve fixing any sort of mechanical, plumbing or electrical device should it become out of order or broken. It also includes performing routine actions which keep the device in working order or prevent trouble from arising. MRO may be defined as, "All actions which have the objective of retaining or restoring an item in or to a state in which it can perform its required function. The actions include the combination of all technical and corresponding administrative, managerial, and supervision actions."

Maintenance types

Generally speaking, there are three types of maintenance in use:

- maintenance: where equipment is maintained before break down occurs. It is maintenance performed in an attempt to avoid failures, unnecessary production loss and safety violations.

The effectiveness of a preventive maintenance schedule depends on the RCM analysis which it was based on, and the ground rules used for cost-affectivity.

Recent studies have shown that Preventive maintenance is effective in preventing age related failures of the equipment. For random failure patterns which amount to 80% of the failure patterns, condition monitoring proves to be effective.

Corrective maintenance, where equipment is maintained after break down. This maintenance is often most expensive because worn equipment can damage other parts and cause multiple damages. Corrective maintenance is probably the most commonly used approach, but it is easy to see its limitations. When equipment fails, it often leads to downtime in production. In most cases, this is costly business. Also, if the equipment needs to be replaced, the cost of replacing it alone can be substantial. It is also important to consider health, safety and environment (HSE) issues related to malfunctioning equipment.

Corrective maintenance can be defined as the maintenance which is required when an item has failed or worn out, to bring it back to working order. Corrective maintenance is carried out on all items where the consequences of failure or wearing out are not significant and the cost of this maintenance is much greater than preventive maintenance.

Reliability maintenance , often known as RCM, is a process to ensure that assets continue to do what their users require in their present operating context.

Reliability centered maintenance is an engineering framework that enables the definition of a complete maintenance regime. It regards maintenance as the means to maintain the functions a user may require of machinery in a defined operating context. As a discipline it enables machinery stakeholders to monitor, assess, predict and generally understand the working of their physical assets. This is embodied in the initial part of the RCM process which is to identify the operating context of the machinery, and write a Failure Mode Effects and Criticality Analysis (FMECA). The second part of the analysis is to apply the "RCM

logic", which helps determine the appropriate maintenance tasks for the identified failure modes in the FMECA. Once the logic is complete for all elements in the FMECA, the resulting list of maintenance is "packaged", so that the periodicities of the tasks are rationalized to be called up in work packages; it is important not to destroy the applicability of maintenance in this phase. Lastly, RCM is kept live throughout the "in-service" life of machinery, where the effectiveness of the maintenance is kept under constant review and adjusted in light of the experience gained.

Self-Check 4	Written Test

I. **Say true or false for the following questions**

1. Measuring instrument should always be in a good condition in order to maintain its accuracy of results.
2. Standard Operating Procedures (SOP) help maximum safety and operational efficiency.
3. Corrective maintenance is a maintenance that is applied, where equipment is maintained after break down.

II. **Choose the correct answer**

1.. ________________, is a process to ensure that assets continue to do what their users require in their present operating context.

A. Reliability or centered maintenance   B. Corrective maintenance C. Preventive maintenance

II. **Give the necessary answers for the following questions**

1. What is maintenance and repair?____

   ____

   ____

2. Write the three types of maintenance. ____

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3. Explain in short the three types of maintenances.____________________________

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