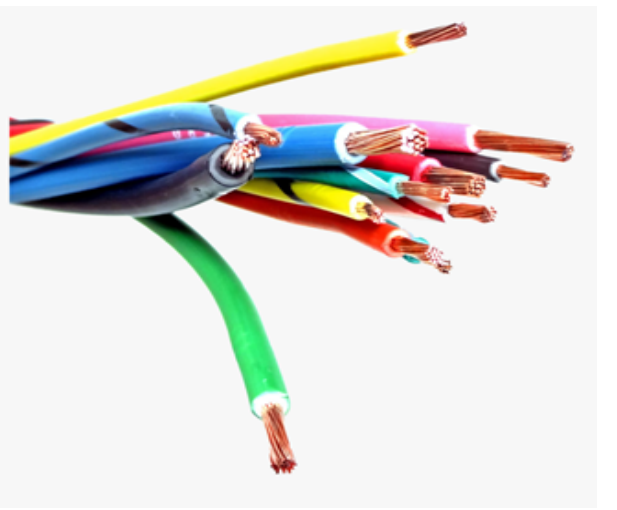
Textbook of

Industrial Electrician

Class-IX



National Vocational & Technical Training Commission (NAVTTC)

Textbook of

Industrial Electrician

Grade – IX

National Vocational and Technical Training Commission

H-9, Islamabad

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PREFACE

This book has been written to cater to the needs of Matric-Tech to teach & train the students for the subject of Industrial Electrician. Matric-Tech is a new initiative of NAVTTC and Industrial Electrician trade is introduced for the first time in it. This trade is highly suitable for present-day needs. Key effort has been made to make the book interesting and useful. The chapters are written to cover all the basic details of the subject in a manner understandable to the students of Matric Tech. All chapters include assessments in form of MCQs, Short Questions & Long Questions. Any suggestions for the betterment of this book will be highly acknowledged. I am really thankful to NAVTTC's team for their cooperation & guidance.

Executive Director
National Vocational & Technical Training Commission
(NAVTTC)

Table of Contents

Chapter 01

Occupational Health, Safety and Environment

Students Learning Outcomes

After completion of this chapter you will be able to:

- explain the importance of health and safety
- understand the safety symbols.
- define hazards at workplace.
- define various types of hazard (chemical, electrical)
- understand risk assessment process.
- follow steps of risk assessment.
- explain ppes.
- describe health and safety regulations.
- explain health and safety precautions.
- deal with problems and ensure in time reporting of the problems to the concerned authority.
- define fire extinguisher.
- explain the types of fire extinguisher and their uses.

1.1 Importance of Health, Safety and Environment

Occupational Health and Safety rules are designed to create a safe and healthy work environment. It can generally be considered as two separate entities.

- Occupational Safety covers the risk factor in your workplace, and potential safety hazards that could possibly cause injury.
- Occupational Health, on the other hand, looks at potential health concerns and wellbeing. Think of Safety as an employee's physical well-being, and Health as everything else, including mental health.

Safety of workers also refers to the provision of a safe working environment, safe equipment, policies, and procedures in order to ensure workers' health and safety.

Workplace safety has become one of the main priorities for organizations across the world. As safe workplaces are also productive ones, employers are trying to find new ways to keep their remote, frontline, and in-office employees safe and healthy.

1.2 Safety Symbols

Safety Symbols or Hazard Symbols are meaningful and recognizable graphical symbols that warn of or identify hazards associated with the location or item. Safety symbols include images, pictograms, shapes, words, phrases, sentences or statements, which are displayed on walls, boards, buildings, doors, entrances, machines, equipment, tools, transports, roads or any other visible area. The symbol informs individuals about the presence of hazardous materials or chemicals, or a hazardous

environment and instructs on how to remain safe or the possible consequences if not avoided.

Safety Symbols are presented with bold backgrounds to warn people that serious injuries can occur from the sitepotetial hazards.

i. Electrical Safety Symbols

There are different kinds of electrical safety symbols which are used for electrical safety signs to provide people with information of what electrical accident can happen and what its probable outcome might be.

Fig 1.1 Electrical Safety Sign

1.3 Hazards at Workplace

A Hazard is a potential source of harm or adverse health effect on a person or persons.

The terms Hazard and Risk are often used interchangeably but this simple example explains the difference between the two.

If there was a spill of water in a room, then that water would present a slipping hazard to persons passing through it. If access to that area was prevented by a physical barrier, then the hazard would remain though the risk would be minimized.

1.4 Types of Hazards (Chemical, Electrical)

i. Safety Hazards

Safety Hazard include unsafe conditions that can cause injury, illness, and death. These are the most common and may be present in most workplaces at one time or another.

Some of the Safety Hazards may include:

Fig 1.2 Electrical Hazards at workplace

- Spills on floors or tripping hazards, such as blocked aisles or cords running across the floor.
- Working from heights, including ladders, scaffolds, roofs, or any raised work area.

- Unguarded machinery and moving machinery parts; guards removed or moving parts that a worker can accidentally touch.
- Electrical hazards like frayed cords, missing ground pins, improper wiring.
- Confined Spaces.
- Machinery-related hazards (lockout/ tag out, boiler safety, forklifts, etc.)
- Biological hazards include viruses, bacteria, insects, animals, etc., that can cause adverse health impacts. For example, mold, blood and other bodily fluids, harmful plants, sewage, dust and vermin.
- Physical Hazards are environmental factors that can harm an employee without necessarily touching them, including heights, noise, radiation and pressure, exposed wires or a damaged carpet might result in a tripping hazard.
- Ergonomic hazards are a result of physical factors that can result in musculoskeletal injuries. For example, a poor workstation setup in an office, poor posture and manual handling.
- Psychosocial Hazards include those that can have an adverse effect on an employee's mental health or wellbeing. For example, sexual harassment, victimization, stress and workplace violence.

ii. Chemical Hazards

Chemical hazards are the risk associated with processing of different chemicals and may cause injury to the person or damage to the machinery / equipment. The effects of the chemical hazards depend on sensitivity of chemical used and worker at the work place. This may can cause illness, skin irritation, or breathing problems. Beware of:

- Liquids like cleaning products, paints, acids, solvents – ESPECIALLY if chemicals are in an unlabeled container!
- Vapors and fumes that come from welding or exposure to solvents.
- Gases like acetylene, propane, carbon monoxide and helium.
- Flammable materials like gasoline, solvents, and

Fig 1.3 Workplace Requirements

explosive chemicals.

- Pesticides

iii. Electrical Hazards

Electricity can kill or severely injure people and cause damage to property. However, you can take simple precautions when working with or near electricity and electrical equipment to significantly reduce the risk of injury to you, your workers and others around you. This section provides a summary of those precautions. The main hazards of working with electricity are:

- Electric shock and burns from contact with live parts
- Injury from exposure to arcing, fire from faulty electrical equipment or installations
- Explosion caused by unsuitable electrical apparatus or static electricity igniting flammable vapors or dusts, for example in a spray paint booth
- Electric shocks can also lead to other types of injury, for example by causing a fall from ladders or scaffolds etc.

Fig 1.4 Various hazards Symbols

Fig 1.5 Electrical Shock Risk

1.5 Risk Assessment Process

Risk assessment process is a process in which user takes a look at their organization to:

- Identify processes and situations that may cause harm, particularly to people.
- Determine how likely it is that

Fig 1.6 Risk assessment

each hazard will occur and how severe the consequences would be.

- Decide what steps the organization can take to stop these hazards from occurring or to control the risk.
- Meeting legal requirements
- Creating awareness about hazards and risk
- Justifying the costs of managing risks

i. Steps of Risk Assessment

i. Identification of the Hazards
ii. Describe who might be harmed and why?
iii. Evaluate the risk and decide on the precautions
iv. Record your findings and implement them
v. Review your assessment and update if necessary

ii. Identification of the Hazards

The first step to create your risk assessment plan is determining what hazards your employees and your business can face, including:

- Natural disasters (flooding, tornadoes, hurricanes, earthquakes, fire, etc.)
- Biological hazards (pandemic diseases, foodborne illnesses, etc.)
- Workplace accidents (slips and trips, transportation accidents, structural failure, mechanical breakdowns, etc.)
- Intentional acts (labor strikes, demonstrations, bomb threats, robbery, arson, etc.)
- Technological hazards (lost Internet connection, power outage, etc.)
- Chemical hazards (asbestos, cleaning fluids, etc.)
- Mental hazards (excess workload, bullying, etc.)
- Interruptions in the supply chain

iii. Who might be harmed and how?

As you look around your organization, think about how your employees could be harmed by business activities or external factors. For every hazard that you identify in step one, think about who will be harmed should the hazard take place?

iv. Risks Evaluation and Precautions

Now that you have gathered a list of potential hazards, you need to consider how likely it is that the hazard will occur and how severe the consequences will be if that hazard occurs. This evaluation will help you determine where you should reduce the level of risk and which hazards you should prioritize first.

v. Record the Findings

If you have more than five employees in your office, you are required by law to write down your risk assessment process. Your plan should include the hazards you've found, the people they affect, and how you plan to mitigate them. The record or the risk assessment plan should show that you:

- Conducted a proper check of your workspace

vi. Determined who would be affected

- Controlled and dealt with obvious hazards
- Initiated precautions to keep risks low
- Kept your staff involved in the process

vii. Assessment Review and Updation

Your workplace is always changing, so the risks to your organization change as well. As new equipment, processes, and people are introduced, each brings the risk of a new hazard. Continually review and update your risk assessment process to stay on top of these new hazards.

1.6 Personal Protective Equipment (PPEs)

The term 'personal protective equipment' (PPE) refers to a vast group of products (e.g. safety helmets, safety footwear and harnesses, eye protection, gloves, high-visibility clothing, etc.) designed with the aim to protect users against low-, medium- and high-level hazards.

i. Head Protection

Wearing PPE for head protection will help you avoid any harm that may come to you from falling materials or swinging objects. Moreover, the head protectors are designed to protect you from knocking against stationary objects. Some kinds of head protection

Fig 1.7 PPEs

equipment (e.g. caps and hair nets) can even protect against entanglement or injury of head with machinery.

Examples of head protection equipment:

- Helmets
- Hard hats
- Bump Caps
- Guards

Fig 1.8 Head protection Equipment

ii. Hand protection

Arms, hands and fingers are often injured and, therefore, it is vital to wear hand protection equipment when it is required. The hand protection equipment can ensure protection against heat, cold, vibrations, burns, and cuts by sharp objects, bacteriological risks and chemical contamination. Examples of hand protection equipment are

- Work gloves
- Wrist cuff arm nets

iii. Hand Protection Equipment

The following activities require hand protection equipment

- Construction and outdoor work
- Working with vibrating apparatus
- Working in hot or cold Environments
- Working with chemicals and hazardous elements
- Manual handling of abrasive or sharp objects

Fig 1.9 Hand protection Equipment

iv. Eye & Face Protection

Fig 1.10 Eye protection Equipment

According to survey about 600 workers worldwide suffer from eye injuries. Such injuries can be avoided simply by wearing the proper eye and face protection equipment. Following PPE can be used.

- Safety glasses and goggles
- Eye and face shields

You are advised to wear eye and face protection equipment when in particular when:

- working with lasers or power driven tools
- using gas or vapors under pressure
- performing welding operations

v. Respiratory Protection

Fig 1.11Respiratory protection Equipment

The respiratory protection covers a broad group of PPE: breathing apparatus, full face or half mask respirators, powered respirators, protective hoods, disposal face masks, detectors, monitors, etc. Adequate training on how users should use the equipment is always required.

This type of PPE must be present when being in contact with large amounts of gases, powders, dust and vapors.

vi. Hearing Protection

Fig 1.12 Hearing protection Equipment

The hearing protection equipment is vital when working in an environment with high-sound levels. The type of hearing protection should not only be suitable for the working environment but also provide a level of hygiene and comfort to the users. A good practice is to provide employees with a range of protectors and then allow them to select the ones which suit them the best.

Examples of hearing protection equipment:

- Earplugs and defenders
- Noise meters

vii. Foot Protection

Fig 1.13 Foot protection Equipment

The foot protection equipment is designed to protect the feet and legs against various hazards, such as extreme temperatures, crushing, piercing, slipping, cutting, chemicals and electricity. It is typically required when users are involved in construction activities, working in very cold or hot environments, working with chemicals and forestry, or when manually handling heavy objects.

As examples of foot protection equipment can be Pointed out the following ones:

- Safety boots and shoes
- Anti-static and conductive footwear

viii. Body Protection

Usually, body protection equipment is required in the following cases:

- For protection against weather conditions when working outdoors
- Ensuring the high-visibility of users when they work in areas where there is a mixed vehicle (e.g. bikes, motors, cars and busses) and pedestrian traffic
- For users' protection against extreme temperatures
- Ensuring protection against entanglement, drowning, chemical contamination, etc.

Examples of body protection equipment:

- Life Jackets
- Clothing for specific weather conditions
- High-visibility clothing
- Harnesses, and others

Fig 1.14 Height protection

ix. Height & Access Protection

This type is highly specialized, and it usually requires users to undergo thorough training before they are allowed to use it.

The height and access protection equipment must be inspected periodically by a competent person to ensure it is still fit for use and the health and safety of users is not threatened in any way.

As examples of height and access protection equipment can be mentioned in the following ones:

- Fall-arrest systems
- Body harnesses
- Lowering harnesses
- Rescue lifting

Activity 1.1
Visit lab of your institute, identify potential hazards. List PPE available and required to work there.
Components/Instruments
Writing Material, PPE etc.
Step 1: Arrange the lab visit Step 2: Identify all the potential hazards Step 3: Enlist all the PPE available there Step 4: Record the findings

Activity 1.2
Check working/ functioning of the tools/equipment, PPE's and materials for insulation
Components/Instruments
Writing Material, PPE etc.
Step 1: Arrange the lab/ workplace visit Step 2: Check working/ functioning of the tools/equipment Step 3: Record the findings

1.7 Observing Occupational Safety and Health (OSH) Regulations

What are the main health and safety regulations?

i. Health and Safety Work Regulations 1999

These rules came into effect in 1993. Main employer duties under the Regulations include:

- Making 'assessments of risk' to the health and safety of its workforce, and to act upon risks they identify, so as to reduce them.
- Appointing competent persons to oversee workplace health and safety.
- Providing workers with information and training on occupational health and safety and operating a written health and safety policy.

ii. The Workplace (Health, Safety and Welfare) Regulations 1992

The main provisions of these Regulations require employers to provide:

- Adequate lighting, heating, ventilation and workspace (and keep them in a clean condition);
- Staff facilities, including toilets, washing facilities and refreshment; and
- Safe passageways, i.e. to prevent slipping and tripping Hazards.

iii. The Health and Safety (Display Screen Equipment) Regulations 1992

The main provisions here apply to display screen equipment (DSE) 'users', defined as workers who 'habitually' use a computer as a significant part of their normal work. This includes people who are regular users of DSE equipment, or rely on it as part of their job. This covers you if you use DSE for an hour or more continuously, and/or you are making daily use of DSE.

Employers are required to:

- Make a risk assessment of workstation use by DSE users, and reduce the risks identified;
- Ensure DSE users take 'adequate breaks';
- Provide regular eyesight tests;
- Provide health and safety information;
- Provide adjustable furniture (e.g. desk, chair, etc.); and
- Demonstrate that they have adequate procedures designed to reduce risks associated with DSE work, such as repetitive strain injury (RSI).

iv. The Personal Protective Equipment at Work Regulations 1992

The main provisions require employers to:

- Ensure that suitable personal protective equipment (PPE) is provided free of charge "wherever there are risks to health and safety that cannot be adequately controlled in other ways." The PPE must be 'suitable' for the risk in question, and include protective face masks and goggles, safety helmets, gloves, air filters, ear defenders, overalls and protective footwear; and
- Provide information, training and instruction on the use of this equipment.

v. The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995

Under these Regulations, employers are required to report a wide range of work-related incidents, injuries and diseases to the Health and Safety Executive (HSE), or to the nearest local authority environmental health department. The Regulations require an employer to record in an accident book the date and time of the incident, details of the person(s) affected, the nature of their injury or condition, their occupation, the place where the event occurred and a brief note on what happened.

The following injuries or ill health must be reported:

- The death of any person
- Specified injuries including fractures, amputations, eye injuries, injuries from electric shock, and acute illness requiring removal to hospital or immediate medical attention
- 'over-seven-day' injuries, which involve relieving someone of their normal work for more than seven days as a result of injury caused by an accident at work
- Reportable occupational diseases, including
- Cramp of the hand or forearm due to repetitive movement;
- Carpal tunnel syndrome, involving hand-held vibrating tools;
- Occupational asthma
- Tendonitis or tenosynovitis (types of tendon injury);
- Hand-arm vibration syndrome (HAVS), including where the person’s work involves regular use of percussive or vibrating tools
- Occupational dermatitis

- Near misses (described in the Regulations as 'dangerous occurrences'). The HSE has produced a list of the kinds of incidents regarded as 'dangerous occurrences'.

1.8 Health & Safety Precautions

Following precautions may be observed at workplaces.

- Your safety is your personal responsibility.
- Never take shortcuts.
- Clean and organize your workspace.
- Ensure a clear and easy route to emergency exits and equipment.
- Be alert and awake on the job.
- Be attentive at all times to your work surroundings.
- When in doubt, contact your supervisor or manager for instruction, guidance, or training.
- Never take risks when it comes to safety.
- Obey safety signs, stickers, and tags.
- Take short breaks when you keep up a repetitive motion for a long period of time, and sit, stand, or walk with good posture.
- Report serious injuries immediately to a supervisor and get emergency assistance.
- Keep things in perspective. Hazards may be limitless, so focus on the most likely risks first.

1.9 Reporting Injuries, Diseases & Dangerous Occurrences

There is a legal obligation to report certain types of incident in the workplace to the relevant authorities. Employers, self-employed people, and people in control of premises have a legal duty to report the following:

- Work-related deaths
- Major injuries or over-three-day injuries
- Work related diseases
- Dangerous occurrences (near miss accidents)
- Reporting of injuries, diseases and dangerous occurrences

Every incident report you file should contain a minimum of the following:

- Type of incident (injury, near miss, property damage, or theft)
- Address

- Date of incident
- Time of incident
- Name of affected individual

A narrative description of the incident, including the sequence of events and results of the incident.

- Injuries, if any
- Treatments required, if any
- Witness name(s)
- Witness statements
- Other workers involved
- Video and/or 360-degree photographs of the scene

Include quantifiable measurements where possible. For example, the ladder capacity is 250 lbs and the victim was hoisting 300 lbs. Finally, where more than one person is injured in an incident, create a unique report for each affected employee.

Activity 1.3
Identify any potential hazards and take appropriate actions to minimize risks
Components/Instruments
Writing material etc.
Step 1: Identification of any potential hazard(s)
Step 2: Take Necessary actions to minimize risks
Step 3: Record the findings

1.10 Fire Extinguisher

A fire extinguisher is an external fire safety system useful to extinguish or control minor fires, often in emergency cases. It is not for use in an out-of-control fire, such as where the fire has reached the ceilings, endangering the customer (i.e., no escape route, smoke, explosion hazard, etc.) or otherwise requires the skills of a fire brigade. Usually, a fire extinguisher consists of a hand-held cylindrical pressure vessel carrying an agent which discharges to extinguish the fire. Fire extinguishers produced with non-cylindrical pressure vessels do exist but are less common.

Fig 1.15 Fire extinguisher

i. Types of Fire and Fire Extinguisher

Types and Classes of Fire Extinguishers

There are five different kinds of fire extinguishers, including wet chemical, CO2, dry powder, foam and water. The requirement for different types of fire extinguishers comes from the different kinds of fuel that can cause a fire.

The various kinds of fires caused by the various types of fuels are categorize into different classes of fires.

Classes of Fires

There are six different types of fire classes

Class A Fire:

Class A fires involve fires caused by fuel materials, including paper, cloth, wood and other flammable solids.

Class B Fire:

Class B fires involve fires triggered by flammable liquids, such as paint, turpentine and petrol, among several others.

Class C Fire:

Class C fires involve fires ignited by flammable gases, including methane, butane or hydrogen, among several others.

Class D Fire:

Class D fires involve fires by combustible metals including potassium, aluminium or magnesium, among several others.

Class F Fire:

Class F fires involve those caused by cooking oils, such as a chip pan fire.

Electrical Fire:

Electric fires apply to the type of fires involving electrical equipment, but after the removal of electrical appliances, the type of fires is changed.

Types of Fire Extinguishers

Foam Extinguishers

Foam Extinguishers are the most common form of fire extinguishers useful for class B fires. However, they are water-based, which means that they are also useful in extinguishing class A fires. These fire extinguishers are for fires caused by various organic materials, like woods, cardboard, coal, textiles and paper, and flammable liquids, including petrol and paint.

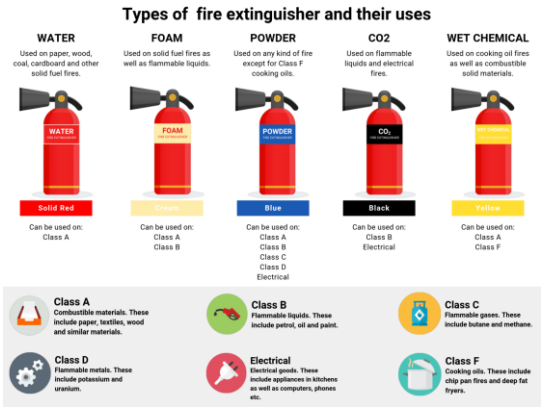


Fig 1.16 Different types of Fire extinguisher

Water Extinguishers

Water Extinguishers; Work as same as foam extinguishers. These are useful for class A fires. Water Extinguishers are also used for fires caused by various organic materials, like woods, cardboard and paper. It is also not useful for fires caused by flammable metals, kitchen fires and fires involving electrical appliances.

Dry Powder Extinguishers

Generic dry powder extinguishers are also known as ABC extinguishers. These can be useful for class A, class B and class C fires. They are not for use in confined spaces as the dry powder in the extinguisher can be inhaled. Often, it's not easy to clean up the residue after the fire. They can also be useful for fires involving electrical appliances.

Along with fires caused by various organic materials, like woods, textiles and paper, and flammable liquids, including petrol and paint, any fire involving electrical equipment up to 1000 V can extinguish with the aid of this fire extinguisher.

Wet Chemical Extinguishers

Wet chemical extinguishers are for use in Class F fires, like cooking oils and fats. They are also useful in Class A fires, but it is more common to use a foam or water extinguisher for this fire hazard.

Carbon Dioxide (CO2) Extinguishers

Carbon Dioxide (CO2) Extinguishers are primarily in use for electrical fire hazards and are typically the primary type of fire extinguisher in data server rooms. They put out Class B fires, too. CO2 extinguishers suffocate fires by displacing the oxygen that the fire needs to burn.

Working of Water Fire Extinguishers

As the fire brigade begins to spray water over the areas where the fire occurred, the water cools off the fire temperature. The ignition temperature of the fuel decreases due to the continuous water spraying. So fuel can no longer burn, so it stops the fire from spreading. In addition, water vapors block the oxygen supply on the fuel surface, thus reducing the supply of oxygen to the fuel surface.

Activity 1.4
Operate Fire Extinguisher
Components/Instruments
Fire Extinguisher, Writing material
Step 1: Arrange class in groups to visit the place where fire extinguisher is located Step 2: Guide students how to operate fire extinguisher Step 3: Give them task to operate fire extinguisher separately Step 4: Record the findings(if any)

Key points

- Occupational Health and Safety rules are designed to create a safe and healthy work environment.
- Safety Symbols are stylized with bold backgrounds to warn people that serious injuries can occur from burn, electric shocks, and hazards
- There are different kinds of electrical safety symbols which are used for electrical safety signs
- A Hazard is a potential source of harm or adverse health effect on a person or persons.
- Chemical hazard is the risk associated with processing of different chemicals
- Electricity can kill or severely injure people and cause damage to property.
- Risk assessment process is a process to identify processes and situations that may cause harm, particularly to people
- Personal protective equipment' (PPE)
- A fire extinguisher is an external fire safety system useful to extinguish or control minor fires, often in emergency cases

EXERCISE

Select the most appropriate option (✓)

1. Try to save the life and the property during work is called -------

   a. punctuality
   b. safety
   c. obedience
   d. governance

2. A sudden and unexpected event is called ----------

   a. prediction
   b. accident
   c. occurrence
   d. mishap

3. In chemical industries, poisonous atmosphere can create --------

   a. bad smell
   b. fatal taste
   c. chest infection
   d. all of the above

4. Once you have spotted a hazard you must

   a. report it to your boss
   b. inform to your colleagues
   c. fix at your own
   d. ignore it

5. Electrical burn is the result of which of the following hazards

   a. mechanical
   b. chemical
   c. electrical
   d. biological

6. Facial protective equipment is

   a. sun glass
   b. face shield
   c. mask
   d. helmet

7. Fire results from a combination of

a. fuel, temperature and water
b. temperature, oxygen and fuel
c. oxygen and fuel
d. water and fuel

8. A work place emergency evacuation plan is the responsibility of

a. company management
b. the government
c. health and safety officer
d. individual

9. Accidents can be controlled by

a. healthy environment
b. decreasing man power
c. training of personal
d. bothe a & c

Give short answer of the following Questions

1. Define Occupational Health & Safety (OHS)
2. List any two electrical hazards
3. Enlist any three causes of hazards at workplace
4. Enlist any three personal protective equipment.
5. What is Hazard?
6. Define risk.
7. Enlist any three hazards found at workplace
8. Why safety laws are necessary?

Answer the following question in detail

1. Write a note on importance of occupational health and safety
2. Explain the personal protective equipment for protecting hands, face, ear, eyes and foot
3. Explain health and safety precautions, regulations/guidelines.
4. Explain the types of Fire Extinguisher and their uses.
5. Describe health and safety regulations.

Practical Activities

1. List PPE available and required to work in lab/ Institute.
2. Recognize the required tools, equipment, PPEs and consumable materials
3. Use Personal Protective Equipment (PPE) and ensure safe handling of equipment.
4. Identify any potential hazard and take appropriate action to minimise the risk.

Instructions for the Teachers

1. Explain the Purpose of the Task. ...
2. Make Sure Your Students Understand.
3. Adopt Health and Safety measures in the lab
4. Use all the available ICT resources for better delivery of the content
5. Ensure proper functioning of lab equipment/PPEs

Chapter 02

Communication Skills

Students Learning Outcomes

After completion of this chapter you will be able to:

- treat team members with respect and maintain positive relationships to achieve common organizational goals.
- provide work related information to team members and identify interrelated work activities to avoid confusion.
- adopt communication skills appropriate to work activities and company procedures.

- collect and confirm work requirements from clients using appropriate communication procedures.
- provide clear information to clients about work.
- provide the requirements including costs and time needed to accomplish the task.
- negotiate with clients regarding wages, time, labor requirements etc.
- create folders and files and learn major commands of operating system/windows.
- type text and use major commands such as printing, editing, creating tables, header footer, footnotes, table of contents and page number etc.
- generate reports for clients using appropriate computer application.
- use internet for sending/receiving emails and connecting through social or other media.

2.1 Working in Team

Working in a team means working with a group of people to achieve a shared goal or outcome in an effective way. Listening to other members of the team and taking everyone's ideas on board, not just your own and working for the good of the group as a whole is the ultimate objective of working in team.

Following practices should be adopted for working in team.

i. Development of Positive Relationships

Here are few tips which can be effective to each other while working in a team:

- Trust yourself, trust your teammates, and stand by one another when issues or mistakes arise.
- Show up, own your work, and do it to the best of your abilities.
- Recognize and respect the efforts and ideas of others.
- Be able to offer and accept constructive criticism.
- Share the goals of the team and work to support them.
- Always communicate with the team and never presume a colleague or customer understands what you're planning, or the work you've done.
- Recognize the skills and talents of your teammates
- Support and respect one another, never undermine with petty jealousy, prejudice, gossip.
- Divide the tasks proportionately among team members.

ii. Provide Work Related Information

Understanding your audience is essential to effective communication at work. This applies to verbal and written communications, presentations, daily emails, companywide announcements or providing status updates on projects. Whether or not your message will be effectively communicated or well received stems from understanding what your audience cares about.

- Who are you targeting with your communication?
- What is the intent of your message?
- What do they need to know?
- What do you need them to do?
- What's the best way to communicate the message to your audience?

- How will your audience perceive or interpret the message?
- How will your audience feel, think, and react when they receive your message?

In order to answer these questions, you'll need to plan ahead, research, and observe the behaviors of your audience. For example, your approach to communication with your team or peers will likely be different from how you communicate to your leader because these groups have different interests.

Activity 2.1
Make a group of 5 students. Visit electrical lab in your school. Make a report of available instruments in the lab
Components/Instruments
Writing material etc.
Step 1: Arrange the class in groups of 5 students Step 2: Conduct visit of electrical lab Step 3: Enlist all the available instruments in lab Step 4: Make a report to show the effective communication skills working as team member

iii. Adopt Appropriate Communication Skills

The relationships between staff in the organization can be:

● **Linear** – this shows a direct relationship between someone in a higher position and someone in a lower position

● **Lateral** – this shows relationships between different departments on the same hierarchical level.

● **Staff** – this shows the relationship between a managerial assistant and other areas. The assistant will be able to offer advice to a line manager, but they have no authority over the line manager's actions.

● **Functional** – this shows the relationship between specialist positions and other areas. The specialist will normally have the authority to ensure that a line manager puts in place any of their instructions.

Activity 2.2
Identify problems and resolve them through discussion and mutual agreement
Components/Instruments
Writing Material etc.
Step 1: Assign task to each student to identify the problem Step 2: Resolve them through discussion Step 3: Adopt effective communication skills Step 3: Record the findings

2.2 Dealing with Clients

Any company's most vital asset is its customers/clients, so you need to make sure you're dealing with your customers properly. Without them, you would not, and could not, exist in business Sometimes it can be challenging to build those relationships.

Following are the few steps to appropriately deal with clients.

i. Collect & Confirm Work Requirement

The collect requirement is the process of determining, documenting, and managing stakeholder needs & requirements to meet project objective using appropriate communication procedure.

Collection Requirement Process

Step 1: Identify the needs of the client

Step 2: Document the needs & requirements.

Step 3: Manage them throughout the project to meet project goals.

a. Sharing Information regarding Project Cost & Execution Time

The information regarding the project cost and its execution timeline be properly shared with the clients and should also be properly documented.

b. Negotiating Labor Requirements (Wages & Time)

All the requirements of the labor pertaining to the project should also be shared and negotiated with client. It is also necessary to document the detail and brought in the form of agreement.

Activity 2.3
Make a team of five students. Assign two students the role of Service Provider and three students the role of Client. Carryout discussion.
Components/Instruments
Writing Material etc.
Step 1: Assign task to each student Step 2: Guide the students for effective discussion among service provider and clients

2.3 Basic IT Skills

In any profession communication skills play a vital role. For effective communication use of IT is need of the time. Following are the aspects of effective communication

i. Creating Folders & Files

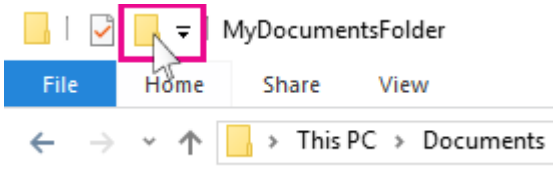
A file is the **common storage unit** in a computer, and all programs and data are "written" into a file and "read" from a file. A folder holds one or more files, and a folder can be empty until it is filled. A folder can also contain other folders, and there can be many levels of folders within folders. In Windows, the primary way of interacting with files and folders is through the File Explorer application.

a. Create a new folder

Open File Explorer using one of the following methods:

- Press the Windows logo key + E.
- Find it from the Start menu (Windows 7 or Windows 10).
- Click the folder icon in the taskbar.
- For Windows 8 or Windows 8.1, swipe in from the right edge of the screen, and tap Search. If you're using a mouse, point to the upper-right corner of the screen, move the mouse pointer down, and click Search. Type File Explorer in the search box, and then tap or click File Explorer.

a) Navigate to where you want to create the new folder, and click New Folder.



3. Type the name of your folder, and press Enter.
4. To save a document to the new folder, open the document, and click **File** > **Save As**, and then browse to the new folder, and click **Save**

b. **Creating a file**

- How do I create a file on a computer? Right click anywhere on your desktop or inside an Explorer window, then highlight New.
- Select the new file type you want, and click it.
- If you want to create a new file of a type not included in this list, you'll have to create it from within the program you're using.

ii. Use of major commands

Printing Document

Printing a document following method is used.

- Click the File Menu and select the Print command from menu OR Press
- Ctrl + P keyboard shortcut. The Print dialog box will appear as shown in figure.
- Click the Name field to select your preferred printer (if more than 1 printer).
- In Page Range area, select one of following options

All: to print all pages in document

Current Page: to print only what you see on current screen.

Pages: to print part of document. For example, type 3-6 to print only pages 3 through 6 OR to print non-sequential pages like 2, 5, 9, 14 etc.

Selection: to print only highlighted text or graphics.

- Enter the required number of copies in the Number of Copies field.
- If you want to print more than one page per sheet, then select the required number in the Pages per Sheet field.
- Click OK to get printouts or hardcopies.

Editing Document

Text editing is the ability to change text by adding, deleting and rearranging letters, words, sentences and paragraphs.

Creating Tables

Procedure to create table

A table is a means of arranging data in rows and columns. The intersection of rows and columns forms cells. A cell is the unit of table to enter data. It's often easier to read or present information in table format than in paragraph format. Using MS Word's table, you can insert text and pictures etc. into the table's cells.

There are two procedures to insert table, by selecting rows and columns and using Insert Table dialog box.

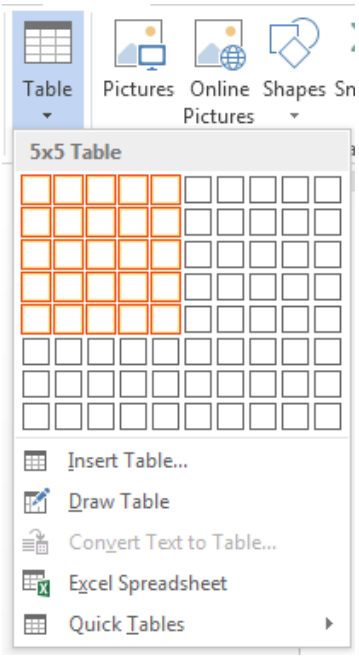


Fig 2.1 inserting a table

1. Rows and Columns Selection Method

- On the Insert ribbon, Click the Table button
- Drag your mouse across the white boxes.
- They will highlight across and down.
- The top bar will tell you how many rows and columns you are creating.
- Click the mouse when you have reached your desired size.

2. Using Dialog Box Method

- On the Insert ribbon, Click the Table button
- Select Insert Table option, Insert Table dialog will open
- Provide Number of Columns and Number of Rows in dialog box.
- You can set AutoFit behavior of table by selecting one choice (optional)
- Click on OK button to create your desired table

Procedure to Modify a Table

To Insert a Row:

- Position the cursor in the table where you want to insert a row
- Select the Layout tab on the Ribbon
- Click either the Insert Row Above or the Insert Row Below button in the Rows & Columns group.

To Insert a Column

- Position the cursor in the table where you want to insert a column
- Select the Layout tab on the Ribbon

- Click either the Insert Columns to Left button or the Insert Columns to Right button in the Rows & Columns group

To Delete a Row

- Position your cursor in the row that you would like to delete
- Select the Layout tab on the Ribbon
- Click the Delete button in the Rows & Column group
- Select Delete Rows

To Delete a Column

- Position your cursor in the column that you would like to delete
- Select the Layout tab on the Ribbon
- Click the Delete button in the Rows & Column group
- Select Delete Columns

Header & Footer

The header is a section (blank space) that appears in the top margin, while the footer is a section (blank space) that appears in the bottom margin.

Header & Footer generally contains important information such as page numbers, date, time, author name, publisher name, chapter name, book name, and document name etc.

Following are the steps to insert header and footer:

- Go to Insert > Header or Footer.
- Choose the header style you want to use. Tip: Some built-in header and footer designs include page numbers.
- Add or change text for the header or footer. ...
- Select Close Header and Footer or press Esc to exit.

Footnotes

Footnotes appear at the bottom of the page and end notes come at the end of the document. A number or symbol on the footnote or endnote matches up with a reference mark in the document.

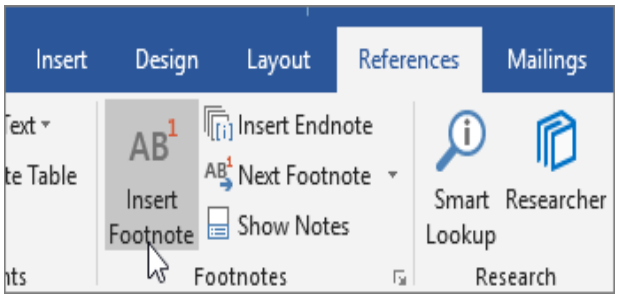


Fig 2.2 Inserting Footnotes

- Click where you want to reference to the footnote or endnote.
- On the References tab, select Insert Footnote or Insert Endnote.
- On the References tab choose Insert Footnote
- Enter what you want in the footnote or endnote.
- Return to your place in the document by double-clicking the number or symbol at the beginning of the note.

Insert page numbers

- Select Insert > Page Number, and then choose the location and style you want.
- If you don't want a page number to appear on the first page, select Different First Page.
- If you want numbering to start with 1 on the second page, go to Page Number > Format Page Numbers, and set Start at to 0.
- When you're done, select Close Header and Footer or press Esc.

Activity 2.4 **Generate reports for clients using appropriate Computer Applications**
Components/Instruments Writing Material, computer etc.
Step 1: Assign task to each student Step 2: Guide the students to Generate reports for clients using appropriate Computer Applications Step 3: record the findings

iii. Use of Internet

Internet is used in every aspect of our daily life. In our official communication we use internet for sending/receiving emails, connecting with social media and searching relative information. We use internet for following purposes.

Email

Email, short for "electronic mail," is one of the most widely used features of the Internet, along with the web. It allows you to send and receive messages to and from anyone with an email address, anywhere in the world.

Email is accessible from anywhere – as long as you have an internet connection. Email is paperless, and therefore, beneficial for the planet.

Write names of two email service provider companies and write method of sending a file through email?

Yahoo mail, Gmail are two email service providers.

- Open Gmail.
- On the left, click Compose.
- To change your window size, in the upper corner, click
- Maximize or Exit Full Screen.
- Add recipients and a subject.
- Enter your message. Email you start writing but don't send are automatically saved in Drafts on the left.
- (Optional) Add attachments, such as Drive files or photos.
- Click Send.

Write method of reading an e-mail.

- From the Gmail inbox, click the tab that contains the type of message you want to view. Your most important messages should be on the Primary tab.
- Select the message you want to read and click anywhere on that message's message line.
- The full text of the message is displayed, as shown in figure below. You can now reply to, forward, or delete the message, as described in the following sections

Activity 2.4 Make a detail invoice for client and send it to him along with your company profile by email as per demand.
Components/Instruments Computer, internet, email account etc
Step 1: Assign task to each student Step 2: Guide the students to make a detail invoice for client and send it to him along with your company profile by email as per demand.

Key points

- Working in a team means working with a group of people to achieve a shared goal or outcome in an effective way
- **Linear** – this shows a direct relationship between someone in a higher position and someone in a lower position
- **Lateral** – this shows relationships between different departments on the same hierarchical level.
- **Staff** – this shows the relationship between a managerial assistant and other areas. The assistant will be able to offer advice to a line manager, but they have no authority over the line manager's actions.
- **Functional** – this shows the relationship between specialist positions and other areas. The specialist will normally have the authority to ensure that a line manager puts in place any of their instructions.
- In any profession communication skills play a vital role. For effective communication use of IT is need of the time
- **Ctrl + P** keyboard shortcut. The Print dialog box will appear
- Text editing is the ability to change text by adding, deleting and rearranging letters, words, sentences and paragraphs
- A table is a means of arranging data in rows and columns.
- Footnotes appear at the bottom of the page and endnotes come at the end of the document.
- Internet is used in every aspect of our daily life
- Email, short for "electronic mail," is one of the most widely used features of the Internet, along with the web.

EXERCISE

Select the most appropriate option (✓)

1. Microsoft Word is a Program.
a. Spreadsheet
b. Word Processing
c. Presentation
d. Database
2. What is included in Microsoft Office?
a. Word
b. Excel
c. PowerPoint
d. All of these
3. Which shortcut key is used to save a file in MS Word?
a. Ctrl + O
b. Ctrl + N
c. Ctrl + S
d. Ctrl + M
4. In a table data is arranged in.
a. rows and column
b. rows and shapes
c. column and circles
d. shapes and circle
5. Which item is placed at the end of a page?
a. Footer
b. End Note
c. Foot Note
d. Header
6. Global network of computers is called:
a. Internet
b. Networking
c. Intranet
d. Extranet
7. All the received emails are stored in ----------folder of your email account.
a. Inbox
b. Sent
c. Spam
d. Draft

Short Answer of the following question

1. What is major objective of working in team?
2. Enlist three essential communication skills?
3. Enlist three objectives of meeting with clients.
4. What is Microsoft Office?
5. Enlist any three MS office applications.
6. What is difference between SAVE and SAVE As command?
7. Write any three advantages of internet.
8. What is meant by "Sign in" with respect to email?

Answer the following question in detail

1. Enlist few tips which can be effective while working in team.
2. Explain the advantages of communication skills for effective communication with clients.
3. Explain the procedure to create, edit and save file in MS Word?

Practical Activities

1. Send a small presentation (Power Point) of your company along with this invoice.

Instructions for the Teachers

1. Explain the Purpose of the Task. ...
2. Make Sure Your Students Understand.
3. Adopt Health and Safety measures in the lab
4. Adopt effective communication skills in the lab
5. Use all the available ICT resources for better delivery of the content
6. Ensure proper functioning of lab equipment/PPEs

Chapter 03

Technical Drawing

Students Learning Outcomes

After completion of this chapter you will be able to:

- describe meaning, importance and use of technical drawing
- describe drawing instruments, their construction, use and handling.
- describe the types of basic lines.
- describe the types of alphabet of lines with their weight, shape and proper construction.
- describe angles, triangles, quadrilateral, polygons and circle elements.
- describe the importance of sketching
- describe the procedure of sketching for shapes, geometric figures and models
- describe the procedure to draw the front, side and top view of an object.
- describe the procedure to draw the isometric and pictorial drawings of simple shape and models

3.1 Introduction of Technical Drawing

A Technical Drawing is a detailed, precise diagram or plan that conveys information about how an object functions or is constructed. It is also called engineering drawing. Engineers, electricians, and contractors all use these drawings as guides when constructing or repairing objects and buildings. Technical drawings bridge the communication between designers, the people who come up with ideas, and producers, the people who put those ideas into practice. It is designed as a universal language to be understood by engineers, contractors, and architects. The end goal of an engineering drawing is to convey all the required information that will allow a manufacturer to produce that component. Technical drawings are intended to convey one specific meaning, as opposed to artistic drawings which are expressive and may be interpreted in a number of ways.

i. Importance of Technical Drawing

- It is very difficult and complex to explain some certain engineering requirements without drawing.
- Well dimensioned and properly scaled graphics can make it easy to understand.
- It provides standards for Technical Personnel
- Any product that is to be manufactured, fabricated, assembled, constructed, built, or subjected to any other types of conversion process must first be designed.
- Is the best way to make the outcome from the design understandable to any third party?

ii. Use of Technical Drawing

Engineering drawing is an essential part of almost all engineering projects. Some important uses of engineering drawing are mentioned below:

- To explain any Mechanisms
- To explain in detail, the complex components of the machines
- To make any product for understandable.
- To convey the ideas of Engineers & designers to the workers
- Technical drawings are used for communication between people involved in design and manufacturing process of some kind of device/construction.
- It is used to show customers the dimensions of a product.

- To make a job that can be put into production.
- It is used in ships for navigation
- For manufacturing of machines, automobiles etc.
- For manufacturing of electric appliances like TV, phone, computers etc.

3.2 Drawing Instruments

i. Drawing Pencil

Pencils are the main drawing instruments used to draw the lines, circles, arcs, polygons, etc.

A **pencil** is a writing utensil with a graphite lead embedded in a wooden shaft. It is mainly used for artistic sketching and drawing, for stenography or notes. Its benefits are the simple usage as well as being able to remove what you've drawn with an eraser. Pencils are used to draw different lines, shapes, symbols and to write texts in engineering drawing.

Types of Drawing Pencils

- **Graphite Pencils**: These are the most common pencils used in art and writing.
- **Charcoal Pencils**: Create dark and rough lines, but not as versatile as the other options.
- **Colored Pencils**: Similar to normal graphite pencils but in color.

Based on the hardness of lead pencils are classified in three major grades ashard, medium and soft.

Most students are familiar with HB pencil, but few know what the 'HB' actually refers to. These grades refer to the hardness and texture of the lead.

- **H stands for hard:** An H grade pencil has more clay in its lead, and it will make a lighter, finer line. The higher the corresponding number, the lighter the lead. So, a 9H pencil is the hardest and lightest pencil, and more like a chisel. H leads do not smudge easily.
- **B stands for blackness:** A B grade pencil has more graphite, and will make a bolder, darker line. The higher the corresponding number, the softer and darker the lead. So, a 9B pencil is the softest and blackest available. B leads smudge easily but are readily erased.
- **F stands for fine point:** A F pencil is capable of producing darker and lighter marks but without any extremes. F leads can stay sharp for a longer period of time – hence why

they're called 'fine'. Generally, for technical drawings, the three grades of the pencil used are HB, H, and 2H. HB pencils fall into the middle of the scale. It is the standard writing penciland also good for linear drawing.

Grade of Pencil	**Hardness of Pencil**
9H	Hardest
6H, 5H, 4H	Extremely Hard
3H	Very hard
2H	Hard
H	Moderately hard
F	Firm
HB	Medium hard
B	Moderately soft and black
2B	Soft and black
3B	Very soft and black
4B, 5B, 6B	Very soft and very black
7B	Softest

Out of the above grades of pencils, the following grades are used in engineering drawings.

Grade of Pencil	**Used to Draw**
3H	Construction lines
2H	Dimension lines, center lines, sectional lines, hidden lines
H	Object lines, lettering
HB	Dimensioning, boundary line

ii. Drawing Paper Specifications

Drawing paper is generally made out of wood cellulose, or cottoncellulose.

Selection of Paper

For ordinary pencil-drawings:

- The paper selected should be tough and strong.
- It should be uniform in thickness
- As white as possible
- When the rubber eraser is used on it, its fibers should notdisintegrate
- Should have good quality and smooth surface
- The paper sizes for architectural, structural and mechanicaldrawing should be A1, A2 or A3.
- Do not use A4. A4 paper size is too small and it looksunprofessional.
- Do not use A0. A0 paper size is too big and it is difficult tohandle.

ISO standard determines the paper dimensions for the A paper series. The most common paper sizes are A0, A1, A2, A3, A4 and A5. The table below shows the dimension of the most common A series paper sizes.

Paper size	**Dimensions (cm)**	**Paper Area**
A5	14.8 x 21 cm	0.03108 m^2
A4	21 x 29.7 cm	0.0612 m^2
A3	29.7 x 42 cm	0.125 m^2
A2	42 x 59.4 cm	0.25 m^2
A1	59.4 x 84.1 cm	0.50 m^2
A0	84.1 x 118.9 cm	1 m^2

iii. Drawing Sheet

Drawing sheet is the material on which the drawings are made. It has been briefly explained in above topic.

iv. T-Square

T-square is a tool used in technical drawing, primarily as a guide to draw straight horizontal lines on a drafting table. It can also be used in conjunction with a set square to draw vertical and

angled lines. Its name is derived from its resemblance to the letter 'T'.

v. Drawing Table/Board

Drawing boards are usually made of white pine, but are sometimes made of other soft woods. The fig shows acommon drawing board.

Drawing board is used to place drawingsheet on it.

Fig 3.1 Drawing table

vi. Set-square

A set square is an object used in engineering and technical drawing, with the aim of providing a straight edge at a right angle or other particular angle to a baseline. The two common set squares are the 45° and the 60°-30° set square.

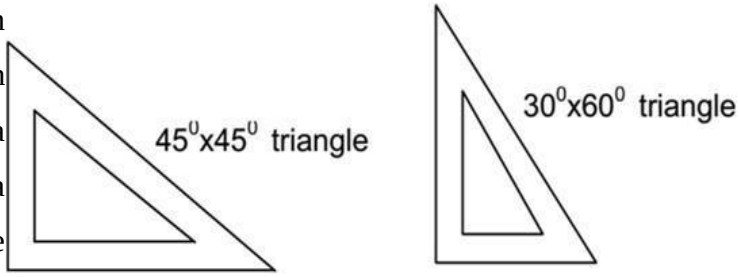


Fig 3.2 Set Square

a. Protector

A protractor, or half circle, is used for measuring or setting off angles other than those obtainable with the set squares. It is divided into 180 equal parts. Each division is one degree.

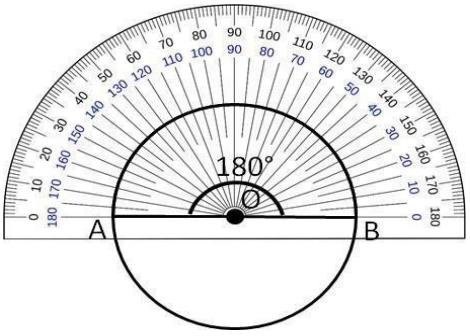
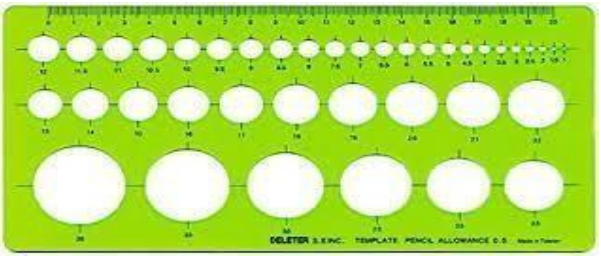


Fig 3.4 Protector Set

b. Scale

In most cases the object that is to be drawn is too big or too small to fit onto the paper available. The drawing can be scaled down using a scale to allow it to be drawn on paper. The scale tells you how many times smaller, or bigger, the drawing is compared to the finished product.



c. **Drafting Templates**

A template is a thin and flat piece of plastic containing various cutout shapes.

French Curves

When it is required to draw mechanical curves other than circles or circular arcs, a French curve is generally employed.

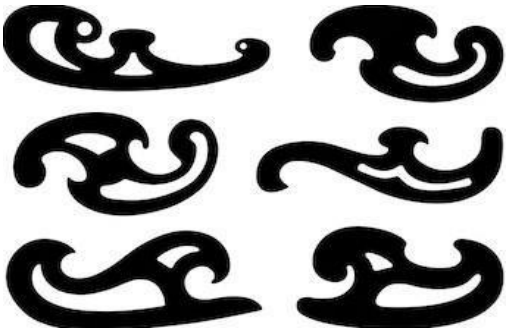


Fig 3.6 French Curves

d. **Divider**

A divider is a drawing instrument used for dividing distances into equal parts or for laying off a series of equal spaces. Dividers like shown in Fig.

Compass

It is used to draw circles and arcs both in pencil and ink.

Fig 3.6 Compass

Sand Paper block

All the lines drawn on sheet have different thickness, to achieve required uniform thickness of lead sand paper block is used.

e. **Duster**

Duster should preferably be of towel cloth of convenient size. Before starting work, all the instruments and materials should be thoroughly cleaned with the duster.

f. **Eraser (Rubber)**

Soft rubber is the most suitable kind of eraser for pencil drawings.

It should be such as not to spoil the surface of the paper.

g. **Pencil Sharpener**

A pencil sharpener is a tool for sharpening a pencil's writing point by shaving away its worn surface in conical shape.

h. **Drafting Machine**

The uses and advantages of the T-square, set-squares, scales and the protractor are combined in the drafting machine. Its one end is clamped by means of a screw, to the distant longer edge of the drawing board. A drafting machine is shown below.

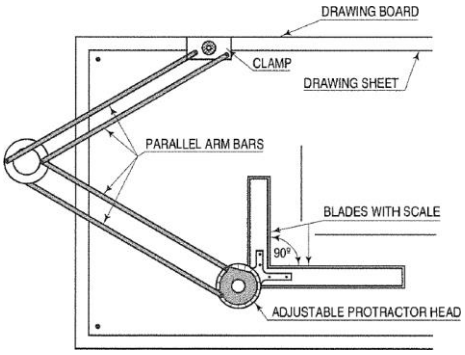


Fig 3.7 Drafting machine

Activity 3.1 Identify drawing instruments
Components/Instruments Drawing instruments, Pencils, etc.
Step 1: Identify all the technical drawing instruments available in lab/workshop

3.3 Basics and Alphabets of Lines

i. Line

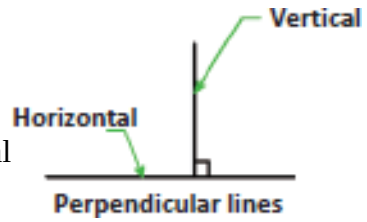
Line can be defined as a path between two points.

Path generated by moving point under certain conditions.

Geometric figurethat has only one dimension or length. Lines are of following types:

ii. Straight Line

The shortest distance between two points is called straight line.

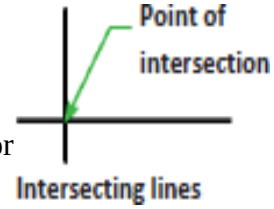


iii. Horizontal Line

A Straight Line drawn from left to right relative to a horizontal reference line iscalled a horizontal line.

iv. Vertical Line

A Straight Line drawn from top to bottom perpendicular to the Horizontal is called vertical line.



v. Parallel Lines

If two lines are equidistant throughout their length and will nevermeet or cross are called parallel lines. The symbol for parallel line is //.

vi. Intersecting lines

Two or more lines crossing each other arecalled intersecting lines.

vii. Point of intersection

The exact location where two lines intersectis called point of intersection.

viii. Perpendicular lines

Lines that intersect or cross and form a right angle are calledperpendicular lines.

The symbol for perpendicular is ⊥.

3.3 Types of alphabet of lines

Object or visible lines – Thick dark line use to show outline of object, visible edges and surfaces.

Construction line – Very light and thin line use to construct layout work.

Dimension line – Thin and dark lines use to show the size (span) of an object with a numeric value. Usually terminates with arrowheads or tick markings.

Hidden line – Short dash lines use to show non visible surfaces. Usually shows as medium thickness.

Centre line – Long and short dash lines. Usually indicates center ofholes, circles and arcs. Line is thin and dark.

Extension line – Thin and dark line use to show the starting and ending of dimension.

Cutting plane line – Extra thick line use to show cutaway views or plane of projection where a section view is taken. Arrow indicates direction ofview.

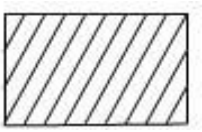
Short and long break lines –Short and long medium line use tshow cutaway view of a long section.

Leader line – Medium line with arrowhead to show notes or label forsize or special information about a feature.

Phantom line – Long line followed by two short dashes

use to showalternate position of a moving part.

Section line – Medium lines drawn at 45 degrees use to show interior view of solid areas of cutting plane line.



ix. Uses of lines

- To organize information
- To connect elements of design
- To separate different parts of product
- To provide definite shape
- Used to convey movement and create texture
- Straight line graphs are used in the research process
- Line graphs are used in preparation of the government budget etc.

3.4 Geometrical Construction

In Geometrical construction following elements are generally considered:

i. Angle
ii. Triangle
iii. Quadrilaterals
iv. Polygon
v. Circle elements

Angle

An angle is a space or opening betweentwo straight lines, intersecting at a point called vertex. Angles are measured in degrees (◦) minutes (′), and seconds (″).

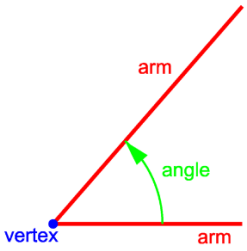


Fig 3.10 Angel

Acute Angle

An angle less than 90° is called acute angle.

Right Angle

An angle of 90° is referred to as a right angle.

Obtuse Angle

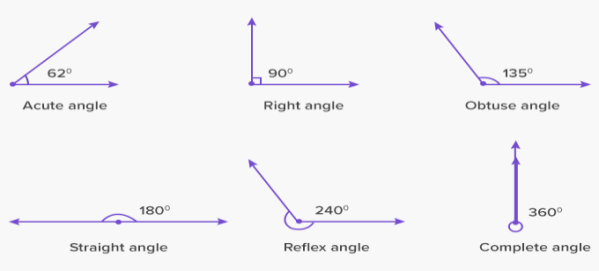


Fig 3.11 Different type of Angels

An angle less than 180° but greater than 90° is called obtuse angle.

Straight Angle

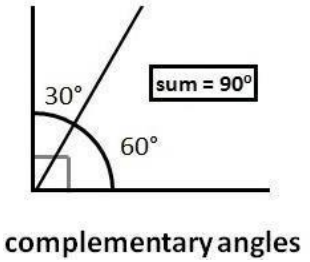
A straight angle is an angle of 180° and appears as a straight line.

Reflex Angle

An angle greater than 180° and less than 360° is called reflex angle.

Complimentary Angles

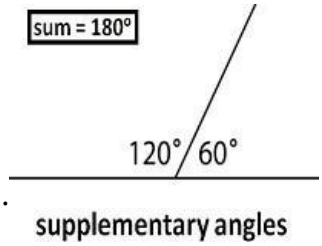
When two angles are combined to total 90°, they are referred to ascomplimentary angles.



complementary angles

Supplementary Angles

When two angles combine to total 180° called supplementary angles.



supplementary angles

Polygons

A polygon is a plane figure bounded by three or more straight sides. Polygons can be mainly classified as regular and irregular.

Irregular Polygons

Irregular polygons are plane figures which either their sides or angles are of different sizes.

Regular Polygons Regular polygons are planes which their sides are kept in a regular manner, such as equal length, equal angles and so on (including equilateral triangles and squares).Sum of the interior angles of a polygon $\sum = (2N - 4) \times 90° = (N - 2) \times 180°$ Where N is the No. of side or angles of polygons.

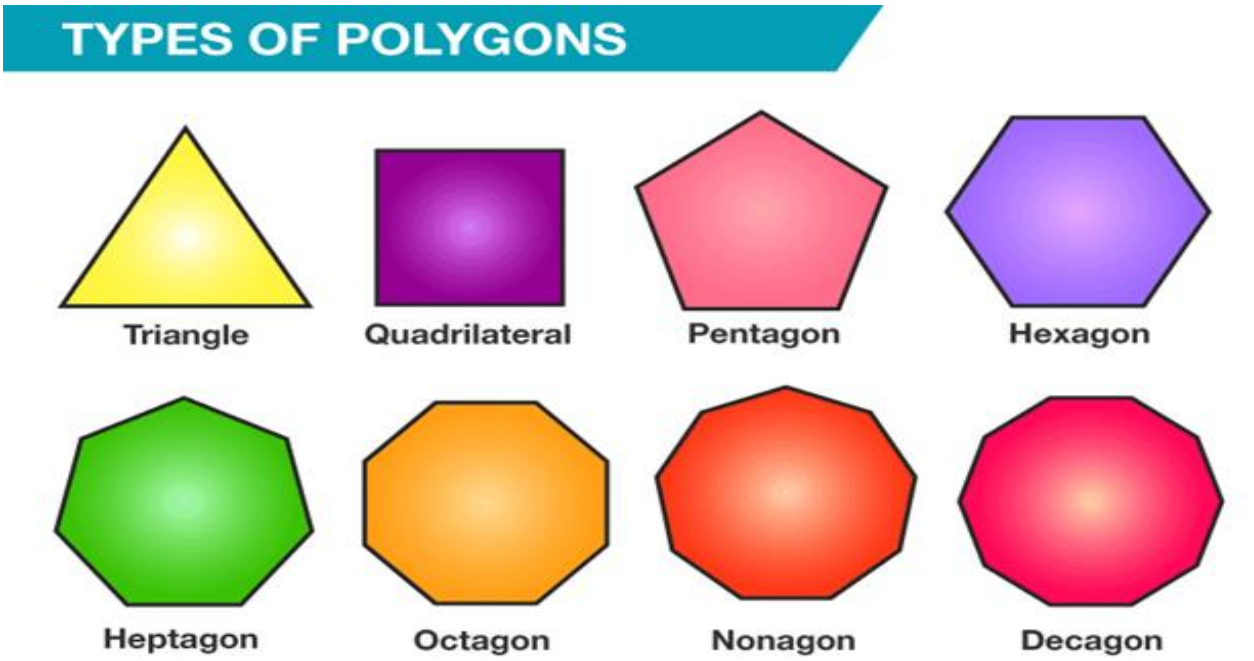


Fig 3.12 Different type of Polygons

Triangle

A plane figure having three sides is called at triangle. The sides of a triangle make three interior angles and the sum of these angles is always 180°.A triangle is classified either by its side or with its angle.

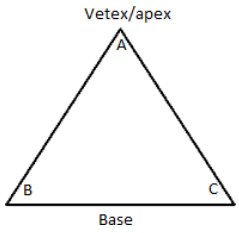


Fig 3.13 Triangle

Classification by its Sides

Equilateral triangle: When all sides and all interior angles (60°) are equal, the triangle is referred to as an equilateral triangle.

Isosceles triangle: When two sides and two angles are equal, thetriangle is an isosceles triangle.

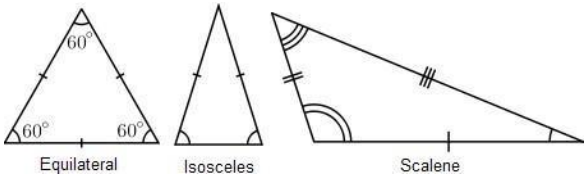


Fig 3.14 Different type of Triangles

Scalene triangle: A triangle does not have any equal sides or angles.

Classification by its Angles

Acute triangle: A Triangle in which all the interior angles are less than 90°.

Right triangle: A Triangle having one angle equal to 90°.

Obtuse triangle: A Triangle having one angle greater than90°.

Quadrilaterals

A quadrilateral is a four-sided plane figure. The sum of the interior angles of a quadrilateral is 360◦. Quadrilaterals may be subdivided into:

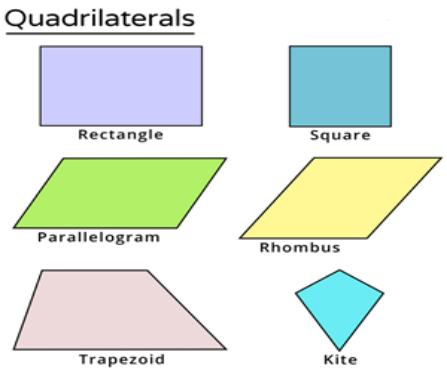


Fig 3.15 Different type of Quadrilaterals

Parallelogram

Parallelogram is a quadrilateral whose opposite sides are parallel, e.g. square, rectangle, rhombus and rhomboid.

Square

Square is a quadrilateral with all the four sides and all the angles are equal.

Rectangle

Rectangle is a quadrilateral, with all four angles is a right angle and opposite sides is equal and parallel.

Rhombus

Rhombus is a quadrilateral; with all four sides have the same length, and equal opposite angles.

Circle

A circle is a round plane figure whose boundary (the circumference) consists of points equidistant from a fixed point which is called center.

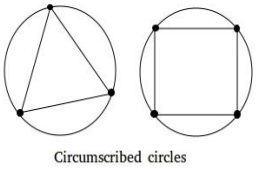
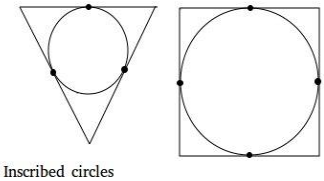


Fig 3.16 Different type of Circles

Inscribed Circle

When a circle is placed inside a polygon, we say that the circle is inscribed in the polygon. Two examples of circles inscribed in a triangle and a square are shown below.



Circumscribed Circle

When a circle is placed outside a polygon and each vertex of the polygon lies on the circle, we

say that the circle is circumscribed about the polygon. Two examples of circles circumscribed about a triangle and about a square are shown below.

Activity 3.2
Draw different types of circles, angles, quadrilaterals, triangles, polygons
Components/Instruments
Drawing Instruments, Stationary etc.
Step 1: Arrange the class in groups Step 2: Draw different types of circles, angles, quadrilaterals, triangles, polygons

3.5 Free Hand Sketching

Technical drawing may be made with instruments, or freehand, or partly with instruments and partly freehand. Instrumental or scale drawingis the term usually applied to technical drawings executed with instruments. Sketching applies to such drawings executed without the aid of instruments.

i. Importance of Sketching

Sketching is a first step to prepare a scale-drawing. In fact, Sketching is a freehand drawing made in correct proportions, but not to scale. A designer records his ideas initially in the form of sketches which are later converted into drawing. Similarly, views of actual objects are in the first instance, sketched freehand. Scale-drawings are then prepared from these sketches. Ideas and objects can be described in words, but the description is made more expressive with the aid of sketches. Thus sketching is of great importance in engineering practice.

ii. Procedure of Sketching

Sketching procedure for various shapes, geometric figure and models is described as under:

- Sketches should never be prepared with the aid of a scale or a straight- edge. All lines must be absolutely free-hand and their measurements must be in proportion only.
- A sketch is considered to be good when its features are shown in correct proportions.
- Its outlines must be black and thin but rigidly firm.

- Dimension lines and center lines should be comparatively light.
- Dimension figures must be inserted with good care, as if they are printed.
- Lettering also should be done in a similar manner.
- A sketch should be so prepared as to give to others a clear idea, complete information and true impression of the object to be constructed.
- It should never be drawn too small.
- The size of a sketch should be such that all the features of the object, together with their dimensions, explanatory notes etc. are clearly incorporated in it.
- Proficiency in sketching can be achieved with constant practice only.

iii. Sketching of Basic Lines and Shapes

Horizontal Lines

Horizontal lines are sketched with the motion of the wrist and the fore-arm. They are sketched from left to right as shown in Fig 3.17. To sketch a horizontal line, mark the end points. Hold the pencil at about 30-40 mm distance from the lead point. Swing it from left to right and backwards, between the two points and without touching the surface of the paper, till the correct direction is achieved. Then begin to draw the line (with the wrist-motion) with short and light strokes. Shift the hand after each stroke. Keep your eyes on the point at which the line is to end. Finish finally with a dark and firm line. Take proper care to maintain straightness and correct direction of the line.

Vertical lines

Vertical lines are sketched downwards with the movement of fingers. They may also be sketched by converting them into horizontal lines by revolving the paper as shown in Fig.

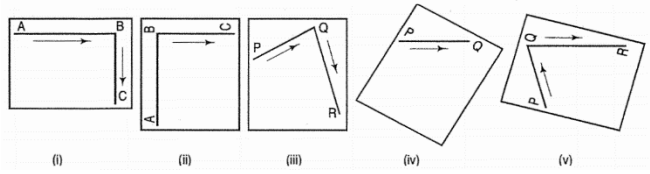


Fig 3.17 Different type of Sketching

Inclined lines

Inclined lines when the line is nearly horizontal, it is sketched from left to right. When line is nearly vertical, then sketched downwards. These lines also may be sketched as horizontal lines by revolving the paper as shown in Fig.

iv. To Sketch Circles and Arcs

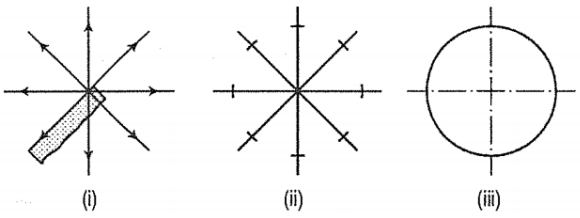


Fig 3.18 Circle and Arc Sketching

Mark the center and through it, draw horizontal and vertical Centre lines Fig. 3.18. Add four radial lines between them. Mark points on these lines at radius-distance from the centre, judging by the eye or using a slip of paper as a trammel, on which the radius-distance has been approximately marked Fig.3.18. Complete the circle with light strokes. The paper may be revolved after about each quarter-circle for easy wrist motion. Erase the additional radial lines completely. Dim all the lines before fairing the circle with a thin and black outline Fig. 3.18. Keep the center lines thin and light.

Large Circles

Large circle may be sketched as described above by adding a few extra radial lines [Fig. 3.19]. An easier method is to mark a number of points by means of a trammel (at radius-distance from the centre) and to sketch the circle through these points [Fig. 3.19].

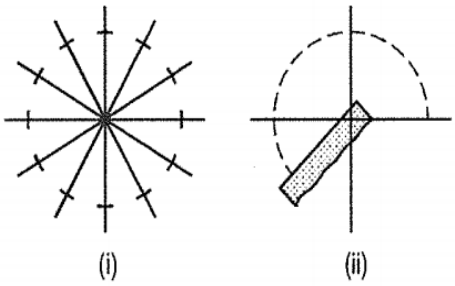


Fig 3.19 Large Circle

Large circles can also be drawn by making a compass of fingers and a pencil. Keep the little finger as a pivot at the Centre. Hold the pencil stationary so that its point is at radius-distance from the Centre and touches the paper. Rotate the paper with the other hand. The pencil-point will mark the circle on the paper. Two pencils may also be used as a compass. One pencil is held as a pivot, while the other describes the circle as the paper is rotated.

Small Circle

Small circle can be sketched within a square. Sketch the circumscribing square (length of the side equal to the diameter of the circle) and mark the diagonals [Fig. 3.20 (i)]. Mark the mid-points of the sides of the square and four

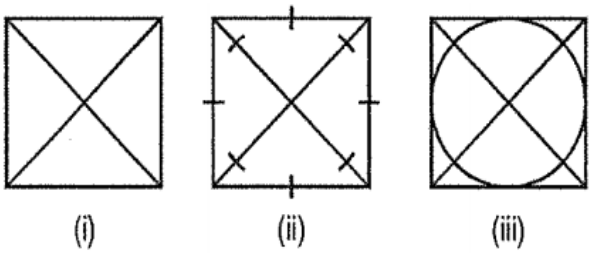


Fig 3.20 S Circle

points on the diagonals at radius-distance from the Centre [Fig. 3.20 (ii)]. Sketch a neat circle through the eight points [Fig. 3.20 (iii)].

Arcs of Small Radii

Arcs of small radii are conveniently drawn by constructing squares [Fig. 3.21 (i)].

Large-Radii Arcs

Large radii arcs may be drawn by one of the methods described above for large circles. Radial-line and trammel methods are shown in Fig. 3.21 (ii) and Fig. 3.21 (iii) respectively.

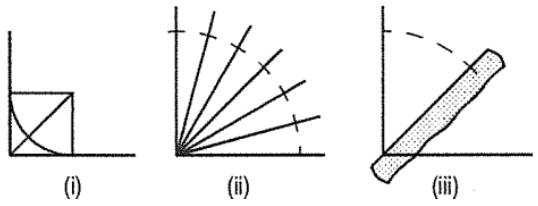


Fig 3.21Large Radii Arcs

3.5 Multiview Drawing

Multiview Drawing is a technique used by drafters and designers to depict a three-dimensional object (an object having height, width and depth) as a group of related two-dimensional (having only width and height, or width and depth) views.

i. Orthographic Drawing

Orthographic Drawing is a type of drawing used to draw Front, Side & Top view of an object. In this type of drawing Parallel Projection is used for the preparation of the drawing of an object. These lines are perpendicular to the plane. In this drawing, it is assumed that the object is at infinity. The shape of an object is seen in actual size in such a drawing. A plane is an imaginary surface on which pictures are prepared imaginably. Then it is transferred to the paper. This plane is faced toward the object whose view is to be prepared. Generally, three views of an object are prepared. These are

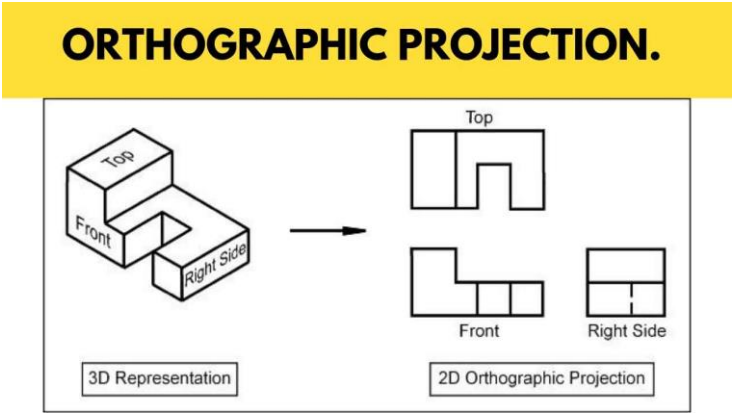


Fig 3.22 Orthographic Drawing

- **Front View**

This view is prepared by placing the object in front. The length and height of an object are shown in this view.

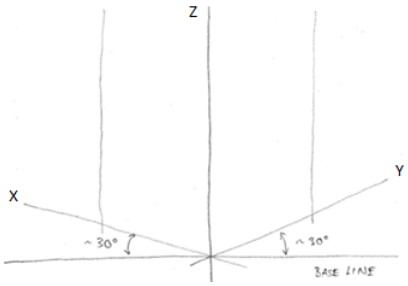
- **Top View**

This view is prepared by looking to the object from the upper side. The length and breadth of the object are shown in it.

- **Side View**

This view is prepared by looking to the object from the right side or left side. The breadth and height of the object are shown in it.

3.6 Pictorial Drawing

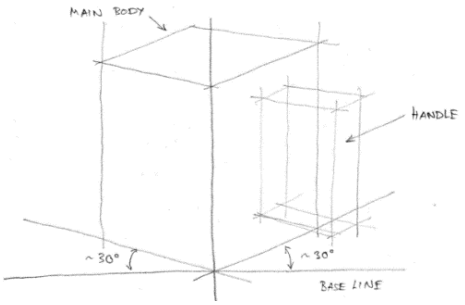


i. 30^0 Isometric Projection of a Cup

Imagine drawing space as 3D cube with Cartesian coordinates.

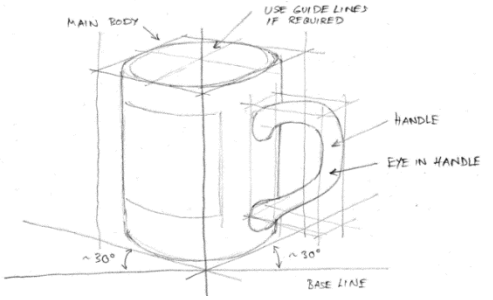
- X and Y axes form horizontal base plane. These axes are shown at 30^0 to horizontal line on page.
- Z axis is vertical. Always shown as vertical on drawing
- Distances along all three axes are equal i.e. 1 unit on x axis is the same length on paper as 1 unit on y or z axis. But angles are not preserved.

Step 1:



- Draw base grid at 30^0 to horizontal.
- Draw in verticals.
- Remember distances along all 3 axes are equal. But axes are not orthogonal.

Step 2:



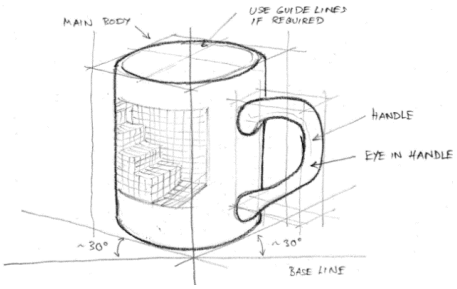
- Sketch in bounding box (es), noting the relative proportion of the component members.

Step 3:

- Eye in position of major features e.g. corner, notch, angle, etc.
- Draw in further bounding boxes as necessary for these features

Step 4:

- Fill in details, again bearing in mind relative position and size.



Activity 3.3
Draw front, side and top view of simple model
Components/Instruments
Drawing Instruments, Stationary etc.
Step 1: Arrange the class Step 2: Assign them task to draw a model using pictorial drawing techniques

Key points

- A Technical Drawing is a detailed, precise diagram or plan that conveys information about how an object functions or is constructed.
- Engineering drawing is an essential part of almost all engineering projects.
- Pencils are the main drawing instruments used to draw the lines, circles, arcs, polygons, etc.
- Drawing paper is generally made out of wood cellulose, or cottoncellulose.
- ISO standard determines the paper dimensions for the A paper series. The most common paper sizes are A0, A1, A2, A3, A4 and A5
- Drawing boards are usually made of white pine, but are sometimes made of other soft woods
- Compass: It is used to draw circles and arcs both in pencil and ink
- Line: Line can be defined as a path between two points.
- An angle is a space or opening between two straight lines, intersecting at a point called vertex
- A polygon is a plane figure bounded by three or more straight sides. Polygons can be mainly classified as regular and irregular.
- A plane figure having three sides is called at triangle
- A quadrilateral is a four-sided plane figure.
- Parallelogram is a quadrilateral whose opposite sides are parallel, e.g. square, rectangle, rhombus and rhomboid.
- Technical drawing may be made with instruments, or freehand, or partly with instruments and partly freehand.
- Multiview Drawing is a technique used by drafters and designers to depict a three-dimensional object
- Orthographic Drawing is a type of drawing used to draw Front, Side & Top view of an object.

EXERCISE

Select the most appropriate option (✓)

1. Drawing is the language of
    a. doctors.
    b. engineers.
    c. contractors.
    d. teachers.
2. If the object has only two dimensions, it is called
    a. mechanical drawing.
    b. solid geometry drawing.
    c. structural drawing.
    d. plane geometry drawing.
3. T-square is used to draw---------- lines.
    a. irregular
    b. inclined
    c. slant
    d. horizontal
4. Which instrument is used for angular measurement?
    a. divider
    b. french curve
    c. protractor
    d. all of these
5. Which three items are needed to complete a sketch?
    a. paper, red pen, eraser
    b. straight edge, paper, pencil
    c. paper, pencil, eraser
    d. compass, straight edge, pencil
6. What is the primary purpose of sketching?
    a. so that parts can be manufactured.
    b. get ideas on paper quickly and communicate ideas with others.
    c. to avoid the use of computers.
    d. so that we do not have to make technical drawings.
7. Which two methods are used for sketching lines?
    a. scribbling and straight edges
    b. short lines and scribbling
    c. dot to dot and short lines
    d. lazy arcs and straight edges

8. The lines that shows working area is called
    a. circle
    b. section
    c. boarder
    d. angle
9. The line which shows the outermost edges of a machine element is called
    a. object
    b. dotted/hidden
    c. cutting plane
    d. straight line
10. The line used for breaking long spans is called
    a. dotted
    b. perforated
    c. long break
    d. bending

Short answer of the following Questions

1. Define a Technical Drawing?
2. List three reasons for using technical drawing.
3. List any five drawing instruments.
4. What are the basic types of lines?
5. Define angle and write its types?
6. What do you understand by complementary angles?
7. Enlist various polygons.
8. Define Sketching.
9. What are the techniques to draw a pictorial sketch?

Answer of the following Questions in detail

1. Describe the importance of technical drawing.
2. Describe various drawing pencils in detail.
3. Explain the criteria for selection of drawing paper.

4. Explain any three drawing instruments in detail.
5. Describe the procedure of free hand sketching in detail.
6. What is an orthographic drawing? Explain front, side, top views in detail.
7. Describe the importance of sketching.
8. State Sketching techniques for horizontal line the help of sketches.
9. State Sketching techniques for circles with the help of sketches.

Practical Activities

1. Draw various models from real life using different drawing techniques

Instructions for the Teachers

1. Explain the Purpose of the Task. ...
2. Make Sure Your Students Understand.
3. Adopt Health and Safety measures in the lab
4. Use all the available ICT resources for better delivery of the content
5. Ensure proper functioning of lab equipment/PPEs

Chapter 04

Measuring Instruments

Students Learning Outcomes

After completion of this chapter you will be able to:

- describe the measuring systems.
- explain moving iron system.
- explain advantages and disadvantages of moving iron system.
- explain electro-dynamic system and its advantages and disadvantages
- use multimeter (digital, analog)

4.1 Measuring Systems

i. Measurement

Measurement is an act of comparison between a predefined and commonly accepted standard quantity and unknown quantity. The result is expressed in numerical values. This result is usually shows the ratio of both quantities of the same kind.

ii. Measuring Instrument

A measuring instrument is a device that is used to compare the two quantities for determining the value or magnitude of an unknown quantity or variable. In electrical engineering, we come across current, voltage, power, energy, flux, frequency, power factor etc. which are not visible to eye. The instruments, which are used to measure these quantities, are known as electrical measuring instruments.

Electrical instruments are broadly classified into two classes or groups, these are:

(i) Absolute instruments

(ii) Secondary instruments

4.2 Moving Iron System

The instrument in which the moving iron is used for measuring the flow of current or voltage is known as the moving iron instrument. It works on the principle that the iron place near the magnet attracts towards it. The force of attraction depends on the strength of the magnet field. The magnetic field induces by the electromagnet whose strength depends on the magnitude of the current passes through it.

i. Construction of Moving Iron Instrument

The plate or vane of soft iron is used as the moving element of the instrument. The vane is so placed that it can freely move in the magnetic field of the stationary coil. The conductor makes the stationary coil, and it is excited by the voltage or current whose magnitude is used to be measured. The moving iron instrument uses the stationary coil as an electromagnet. The electromagnet is the temporary magnet whose magnetic field strength increases or decreases with the magnitude of the current passes through it.

ii. Working of the Moving Iron Instrument

The moving iron instruments use the stationary coil of copper or aluminum wire which acts as an electromagnet when an electric current passes through it. The strength of the magnetic field induces by the electromagnet is directly proportional to the current passes through it.

The plates or vane of the iron pass through the coil increases the inductance of the stationary coil (the inductance is the property of the conductor which increases their electromotive force when the varying current passes through it).

The electromagnet attracts the iron vane. The vane passes through the coil tries to occupy the minimum reluctance path (the reluctance is the property of the magnet which opposes the flow of electric current).

The vane passes through the coil experience a force of repulsion caused by the electromagnet. The repulsion force increases the strength of the coil inductance. This happens because the inductance and reluctances are inversely proportional to each other.

iii. Classification of the Moving Iron Instruments

The attraction and the repulsion are the types of the moving iron instruments. Their detail explanation is shown below.

1. Attraction Type

The instrument in which the iron plate attracts from the weaker field towards the stronger field is known as the attraction type instrument.

Construction of Attraction Type Instrument

The stationary coil of the attraction type instrument is flat and has a narrow opening. The moving element is the flat disc of the iron core. The current flow through the stationary coil produces the magnetic field which attracts the iron coil.

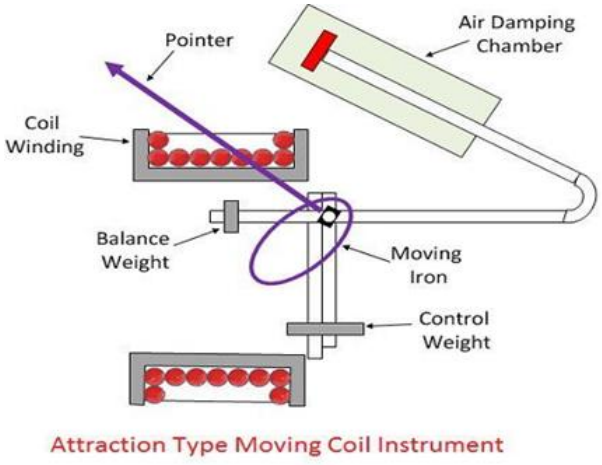


Fig 4.1 Attraction type measuring instrument

The iron vane deflects from the low magnetic field to the high magnetic field, and the strength of the deflection is directly proportional to the magnitude of the current flow through it. In short, we can say that the iron coil attracts towards in.The attraction type instruments use spring, which provided the controlling torque. The deflection of the coil is reduced by the aluminum piston which is attached to the moving coil.

2. Repulsion Type Instruments

The repulsion type instrument has two vanes or iron plates. One is fixed, and the other one is movable. The vanes become magnetized when the current passes through the stationary coil and the force of repulsion occur between them. Because of a repulsive force, the moving coil starts moving away from the fixed vane.

The spring provides the controlling torque. The air friction induces the damping torque, which opposes the movement of the coil. The repulsion type instrument is a non-polarized instrument, i.e., free from the direction of current which passes through it. Thus, it is used for both AC and DC.

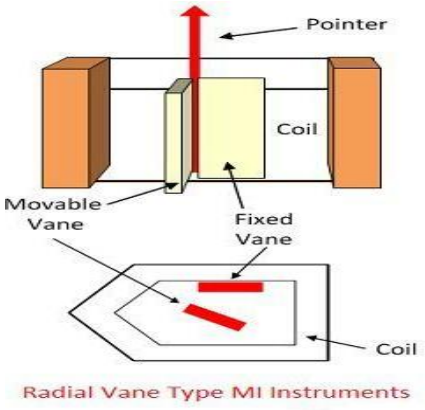


Fig 4.2 Repulsion type measuring instrument

iv. Advantages of the (Moving Iron) MI Instruments

The following are the advantages of the moving iron instruments.

- **Universal use** – The MI instrument is independent of the direction of current and hence used for both AC and DC.
- **Less Friction Error** – The friction error is very less in the moving iron instrument because their torque weight ratio is high. The torque weight ratio is high because their current carrying part is stationary and the moving parts are lighter in weight.
- **Cheapness** – The MI instruments require less number of turns as compared to PMMC instrument. Thus, it is cheaper.
- **Robustness** – The instrument is robust because of their simple construction. And also because their current carrying part is stationary.

v. Disadvantages of Moving Iron Instruments

The following are the disadvantages of Moving Iron Instrument.

- **Accuracy**
- The scale of the moving iron instruments is not uniform, and hence the accurate result is not possible.
- **Errors**
- Some serious error occurs in the instruments because of the hysteresis, frequency and stray magnetic field.
- **Waveform Error**
- In MI instrument the deflection torque is not directly proportional to the square of the current. Because of which the waveforms error occurs in the instrument.
- **Difference between AC and DC calibration**
- The calibration of the AC and DC are differed because of the effect of the inductance of meter and the eddy current which is used on AC. The AC is calibrated on the frequency at which they use.

Two type of error occurs in the MI instruments i.e., the error which occurs on both AC and DC and the error which only occur on AC

4.3 Electrodynamics System

The electrodynamometer is a transfer-type instrument. A transfer-type instrument is one that may be calibrated with a dc source and then used without modification to measure AC. This requires the transfer type instruments to have the same accuracy for both DC and AC. These instruments are also called Electrodynamics or Dynamometer Type Instruments.

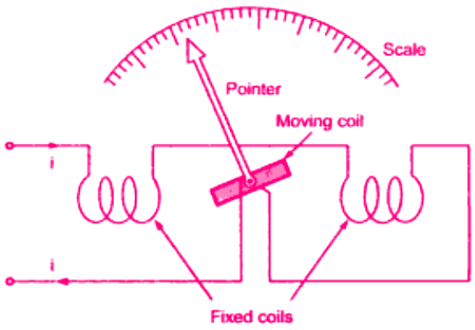


Fig 4.3 Electrodynamics measuring instrument

An electrodynamics instrument is a moving-coil instrument in which the operating field is produced, not by a permanent magnet but by another fixed coil. This instrument can be used either as an ammeter or a voltmeter but is generally used as a wattmeter. The electrodynamic or

dynamometer-type instrument is a moving-coil instrument but the magnetic field, in which the coil moves, is provided by two fixed coils rather than by permanent magnets (eg: PMMC instruments).The schematic diagram of the electrodynamic instrument and a practical meter is shown.

It consists of two fixed coils, which are symmetrically situated. It would have torque in one direction during one half of the cycle and an equal effect in the opposite direction during the other half of the cycle.

If, however, we were to reverse the direction of the flux each time the current through the movable coil reverses, a unidirectional torque would be produced for both positive half and negative half of the cycle. In electrodynamic instruments, the field can be made to reverse simultaneously with the current in the movable coil if the fixed coil is connected in series with the movable coil.

i. Working Principle of Electrodynamometer Instruments

The working principle of the electrodynamometer instrument be understood by taking up a permanent magnet moving coil instrument and considering how it would behave on AC.

It would have torque in one direction during one half of the cycle and an equal effect in the opposite direction during the other half of the cycle.

If the frequency were very low, the pointer would swing back and forth around the zero point. However, for an ordinary meter, the inertia is so great that on power frequencies the pointer does not go very far in either direction but merely stays (vibrates slightly) around zero.

If, however, we were to reverse the direction of the field flux each time the current through the movable coil reverses, the torque would be produced in the same direction for both halves of the cycle.

The field can be made to reverse simultaneously with the current in the movable coil if the field coil is connected in series with the movable coil

ii. Construction of Electrodynamometer Instruments

An electrodynamometer comprises of following parts.

i. Fixed Coil
ii. Moving Coil

iii. Control
iv. Moving System
v. Damping
vi. Shielding
vii. Cases and Scales

i. **Fixed Coils**

The field is produced by a fixed coil. This coil is divided into two sections to give a more uniform field near the center and to allow passage of the instrument shaft.

The instrument as shown in the figure by a millimeter, or may become a voltmeter by the addition of series resistance. The fixed coils are wound with fine wire for such applications.

Field (fixed) coils are usually wound with a heavy wire carrying the main current in ammeters and watt-meters.

The wire is stranded where necessary to reduce eddy current losses in conductors. The coils are usually varnished and baked to form a solid assembly.

These are then clamped in place against the coil supports, this makes the construction rigid so that there is no shifting or change in dimensions which might affect the calibration. The mounting supports are preferably made out of ceramic, as metal parts would weaken the field of the fixed coil on account of eddy currents.

ii. Moving Coil

A single element instrument has one moving coil. The moving coil is wound either as a self-sustaining coil or else on a non-metallic former.

A metallic former cannot be used as eddy currents would be induced in it by the alternating field. Light but rigid construction is used for the moving coil. It should be noted that both fixed and moving coils are air-cored.

iii. Control

The controlling torque is provided by two control springs. These springs act as leads to the moving coil.

iv. Moving System

The moving coil is mounted on an aluminum spindle. The moving system also carries the counter weights and truss type pointer. Sometimes a suspension may be used in case high sensitivity is desired.

v. Damping

Air friction damping is employed for these instruments and is provided by a pair of aluminium vanes, attached to the spindle at the bottom. These vanes move in sector-shaped chambers.

vi. Shielding

The field produced by the fixed coils is somewhat weaker than in other types of instruments. It is nearly 0.005 to 0.006 Wb/m^2.In DC measurements, even the earth's magnetic field may affect the readings. Thus it is necessary to shield an electrodynamometer type instrument from the effect of stray magnetic fields, Air cored electrodynamometer type instruments are protected against external magnetic fields by enclosing them in a casing of high permeability alloy.

vii. Cases and Scales

Laboratory standard instruments are usually contained in highly polished wooden cases. These cases are so constructed as to remain dimensionally stable over long periods of time.

The glass is coated with some. conducting material to completely remove the electrostatic effects. The case is supported by adjustable levelling screws. A spirit level is also provided to ensure proper levelling.

Types of Electrodynamometer Instrument

There are three types of electrodynamometer instruments.

1. Electrodynamic Ammeter
2. Electrodynamic Voltmeter
3. Electrodynamic Wattmeter

Advantages of Electrodynamometer-type Instruments

The advantages of electrodynamometer type instruments are:

- They can be used on ac as well as dc measurements.
- These instruments are free from eddy current and hysteresis errors.
- Electrodynamometer-type instruments are very useful for accurate measurement of RMS values of voltages irrespective of waveforms.
- Because of precision grade accuracy and the same calibration for ac and dc measurements, these instruments are useful as transfer type and calibration instruments.

Disadvantages of Electrodynamometer-type Instruments

The advantages of electrodynamometer type instruments are

- As the instrument has a square-law response, the scale is non-uniform.
- These instruments have a small torque/weight ratio, so the frictional error is considerable.
- More costly than Permanent magnet moving coil (PMMC) and Moving Iron (MI) type of instruments.
- Adequate screening of the movements against stray magnetic fields is essential.
- Power consumption is comparably high because of its construction.

4.4 Multimeter (Digital, Analog)

A Multimeter is an electronic instrument, every electronic technician and engineer's widely used piece of test equipment. A multimeter is mainly used to measure the three basic electrical characteristics of voltage, current, and resistance. It can also be used to test continuity between two points in an electrical circuit. The multimeter has multi functionalities like, acts like ammeter, voltmeter, and ohmmeter. It is a handheld device with positive and negative indicator needles over a numeric LCD digital display. Multimeter can be used for testing batteries, household wiring, electric motors, and power supplies.

The essential parts of the multimeter mainly include a display, power source, probes, and controls.

i. Use of Multimeter

The function and operation of a multimeter are similar for both analog and digital types. This instrument includes two leads or probes namely red and black & three ports. The black color lead is used to plug into the common port, whereas the red color leads plug into other ports based on the requirement.

Once the leads are plugged in, the knob can be switched ON in the center of the instrument so that the appropriate function can be done for the specific component test. For instance, once the knob is situated to 20V DC, then the multimeter will notice DC voltage up to 20V. To calculate low voltages, then set the knob in the multimeter to the 2V/200mV range.

To obtain a reading from the meter, you need to touch the end of each probe to the end of the terminals of components.

ii. Application of Multimeter

Multimeters are capable of measuring different quantities based on the model. So basic types of multimeter are mainly used to measure amperage, resistance, voltage, checks continuity and a complete circuit can be tested like the following.

- Resistance in Ohms
- Capacity in Farads
- The temperature in Fahrenheit/ Celsius
- AC Voltage & Amperage
- Inductance Henrys
- DC Voltage & Amperage
- Frequency in Hz
- Conductance in Siemens
- Decibels
- Duty Cycle

To some types of multimeters, special sensors or accessories can be attached for extra readings like acidity, light level, alkalinity, wind speed & relative humidity.

iii. Types of Multimeter

There are different types of multimeters like Analog, Digital, and Fluke multimeters.

Analog Multimeter

The Analog Multimeter or VOM (Volt-Ohm-Milliammeter) is constructed using a moving coil meter and a pointer to indicate the reading on the scale. The moving coil meter consists of a coil wound around a drum placed between two permanent magnets.

Fig 4.4 Analog Multimeter

As current passes through the coil, the magnetic field is induced in the coil which reacts with the magnetic field of the permanent magnets and the resultant force causes the pointer attached to the drum to deflect on the scale, indicating the current reading. It also consists of springs attached to the drum which provides an opposing force to the motion of the drum to control the deflection of the pointer.

Analog Multimeter

For the measurement of DC, the D Arsonval movement described above can be directly used. However, the current to be measured should be lesser than the full-scale deflection current of the meter. For higher currents, the current divider rule is applied. Using different values of shunt resistors, the meter can also be used for multi-range current measurements. For current measurement, the instrument is to be connected in series with the unknown current source.

For measurement of DC voltage, a resistor is connected in series with the meter, and the meter resistance is taken into account such that the current passing through the resistor is the same as the current passing through the meter and the whole reading indicates the voltage reading. For voltage measurement, the instrument is to be connected in parallel with the unknown voltage source. For multirange measurement, different resistors of different values can be used, which are connected in series with the meter.

For measurement of resistance, the unknown resistance is connected in series with the meter and across a battery, such that the current passing through the meter is directly proportional to the unknown resistance. For AC voltage or current measurement, the same principle is applied, except for the fact that the AC parameter to be measured is first rectified and filtered to get the DC parameter and the meter indicates the RMS value of the AC signal.

Advantages of an Analog Multimeter are that it is inexpensive, doesn't require a battery, can measure fluctuations in the readings. The two main factors affecting the measurement are sensitivity and accuracy. Sensitivity refers to the reciprocal of the full-scale deflection current and is measured in ohms per volt.

Digital Multimeters

We mostly used a multimeter is a digital multimeter (DMM). The DMM performs all functions from AC to DC other than analog. It has two probes positive and negative indicated with black and red color is shown in the figure. The black probe connected to COM JACK and the red probe connected by user requirement to measure ohm, volt, or amperes.

The jack marked VΩ and the **COM** jack on the right of the picture are used for measuring voltages, resistance, and for testing a diode. The two jacks are utilized when an LCD shows what is being measured (volts, ohms, amps, etc.). Overload protection prevents damage to the meter and the circuit and protects the user.

Fig 4.5 Digital Multimeter

Digital Multimeter

The Digital Multimeter consists of an LCD, a knob to select various ranges of the three electrical characteristics, an internal circuitry consisting of a signal conditioning circuitry, an analog to digital converter. The PCB consists of concentric rings that are connected or disconnected based on the position of the knob. Thus as the required parameter and the range are selected, the section of the PCB is activated to perform the corresponding measurement.

To measure the resistance, current flows from a constant current source through the unknown resistor, and the voltage across the resistor are amplified and fed to an Analog to Digital Converter and the resultant output in form of resistance is displayed on the digital display. To measure an unknown AC voltage, the voltage is first attenuated to get the suitable range and then rectified to DC signal and the analog DC signal is fed to an A/D converter to get the display, which indicates the RMS value of the AC signal.

Similarly, to measure an AC or DC, the unknown input is first converted to a voltage signal and then fed to an analog to digital converter to get the desired output (with rectification in case of AC signal). Advantages of a Digital Multimeter are its output display which directly shows the measured value, high accuracy, ability to read both positive and negative values.

Types of Digital Multimeter

Digital types of multimeter are available in three types.

Fluke Multimeter

The fluke digital multimeter can be designed with various collaboration functions. Generally, it includes a large display and this instrument is used to measure the voltage as well as electrical resistance. Some kinds of devices are available with advanced features to measure humidity, duty cycle, pressure, frequency temperature, etc. The fluke multimeter is one of the most frequently and famous instruments.

Fig 4.5 Fluke DMM

This kind of multimeter is mainly used for calibration efforts and used to calibrate currents, volts & other electrical units.

Fluke Multimeter

The fluke multimeters are protected against the transient voltage. It is a small portable device used to measure voltage, current, and test diodes. The multimeter has multi selectors to select the desired function. The fluke MM automatically ranges to select most measurements. This means the magnitude of the signal does not have to be known or determined to take an accurate reading, it directly moved to the appropriate port for the desired measurement. The fuse is protected to prevent damage if connected to the wrong port.

Clamp Digital Multimeter

The clamp digital multimeter is used to measure the electricity flow. As the name suggests, this multimeter includes the feature namely clamp which measures the amps whenever the probes measure the volts. The adjustment of power utilization otherwise watts can be done through multiplying the reading of voltage with the amps. This multimeter also includes an additional feature that is different kinds of settings. The appropriate feature is used while measuring.

Fig 4.6 Clamp DMM

Clamp Type

This kind of multimeter includes fixed tools for measuring the current flow. This device extremely changes from the fluke type because, in the fluke multimeter, it utilizes a clamp to measure the flow of current. So, this instrument is usually recommended for professionals only.

Auto ranging Multimeter

The auto-ranging multimeter is a simple multimeter to utilize even though it is similarly the most costly of all kinds of digital multimeters. This multimeter includes a knob in the center and has less position. So it doesn't switch automatically to measure. This instrument is applicable in simple projects. For beginners as well as electricians at home, this instrument is highly recommended. Generally, it measures a single component at a time.

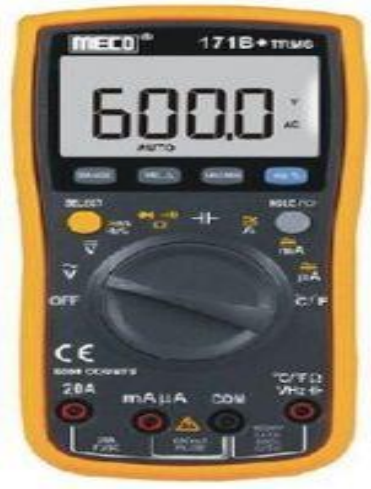


Fig 4.6 Auto ranging DMM

iv. Advantages and Disadvantages of Digital Multimeters

The advantages of a digital multimeter include the following.

- It gives an automatic o/p display.
- The measurement results of the meter can record and store in memory and synchronizes through a PC
- It includes auto polarity functions
- The meter reading accuracy cannot depend on the charging of the battery
- It ensures accuracy
- Resistance toward mechanical damage.
- Multifunctional
- Zero adjustments cannot be required
- Measurement accuracy is high
- Measuring ranges can be selected through manual or automatically

The disadvantages of digital multimeter include the following

- As compared to analog, it is expensive
- This multimeter does not work properly through measurement fluctuations. It can be tricky to discover one for your exact needs.

v. Advantages and Disadvantages of Analog Multimeter

The advantages of an analog multimeter include the following.

- Possibility of achieving measurements at below-30 ° C temperature
- Power utilization is not required from the fixed power supply while measuring current and voltage
- When high precision is not necessary, then quick operation through a large amount of measurement can be done.
- By using this instrument, all measurements can be done simply.
- The signal level can be observed

The disadvantages of analog multimeter include the following

- These meters are large
- These are expensive
- Voltage polarity cannot be recognized

- They are susceptible to vibration or shock.
- The movement of the pointer is slow and it cannot be utilized to measure voltages through frequencies above 50 HZ.
- Incorrect because of the earth's magnetic field effect.
- An unexpected change in the signal can notice through an analog multimeter more quickly as compared with a digital multimeter.
- These are sensitive to vibration, mechanical damage.
- Input resistance is less, thus a high error while measuring less voltage

Activity 4.1
Perform measurements of electrical quantities with the help of multimeter
Components/Instruments
Multimeter, Any electrical circuit
Step 1: Turn the dial for desired measurement (V, I, R) Step 2: Insert black and red leads into jack Step 3: Connect the test leads to the circuit Step 4: Read the measurement in the display

Key Points

- Measurement is an act of comparison between a predefined and commonly accepted standard quantity and unknown quantity.
- A measuring instrument is a device that is used to compare the two quantities for determining the value or magnitude of an unknown quantity or variable
- The instrument in which the moving iron is used for measuring the flow of current or voltage is known as the moving iron instrument
- The instrument in which the iron plate attracts from the weaker field towards the stronger field is known as the attraction type instrument
- The repulsion type instrument has two vanes or iron plates. One is fixed, and the other one is movable.
- The electrodynamometer is a transfer-type instrument.

EXERCISE

Select the most appropriate option (✓)

1. Multimeter is used to measure
   a. current
   b. voltage
   c. resistance
   d. all of above

2. Multimeter are of ----------types.
   a. 2
   b. 4
   c. 6
   d. 8

3. Flow of current/voltage is measured by ----------
   a. multimeter
   b. moving iron
   c. electrodynamic meter
   d. permanent magnet meter

4. ---------- is an act of comparison between a predefined and unknown quantity.
   a. calculation
   b. measurement
   c. assessment
   d. monitoring

5. The ---------- is used to measure the electricity flow.
   a. wattmeter
   b. clamp digital meter
   c. flux meter
   d. voltmeter

Short answer of the following questions

1. Define measurement.

2. Define measuring instruments?

3. What is meant by moving iron system?

4. What is attraction type instrument?
5. Give two advantages of moving iron instruments.
6. Write three disadvantages of moving iron instruments.
7. Define electrodynamic instrument.
8. Enlist types of electrodynamic instruments.
9. Define a multimeter.
10. What are types of multimeter?
11. Write three advantages of digital multimeter.

Answer of the following questions in detail

1. Describe the Construction of moving iron multimeter.
2. Explain the working principle of moving iron instruments.
3. Describe the use of digital multimeter.
4. Explain the construction of Electrodynamic system.

Practical Activities

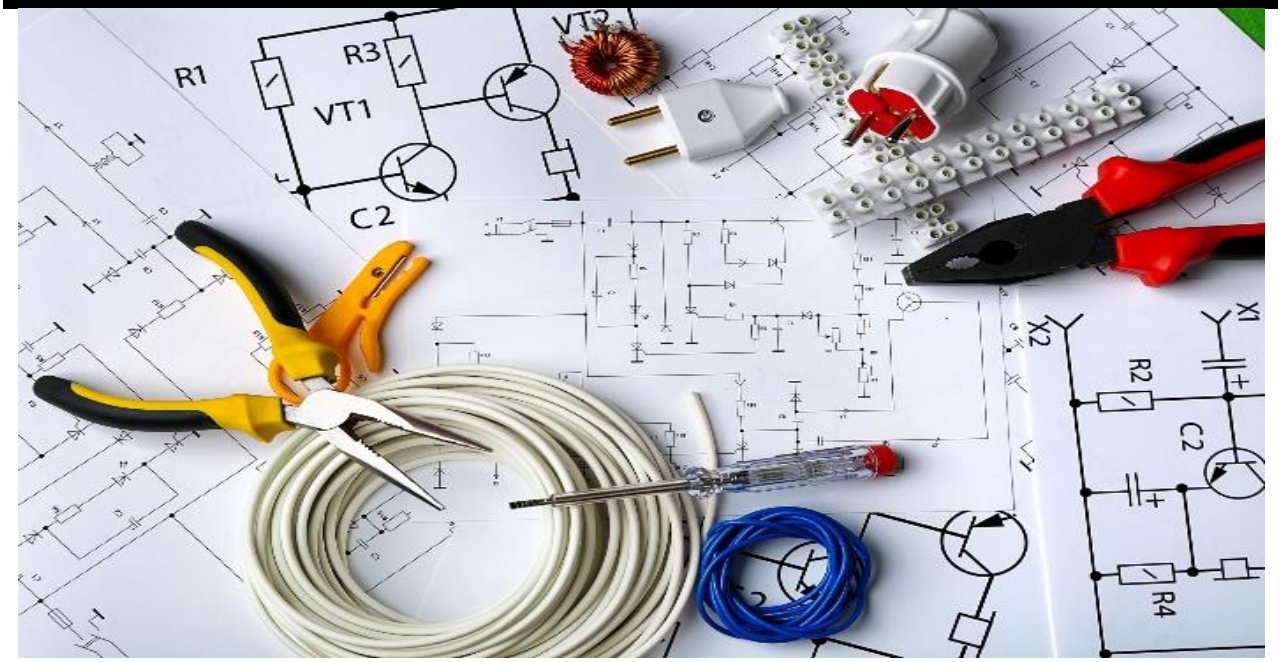
1. Measure the electrical parameter (I, V, R) with the help of analog and multimeter.

Instructions for the Teachers

1. Explain the Purpose of the Task. ...
2. Make Sure Your Students Understand.
3. Adopt Health and Safety measures in the lab
4. Use all the available ICT resources for better delivery of the content
5. Ensure proper functioning of lab equipment/PPEs

Chapter 05

Electrical Wiring (Domestic)



Students Learning Outcomes

After completion of this chapter you will be able to:

- explain the single-phase wiring.
- describe interpretation of electrical drawing/wiring diagram
- describe types of cables and their specifications
- explain different types of cable joints
- describe the types of insulation material
- explain the importance of insulation materials
- explain installation techniques of electrical wiring.
- understand the cable joints making techniques.
- understand the cable joints insulation
- describe the testing equipment for wiring test.
- understand procedure for connection of main board with wiring
- understand techniques for preparing of series test board
- define various types of wiring testers (phase tester, test lamp, avo meter, megger)
- describe importance of electrical wiring test
- explain types of electrical wiring test
- explain techniques of testing equipment/ instruments

5.1 Electrical Wiring

Definition

Laying of wires / cables and fitting the wiring accessories in a building, according to the safety and electricity rules, keeping in view the architectural beauty of the building is called electrical wiring. The purpose of electrical wiring is to provide electric power to the electric machines/appliances. A wiring system uses wiring cables and different wiring accessories in order to implement a particular task.

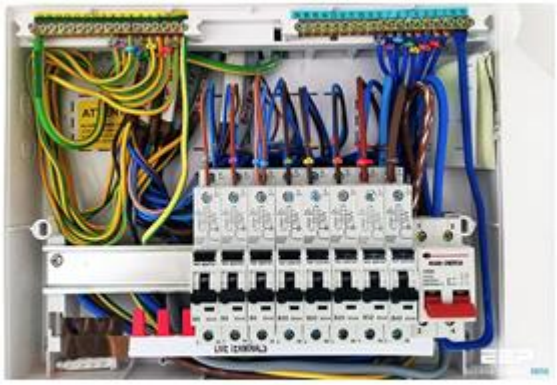


Fig. 5.1

Single Phase Wiring

Single Phase wiring installation is the most common wiring in residential buildings. In Single Phase supply (230V in Pakistan/UK, EU and 120V & 240V in the US & Canada), there are two (one is Line Phase/ Hot / Live and the other one is Neutral) incoming cables from the poles to the kWh energy meter and then directly connected to the main distribution board

5.2 Wiring Cables

Different types and sizes cables are used for wiring of electrical installations The purpose of electric cables is to carry current from supply point to different machines and appliances installed in a building efficiently and safely.

Terms related to Cables

Wire

A bare solid or stranded conductor is called wire. Insulated conductor with single strand is also called wire.

Examples: Stranded bare conductors of transmission and distribution lines, enamelled conductors of motor winding and fuse element wire in fuses.

Cable

A stranded insulated conductor (with or without outer cover) is called cable.

Examples*:* All stranded cables from 1.5mm^2, 2.5 mm^2, 4 mm^2 to 630 mm^2 sizes.

Core

Insulated conductor/conductors in a protective cover/sheath is called core of the cable.

Armouring

A twisted layer of galvanized steel wires (or sometimes steel tape) over the sheath of cables is called armouring. Armouring is provided for the mechanical protection of sheath and insulation of cables from mechanical damage. Sometimes aluminium wires are also used in Pakistan for this purpose. Armouring is usually provided in power cables for underground use.

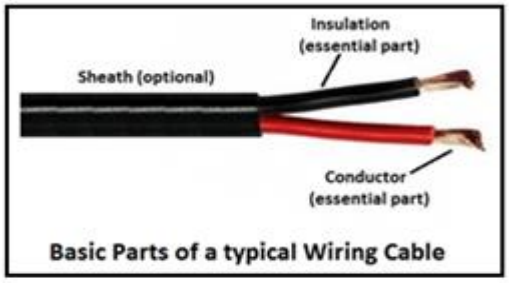


Fig.5.1 (a) Parts of Cable

Conductor

The inner most essential part of wiring cable that is used to pass current is called conductor. Size of conductor depends upon the amount of current to be passes through the conductor. Mostly annealed copper conductor is used in wiring cables. Aluminium conductor above 10 mm^2 size can also be used in wiring cables. Conductors in wiring cables may be solid or most usually stranded.

Insulation

An insulating material is used over the cable conductor to prevent leakage/flow of current from conductor to earth, is called cable insulation. It is also an essential part of electric cables used. Thickness of insulation on cables mainly depends upon the voltage level on which cable is to be used.

Sheath

The outer protective cover over the insulated conductor is called **Sheath.** In wiring cables, it serves as mechanical protection layer of insulation. American calls it Jacket.

Types of Wiring Cables

Types of Electrical Cables with respect to Applications:

i. **Wiring Cables**

These are mostly used as single core for internal wiring; however, two, three or four cores are also used. Available in low and medium voltage grade.

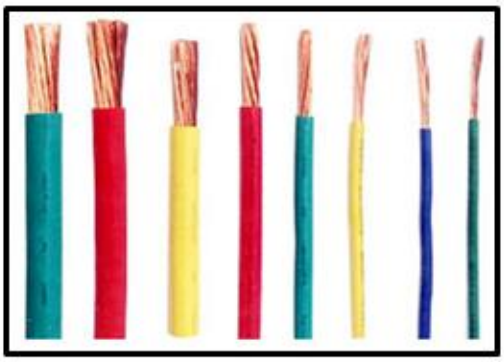


Fig. 5.2 Some typical single core wiring cables

ii. **Control Cables**

Control cables are used on substations and industries to transmit control signals from machines/ equipment to any alarming devices or protecting relays. Usually these are multi core (2, 4, 5, 7, 12, 20, 30, 48, 70, and 100) and manufactured in 0.75, 1, 1.5 and 2.5mm^{2}sizes. Usually these are designed to work on 11KV on substations.

iii. **Power Cables**

Used in power system to carry high power for transmission and distribution purpose. In wiring, these may be used as service, main or sub main cables in high load installations.

Types of Cables with respect to Insulation

i. **PVC** (poly vinyl chloride) Insulated cables.
ii. **VRI** (Vulcanized rubber insulation) cables.
iii. **TRS & CTS cables** i.e. TRS (tough rubber sheathed cables) and CTS (Cab tyre sheathed cables).
iv. **Butyl Rubber** insulated cables.
v. **Silicon rubber** insulated cables.
vi. **Ethylene propylene rubber** insulated cables.
vii. **Mineral** (Magnesium Oxide) **insulated** cables. Used in fire places.
viii. **Impregnated paper** insulated cables. (Used as high voltage underground supply cables).
ix. **Varnished cambric** insulated cables. (old version, now outdated)

Types of Wiring Cables with Respect to Cores

i. **Single core**

Mainly used for internal wiring. Single core armoured cables shall not be used for AC supply.

ii. **Two Core or Twin Core.**

Used as a main cable, sub main cable or internal wiring cable in single phase supply.

iii. **Three Core.**

Used as service cable, main cable or sub main cable in industries and three phase installations.

iv. **Four Core.**

Used as service cable, main cable or sub main cable in industries and three phase installations.

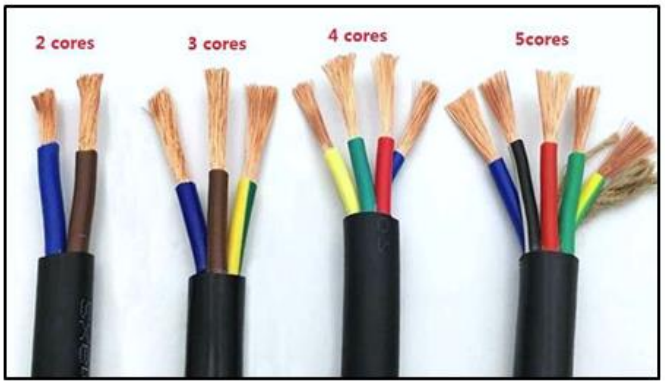


Fig.5.3 Two ,three , four and five core wiring cables

v. **Five Core.**

Three phases, one neutral and one earth core. Used as service cable, main cable or sub main cable in industries and three phase installations.

Types of Cables with Respect to Conductor

Annealed copper and Aluminium conductors are used in wiring cables.

Copper:

Annealed copper is mainly used for internal wiring cables for all sizes.

Aluminium:

Cables with Aluminium conductor are not used for internal wiring cables in Pakistan. However, above 10mm^2 size, cables with Aluminium conductor can be used as, main cables, sub main cables and service cables of an electrical installation.

Fig. 5.4 Colours of Cable Cores in Pakistan

Conductors of wiring cables are manufactured both in solid and stranded form as give below.

- 1mm^2 size: In solid form only
- 1.5mm^{2}and 2.5mm^2 size: Both in solid and stranded form.
- 4mm^2 to 630mm^2 sizes: In stranded form only

No of strands in stranded conductors used are: 1, 7,19,37,61,127

Wiring Cable Sizes

There are two methods of describing the cable sizes.

1. **Imperial (or British or English) System.**

   This is the old system used in England, India and Pakistan. In Pakistan, this system is still in use but not being used in England now.

2. **Metric System.**

This is the new system of cables sizes used almost worldwide now days.

In Pakistan, wiring cables are being manufactured in both imperial and Metric sizes.

Explanation of Cable Conductor Sizes

In imperial system, the diameter of each strand of cable conductors is described in inches and cross sectional area of cable conductors is described in inches^2. In metric system, the diameter of each strand of cable conductors is described in mm and cross sectional area of cable conductors is described in mm^2.

Some imperial sizes of cables are 1/0.044", 3/0.029", 3/0.036", 7/0.029", and 7/0.044" etc.

7/0.029" is a typical size of cable in imperial system. In this cable size, the digit 7 represents the number of strands in the cable conductor and 0.029" is the diameter of each strand of conductor in inches. Over all diameter of cable conductor is described in square inches.

Similarly, in 3/0.036" size, the digit 3 represents the number of strands in the cable conductor and 0.036" is the diameter of each strand of conductor in inches.

The Metrics system: Some metric sizes of cables are 1.0mm^2 (1/1.13), 1.5mm^2(1/1.38), 2.5 mm^2 (1/1.78), 4mm^2(7/0.85), 6mm^2(7/1.04), 10mm^2 (7/1.35), 16mm^2 (7/1.70) and 25mm^2 (7/2.14).

In 6mm^2 (7/1.04) cable size, 6mm^2 is the overall cross sectional area of conductor square millimetres. The digit 7 represents the number of strands in the cable conductor and 1.04 is the diameter of each strand of conductor in mm.

Metric sized cables are usually described in overall cross sectional area of conductor.

Factors affecting Current Carrying Capacity of Cables

Many other factors also affect the current carrying capacity of cables, such as

a. Ambient temperature.
b. Class of access current protection.
c. Bunching of cables
d. Method of installation. (Cable installed in open air such as in batten wiring system or cleat wiring system has more current capacity than concealed systems).
e. Type of cable insulation and sheath.
f. Length of Cable

Selection of Cable for a particular Application

A variety of cables is manufactured to meet different requirements of electrical field. Selection of proper type and size of cable is of utmost importance for satisfactory service of electrical machines and circuits to whom this cable will feed the electric power. Selection of proper cable for a particular application depends upon following factors

- Type of load (either it is single phase or three phase, fluctuating or steady).
- Atmospheric conditions and temperature.
- Required degree of mechanical protection according to the place of installation.
- Level of supply voltage where cable will be installed.
- Location in the installation (either it will be used as main cable, as sub main cable or as final sub circuit cable)

Voltage Drops in Cables and its simple Calculation

Points to consider for the calculation of voltage drops in Cables

i. Voltage drop calculation is not needed if length of circuit is less than 33.3 meters. Or 100 feet.
ii. Maximum limit of voltage drop from main distribution box to any load point in the wiring is 1.25% of the declared supply voltage.
iii. Maximum limit of voltage drop from main distribution box to any load point in the wiring is 2.5% of the declared supply voltage.

Fig.5.4 (a) Cable Insulating Material

5.3 Cable Insulation Materials

The life and satisfactory operation of a cable depends to a great extent upon the characteristics of the insulation employed. So the proper choice of the insulating material for the cables is considerably important. The following materials are typically used for cable insulation. The main requirements of the insulating materials used for the cable are:

- High insulation resistance to avoid leakage current.
- High dielectric strength to avoid electrical breakdown of cable.
- Good mechanical properties (tenacity and elasticity). Good tenacity is required in the materials to withstand the mechanical handling of the cables
- Immune to attacks by acids and alkalies, over a range of temperature of about -18^{o}C to 94^{o}C
- Non inflammable
- Low coefficient of thermal expansion
- Low permittivity
- Capable of withstanding high rupturing voltage

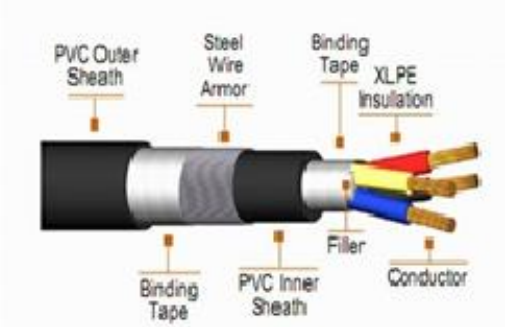


Fig.5.4 (b)

No one insulating material possesses all the above mentioned qualities. So the type of insulating material used in a cable depends upon the service for which the cable is required. The various insulating materials used in manufacturing of cables are Rubber, VIR (Vulcanized India Rubber), Paper, Polyvinyl Chloride (PVC), Varnished Cambric, Polyethylene, Silk, Cotton, Enamel etc.

5.4 Cable Jointing:


Fig.5.4 (c)

Joint

It is a process of connecting two lengths of a cable (or of bare conductors) in such a way that they are mechanically and electrically as strong as the equal length of the sound cable itself.

Necessity of Joints

Joints on electrical conductors/cables should be avoided if possible, if not; it should be electrically and mechanically sound and readily accessible for inspection and repair. However practically, joints cannot be avoided completely as because cables come in limited lengths.

Joints should be (where necessary) made with great care because bad or loose joints can cause following faults in wiring or power systems.

i. Loss of power in the form of heat on loose joints.
ii. Open circuit may occur.
iii. Can cause short circuit or ground fault.
iv. Current can leak due to bad joint.
v. A main reason of fire in buildings is the short circuit of cables/conductors which is mainly due to bad joints.

Difference between Joint and Termination

Joint is made between two cables/conductors while termination is made between a cable/conductor and a terminal of any machine, device, bus bar etc.

Solder

It is an alloy of two or more metals used to join two surfaces (or ends of two conductors) by filling the gaps between surfaces or of a joint by melting. To make the cable joints strong and homogenous, soldering is applied on joints. A solder also protects the joints from corrosion.

Jointing of Low Voltage Wiring Cables

Jointing process of low voltage wiring cables is very simple as compared to power cables, because the construction of wiring cables is very simple. Internal wiring cables have mostly stranded conductors with PVC or rubber insulation over them. Multi cores cables have a PVC outer sheath also.

Steps of Making a Joint

Following steps are used for jointing a cable.

Skinning (or Insulation Removing)

In this process the insulation is removed from the end of cable up to required length with sharp knife or wire stripper (sometimes called skinner). Electrician

Fig.5.5: Removing the Cable Insulation with Electrician Knife and Wire Stripper

pliers should not be used for this purpose. Insulation is removed with knife just like sharpening the lead pencil. It is shown in figure See Fig 5.5 .

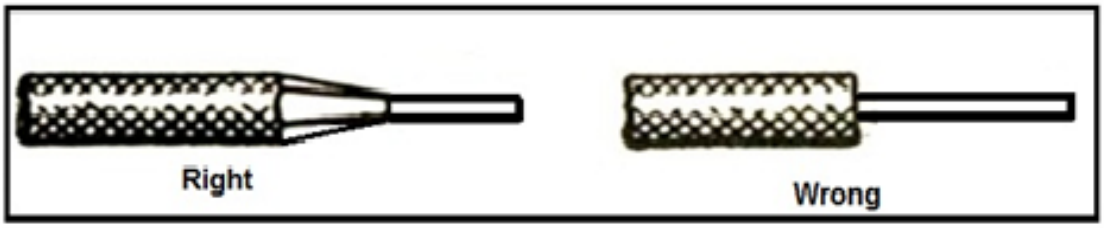


Fig.5.6: Right and Wrong Insulation Removed

Angle between knife blade and conductor is kept between 30º to 35º. Angle more than this can damage the conductor which will lead to condor breakage or generating hotspot that will cause fire.

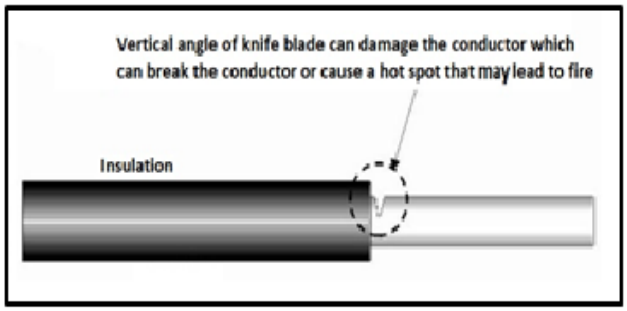


Fig.5.7 Result of Insulation Removing with Wrong Tool

1. **Scrapping**

Surface of conductor is cleaned and rubbed with an old sand paper to make its surface rough for better adhereing og solder. Oil or grease if there is, should also removed from the conductor surface. Care should be taken while scrapping tinned conductors.

2. **Jointing**

To make joint on wiring cables, the stranded conductors are twiststed firmly together with no strand or its sharp end out side the overall joint.The method of twisting are different for different single and multicore cables.

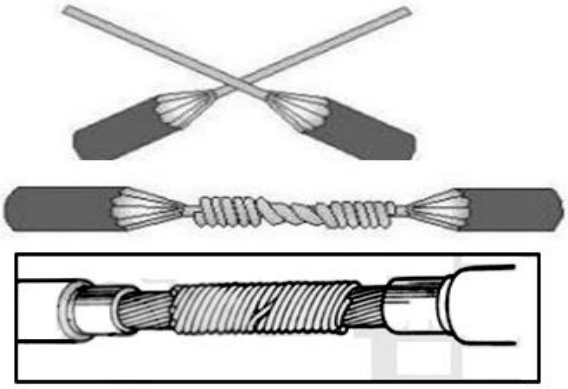


Fig.5.7: Jointing of Cables

3. **Soldering**

Joint is soldered with soft solder wire for ultimate contact of conductor strands and to increase the strength of joint. For soldering, Joint is heated up to suffiect level with torch or sodering iron and then a thin layer of flux is applied on the surface of joint.

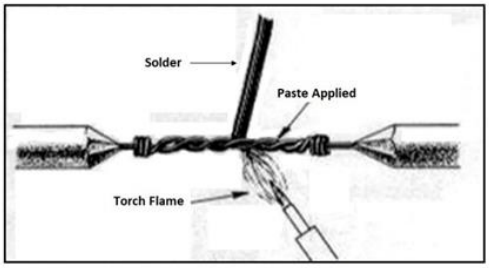


Fig.5.8: Soldering of Small Cables

Now solder wire is touched on the surface of joint to melt and fill the uneven suface of joint. Soldering iron can be used for cables up to 2.5 mm2 conductor size. Above this size, blow lamp and solder pot and ledle is used for soldering.

4. **Tapping**

A cable joint is never left unprotected.In small wiring cables two or three spirally wound successive layers of 19mm wide PVC or rubber insulation are applied on the joint for insutaion purpose.The procedure is clear from picture.

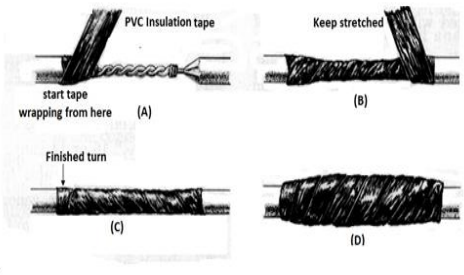


Fig.5.9: Tapping of Cable Joint

Activity 5.1

Demonstrate making of different cable joints (Straight, T-joint, Cross, Married) and insulate them

Components/Instruments

Cable, Tape, Toolbox, Electrical components

Step 1: Remove the insulation

Step 2: Bring the two conductors to a crossed position and then make a long bend or twist in each wire.

Step 3: Wrap the end of one of the wires around the straight portion of the other wire, and then do the same for the other wire. Repeat this for about four or five times.

Step 4: Press ends of the wires down close to the straight portions of the wire to prevent the ends from piecing through the insulation tape.

Step 5: Insulate the joint using the tape

5.5 Interpretation of Electrical Drawing/Wiring Diagram

A wiring diagram is a simplified conventional pictorial representation of an electrical circuit. It shows the components of the circuit as simplified shapes, and the power and signal connections between the devices.

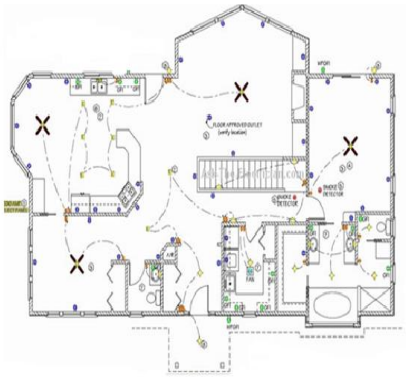


Fig 5.10

A wiring diagram usually gives information about the relative position and arrangement of devices and terminals on the devices, to help in building or servicing the device. This is unlike a schematic diagram, where the arrangement of the components' interconnections on the diagram usually does not correspond to the components' physical locations in the finished device. A pictorial diagram would show more detail of the physical appearance, whereas a wiring diagram uses a more symbolic notation to emphasize interconnections over physical appearance. A wiring diagram is often used to troubleshoot problems and to make sure that all the connections have been made and that everything is present.

5.6 Wiring Accessories

All the items which are fitted in a building (other than current consuming devices/equipment/machines) during electrical installation work to give/control supply to the electrical appliances and machines are called electrical wiring accessories. For example switches, Socket outlets, Ceiling Roses, Cable Clips, PVC Conduit, Lamp Holders etc.

A large variety of electrical accessories is available in the market for electrical installation. To cover all these in detail is beyond the scope of this book. Some important accessories along with purpose and rating are listed below.

Important Wiring Accessories and their Purpose

1. Switches

These are used to make or break the electric circuit (or to change the direction of current flow) manually.

a. Types of switches with respect to poles are:
   Single pole (SP), Double pole (DP), Triple pole (TP), Four pole (TP&N).
b. Types of switches with respect to materials:
   Iron clad (for TP and TP& N), Bakelite, Bakelite with porcelain base.
c. Types of switches with respect to throw: Single throw or double throw.

Simple piano type switch fitted in your room to control the fan is an example of single throw switch while change over switch is an example of double throw switch

d. Types of switches with respect to ways:
   One way, two ways and intermediate (4 ways in USA).
e. Space between switch contacts on opening for 230V: 6mm

f. Working voltage: 250V and 500V.

g. Current Rating:

Branch switches: 5A, 6A, 15A, 30A.

h. Shape and use: Piano key switch, tumbler type switch, ceiling switch, bed switch, toggle switch, figure touch (short piano) switch, rotary switch etc.

i. Fitting: Surface type or flush type

Application

Main switches are used to control single or three phase main supply and branch switches are used to control branch circuits and final sub circuit.

Types of Switches with respect to Shape and Use

Piano, Tumbler, Ceiling, Bed, Toggle etc.

Fig. 5.11 Typical Surface Fitting Bakelite Switch & Soket

Tumbler Switch

It is small two-position or three-position round (or some time square shape) switch, operated by an arm-and-spring mechanism. Tumbler switches are mainly used for switching the lighting circuits of electrical apparatus, and devices. Their current rating is 5, 10 or 15 ampere and voltage rating 250V. These are made with Bakelite material. High current rating tumbler swathes have porcelain base. The switches are mounted on wooden board, fixed over the surface of the wall.

Fig5.12 Flush Type Piano Key Switches

Piano Type Switch

These switches are used where good appearance is required. The switches are fixed in boards in flush form. Some type piano switch comes on plate which is directly fitted in flush type board. These switches are also known as "Piano Type Switches" due to their name.

Fig. 5.13: 6+2 & 8+2 Flush type China fitting Switches with plates

China Fitting Type Switch

Initially these switches were imported from china therefore these are called china fitting switches. Now these are being manufactured in Pakistan too. Usually they come along with fitting plate in special combination of switches and sockets. These are fancy fitting and available in matching colours with wall distemper colours.

Bed Switch

As the name indicates, it is used to switch "ON or OFF" the light from the place, other than switch-board or from near the bed, while going to sleep or getting up. This switch is hanged near bed through flexible cord/wire.

Rotary Switch

This switch is used to control different lamps from one places one by one or as selector switch, to select different voltage tapping of transformer in voltage stabilizer.

Fig. 5.14: A Typical Rotary Switch, Bell Push Switch, Ceiling Switch Bed Switch

Bell Push Switch

These switches are used to control the electric bell and indicating lamps etc. When the push button is pressed, the circuit is completed and the bell or lamp is switched on. The supply to bell or lamp is switched off as the push button is released.

Ceiling Switch

These switches are operated with a single pull of the cord, for the on and off position. These are also used in bedroom and bathroom. These switches are fixed near the ceiling and hence these are also known as "Ceiling Switches".

Fig.5.15: A Typical Intermediate Switch Front & Back Side View

Intermediate Switch

This switch has four terminals and four different connection position. The main function of this switch is to control a lamp from three or more different places, along with ordinary two-way switch. Generally, this switch is used in double stair case wiring or corridor wiring. This switch is also known as four-way switch.

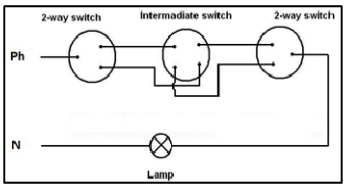


Fig. 5.16: Connections of an Intermediate Switch to Control One Lamp From Three Places

Two Way Switch

A two-way switch is a simple single pole "changeover" switch with three terminals. These are typically labelled COM, L1, and L2. In one switch position the COM terminal is connected to L1. In the other switch position, it changes over so that COM is connected to L2. The design is a "break before make" type, such that the connection to the first terminal is disconnected before the connection to the new one is made. Usually it is used to control one device from two places.

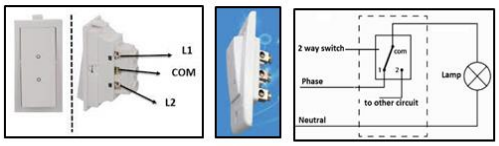


Fig. 5.17: 2-Way Switch & its Connections

Main Switch

As the name indicates this switch is used to switch "ON or "OFF" the main supply. In other words, these switches are used to control the whole supply for a house, office and machine. In single-phase circuit I.C.D.P. main switches are used, whereas in three-phase circuits I.C.T.P. main switches are used to control the supply. The main switches are of the following types:

a) Bakelite DP Main Switch

Bakelite Double Pole main switches are used to control single-phase supply at homes and shops. These are available in 15 Amp and 30 Amp current ratings. These are used to make and break phase and neutral wires at the same time. Usually an indicating light is housed in the body to show the availability of supply.

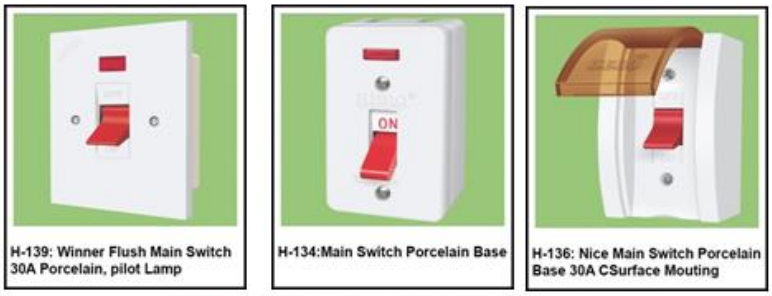


Fig. 5.18: Two Pole Bakelite main switches

b) I.C.D.P. Switch

Iron Clad Double Pole main switch is used in single-phase supply circuits. These are available in 15 Amp, 30 Amp, 60 Amps and 100 amperes current rating. In these switches, either two numbers of fuse links are provided or a fuse link and a neutral link is provided. The neutral wire is directly connected with the neutral link and phase wire is connected with the fuse


Fig 5.19 Iron Clad Main Switches

link. Normally 15 Amp current rating main switches are made of plastic molding instead of iron.

c) I.C.T.P Switch

Iron Clad Triple Pole main switches are used to control the three phase supply circuit. These are available in 15 Amp, 30 Amp, 60 Amp, 100 Amp, 150 Amp, 200 Amps, 250Amps and 300Amps current rating. Generally, these switches are also known as 3 phase 4 wires main switches. In these switches, three fuses and a neutral link is available. The neutral wire is directly connected with the neutral link and phase wires are connected with these fuse links.

2. Socket Outlets

These are fitted in wiring to give supply to the portable appliances by inserting a plug in the receptacles (tubes) of the sockets. Their proper quantity installed in the building reduces the extra use of loose wires which may lead to any accident.

Fig5.20 Flush Type Piano & Surface Type Two Pin Sockets

Every socket outlet should be controlled by a separate switch. Switch sockets have a switch fitted in the socket body. These may be three pin five pin or universal type. Three pin 30A switch socket is called power socket. Socket above 30 A should not be used.

Types of Socket outlets with respect to Pins

Two pins and three pins

a. Shape of pins: flat or round.
b. Current rating:

   Two pin 2A, 5A, 13A and 15A, Industrial: 16, 30, 32, 63and 125A.

c. Working voltage: 250V
d. Materials: Bakelite, Bakelite with porcelain base for higher ratings.
e. Fitting: Surface type or flush type.

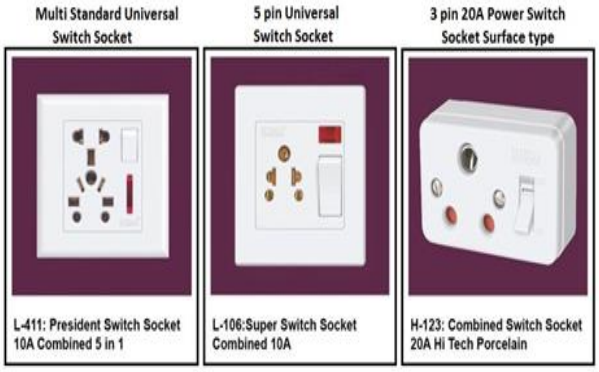


Fig. 5.21: Some Typical Switch Sockets

3. Plugs

Plug is connected at the end of the flexible cord (supply lead) of portable electrical appliances. It is then inserted into the socket tubes to get supply for that appliance. Plugs may have two or three (straight flat, straight round) pins. These pins are made of phosphor bronze or hard drawn brass either solid or slotted. Slotted pins form the spring to make batter contact with socket tubes.

A fused plug has a cartridge fuse in it. The three pins of three pin fused plugs are clearly marked L (for line), N (for Neutral) and E (for earth). Male and female plugs are just lik e socket and plug. Ratings are similar to sockets.

Around the world, different types of plugs are used. Their names are!

Type A, Type B, Type C, Type D, Type E, Type F, Type G, Type H, Type I, Type J, Type K, Type L, Type M, Type N, Type O.

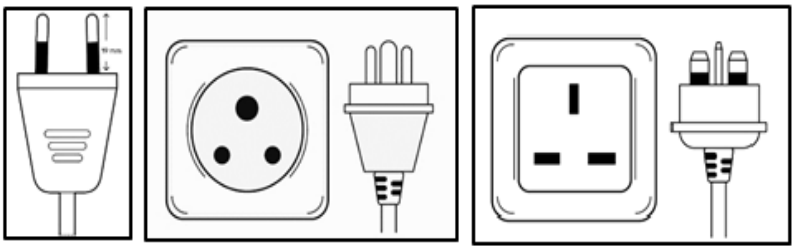


Fig. 5.22: Type"**C**"2.5A, type "**D**"5A, type "**G**" 15A plugs

In Pakistan, Type C, Type D, Type G and Type M plugs are used.

The Type C Plug has only two pins (phase and neutral) and current rating of2.5A, voltage range of 220-240V.The pins of the Type C Plug (& Socket) have a diameter of .16"-.19" (4-4.8 mm), length of 0.75"(19 mm), and are fitted with a .39"(10 mm) insulating sleeve. The two pins are set .69"-.73" (17.5-18.6 mm) apart.

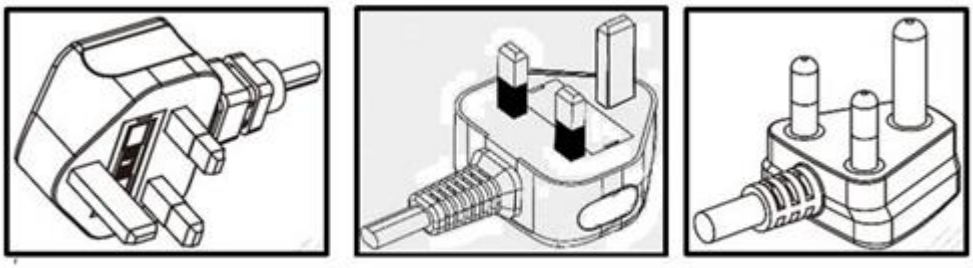


Fig.5.23: Three Pin Plugs of Different Current Ratings

4. Lamp Holders

A lamp holder a wiring accessory which is fitted in buildings to fit and remove the light lamp quickly and easily.

Material

Insulated Bakelite or brass with porcelain interior.

Shapes & Designs

Batten type, angle type, bracket type, key type, pendant type. Energy savers of almost all ratings are available with pin cap (Bayonet cap) or screwed caps lamp holders for lower power ratings are also being manufactured in both cap types.

a) Batten Lamp Holder

The holders are fixed on either on round block or wooden board with the help of wooden screws.

b) Pendant Lamp Holder

This lamp holder is used to hang the lamp from ceiling rose, with flexible cord/wire. Sometime these holders are provided with lamp shades to divert the upper light to down ward. These may be of brass or Bakelite with brass plunger.

c) Angle Lamp Holder

The angle holder is used to focus the light at an angle and is fixed directly on wall or round block. These may be of brass or Bakelite with brass plunger.

d) Swivel Lamp Holder

e) These lamp holders are used for lighting of shop windows, show case etc. It consists of ball and socket joint fitted between back plate and lamp holder, for the purpose to move the light to a wide angle.

f) Bracket Lamp Holder

These lamp holders are used to focus the light on the floor or at some angle, slightly away from the walls. Light shades can also be used for diverting all light on floor. Such lamps are provided with such fittings which make them water tight so that these can be used outside the houses or for street lighting. The lamp holder is simply a pendant holder made of brass or Bakelite.

Fig.5.24: Some Fancy Bakelite Body Screw & Bayonet Type Lamp Holders

5. Fuse

It is the most common and important type of safety device used for domestic and commercial installations. These fuses are of kit-Kat type and are also known as cut-out. These cut-outs are made of porcelain in current rating of 15 to 300 amperes. The material used as a fuse wire is tin, lead, silver, antimony, copper and aluminum etc. Copper or lead, tin alloy is mostly used in ordinary fuse wire.

Fig.5.25: Various Fuses

6. Ceiling Rose

Final circuit of pendant lamps, ceiling fans, exhaust fans, and tube lights is terminated/ ended in ceiling rose. It is a round shaped accessory consisting of two parts i.e. base and cover. Two or three metallic terminals are fitted in ceiling rose to make connection to the fix devices via a flexible piece of twin cable.


Fig.5.26: Two types of ceiling roses

7. Distribution Box/Board

The term distribution box is more appropriate than distribution board because it has length, width and depth**).** It is used to distribute electrical energy to final sub circuits or to other sub distribution boards in the installation. It is usually made with sheet steel. It has some protective devices (fuses, MCCBs or MCBs), line, earth and neutral bus bar, installed in it. Phase indicator lights, voltmeter, ampere meter and volt & am meter selector switch ore optional. No. of sub circuits through holes in the body. These are called "ways". No of ways may be from 2, 3, 4, 5, 6, 8, 10, 12…….. to 42

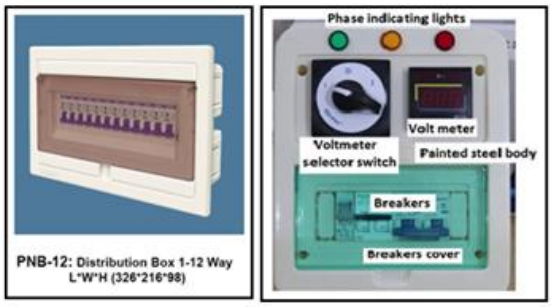


Fig 5.27 Distribution Board

Current rating may be from few amperes to thousands ampere and voltage 250V and 500V and above. Two types are:

i. Main distribution box / board (MDB)

ii. Sub distribution box/board (SDB)

8. MCCB and MCB: A circuit breaker is a protective device used to make and break the electric circuit both in normal (manually) or abnormal (automatically) conditions. Moulded case circuit breakers are usually used as main circuit breaker and miniature circuit breakers are used as branch circuit breakers.

Fig. 5.28 MCCBs & MCBs

Tripping: Thermal or magnetic.

Body Material: Bakelite.

Current Ratings

0.5,1,1.5,2,3,4,5,67,8,10,15,16,20,25,30,32,35,40,50,63,80,100,125,1510,175,200,225,250,300,350,400,500,630,800A

Working Voltage: 250,380,400,500,660V

9. Cables

Cables are installed in a building to transmit electric power from supply point to all the current consuming devices (points). Cables may be: Single core, two core, three core, three and half core, four core, five core. Conductors may be: Copper or Aluminium (above 10mm^2 only)

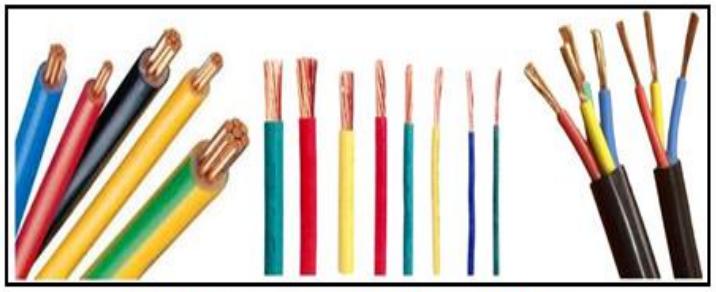


Fig.5.29: Some Typical Wiring Cables

Insulation may be:

i. P.V.C (poly vinyl chloride).

ii. V.R.I (or V.I.R) Vulcanized rubber insulation.

iii. Rubber insulated cables i.e. TRS (tough rubber sheathed) and CTS (Cab tyre sheathed), butyl rubber, and silicon rubber. Magnesium Oxide

Voltage Grade: Low (250/400V) & Medium (600/1000V).

Conductor may be: Solid (1mm^2, 1.5mm^2 and 2.5mm^2) or Stranded (From2.5mm^2 and upward) Cables may be round or flat, flexible or non-flexible, single or multi cored, armoured or non-armoured type.

Miscellaneous Wiring Accessories

i. Cleats (wood or plastic material, voltage 250V)
ii. Switch boards and switchboard frames (plastic, plastic with Bakelite sheet, sheet metal box with Bakelite sheet), sizes:4"x4",7"x4", 8"x10", 10"x12", 4"x10", 4"x12",4"x16".
iii. Cable saddles and cable clips (See fig below).
iv. Conduits: PVC conduit and fittings (3/4" to 3" size), heavy gauge metal conduits and fittings (3/4" to 3" size), light gauge metal conduits and fittings (3/4" to 2" size).
v. Batten and fittings (1/2",3/4" and 1" size)
vi. PVC duct ((used for single phase supply, for sizes, see chapter No 3)
vii. Rawal Plugs
viii. Nails and screws (1/2" size to 3(3/4" to 3" size) size)
ix. Holder adopters, multi socket plug, fan regulators or dimmers etc.

5.7 Types and Installation of Wiring Systems

1. Domestic (or Residential) Wiring Systems

i. Cleat Wiring System
ii. Wood Casing and Capping wiring system (now obsolete).
iii. PVC Duct or PVC Casing - Capping wiring system.
iv. Batten wiring (CTS or TRS) wiring system (Now obsolete).
v. Lead Sheathed Wiring System.
vi. PVC Conduit Wiring System. (Open or Concealed)

2. Industrial or Commercial Wiring

i. Steel Conduit wiring system.
ii. Metal Trunking wiring system.
iii. Ducting wiring system.
iv. Catenary wiring system
v. Tough sheathed wiring system.
vi. Overhead bus bar wiring system or metal clad bus bar system.

Detail of Conduit and PVC Duct Wiring Systems

Conduit Wiring System

Conduit wiring system can be classified as below

a. **Steel Conduit Wiring System**

Mostly used in industry or large commercial buildings.

b. **Non Metallic (PVC) Conduit Wiring System**.

Usually used in homes and shops. It may be

i. Surface or open type PVC conduit wiring system

ii. Concealed type PVC conduit wiring system

Introduction to PVC Conduit and Duct Wiring Systems

Due to numerous advantages and easy availability of materials, non-metallic conduit and duct wiring systems have almost swept away all wiring systems which use wood like batten wiring, wood casing capping wiring system and wood cleat wiring system.

Non-metallic Conduit or PVC conduit wiring system

A rigid/solid PVC conduit wiring system is very popular now a day in small buildings like homes, offices, shops, villas and bungalows etc. It is cheaper, flexible, light weight, easy to handle, easy to bend and easy to install as compared to steel conduit. PVC conduits are safe from corrosion, many chemicals, acids and insect attack. Since the PVC conduit is not conductive, so there is no risk of electric shock. PVC conduit fittings like connectors, couplings, tees, and bens/elbows are easily available in all sizes. PVC conduit and its fittings can easily be attached together with a PVC glue. Because PVC is an insulating material, so PVC conduit cannot be used as earth continuity conductor like steel conduit. Therefore, a separate earth wire in the conduit is used as an earth continuity conductor. Mostly ¾ inch and 1-inch size of PVC pipe is used for final sub circuits of domestic wiring. However, following sizes of conduits are also used in electrical wiring.

Sr. No	Cond. Size in mm(rounded)	Cond. Size in inches
1	13	0.5
2	20	.75
3	25	1
4	38	1.5
5	50	2
6	63.5	2.5

i. Surface Type PVC Conduit Wiring System

As the name indicates, it is a wiring method in which non-metallic (rigid PVC) conduits are installed on the surface of wall or roof with the help of conduit saddles. Saddles may be PVC side nail type or steel space bar type Saddle. In this wiring method, holes on the surface of wall or roof on equal distances are made with the help of electric drill machine or hand rawal plug tool. Plastic or wooden gatties are inserted in these holes. Then saddles are fitted on these Gatties and conduits are fixed and wired up. Space bar metal saddles should be used instead of plastic steel nail saddles.

Fig. 5.30: Surface Type PVC Conduit Wiring System

Material required for Surface Type PVC Conduit Wiring

i. PVC conduit and its fittings of required size and quantity/length.
ii. Metal Saddles/ hooks/ clips of required size, type and quantity.
iii. Rawal plugs or Gatties.
iv. Cotton string and blue or black liquid for string immersion.
v. Wooden screws of different sizes.
vi. Cables of different sizes as required.
vii. Different accessories like switches, sockets, power sockets, switch boards, ceiling roses, lamp holders etc. as per requirement of the installation.
viii. Draw Wire/fish wire.
ix. Conduit & Fitting jointing Glue.

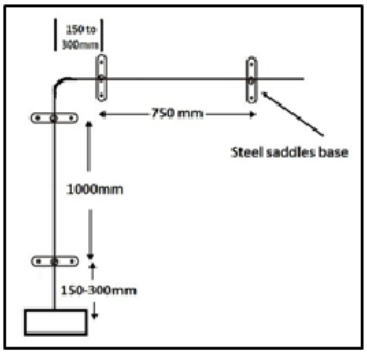


Fig 5.31: Distances of Saddles on Vertical & Horizontal Runs of Surface Conduit.

Tools Required For Surface Type PVC Conduit Wiring:

i. Spirit Level.
ii. Heck Saw.
iii. Electric Drill Machine with concrete drill bits

iv. Screw Drivers of different types and sizes.

v. Phase Tester.

vi. Measuring Tape.

vii. Electrician Pliers.

viii. Long nose Pliers.

ix. Side cutting Pliers.

x. Hammer.

xi. Electrician Knife or Wire Stripper.

Method of Installation of Surface Type PVC Conduit Wiring System

i. Decide and indicate the circuit routes.

ii. Mark blue coloured lines on these routs with the help of cotton string immersed with blue liquid. Ask the method of using cotton string to draw horizontal and vertical rout lines to your teacher.

iii. Mark dots at appropriate equal distances on the cable routs on walls and ceiling.

iv. Make holes on doted points of walls and ceiling with electric drill machine or hand Rawal plug tool. Insert the plastic Rawal plugs with hammer in these holes.

v. Insert the plastic Rawal plugs with hammer in these holes.

vi. Fit the lower part of metal saddles on the holes as shown below.

vii. Put the conduit lengths on these saddle bases and fix the upper part of saddles.

viii. Fit lamp holders, ceiling roses and switch boards etc. on their places as per drawing.

ix. Draw the wires/cables in the conduits with fish wire.

x. Make connection with ceiling roses, lamp holders, switch boards and appliances etc.

xi. Perform the necessary tests.

Maximum Spacing of Supports (Saddles) for Surface type PVC Conduits

Conduit size	Horizontal spacing	Vertical spacing
Up to 16mm	0.75meter	1.0 meter
16-25mm	1.5 meter	1.75 meter
25-40mm	1.75 meter	2 meter
Above 40mm	2 meter	2 meter

Advantage of Surface type PVC Conduit Wiring System

i. Easy to install.
ii. Cheaper in cost.
iii. Take less time to install.
iv. No danger of electric shock as in metal conduit.
v. No corrosion on plastic pipes as in metal conduit.
vi. No need to earth the pipes like metal conduit.
vii. No effect of acid, oil, grease etc. on pipes.
viii. Repairing and maintenance is easy.
ix. Any change can be made easily in future.
x. Alteration/addition is easy.
xi. No risk of damage of insulation of cables during drawing in pipes.
xii. Making new connections is easy.
xiii. No high skill is required to install this system.
xiv. Building strength does not effect as no channels are made in walls.
xv. Fault can be easily detected and can be fixed quickly.
xvi. Less planning in advance is required as compared to concealed wiring.
xvii. No chances of leakage of water and cracks.
xviii. The whole wiring system can be replaced in short period of the time and material of wiring may be reused at another place.

Disadvantage of surface type PVC Conduit Wiring System

i. Appearance is not so good looking.
ii. Mechanically weak and risk of mechanical injury is more
iii. Life is short (15-20 years) as compared to concealed PVC conduit and metal conduit systems.
iv. More risk of fire than concealed PVC conduit and metal conduit systems.
v. Saddles are required to fix the conduits.
vi. Thermal expansion can make the conduits crooked.
vii. Conduits become loose and saggy after some time which seems very ugly.

Concealed Type PVC Conduit Wiring System

Concealed means "Hidden". In this wiring system, PVC pipes are buried in the brick walls or roof surface and then plastered. After that, electrical wires/cables are pulled inside the conduits. Concealed conduit wiring system is the most popular, visually beautiful, safer and comparatively. It is most common type of electrical wiring system used nowadays in homes, bungalows, offices etc. because after wiring, the surface looks neat and clean.

Fig.5.32 Concealed Conduit Wiring Under Construction (Left) & after Finish (Right)

Material required for concealed PVC conduit wiring system

i. PVC conduit and its fittings of required size and quantity/length.
ii. Hooks to fix the conduits in wall grooves.
iii. Cotton string and blue or black liquid for string immersion.
iv. Wooden screws of different sizes.
v. Cables of different sizes as required.
vi. Different flush type accessories like switches, sockets, power sockets, switch boards, ceiling roses, lamp holders etc. as per requirement of the installation.
vii. Draw wire/fish wire.
viii. Conduit/accessories jointing glue.

Tools required for concealed PVC conduit Wiring

i. Wall chaser/Groove cutting machine or angle grinder cutting machine.
ii. Cold chisel.
iii. Lump hammer
iv. Spirit level.
v. Heck saw.
vi. Trowel.
vii. Electric drill machine with concrete drill bit or hand Rawal plug tool.

viii. Screw drivers of different types and sizes.

ix. Phase tester.

x. Measuring tape.

xi. Electrician pliers.

xii. Long nose pliers.

xiii. Side cutting pliers.

xiv. Hammer.

xv. Electrician knife or wire stripper.

Method of Installation of Concealed PVC Conduit Wiring

1) Decide and indicate the circuit routes.
2) Mark blue coloured lines on these routs with the help of cotton string immersed with blue liquid. Ask the method of using cotton string to draw horizontal and vertical rout lines to your teacher.
3) Cut chases/grooves/channels*on the cable routs on walls with the help of wall chaser/Groove cutting machine or angle grinder cutting machine.
4) Put the pipes in these grooves and fix them in place with pipe hooks.
5) Make pits/spaces for flush type switch boards, lamp holders and ceiling roses etc.
6) Once the conduits, boxes and accessories are fixed, fill the chiselled surface with cement mortar and chick mesh wrapped around the conduits.
7) Fit lamp holders, ceiling roses and switch boards etc. on their places as per drawing.
8) Fill the space around these accessories with cement mortar.
9) Also fill the grooves with cement mortar and level it.
10) Draw the wires/cables in the conduits with fish wire.
11) Make connection with ceiling roses, lamp holders, switch board sand appliances etc.
12) Perform the necessary tests.

Cutting of Grooves in the Brick Walls

Fig 5.33: Wall Chasing and Slotting Machines

Cutting the electrical hases/channels/grooves in brick walls is simple job and requires simple chasing tools. Basically, an angle grinder with two parallel cutting blades with a depth setting is used. A chasing machine can also

be used for this purpose. The depth gauge simply sets and runs the grinder up, down or across the wall making two parallel cuts. The waste between the cuts is knocked out with the use of a cold chisel.

Precautions/Rules for Cutting the Wall Grooves

1) As far as possible, the services should be planned with the vertical chases. Horizontal electrical chases should be avoided, as they reduce the strength of the wall.
2) The depth of vertical chases and horizontal chases should not exceed one-third and one-sixth of the thickness of the masonry respectively.

Fig 5.34: Grooves in Brick Wall For Concealed Conduit/Boards Installation

3) If horizontal chases are unavoidable, then it should be located in the upper or lower one-third of storey and not more than three chases should be permitted in any stretch of a wall.
4) No continuous horizontal chase should exceed 1 meter in length.
5) If unavoidable, stresses in the affected area should be checked and kept within the permissible limits.
6) Vertical chases for fixing electric conduits, I pipes or a recess for fixing electrical metal boxes should not be cut within 1.5 feet from the edge of the wall.
7) No chases, horizontal or vertical, should be made back to back.

Filling the Wall Grooves

1) Once the cable is installed, use a paint brush to wet the sides and back of the chase by using clean water, and then apply a coat of neat PVA adhesive to the sides/back of the chase and conduit/ pipe. This will aid the adhesion of the filler.
2) As a filler, the materials to be used are:
3) A strong sand/ cement mix (3:1:1 – 3 part of soft sand: 1 part of sharp sand: 1 part of cement).
4) One coat of plaster or patching plaster.
5) A standard decorator's filler.

6) If applied to a deep chase, both the plaster and filler may sag and hence they need to be built up in layers.
7) The chases must be filled from the back and around the conduit/ pipe from the front. A small trowel will help push the filler into the back corners and behind the conduit/ pipe. Use the trowel across the sides of the wall surface to cut off the filler to the line of the wall. If channelling is used, there is no need to try to fill the chase behind it.
8) If the wall is to be tied, there is no need to give a fancy finish to the wall. But if the wall is to be painted or papered, cut back the surface of the filler by about 3 mm before it fully hardens.
9) Electrical chases can also be filled with a plaster called patching plaster or one coat plaster. This can generally be applied in coats up to 50 mm thick. If there is a deep chase, build the fill up in layers. If using one coat plaster, make sure that you wet the chase really well before applying it. The plaster will dry out quickly and crack badly if its moisture content is not maintained. Recon fibres with mortar can also be used for filling the chases.

Advantage of Concealed Type PVC Conduit Wiring System

- Appearance is good looking.
- Finished surface is neat and clean.
- Mechanically safe and risk of mechanical injury is almost nil.
- No risk of damage of cable insulation.
- Comparatively long life as compared to surface PVC conduit system.
- Less risk of fire than surface PVC conduit system.
- No saddles are required to fix the conduits.
- Safe from humidity, chemical affects and smoke
- Safe from weather conditions.
- Conduits do not become loose and saggy after passage of time.
- No risk of shock
- Most Reliable and popular wiring system for domestic installations.
- Do not hamper interior layout as conduits are concealed in wall.
- Renovations can be easily performed by replacing the old wires.
- No corrosion on plastic pipes as in metal conduit.
- No need to earth the pipes.

- No effect of acid, oil, grease on pipes.
- No risk of damage of insulation during drawing.

Disadvantage of Concealed PVC Conduit Wiring System

- Installation is difficult as compared to surface conduit method.
- Expensive as compared to surface conduit method.
- Take more time to install.
- Repairing and maintenance is not easy.
- Any change cannot be made easily in future.
- Difficult to add/manage additional connection in the future.
- High skill is required to install this system.
- Building strength become weak when grooves/channels are made in walls.
- Fault cannot be detected and fixed quickly and easily.
- Good planning in advance is required.
- Chances of leakage of water and cracks.
- The whole wiring system cannot be replaced in short period of the time and material of wiring may not be reused at another place.

PVC Duct (PVC Channel) Wiring System

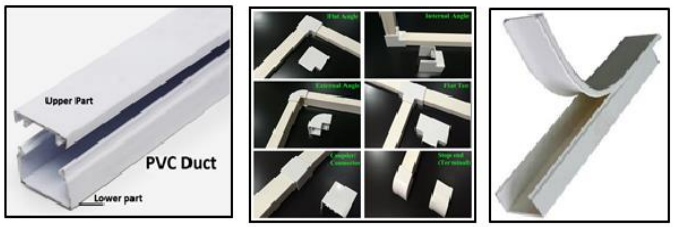


Fig 5.35: PVC Ducts & PVC Ducts Fittings

Due to ease in installation and alteration, PVC duct system has almost replaced the surface type PVC conduit wiring system in Pakistan. It is called PVC ducting or PVC channel wiring system. PVC trunking is another name used for this system. Because it was introduced as substitute of wood casing and capping system, so it is also sometimes called PVC casing and capping wiring system. PVC ducting system is particularly suitable for corrosive atmospheres. Plastics material is easier to cut, handle and install but plastic material is affected by high temperature. Buckling occurs at high temperatures and the PVC becomes brittle at low temperature around $0^{o}C$.

Material required for the installation of PVC Duct Wiring

- PVC duct and its fittings of required size and quantity/length.
- Washer headed timber screws of 1 and1.5 inch size.
- Cable ties.
- Rawal plugs or Gatties.
- Cotton string and blue or black liquid for string immersion.
- Wooden screws of different sizes for fixing the switch boards, lamps, ceiling roses etc.
- Cables of different sizes as required.
- Different accessories like switches, sockets, power sockets, switch boards, ceiling roses, lamp holders etc. as per requirement of the installation.

Tools required for Surface conduit Wiring

- Spirit level.
- Heck saw.
- Electric drill machine with concrete drill bit or hand Rawal plug tool.
- Screw drivers of different types and sizes.
- Phase tester.
- Measuring tape.
- Electrician pliers.
- Long nose pliers
- Side cutting pliers.
- Hammer.
- Electrician knife or wire stripper.

Method of installation of PVC Duct Wiring

- Decide and indicate the circuit routes.
- Mark blue coloured lines on these routs with the help of cotton string immersed with blue liquid. Ask the method of using cotton string to draw horizontal and vertical rout lines to your teacher.

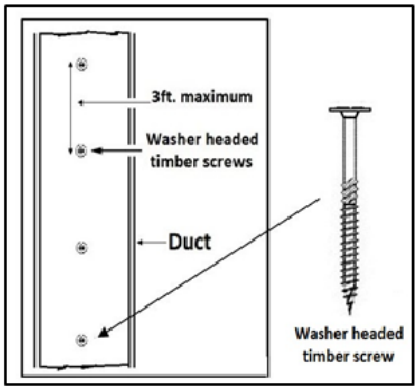


Fig 5.36: PVC Duct Fixing Method & Screw

- Mark dots at appropriate equal distances on the cable routs on walls and ceiling.
- Make holes on doted points of walls and ceiling with electric drill machine or hand Rawal plug tool.
- Insert the plastic Rawal plugs with hammer in these holes.
- Fit the lower part of duct on the holes with washer headed wooden screws or use metal washers with wooden screws.
- Fit lamp holders, ceiling roses and switch boards etc. on their places as per drawing.
- Put the wires/cables in the ducts.
- Hold the wires and cables in the duct with cable ties.
- Put the upper part of the duct on lower part and press with hands to attach with the lower part.
- Make connection with ceiling roses, lamp holders, switch boards and appliances etc.
- Perform the necessary tests.

Advantage of PVC duct Wiring System

- Good substitute of PVC conduit.
- Very cheap in cost.
- Lighter in weight.
- Very easy to install.
- Less time is required to install.
- No danger of electric shock.
- No corrosion on plastic duct as in metal conduit.
- No need to earth the duct like metal conduit.
- No effect of acid, oil, grease etc. on pipes.

1. No risk of damage of insulation of cables during drawing in ducts.
2. Making new connections is easy.
3. No high skill is required to install this system.
4. Fault can be easily detected and can be fixed quickly.
5. No material wastage.
6. Good appearance.
7. Addition and alteration of cables is easy.

8. Laying of cables is easy than drawing of cables in conduits.
9. No special skill is required for installation.

Disadvantage of PVC duct Wiring System

1. Plastic gets weak with the time so life is small.
2. Cannot bear the load of heavy cables.
3. Not suitable in high (above 70^oC) and very low (less than 0^oC) temperatures.
4. Not water and fire proof.
5. Thermal expansion can make the duct crooked.
6. Duct become loose after some time which seems very ugly
7. Mechanically weak than steel conduit and trunking.

Precautions in the Installation of Surface type PVC duct Wiring System

1) Select the correct rout before installation of conduit.
2) Always use vertical or horizontal runs between two points instead of using diagonal run.
3) Use washer headed wooden screws or use metal washers with wooden screws to fit the lower part of duct on walls or ceilings.
4) Use standard fittings of duct like Tees, internal, external 90^o bends etc. instead of bending the duct.
5) Always select the correct size of duct according to the number and size of cables to be used in duct.
6) Do not use too much cables in duct (keep at least 60% internal space of duct free).
7) There should not be more than two 90^o bends (or their equivalents) between two draw in boxes.

Applications of Surface Conduit Wiring System:

Like surface conduit, this system of wiring provides less protection against fire and mechanical damage, so this system is confine for use in homes, shops, computer labs, offices and small installations of single phase supply only.

Activity 5.2
Install electrical wiring as per drawing
Components/Instruments
Cable, Tape, Toolbox, Electrical components, Electrical wiring drawing
Step 1: Follow precautionary measures
Step 2: Make the connections as per drawings
Step 3: Perform testing

Activity 5.3
• Prepare Main Boards & cconnect main board with wiring.
Components/Instruments
Switch, Plug, Plug Socket, Cable, Board with screws
Step 1: Fit the Switches, Sockets, Holder and Meters etc. in the frame.
Step 2: Make All the Wiring Connections Correctly.
Step 3: Perform Testing.

Activity 5.4
Perform electrical wiring of stair case circuit
Components/Instruments
Cable, Tape, Toolbox, Electrical components, Electrical wiring drawing
Step 1: Follow precautionary measures
Step 2: Make the connections as per drawings
Step 3: Perform testing

5.8 Testing of Wiring

IEE Regulations state that "every installation shell be tested on completion and the defects discovered shall be corrected".

Therefore, the insulation resistance of a complete installation, section of an installation or an addition to an existence installation must be tested before connecting it to the permanent power supply.

Tests of Wiring

Tests to be performed on an installation (section of an installation or an addition to an existence installation) are:

1. Polarity test.
2. Insulation resistance test.
    a. Insulation resistance test between wiring and earth (it is also called **Leakage test** of wiring).
    b. Insulation resistance test between cables/conductors of wiring (it is also called **Short Circuit Test** of wiring).
3. Continuity test.
    a. Test for the continuity of wiring cables.
    b. Test for the continuity of earthling system.
    c. Test for the continuity of wiring conduits/ trunking etc.

Instruments used in testing of wiring

Following instruments are used in different wiring tests.

1. Continuity tester
2. Megger (or Insulation resistance tester).
3. Test lamp.
4. Multi-meter.
5. Earth resistance tester.

Test Lamp:

A test lamp is used to check the presence of power supply at any point in an installation. A general tungsten filament lamp fitted in insulated holder and guarded by steel wires is used for this purpose. Two insulated wires of required length are also attached as test leads. See Fig.5.37 an insulated handle is also fitted behind the lamp holder for holding purpose. Sometimes a neon test lamp can also be used for this purpose.

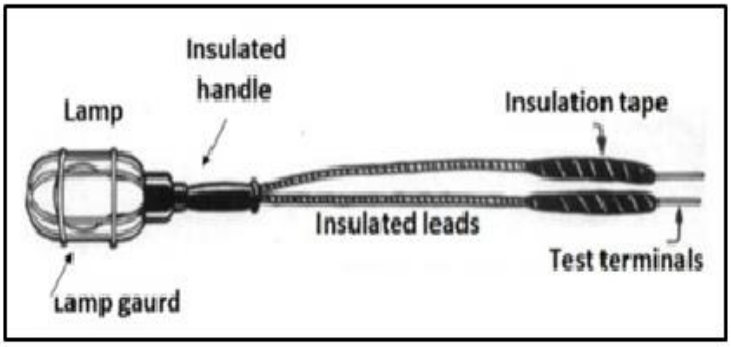


Fig. 5.37 : Proper Homemade Test Lamp

Continuity Tester

It is a cheap test set and can be made at home. It consists of a 6V lamp in series with two 6V batteries housed in a box. Two terminals are fitted outside the box for connecting the test leads. It is used to check the continuity of cable conductors, conduits and earth continuity conductor.

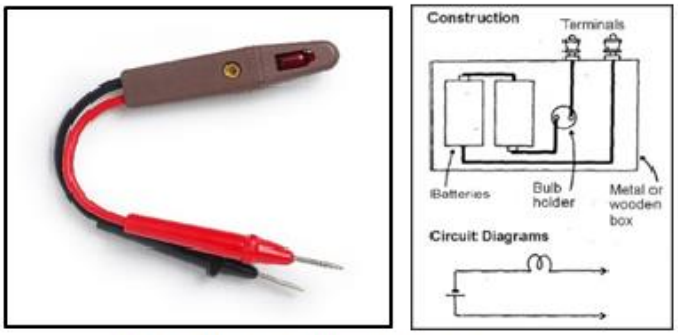


Fig.5.38 A Continuity Tester

Megger (Insulation Tester)

It is a portable test instrument used to measure resistance of machines and electrical installations in mega ohms. It contains a hand driven dc generator and direct reading mega-ohm meter mounted altogether in a case with two terminals outside the case. One terminal is marked

"L" and the other is marked "E". A third terminal is called the "guard terminal" to protect the operator from electric shock. Megger is available in 100V to 2500V. For testing the electrical installations, usually 500V Megger is used for single phase supply and 1000V Megger is used for the testing of installations having three phase supply.

Fig. 5.39 : High Voltage Digital Insulation Tester (Megger)

As a general rule, the voltage of Megger should be double of the voltage of machine/installation that is to be tested. Some Megger are available with double scales, one is the mega-ohm scale for insulation resistance and the other is the continuity testing scale up to 100Ω range. Now a days, digital Megger are commonly used with multi range scale.

Multimeter

Multi-meter is also a portable test instrument less commonly used in wiring testing. However, it can not only be used for measuring resistance but also to measure the ac or dc voltage in an installation. Continuity can also be checked with multi-meter.

Fig. 5.40: A digital and an Analog Multimeter

Earth Resistance Tester

The earth tester is a Megger like test instrument specially designed to check the resistance of earth electrode to the surrounding ground. It has a generator, an ohm-meter and a current reversing mechanism in a common case having a handle outside.

It has four terminals C1, P1 & C2, P2. The two terminals are shorted together to form one common terminal. Here in the picture given below, E is the common terminal and Y, Z are the other two terminals. E terminal is connected to the main earth electrode under test and other two terminals are connected to the two electrodes (rods) driven in the ground near the main electrode during the test.

Fig.5.41: An Earth Tester With Accessories

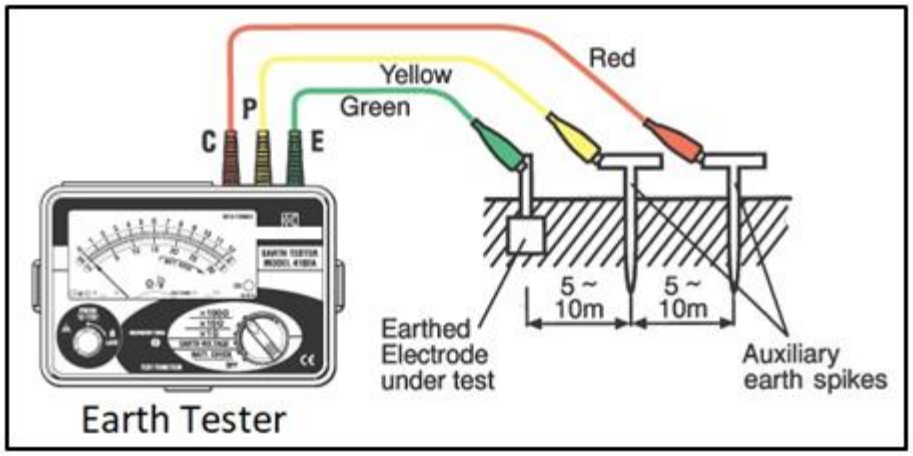


Fig.5.42: Earth Resistance Arrangement

Testing the Electrical Installation (Wiring)

1. Polarity Test

IEE regulation 501 and Pakistan electricity rule 51 states that :

"In a two wire installation (connected to earth on one pole) all fuses and single pole switches, and single poles circuit breakers and like, shall be fitted on phase wire only". Two wire non earthed installations require two pole main switches.

Connecting the single pole switches on phase wire is necessary, so that by making the S.P switches "OFF", the lamp and its circuit (wire from switch to lamp) could be made quit dead. If the single pole switch is provided on neutral wire, the metal type lamp holders and the fans as well as part of wiring will remain alive, even when the single pole switch is in OFF position. This may cause an accident. For example, a person who is replacing a lamp, even after opening (making off) the single pole switch, is liable to get electric shock if he comes in contact with the phase terminals of the lamp holder.

Polarity test is carried out to ensure that all the single pole switches are connected on phase line and not on the neutral line. However, if the proper coloured cables are used throughout the two wire installation i.e. red colour for phase wire and black colour for neutral wire (in Pakistan), then no confusion will arise.

Testing The Polarity

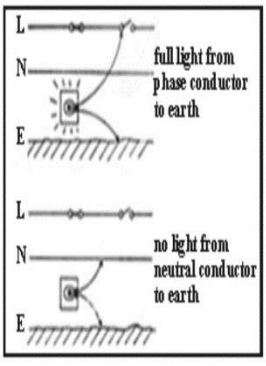
Polarity test can be performed using following test instruments.

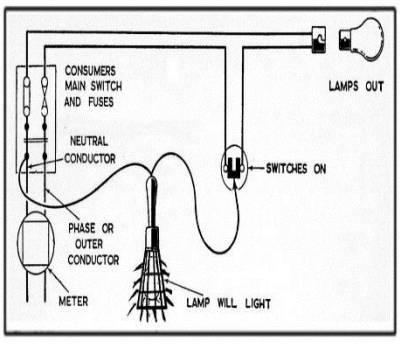
i. Test lamp. (If supply is available).
ii. Megger (if supply is not available and circuit is dead).
iii. Continuity tester (if supply is not available and circuit is dead).

Testing of Polarity if Circuit is Live

Testing of Polarity with Test Lamp

For this purpose, the test lamp is connected between phase wire (first terminal of switch) and earthed metal work of the installation. If lamp lights up, it means that switch is in phase wire and if lamp does not lit (give light), it means that





switch is on neutral wire. In this way all the switches can be checked one by one.

If earthed point or earthed metal work is not available in the installation (as the case is usually in Pakistan), then use the neutral wire for the above said purpose (i.e. testing the polarity of single pole switches). The method is as follows:

i. Switched on at the main switch.
ii. All single pole switches should be ON with their covers removed for old tumbler switches (and turn back the Bakelite sheet of switch board if piano type switches have been used).
iii. All lamps out and all other apparatus disconnected.

If the single pole switches are on the phase wire, they will be alive. The end of one probe is connected to the neutral wire at mains switch and the other probe is touched to the single pole switch terminals, the test lamp will light up. If the switch is wrongly connected on neutral wire, the lamp will not glow as the lamp is on earth potential. The procedure is repeated for all the switches turn by turn.

In testing, the screw type lamp holders should be used and ensure that the outer contact is earthed, one probe is touched to the live side of the mains switch and the other probe to the outer contact of the lamp holder, the test lamp lights up to indicate that the outer case is earthed.

- In the case of two way switches, the three terminals of the two way switches are temporarily connected together for test purpose.
- Three pin sockets should also be tested to verify that the terminal mark "L" of the socket out let is connected with phase wire or not.
- In a large installation, the work can be sectionalized by checking the polarity of the bus bars at the distribution boards and working from these positions instead of running the test lead back to the main switch.

Testing of Polarity with neon Tester (Phase tester)

It is very easy method of testing the polarity on live circuits. For testing the correct polarity of SP switches, the tip of tester is touched with both the terminals of SP switches and neutral turn by turn keeping the thumb on the metal part on back side of the tester. The phase tester lit on phase wire and does not on neutral wire.

Testing of Polarity if Circuit is Dead

If supply is not available in newly constructed building, then battery pack continuity tester, Megger continuity tester or multi-meter can be used to test the correctness of polarity.

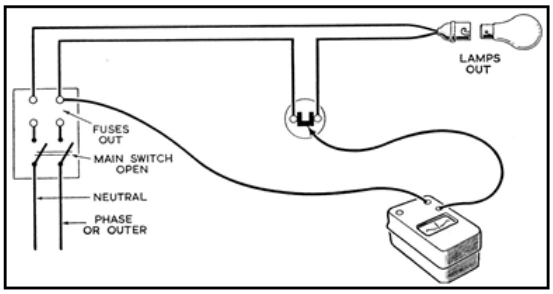


Fig.5.43 Testing of Dead Circuit Polarity

Testing of polarity with continuity tester

Before starting the test:

i. Turn OFF the main switch.

ii. Pull out the main fuses.

iii. Disconnect the apparatus and pull out the lamps from their holders.

iv. Turn ON all the single pole switches.

Now connect one lead of the continuity tester to the phase wire at the outgoing side of main switch fuse and other lead to the terminals of single pole switches turn by turn. If lamp of tester lights up (or Megger continuity tester gives less than one ohm reading by rotating its handle at constant speed), it means polarity is correct. If switches are on wrong polarity, then lamp will not glow (or Megger continuity tester will give very high resistance).

2. Insulation Resistance Test

a. Leakage Test (or testing of insulation resistance between the wires and earth)

According to the Pakistan electricity rule no 25, the insulation between the wiring of an installation and earth should be of such a value that a leakage current may not exceed $1/5000^{th}$ of the full load current (or 0.02% of the full load current).

The aim of this test is to check the insulation of cables used in wiring, either these have sufficiently high resistance (it should be in mega-ohms) to avoid the leakage of current or not. Test is performed with 500V Megger.

Before making the insulation test, ensure that:

i. Main switch is in OFF position.

ii. Main fuse is taken out and all the other fuses in position.

iii. All the switches are in ON position.

iv. All the lamps are in position (or holder points are short circuited).

v. Phase and neutral wire is shorted together.

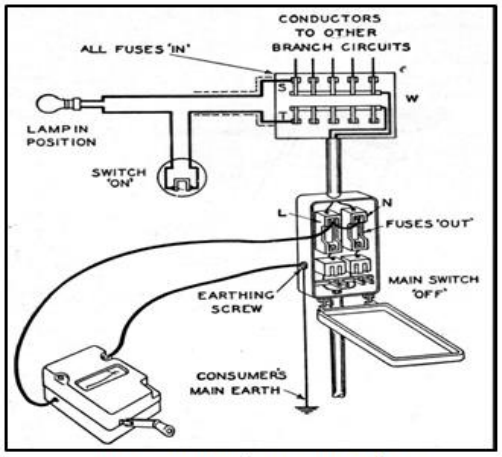


Fig.5.44: Conductor to Earth Test

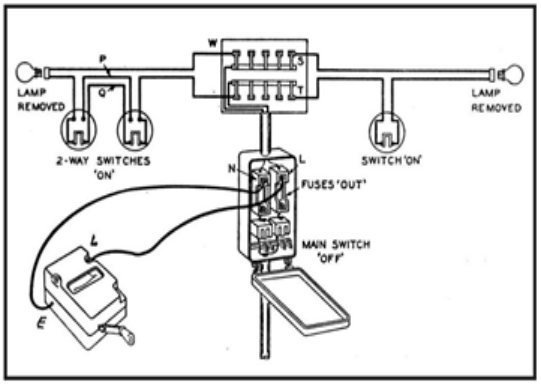


Fig. 5.45: Conductor to conductor test

The "L" terminal of Megger is connected to the point where phase and neutral wires at the main switch have been short circuited and "E" terminal of Megger is connected to the earth. Now handle of Megger is rotated at full constant speed and reading from the dial is noted. Heating appliances should be checked separately for insulation test.

Result: The insulation resistance in no case should be less than 0.5 mega ohms.

OR

Measured resistance should not be less than 50 mega ohms divided by no of out lets. If its result is more than unity, then one mega ohm should be taken as maximum working value.

b. Testing of insulation resistance between the conductors of wiring (or short circuit test)

The socket outlet, appliance, or lighting fitting incorporating a switch is regarded as one outlet.

The purpose of this test is to ensure that the insulation is sound enough between conductors of wiring to prevent any leakage current between them and leading to a short circuit.

Before making the insulation test, ensure that:

i. Main switch is in OFF position.
ii. Main fuse is taken out and all the other fuses in position.
iii. All the switches are in ON position.
iv. All the lamps are taken out (and all the connections between phase and neutral are removed).
v. Phase and neutral wires are kept separate at main switch.

The "L" and "E" terminals of Megger are connected to the phase and neutral wire on wiring side of the main switch. Now handle of Megger is rotated at full constant speed and reading from the dial is noted.

Result: Measured resistance should not be less than 50 mega ohms divided by no of out lets but the insulation resistance in no case should be less than 0.5 mega ohms and need not to be more than one Mega-ohm.

For PVC insulated cables, the resistance should be 12.5/no of out lets.

1. Continuity Test:

Following are to be tested for continuity in an installation.

i. Continuity of wires.
ii. Continuity of earth system (earth continuity conductor)
iii. Continuity of metal conduits of wiring.

Testing the Continuity of Wires:

The testing of continuity of short and long wires of conduit wiring is very clear in the Fig.5.50 & 5.51 given below, if supply is not available. This test should be completed on wires before connecting them to the devices.

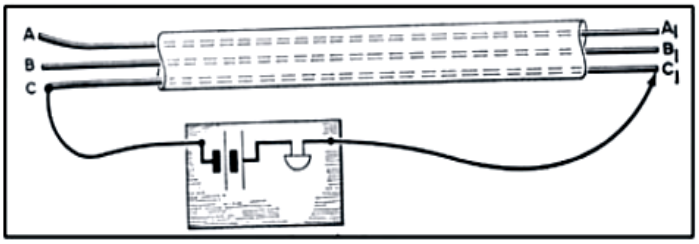


Fig. 5.46 : Continuity Test of Short Length Wires

Following method is adopted for testing the continuity of wires of a wiring system if supply is available.

Before making the continuity test of wiring, ensure that:

i. Main switch is in OFF position.
ii. Main fuse is taken out and all the other fuses in position.
iii. All the switches are in ON position.
iv. All the lamps are taken out and all the apparatus is disconnected.
v. Terminals of ceiling roses, holders, and sockets are joined together.

The "L" and "E" terminals of Megger are connected to the phase and neutral wire on wiring side of the main switch. Now handle of Megger is rotated at full constant speed and reading from the dial is noted.

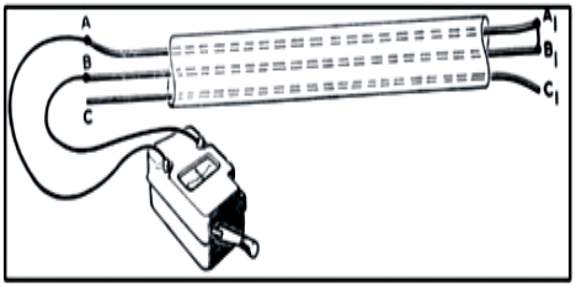


Fig.5.47: Continuity test of long wires

Result: If pointer of Megger comes to zero, it means good continuity of wires otherwise not.

All the metal conduits (especially if these are being used as earth continuity conductor), and other metal work must be solidly connected to earth for safety. Otherwise in case of insulation damage, the leakage current will start flowing to the ground and gives sever shock to a person touching it.

Before making the continuity test of conduits or ECC, ensure that:

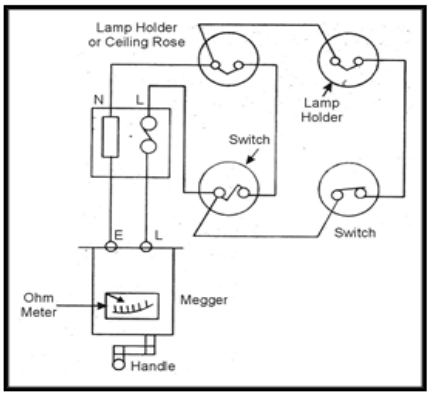


Fig.4.48 : Continuity Test of Wiring

Testing the Continuity of Conduits and Earth Continuity Conductor

i. Main switch is in OFF position.
ii. Main fuse out and all the other fuses in position.
iii. All lamps in position and all the switches in ON position.
iv. Phase wire coming out of main board and "E" terminal of the Megger is connected to the earth connecting point.
v. The line wire of Megger is touched to all metal switches, lamp holders and conduits and earth continuity conductor (ECC) at different points and handle of Megger is rotated at constant speed.
vi. All the points are checked turn by turn.

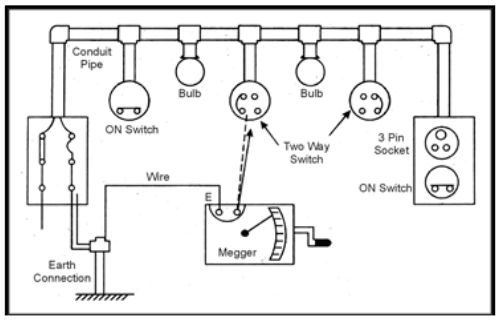


Fig. 5.49 : Continuity Test of Conduits

Result: If pointer of Megger comes to zero, it shows good continuity of conduits/ECC, switches or other metal work to earth that is being tested. If it shows more than one ohm resistance, it means continuity is not good and need to be correct.

Testing the Resistance of Earth Electrode:

The common terminal P1& C1 (or E) is connected to the earth electrode via earthling lead and other

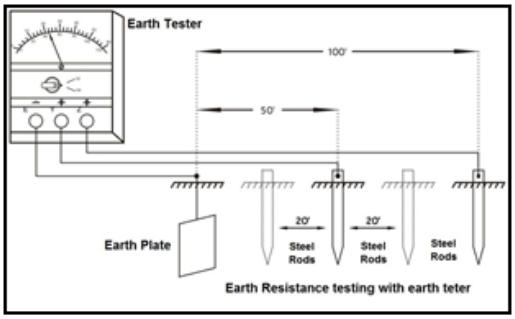


Fig.5.50 Testing the Resisitance Earth Electrode

two terminals are connected to the two other steel or copper rods A & B(or Y & Z as per given picture) specially driven in the ground for this test. Rod Y is driven in the ground 16.5 meter from the main electrode and rod Z is placed about 33meter away from main electrode. The instrument is placed on a horizontal firm stand free from the surrounding magnetic field. The range switch is set to a suitable scale and handle is rotated at required speed in proper direction. The reading is noted. Two more readings are taken by placing the middle rod about 7 meters towards and away from the main electrode. If these readings are equal to the first reading then OK, otherwise average of three readings is taken. Resistance should be less than one ohm.

Activity 5.5
Perform Earthing Test (Wenner Method)
Components/Instruments
Earth Tester (4 Terminal), 4 No's of Electrodes (Spike), 4 No's of Insulated Wires, Hammer, Measuring Tap
Step 1: Make the connections as per drawings Step 2: Follow the Teacher's instructions Step 3: Perform the desired test Step 4: Record the readings Step 5: Generate a report

Activity 5.6
Perform the following electrical wiring tests: • Continuity • Polarity • Short circuit test • Insulation test
Components/Instruments
Multimeter, Electric tester, Magger, Insulation tester, Electrical toolbox

Step 1: Make the connections as per drawings(where required)

Step 2: Follow the Teacher's instructions

Step 3: Perform the desired test

Step 4: Record the readings

Step 5: Generate a report

Key Points

1. Laying of wires / cables and fitting the wiring accessories in a building, according to the safety and electricity rules, keeping in view the architectural beauty of the building is called **Electrical Wiring.**
2. **Single Phase wiring installation** is the most common wiring in residential buildings. In Single Phase supply (230V in Pakistan/UK, EU and 120V & 240V in the US & Canada), there are two (one is Line Phase/ Hot / Live and the other one is Neutral) incoming cables from the poles to the kWh energy meter and then directly connected to the main distribution board.
3. A bare solid or stranded conductor is called wire. Insulated conductor with single strand is also called **Wire.**
4. A stranded insulated conductor (with or without outer cover) is called **Cable.**
   Examples*:* All stranded cables from 1.5mm^2, 2.5 mm^2, 4 mm^2 to 630 mm^2 sizes
5. A twisted layer of galvanized steel wires (or sometimes steel tape) over the sheath of cables is called **Armouring**. Armouring is provided for the mechanical protection of sheath and insulation of cables from mechanical damage.
6. Types of Wiring Cables with Respect to Cores are single core, two core, three core ,four core & five core
7. Some imperial sizes of cables are 1/0.044", 3/0.029", 3/0.036", 7/0.029", and 7/0.044" etc. widely used in Pakistan.
8. Maximum limit of voltage drop from main distribution box to any load point in the wiring is 1.25% of the declared supply voltage.
9. The Various **Insulating Materials** used in manufacturing of cables are Rubber, VIR (Vulcanized India Rubber), Paper, Polyvinyl Chloride (PVC), Varnished Cambric, Polyethylene, Silk, Cotton, Enamel etc.
10. **Cable Jointing** is a process of connecting two lengths of a cable (or of bare conductors)

in such a way that they are mechanically and electrically as strong as the equal length of the sound cable itself.

11. All the items which are fitted in a building (other than current consuming devices/equipment/machines) during electrical installation work to give/control supply to the electrical appliances and machines are called electrical **Wiring Accessories**.

12. Tests to be performed on an installation (section of an installation or an addition to an existence installation) are:

i. Polarity test.

ii. Insulation Resistance test.

a. Insulation resistance test between wiring and earth (it is also called **Leakage Test** of wiring).

b. Insulation resistance test between cables/conductors of wiring (it is also called **Short Circuit Test** of wiring).

iii. Continuity test.

c. Test for the continuity of wiring cables.

d. Test for the continuity of earthling system.

e. Test for the continuity of wiring conduits/ trunking etc.

EXERCISE

Select the most appropriate option (✓)

1) A stranded insulated conductor is called

   a. cable b. core

   c. wire d. sheath

2) A bare solid or stranded conductor is called

   a. wire b. Core

   c. Wire d. sheath

3) This is not the part of internal wiring cable

   a. Conductor b. Insulation

   c. Sheath d. Armoring

4) No of strands in the conductors of stranded wiring cable may be

   a. 19 b. 07

   c. 37 d. All these

5) L.T power cables are manufactured for this voltage grade

   a. 600/1000V b. 1900/3300V

   c. 11000/33000V d. Both a & b

6) Joints on electrical conductors should be

   a. Avoided if possible b. Mechanically strong

   c. Electrically strong d. All these

7) The process of removing insulation of a cable end is called

   a. Skinning b. Soldering

   c. Tinning d. Scrapping

8) A switch is used to

   a. Make the electric circuit

   b. Break the electric circuit

   c. changes the direction of current flow

   d. All these

9) No of poles of switches used in wiring may be

   a. One b. Two

   c. Three or four b. Any of these

10) Switch with respect to throw may be

a. Single throw b. Double throw

c. Triple throw d. Both a and b

11) This switch should be used in bath rooms

a. Push button switch b. Ceiling switch

c. Toggle switch d. Iron clad switch

12) Single pole switch should be installed on

a. Phase wire b. Neutral wire

c. Both (a) & (b) d. None of these

13) Pins of electrical plug should be made of this material

a. Phosphor Bronze b. Hard Drawn Brass

c. Aluminum d. Any of (a) or (b)

14) This is not a domestic wiring system

a. Batten wiring

b. PVC conduit wiring

c. Catenary wiring

d. PVC duct (casing capping) wiring.

15) This wiring is very cheap and easy to install

a. Cleat wiring

b. Batten wiring

c. PVC surface conduit wiring

d. Concealed PVC conduit wiring

16) Conduit wiring system is installed

a. on wall surface b. on ceiling surface

c. concealed in walls and ceiling

d. All these

Short answer of the following question Questions

1. Define Electric wiring.
2. Define Cable.
3. Define Wire.

4. Write difference between wire and cable.
5. Define core of cable.
6. Write the names of main parts of a wiring cable.
7. Write the purpose of cable in internal wiring.
8. Define flexible cord.
9. Define flexible cable.
10. What is difference between wiring and power cable?
11. Why joints are used on electric cables.
12. What are two basic characteristics of a cable joint?
13. Write the names of surface type wiring systems.
14. Define indoor and outdoor type wiring systems.
15. Write two differences between domestic and industrial wiring systems.
16. Write names of two methods of making connections in wiring.
17. Write 02 disadvantages of metal conduit wiring system.

Answer of the following question in detail

1. Write the types of wiring cables with respect to insulation along with characteristics of any two insulations.
2. Write the types of wiring cables with respect to cores.
3. Write the types of wiring cables with respect to voltage grade.
4. Write step wise procedure to find the proper metric size of cable for particular installation.
5. Write all steps for making a joint on wiring cable.
6. Enlist 10 wiring accessories along with their purpose.
7. Define and enlist types of socket outlets and plugs.
8. Define switch. Write the types of switch with respect to poles and throw.
9. Define main distribution board.
10. Write difference between socket outlet and switch socket.
11. Compare PVC and metal conduit wiring system
12. Write advantages and disadvantages of steel conduit wiring system.

Practical Activities

1. Identify the testing equipment as per requirement of job.
2. Apply various types of wiring testers (Phase tester, Test lamp, AVO Meter, Megger).
3. Perform the electrical wiring of multi storey electric bell circuits.

Instructions for the Teachers

1. Adopt Health and Safety measures in the lab
2. Use ICT resources for better delivery of the content
3. Ensure proper functioning of lab equipment
4. Ensure assessment during course of the activity and give input to the Trainee.

Words/Terms	Meanings/Descriptions
Chapter 1:	
Occupational Safety	Occupational Safety covers the risk factor in your workplace, and potential safety hazards that could possibly cause injury.
Hazard	A Hazard is a potential source of harm or adverse health effect on a person or persons.
Personal Protective Equipment' (PPE)	The term 'personal protective equipment' (PPE) refers to a vast group of products (e.g. safety helmets, safety footwear and harnesses, eye protection, gloves, high-visibility clothing, etc.) designed with the aim to protect users against low-, medium- and high-level hazards.
Fire Extinguisher	A fire extinguisher is an external fire safety system useful to extinguish or control minor fires, often in emergency cases.
Chapter 2:	
Linear	Shows a direct relationship between someone in a higher position and someone in a lower position
Lateral	Shows relationships between different departments on the same hierarchical level.
File	A file is the **common storage unit** in a computer, and all programs and data are "written" into a file and "read" from a file.
Folder	A folder holds one or more files, and a folder can be empty until it is filled
Header & Footer	The header is a section (blank space) that appears in the top margin, while the footer is a section (blank space) that appears in the bottom margin. Header & Footer generally contains important information such as page numbers, date, time, author name, publisher name, chapter name, book name, and document name etc.
Email	Email, short for "electronic mail," is one of the most widely used features of the Internet, along with the web

Chapter 3:	
Technical Drawing	A Technical Drawing is a detailed, precise diagram or plan that conveys information about how an object functions or is constructed
T-Square	T-square is a tool used in technical drawing, primarily as a guide to draw straight horizontal lines on a drafting table.
Drafting Templates	A template is a thin and flat piece of plastic containing various cutout shapes.
Intersecting lines	Two or more lines crossing each other are called intersecting lines
Polygons	A polygon is a plane figure bounded by three or more straight sides. Polygons can be mainly classified as regular and irregular.
Quadrilaterals	A quadrilateral is a four-sided plane figure. The sum of theinterior angles of a quadrilateral is 360◦.
Multiview Drawing	Multiview Drawing is a technique used by drafters and designers to depict a three-dimensional object
Orthographic Drawing	Orthographic Drawing is a type of drawing used to draw Front, Side & Top view of an object
Chapter 4:	
Measurement	Measurement is an act of comparison between a predefined and commonly accepted standard quantity and unknown quantity.
Measuring Instrument	A measuring instrument is a device that is used to compare the two quantities for determining the value or magnitude of an unknown quantity or variable
Moving Iron System	The instrument in which the moving iron is used for measuring the flow of current or voltage is known as the moving iron instrument
Electrodynamic System	The electrodynamometer is a transfer-type instrument. A transfer-type instrument is one that may be calibrated with a dc source and then used without modification to measure AC.

Chapter 5:	
Cable	A stranded insulated conductor (with or without outer cover) is called cable. Examples*:* All stranded cables from 1.5mm^2, 2.5 mm^2, 4 mm^2 to 630 mm^2 sizes
Core	Insulated conductor/conductors in a protective cover/sheath is called core of the cable.
Sheath	The outer protective cover over the insulated conductor is called Sheath

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The Author of the Book, Engr. **Shahbaz Hussain** is a renowned TVET Expert having almost 26 years of experience in the sector. He has got his education from GCU and UET, Lahore. He has received training from UK in the field of Curriculum Development. He has vast experience of teaching, TVET administration as Principal, District Manager, Director in the P-TEVTA and NAVTTC. He is the author of almost a dozen of books for the TVET-DAE students. His famous publications/textbooks include:

i. Electric Circuits / Electrical Essential & Networks (ELTR-114)
ii. Electrical Essential & Networks (MTR-132)
iii. Electronic Devices & Circuits (ELTR-123)
iv. Microprocessor Architecture (ELTR-314)
v. Principles of Electrical Engineering (ET-115)
vi. Propagation of Electromagnetic Waves (ELTR-212)
vii. Electrical Machines/Motors and Generators (ELTR-243)
viii. Electronics-1 (CIT-134)
ix. Digital Logic Design (ET-282)

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