GRADE 10 NOTES

ELECTRICAL TECHNOLOGY

COMPREHENSIVE HANDBOOK NOTES

Well-organized, simplified learning notes that provide clear, concise information in a logical sequence, making key concepts easily accessible and memorable, enhancing understanding and retention while fostering engagement and facilitating effective study. By providing a clear focus on key ideas, these Mwalimu Consultancy Ltd Notes foster better retention and comprehension, making learning more accessible and enjoyable.

MWALIMU VERSION

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STRAND 1.0: FUNDAMENTALS OF ELECTRICAL TECHNOLOGY

Sub-strand 1.0: Introduction to Electrical Technology

a) Importance of Electrical Technology in Society:

Electrical technology is fundamental to modern society. It powers our homes, industries, transportation, and communication systems.

- **Domestic Uses:**

✓ Lighting: Providing illumination in homes, schools, and streets.

✓ Appliances: Operating refrigerators, washing machines, cookers, and entertainment systems.

✓ Heating and Cooling: Regulating indoor temperatures with air conditioners and heaters.



- **Industrial Uses:**

✓ Manufacturing: Powering machinery and automation systems.

✓ Construction: Operating power tools and equipment.

✓ Mining: Running heavy machinery and extraction processes.



- **Transportation:**

✓ Electric vehicles (EVs) and trains.

✓ Electric bale vehicles

✓ Traffic management systems.

- **Communication:**

✓ Powering telecommunications networks, internet infrastructure, and electronic devices.



- **Healthcare:**

✓ Operating medical equipment, diagnostic tools, and life support systems.

- **Agriculture:**

✓ Irrigation systems, lighting for greenhouses, and powering farm machinery.

b) Career Opportunities in Electrical Technology:

- ✓ **Electrician:** Installing, maintaining, and repairing electrical systems in buildings and industries.



- ✓ **Electrical Engineer:** Designing and developing electrical systems, power generation, and distribution networks.



- ✓ **Electronics Technician:** Repairing and maintaining electronic equipment.
- ✓ **Power Plant Operator:** Monitoring and controlling power generation systems.
- ✓ **Telecommunications Technician:** Installing and maintaining communication networks.
- ✓ **Renewable Energy Technician:** Installing and maintaining solar, wind, and other renewable energy systems.
- ✓ **Automation and Control Technician:** Working on industrial automation systems.

c) Safety Regulations in Electrical Tasks:

✓ **Personal Protective Equipment (PPE):**

- Insulated gloves: Protecting hands from electric shock.
- Safety glasses: Protecting eyes from sparks and debris.
- Safety shoes: Protecting feet from electrical hazards and falling objects.



✓ **Lockout/Tagout Procedures:** Ensuring circuits are de-energized before work begins.

✓ **Proper Tool Usage:** Using insulated tools and equipment.

✓ **Safe Work Practices:** Avoiding contact with live wires, maintaining a clean workspace, and following safety guidelines.

✓ **Awareness of electrical hazards.**

d) Roles of Stakeholders in Electrical Safety:

- **Kenya Power (KPLC):**

✓ Responsible for the distribution and retail of electricity.

✓ Ensures the safety of its infrastructure and connections.

✓ Plays a vital role in public awareness campaigns regarding electrical safety.

✓ Must adhere to safety regulations and standards.

✓ They also have policies in place regarding stakeholder engagement, to ensure the safety of the public.

 Kenya Electricity Transmission Company Limited (KETRACO):

✓ Focuses on the transmission of high-voltage electricity.

✓ Prioritizes the safety of its transmission lines and substations.

✓ Has a responsibility to provide a safe working environment for its employees and contractors.

✓ They also must ensure that their operations do not put the public at risk.

 Energy and Petroleum Regulatory Authority (EPRA):

✓ The regulatory body overseeing the energy sector.

✓ Sets and enforces electrical safety standards and regulations.

✓ Conducts inspections and audits to ensure compliance.

✓ Investigates electrical accidents and incidents.

 Government Agencies:

✓ The Ministry of Energy: Formulates energy policies and strategies, including those related to safety.

✓ County governments: Play a role in enforcing building codes and electrical installation regulations at the local level.

✓ The government is responsible for creating and enforcing the legal framework that electrical companies must follow.

 Electrical Contractors and Technicians:

✓ Responsible for safe electrical installations and repairs.

✓ Must adhere to industry standards and regulations.

✓ Should be licensed and qualified to perform electrical work.

✓ They are the ones who are on the ground preforming the electrical work, so they must be well trained.

 Consumers (Public):

✓ Responsible for using electricity safely in their homes and businesses.

✓ Should be aware of electrical hazards and take precautions.

✓ Should report any electrical safety concerns to the relevant authorities.

✓ Public education is a very important part of electrical saftey.

- **Educational and Training Institutions:**

✓ Provide training and education on electrical safety to professionals and the public.

✓ Help to develop a skilled workforce that understands and practices safe electrical work.

- **Industry Associations:**

✓ These associations help to develop and promote best practices for electrical safety within the industry.

Key Aspects of Stakeholder Involvement:

❖ **Regulation and Enforcement:** EPRA's role in setting and enforcing standards is critical.

❖ **Infrastructure Safety:** KPLC and KETRACO must maintain safe infrastructure.

❖ **Public Awareness:** Educating the public about electrical hazards is essential.

❖ **Skilled Workforce:** Training and licensing qualified electricians is vital.

❖ **Workers:** Following safety regulations, using PPE, and reporting hazards.

❖ **Employers:** Providing safe working conditions, training, and PPE.

❖ **Government Agencies:** Enforcing safety standards and regulations.

❖ **Professional organizations:** Creating and updating safety standards.

SUB-STRAND 1.2: D.C CIRCUITS

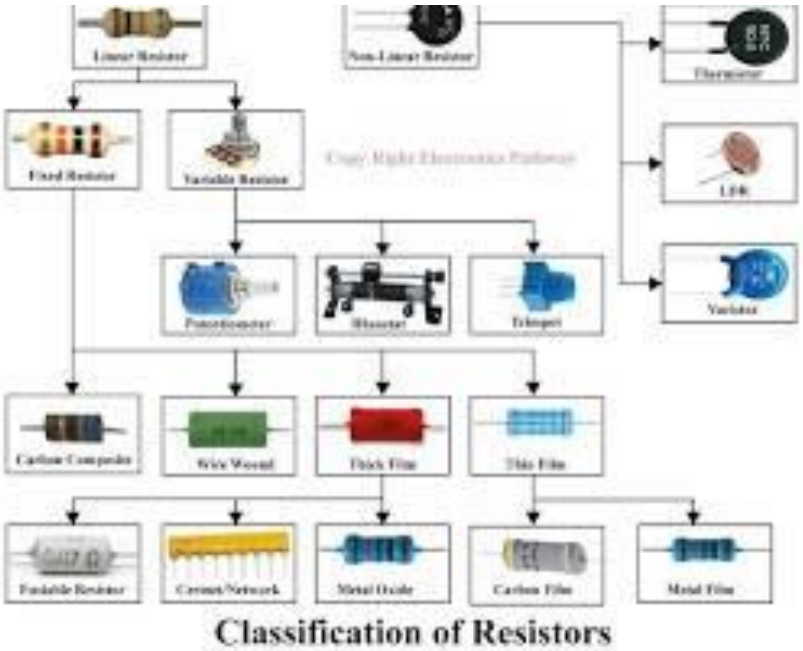
a) Properties of Resistors in DC Circuits:

- **Resistance (R):**

✓ The opposition to the flow of electric current, measured in ohms (Ω).

✓ Resistors limit current and control voltage in circuits.

✓ Types of resistors: carbon, wirewound, variable (potentiometers, rheostats).



Classification of Resistors

- **Ohm's Law:**

✓ Relates voltage (V), current (I), and resistance (R): V=IR.

✓ This law is fundamental to analyzing DC circuits.

- **Power Dissipation:**

✓ Resistors dissipate electrical power as heat: P=IV=I2R=V2/R.

✓ Power rating of a resistor indicates the maximum power it can safely dissipate.

- **Color Codes:**

✓ Resistors are marked with color bands to indicate their resistance value and tolerance.



Brown	1	1	x10	±1%
Red	2	2	$x10^2$	±2%
Orange	3	3	$x10^3$	±3%
Yellow	4	4	$x10^4$	±4%
Green	5	5	$x10^5$	±0.5%
Blue	6	6	$x10^6$	±0.25%
Violet	7	7	$x10^7$	±0.1%
Grey	8	8	$x10^8$	±0.05%
White	9	9	$x10^9$	

b) Analyze DC Circuits Using Circuit Laws:

- **Ohm's Law:**

✓ V=IR (Voltage = Current × Resistance)

- **Kirchhoff's Laws:**

✓ **Kirchhoff's Current Law (KCL):** The total current entering a junction is equal to the total current leaving the junction.

✓ **Kirchhoff's Voltage Law (KVL):** The algebraic sum of the voltages in a closed loop is zero.

✓ These laws are essential for analyzing complex DC circuits.

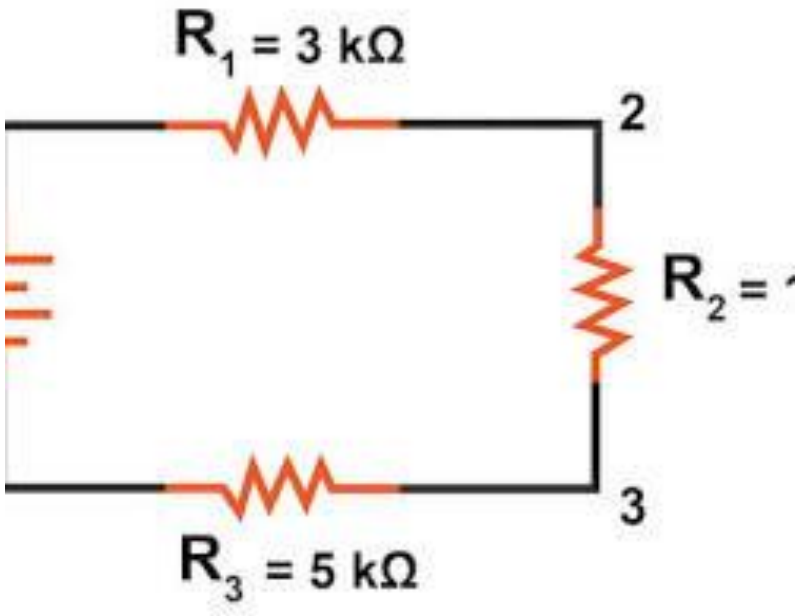
- **Series Circuits:**

✓ Resistors are connected end-to-end.

✓ Total resistance: R_T=R_1+R_2+R_3+...

✓ Current is the same through all resistors.

✓ Voltage is divided across resistors.



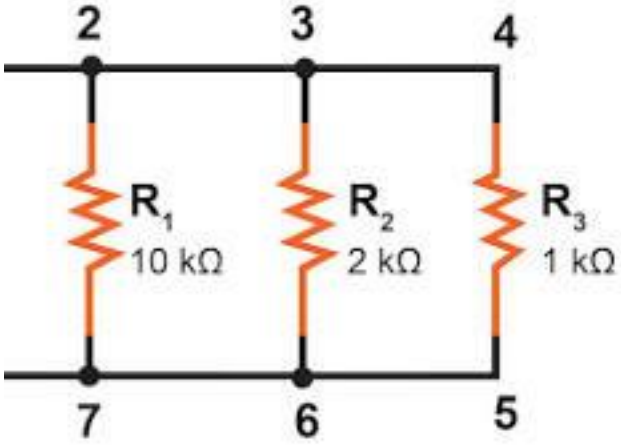
- **Parallel Circuits:**

✓ Resistors are connected side-by-side.

✓ Total resistance: 1/R_T=1/R_1+1/R_2+1/R_3+...

✓ Voltage is the same across all resistors.

✓ Current is divided among resistors.



c) Construct Resistor Networks in DC Circuits:

- **Series Resistor Networks:**

✓ Use breadboards or PCBs to connect resistors in series.

✓ Measure total resistance and voltage drops.

- **Parallel Resistor Networks:**

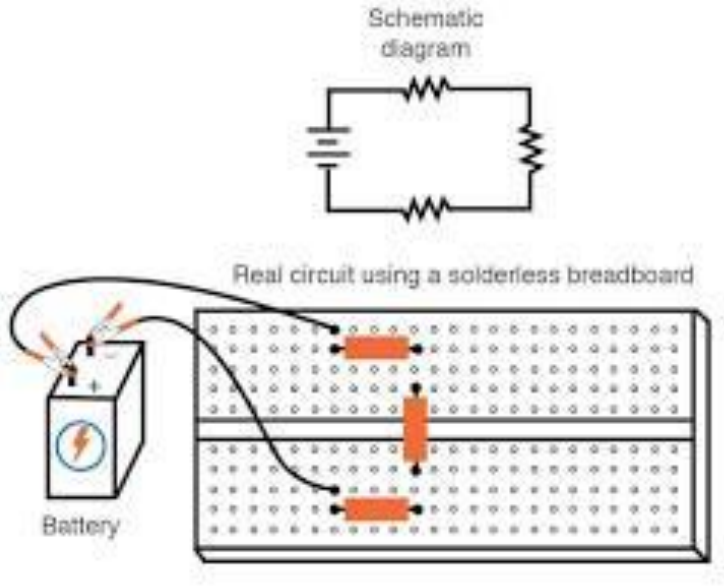
✓ Use breadboards or PCBs to connect resistors in parallel.

✓ Measure total resistance and current division.

- **Combination Networks:**

✓ Combine series and parallel connections to create more complex circuits.

✓ Use Ohm's Law and Kirchhoff's Laws to analyze the circuits.



d) Troubleshoot DC Circuits in Electrical Appliances:

- **Fault Identification:**

✓ Open circuits: Break in the circuit, no current flow.

✓ Short circuits: Unintended path for current, excessive current flow.

✓ Faulty components: Resistors, capacitors, diodes, etc.

✓ Dry joints: Poor solder connections.

✓ Loose terminals: Loose wire connections.

- **Troubleshooting Tools:**

✓ Multimeter: Measuring voltage, current, and resistance.

✓ Continuity tester: Checking for breaks in circuits.



- **Troubleshooting Techniques:**

✓ Visual inspection.

✓ Voltage measurements.

✓ Resistance measurements.

✓ Component testing.

e) Practical Applications of DC Circuits in Day-to-Day Life:

- **Home Automation:**

✓ Lighting control systems.

✓ Thermostats and HVAC systems.

✓ Security systems.

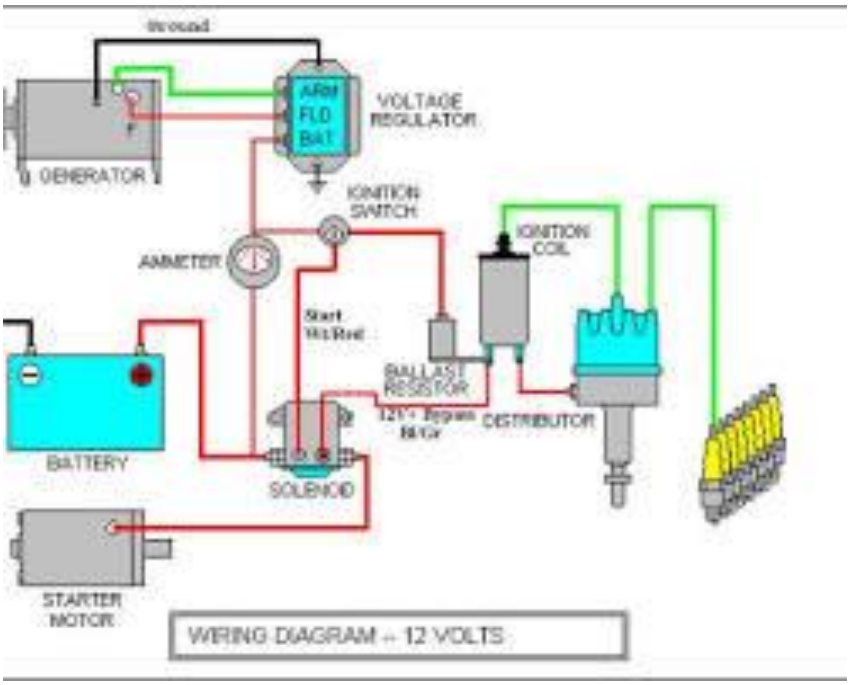


- **Car Safety Applications:**

✓ Automotive lighting systems.

✓ Sensors and control systems.

✓ Electronic control units (ECUs).



- **Portable electronic devices:**

✓ Cell phones, laptops, and tablets.

- **Renewable Energy systems:**

✓ Solar panels.

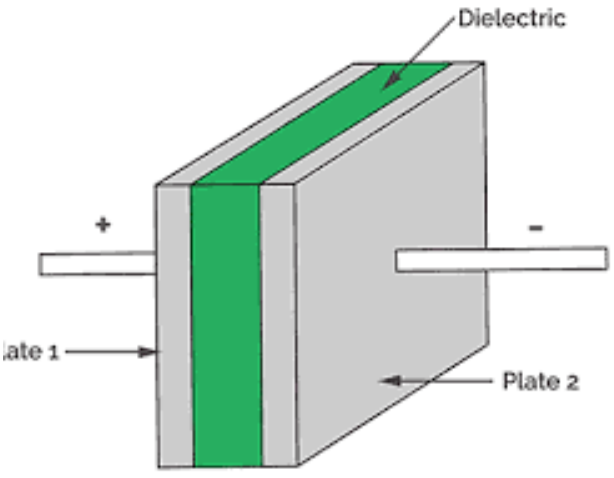
✓ Battery storage.

Sub-strand 1.3: Capacitors and Capacitance (8 Lessons)

1.3: Capacitors and Capacitance

a) Principle of Operation of a Capacitor:

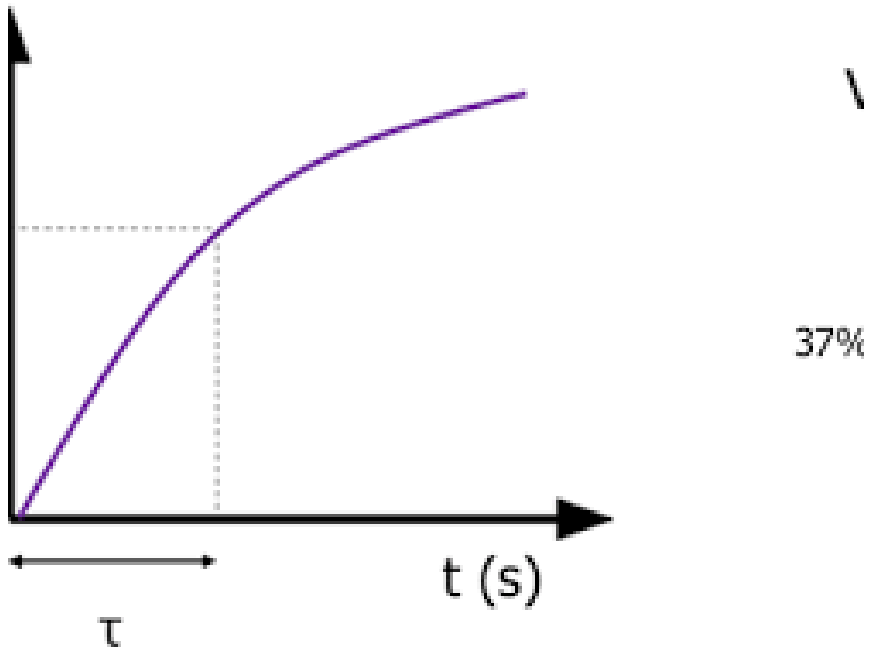
- A capacitor stores electrical energy in an electric field between two conductive plates separated by an insulator (dielectric).
- When voltage is applied, charge accumulates on the plates, creating an electric field.
- Capacitance (C) is the ability to store charge, measured in farads (F).



Basic capacitor structure showing plates and dielectric

b) Characteristics of Capacitive Circuits:

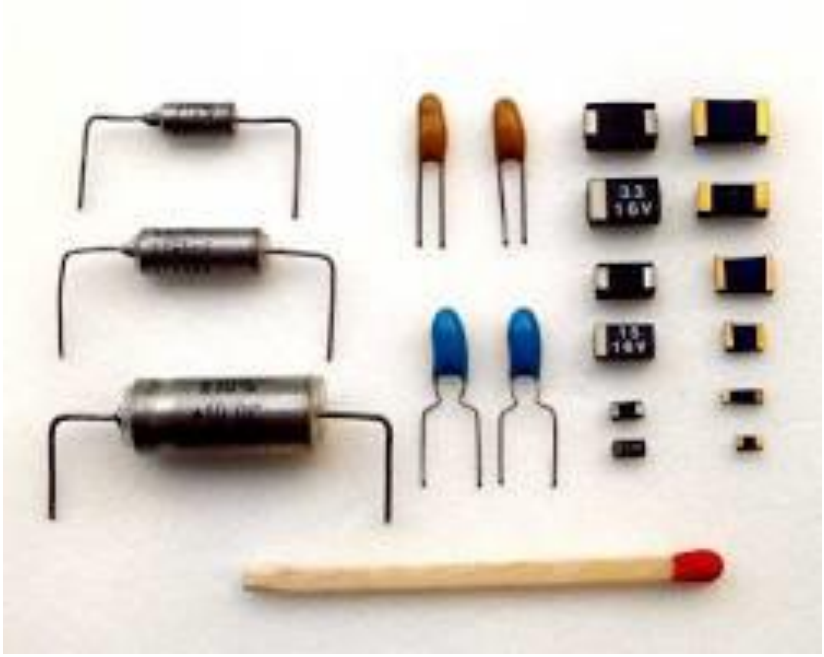
- ✓ **Charging and Discharging:** Capacitors charge when connected to a voltage source and discharge when the source is removed.
- ✓ **Voltage-Time Characteristics:** Voltage across a capacitor increases exponentially during charging and decreases exponentially during discharging.
- ✓ **Current-Time Characteristics:** Charging current is high initially and decreases exponentially; discharging current is reversed.
- ✓ **Time Constant (RC):** In an RC circuit, the time constant determines the rate of charging and discharging.



Voltage time graph for a charging capacitor

c) Selecting Appropriate Capacitors:

- **Capacitance Value:** Determined by the application's requirements.
- **Voltage Rating:** Must exceed the maximum voltage in the circuit.
- **Dielectric Type:** Affects capacitance, voltage rating, and temperature stability. (e.g., ceramic, electrolytic, tantalum).
- **Physical Size and Mounting:** Considerations for circuit board layout.
- **Datasheets:** Provide detailed specifications for capacitor selection.



Various types of capacitors (ceramic, electrolytic, tantalum)

d) Series and Parallel Connection of Capacitors:

- **Series Connection:**

✓ Total capacitance: 1/C_T=1/C_1+1/C_2+1/C_3+...

✓ Total capacitance is less than the smallest individual capacitance.

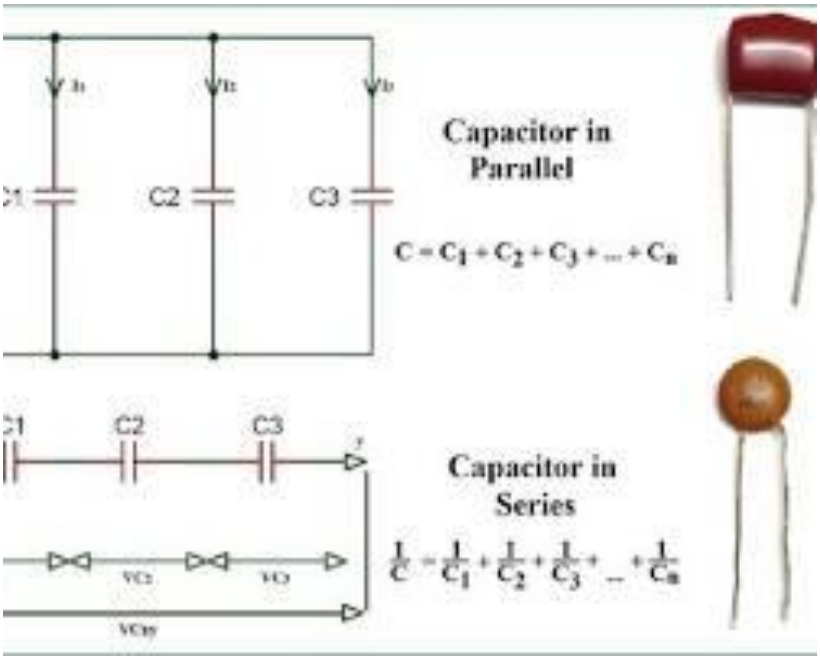
✓ Voltage is divided across capacitors.

- **Parallel Connection:**

✓ Total capacitance: C_T=C_1+C_2+C_3+...

✓ Total capacitance is the sum of individual capacitances.

✓ Voltage is the same across all capacitors.



Series capacitor circuit diagram

e) Importance of Capacitors in Electrical Appliances:

- **Charge Storage:** Used in power supplies for smoothing and filtering.
- **Motor Control:** Used for starting and running induction motors.
- **Timer Circuits:** Used in timing applications, such as traffic lights and electronic timers.
- **Filtering:** Used to remove unwanted AC components from DC signals.
- **Coupling and Decoupling:** Used to block DC signals and pass AC signals.

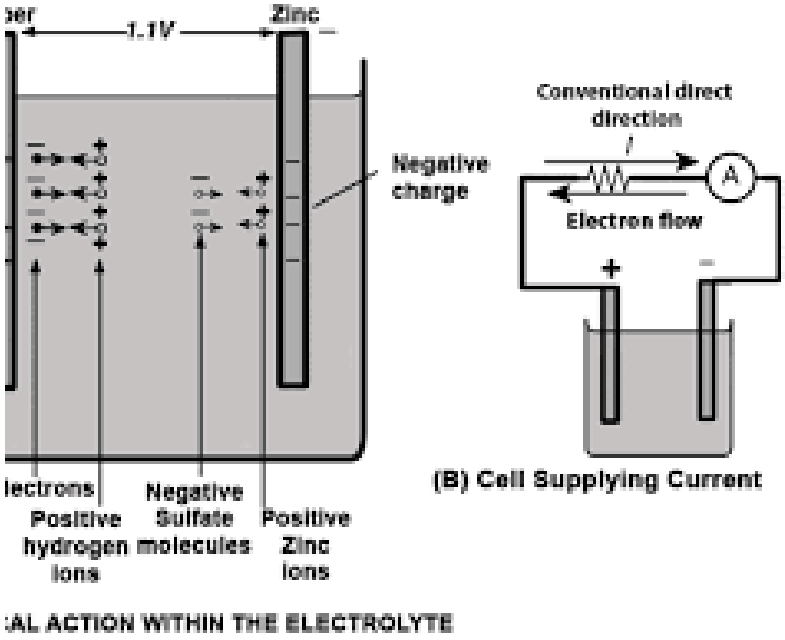


Traffic light circuit board with capacitors

Sub-strand 1.4: Cells and Batteries

a) Principle of Operation of a Simple Cell:

- A simple cell converts chemical energy into electrical energy.
- It consists of two different electrodes (metals) immersed in an electrolyte (solution).
- A chemical reaction between the electrodes and electrolyte produces a voltage.
- Electrons flow from the negative electrode (anode) to the positive electrode (cathode) through an external circuit.



Simple voltaic cell diagram

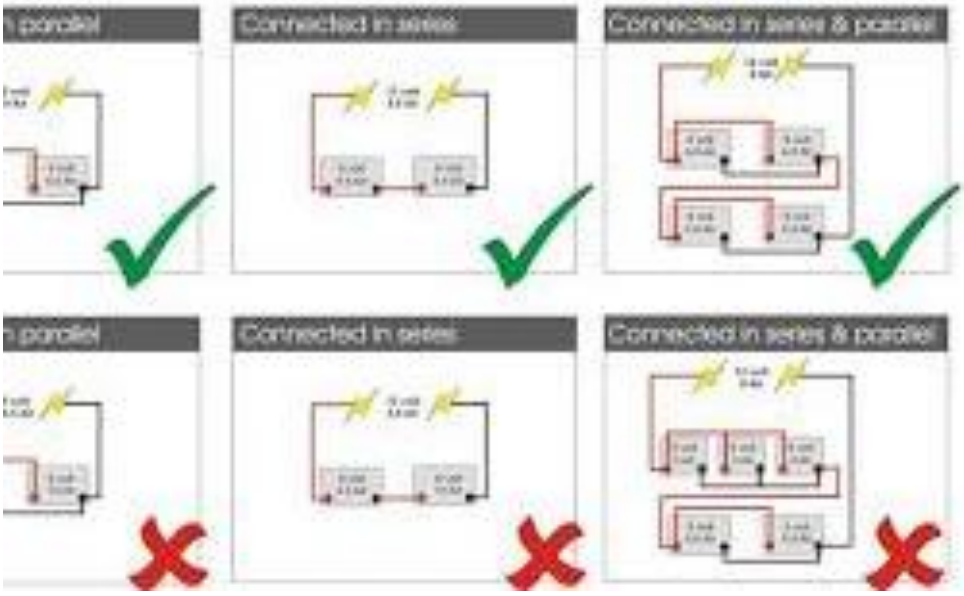
b) Connecting Series and Parallel Battery Arrays:

- **Series Connection:**

✓ Connecting batteries in series increases the total voltage.

✓ The positive terminal of one battery is connected to the negative terminal of the next.

✓ Total voltage: $V_T=V_1+V_2+V_3+...$



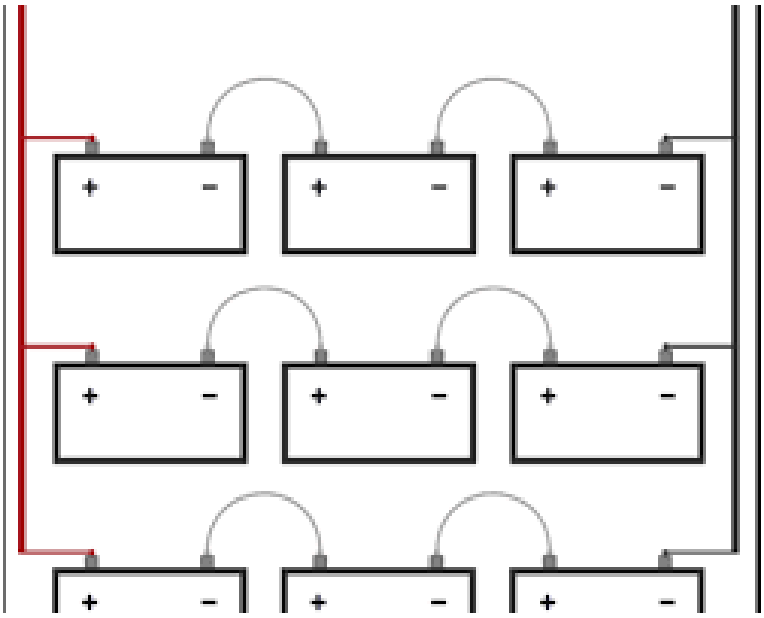
Batteries connected in series

- **Parallel Connection:**

✓ Connecting batteries in parallel increases the total current capacity.

✓ Positive terminals are connected together, and negative terminals are connected together.

✓ Total voltage remains the same.



Batteries connected in parallel

c) Battery Charging Procedure for a Secondary Battery:

- Secondary batteries (rechargeable) can be recharged by reversing the chemical reaction.
- A charger provides a reverse current to restore the battery's chemical state.
- Charging rate and voltage must be controlled to prevent damage.
- Proper ventilation is essential during charging.



Battery charger connected to a car battery

d) Maintenance Procedures for Cells and Batteries:

✓ **Terminal Cleaning:** Clean corroded terminals to ensure good contact.

✓ **Water Level Maintenance:** For lead-acid batteries, maintain the electrolyte level with distilled water.

✓ **Proper Storage:** Store batteries in a cool, dry place.

✓ **Prevention Against Overcharging and Undercharging:** Use appropriate chargers and avoid deep discharges.



Cleaning battery terminals

e) Importance of Safe Disposal of Cells and Batteries:

- Batteries contain hazardous materials (heavy metals, acids) that can contaminate the environment.
- Recycle batteries through designated collection centers.
- Avoid disposing of batteries in regular trash or burning them.



Battery recycling symbol

STRAND 2.0: ELECTRICAL MACHINES

Sub-strand 2.1: Magnetism

a) Magnetic Properties of Materials:

✓ **Ferromagnetic Materials:** Strongly attracted to magnets (iron, nickel, cobalt).

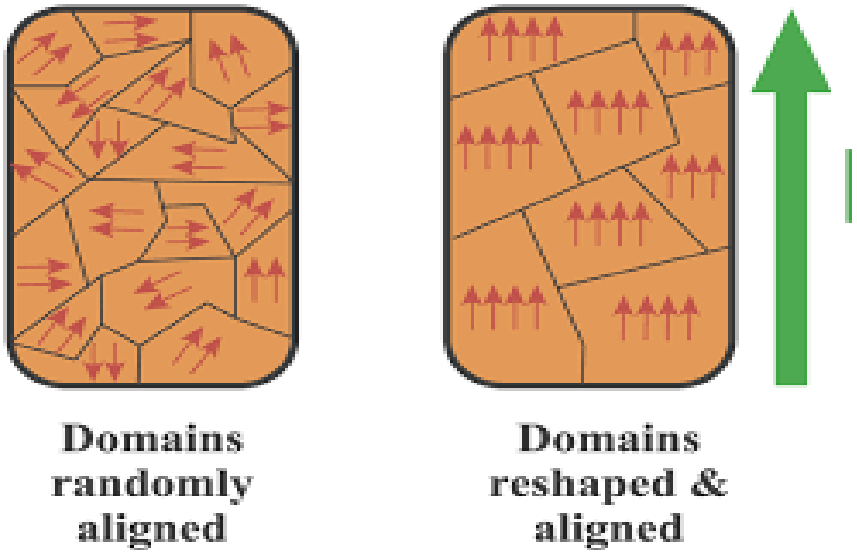


Iron filings attracted to a magnet

✓ **Paramagnetic Materials:** Weakly attracted to magnets (aluminum, platinum).

✓ **Diamagnetic Materials:** Weakly repelled by magnets (copper, water).

✓ **Magnetic Domains:** Microscopic regions within ferromagnetic materials that align to produce magnetism.



Magnetic domains in a material

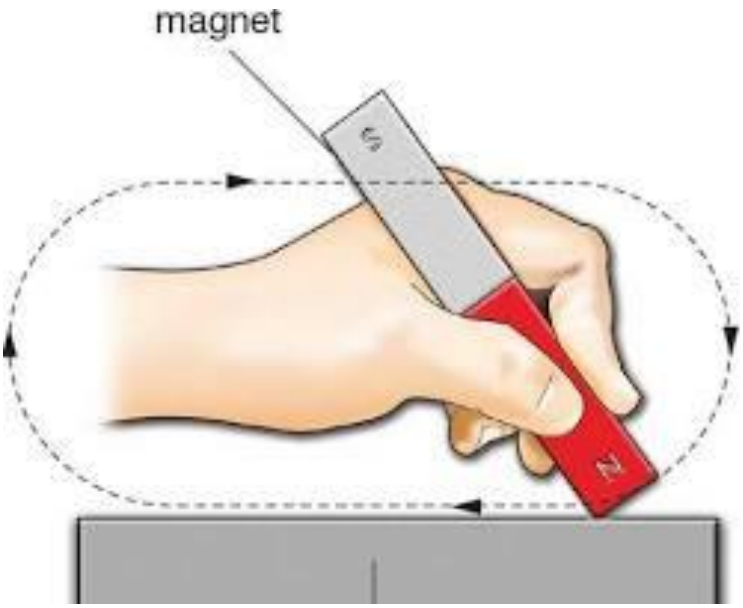
b) Magnetization and Demagnetization Procedures:

- **Magnetization:**

✓ Stroking with another magnet.

✓ Placing in a strong magnetic field.

✓ Using an electromagnet.



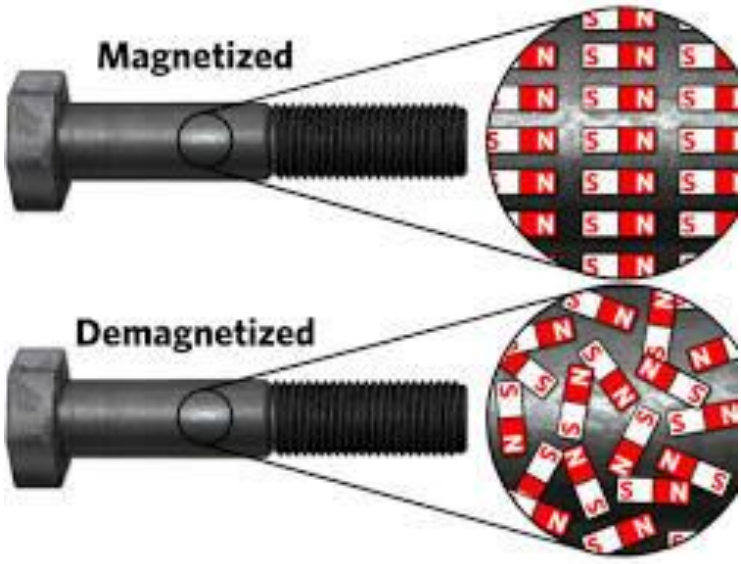
Stroking a metal with a magnet

- **Demagnetization:**

✓ Heating.

✓ Hammering or dropping.

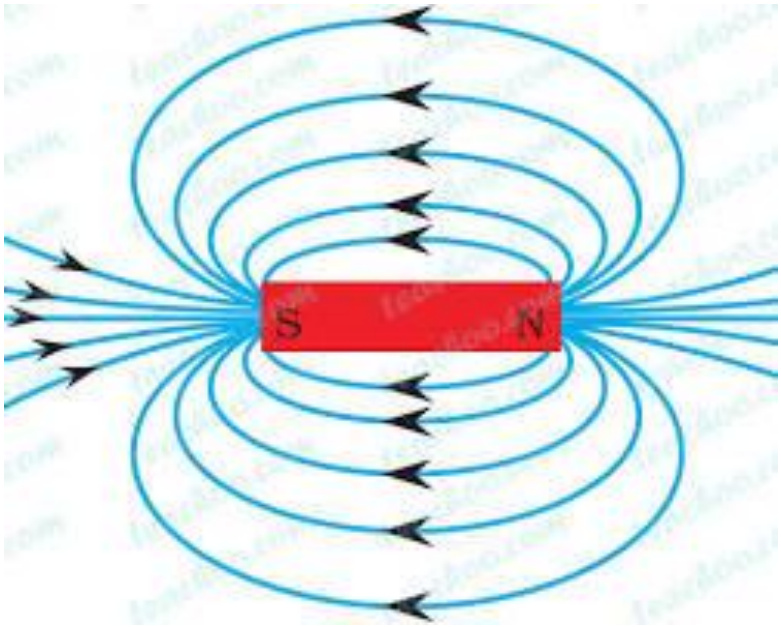
✓ Placing in an alternating magnetic field.



Metal being heated to demagnetize it

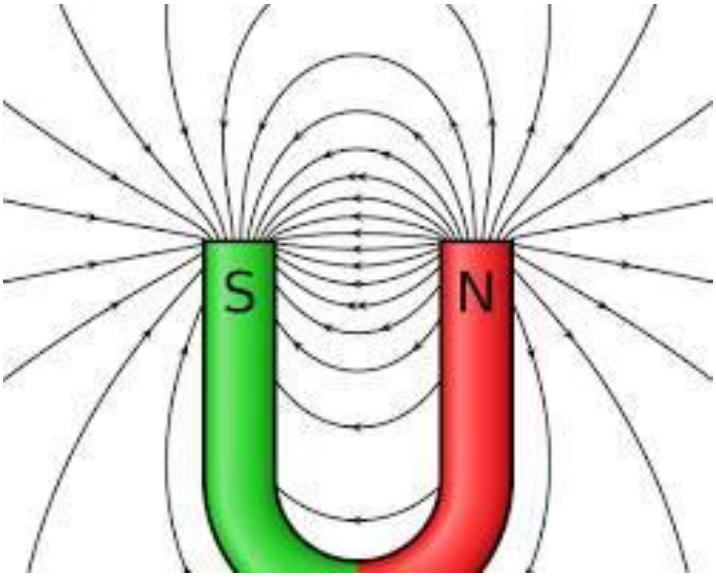
c) Magnetic Field Patterns Around a Magnet:

- **Magnetic Field Lines:** Invisible lines that show the direction and strength of a magnetic field.
- **Bar Magnet:** Field lines loop from the north pole to the south pole.



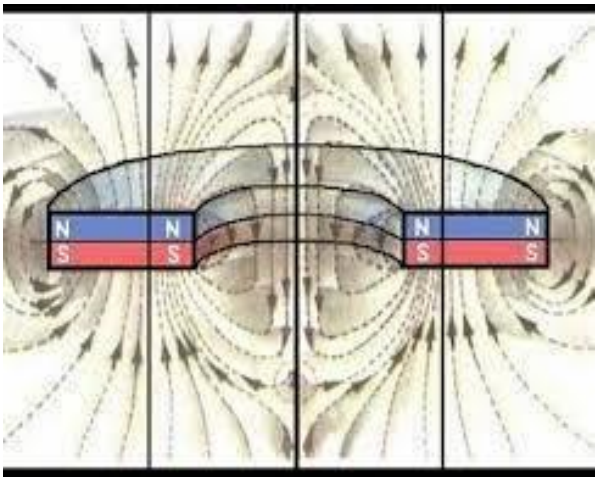
Magnetic field lines around a bar magnet

- **U-Shape Magnet:** Concentrated field between the poles.



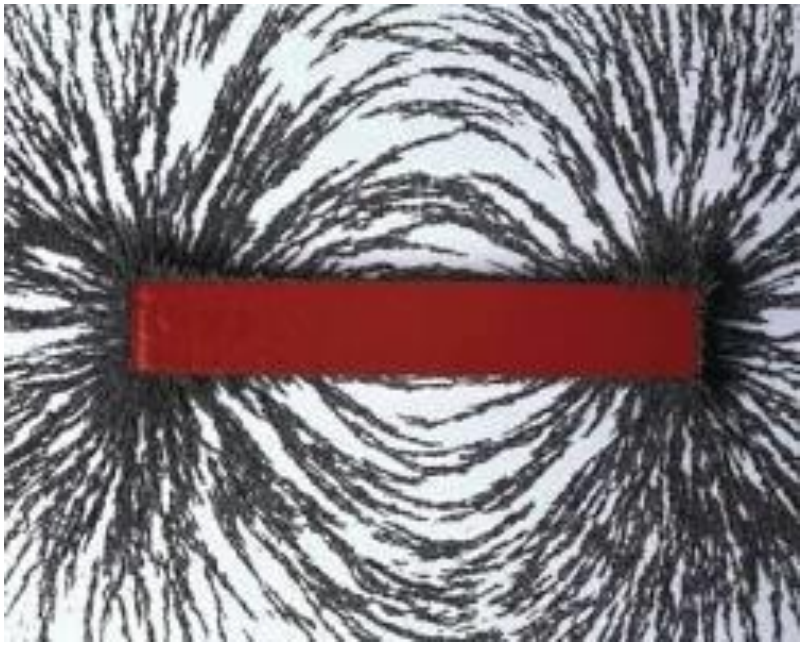
Magnetic field lines around a U-shape magnet

- **Ring or Disc Magnet:** Field lines form closed loops.



Magnetic field lines around a ring magnet

- **Visualizing Magnetic Fields:** Iron filings, compasses, magnetometers, and Ferro fluids.



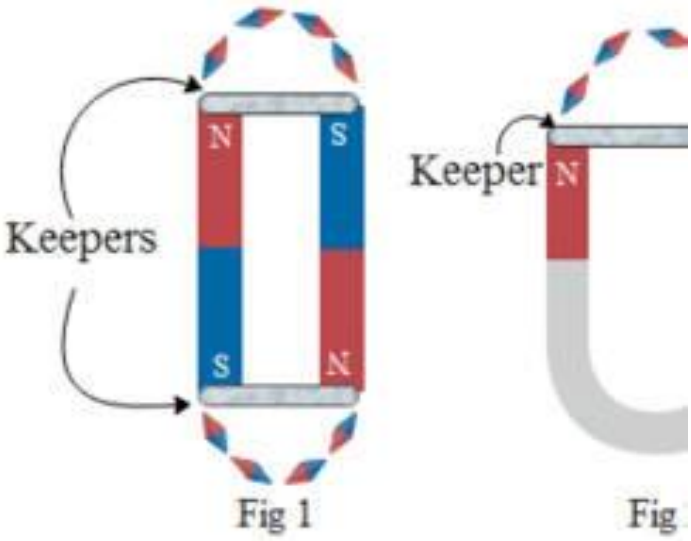
Iron filings showing magnetic field lines

d) Care for Magnets Used in Equipment at a Workplace:

- **Storage:**

✓ Use magnetic keepers to maintain strength.

✓ Store in north-south orientation to prevent demagnetization.



Magnets stored with magnetic keepers

- **Handling:**

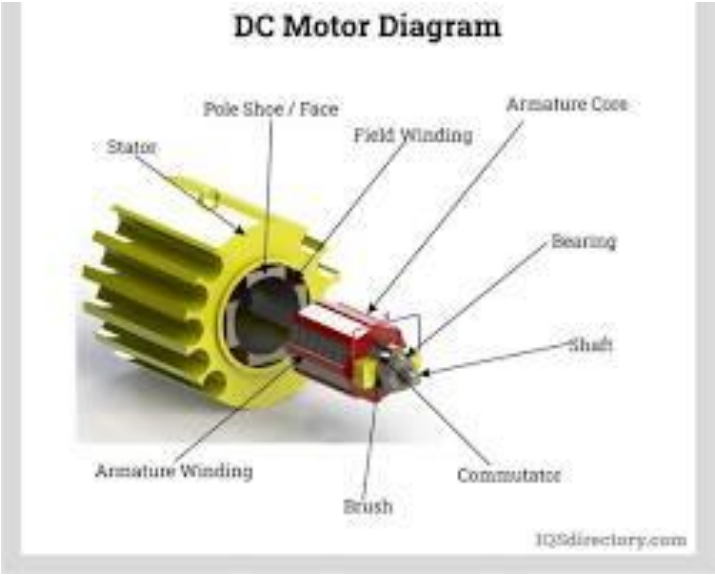
✓ Avoid dropping or hitting magnets.

✓ Keep away from high temperatures.

✓ Shield from strong magnetic fields.

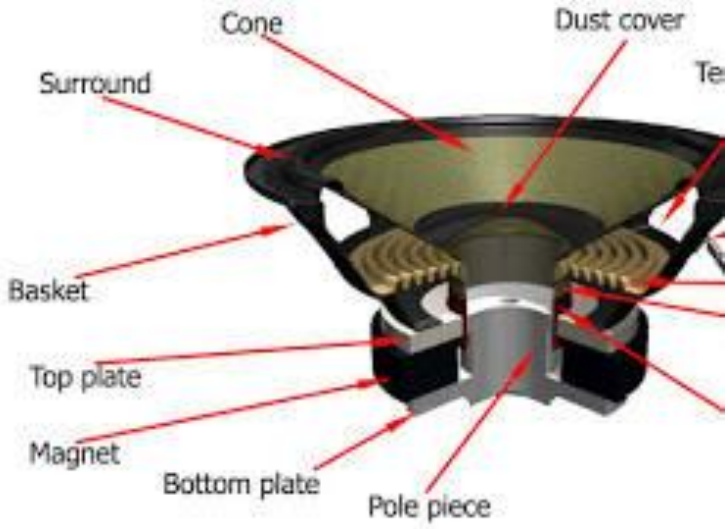
e) Application of Magnets in Day-to-Day Life:

- **Electric Motors and Generators:** Convert electrical and mechanical energy.



Electric motor

- **Speakers and Microphones:** Convert electrical signals to sound and vice versa.



Speaker showing a magnet

- **Magnetic Storage Devices:** Hard drives, magnetic tapes.



Hard drive showing magnetic platters

- **Magnetic Resonance Imaging (MRI):** Medical imaging.



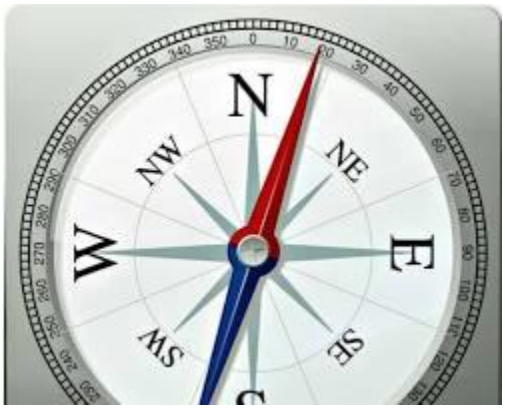
MRI machine

- **Magnetic Levitation (Maglev) Trains:** High-speed transportation.



Maglev train

- **Compass:** Navigation.

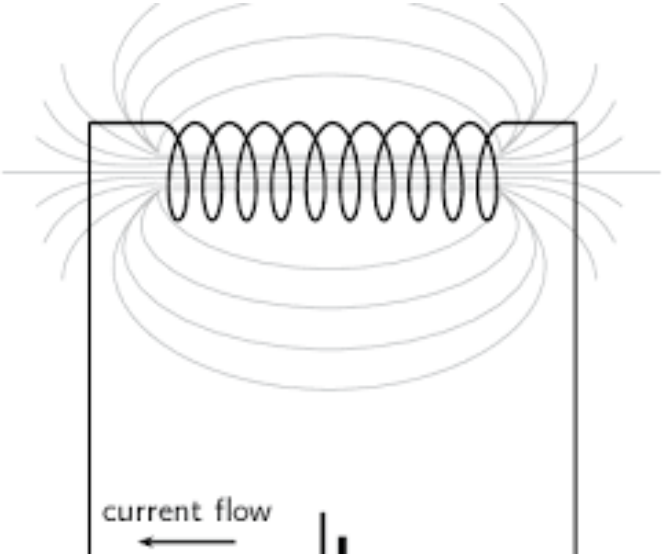


Compass

Sub-strand 2.2: Electromagnetism

a) Principle of Electromagnetism:

- Electromagnetism is the interaction between electricity and magnetism.
- A current-carrying conductor produces a magnetic field.
- A changing magnetic field induces an electric current.

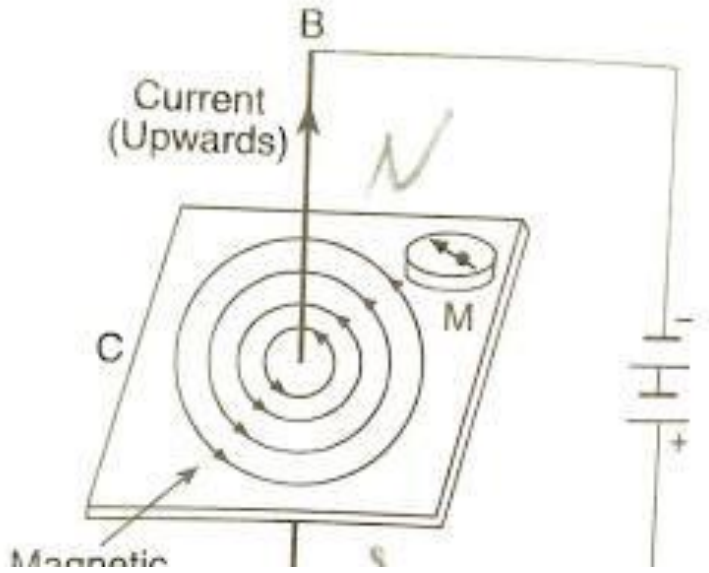


Wire with current flowing, showing the magnetic field around it

b) Magnetic Field Pattern of a Current-Carrying Conductor:

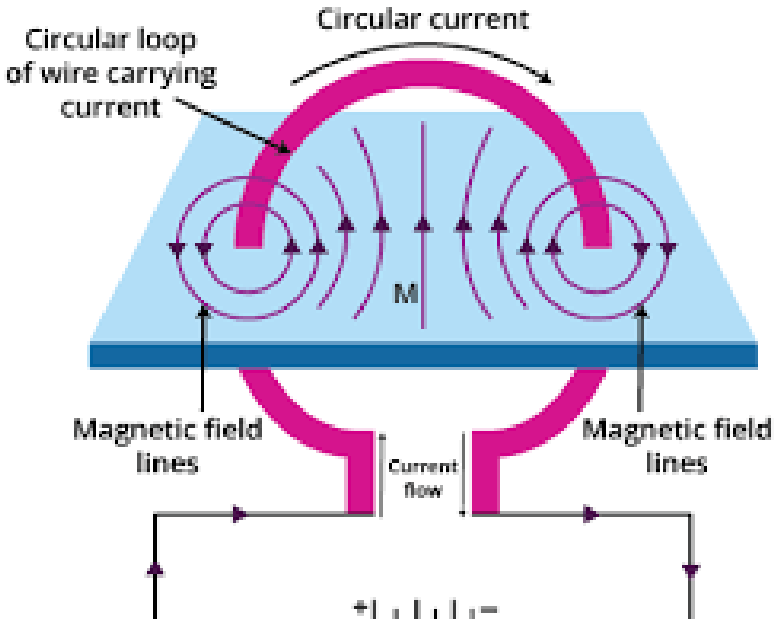
- **Straight Wire:** Magnetic field forms concentric circles around the wire.

✓ Right-hand rule: Thumb points in the direction of current, fingers curl in the direction of the magnetic field.



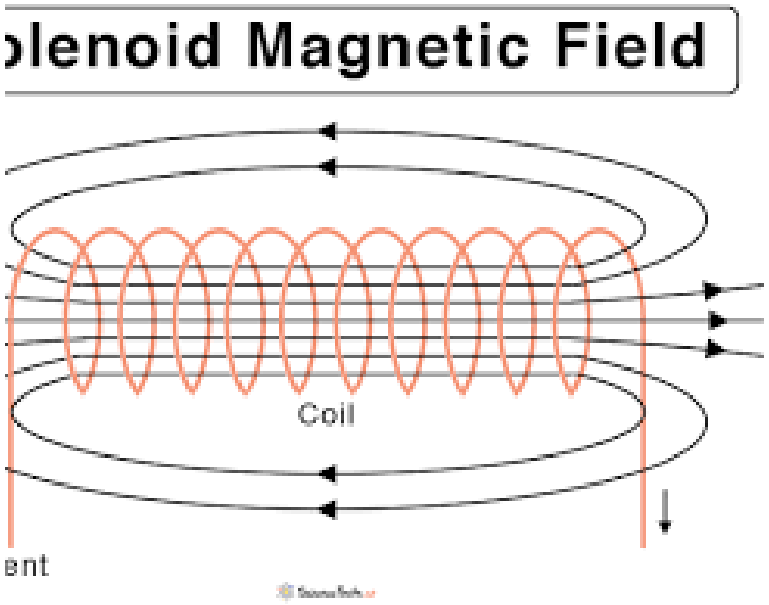
Magnetic field around a straight current carrying wire

- **Coil (Loop):** Magnetic field lines pass through the center of the loop, creating a stronger field.



Magnetic field around a current carrying loop

- **Solenoid:** A coil of wire that produces a strong, uniform magnetic field.



Magnetic field around a solenoid

c) Constructing a Solenoid:

- Parameters affecting solenoid strength:

✓ Number of turns: More turns, stronger field.

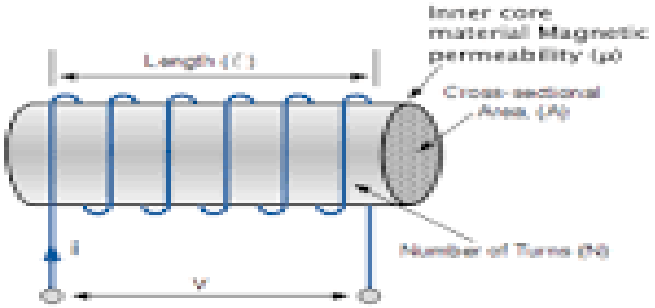
✓ Current: More current, stronger field.

✓ Core material: Ferromagnetic core (iron) increases field strength.

✓ Coil length: Shorter length, stronger field.

Question 7

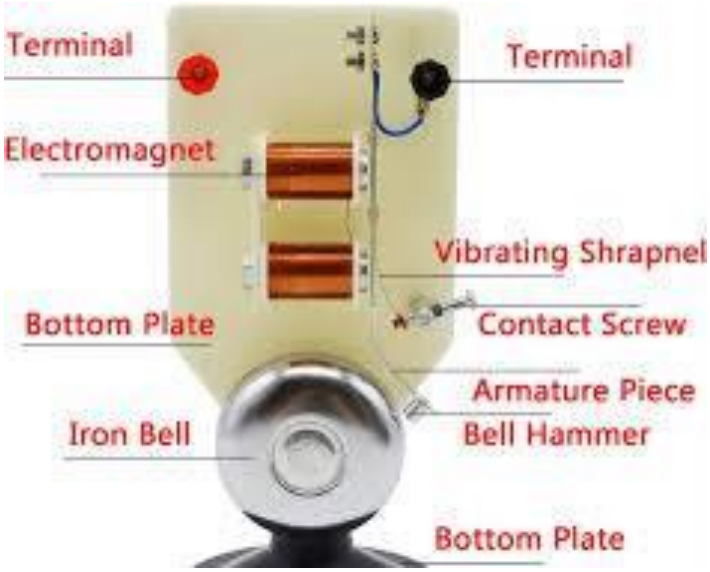
The solenoid in the figure below has N turns of wire wra
with magnetic permeability μ. The length of the solenoid
What are four ways to increase the inductance of this so



Constructed solenoid with a wire wrapped around a core

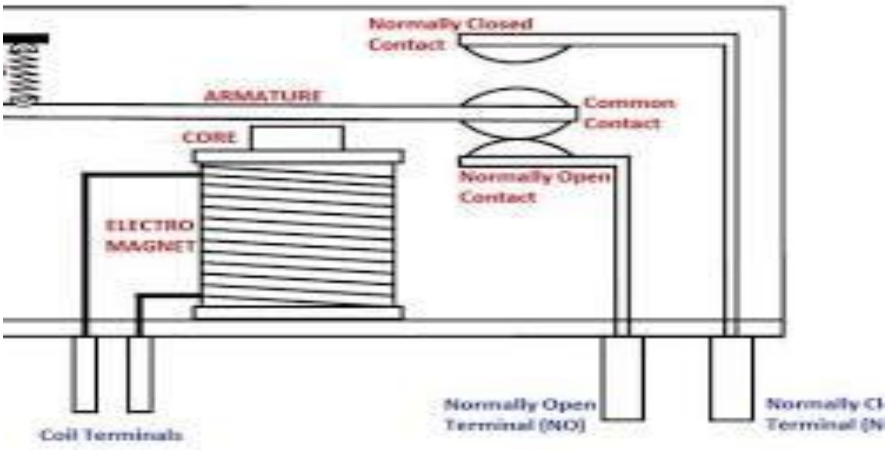
d) Constructing Electromagnetic Devices:

- **Electric Bell:** Uses an electromagnet to strike a bell.



Disassembled electric bell showing the electromagnet

- **Relay:** Electromagnetically controlled switch.



Relay showing the electromagnet and switch contacts

- **Magnetic Pickup:** Used in sensors and audio equipment.



Magnetic pickup from a guitar

e) Troubleshooting Electromagnetic Circuits:

- **Fault Identification:**

✓ Open circuits: Broken wires, faulty connections.

✓ Short circuits: Unintended paths for current.

✓ Loose connections: Poor electrical contact.

- **Troubleshooting Tools:**

✓ Multimeter: Measuring voltage, current, and resistance.

✓ Continuity tester: Checking for breaks in circuits.



Person using a multi-meter to test a circuit

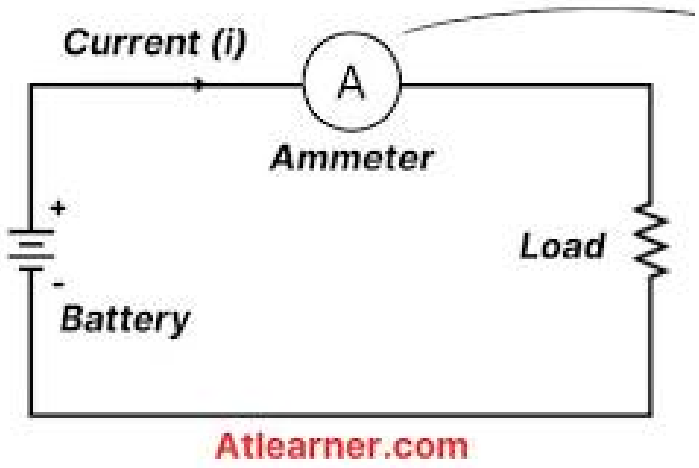
f) Importance of Electromagnetism:

- Electric motors and generators.
- Transformers.
- Electromagnets in industrial applications.
- Magnetic levitation.
- Medical imaging (MRI).

Sub-strand 2.3: Measuring Instruments

a) Principle of Operation of Coil-Based Measuring Instruments:

- These instruments use the interaction between a magnetic field and a current-carrying coil to measure electrical quantities.
- A moving coil galvanometer is a fundamental component.
- When current flows through the coil, it experiences a torque, causing it to rotate.
- The pointer attached to the coil indicates the measured value on a scale.



Basic analog ammeter internal structure

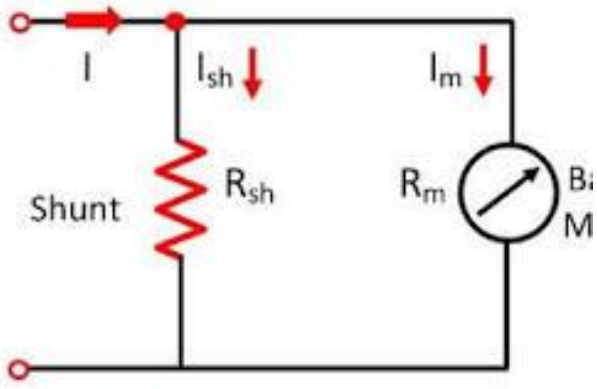
b) Computing Resistance Values for 'Shunts and Multipliers':

- **Shunts:**

✓ Used to extend the current range of an ammeter.

✓ A low-resistance shunt is connected in parallel with the coil.

✓ The shunt bypasses a portion of the current.



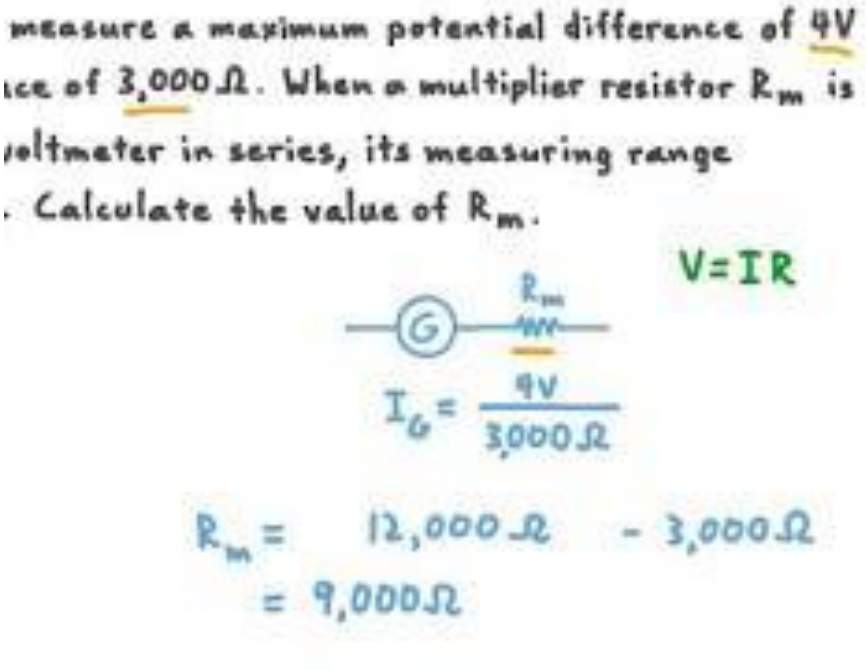
Ammeter with a shunt resistor

- **Multipliers:**

✓ Used to extend the voltage range of a voltmeter.

✓ A high-resistance multiplier is connected in series with the coil.

✓ The multiplier drops a portion of the voltage.



Voltmeter with a multiplier resistor

- Calculations involve using Ohm's law and circuit analysis to determine the appropriate resistance values.

c) Calibrating Coil-Based Measuring Instruments:

- **Zero Calibration:**

✓ Adjusting the pointer to zero when no current or voltage is applied.

- **Fine-Tuning:**

✓ Adjusting internal components to improve accuracy.

- **Range Calibration:**

✓ Comparing the instrument's readings with a known standard.

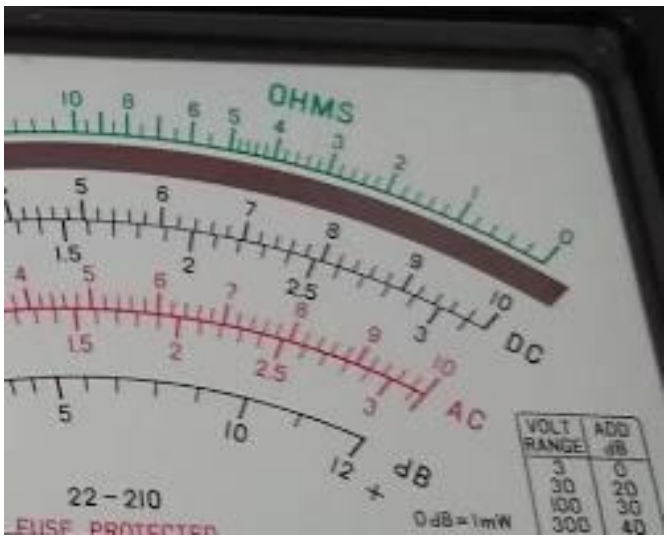
- Using calibrated standards to insure accuracy.



Person calibrating an analog multimeter

d) Selecting a Suitable Scale:

- Choosing a scale that provides adequate resolution for the measured quantity.
- Considering the range of expected values.
- Avoiding overloading the instrument.
- Example: using a miliamp scale for measuring small currents, or using a kilo volt scale for measuring high voltages.



Analog multimeter showing different scale selections

e) Importance of Electrical Measuring Instruments:

- Monitoring electrical systems.
- Troubleshooting electrical faults.
- Ensuring accurate measurements in electrical experiments.
- Controlling electrical processes.
- Safety in electrical work.



Various electrical measuring instruments (ammeter, voltmeter, ohmmeter)

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