Grade 10 Electrical Technology

Terms 1, 2 and 3 - notes for 13 topics

IN EVERY TOPIC

- What you will learn and the key words.
- Short, clear notes with worked examples.
- Questions to try and a topic test, with the answers at the back.

TOPICS IN THESE NOTES

Topic	Name	Term
1.1	Introduction to Electrical Technology	1
1.2	D.C Circuits	1
1.3	Capacitors and Capacitance	1
1.4	Cells and Batteries	1
2.1	Magnetism	1
2.2	Electro-magnetism	2
2.3	Measuring Instruments	2
3.1	Generation, Transmission and Distribution of Electricity	2
3.2	Equipment at Consumers intake point	2
3.3	Final Circuits	3
4.1	Semiconductor Theory	3
4.2	Semiconduc tor Diodes	3
4.3	Transistor	3

Elimu254 • Learn • Grow • Build Tomorrow

CONTENTS

Topic	Name	Term	Page
1.1	Introduction to Electrical Technology	1	3
1.2	D.C Circuits	1	8
1.3	Capacitors and Capacitance	1	18
1.4	Cells and Batteries	1	22
2.1	Magnetism	1	27
2.2	Electro-magnetism	2	34
2.3	Measuring Instruments	2	42
3.1	Generation, Transmission and Distribution of Electricity	2	49
3.2	Equipment at Consumers intake point	2	57
3.3	Final Circuits	3	63
4.1	Semiconductor Theory	3	72
4.2	Semiconduc tor Diodes	3	80
4.3	Transistor	3	89
	Answers		98

Elimu254
Learn • Grow • Build Tomorrow

Strand 1.0 Fundamentals of Electrical Technology | Term 1

1.1 Introduction to Electrical Technology

WHAT YOU WILL LEARN

By the end of this topic you should be able to:

- explain the importance of electrical technology in society
- identify career opportunities in the electrical technology field
- apply safety regulations while carrying out electrical tasks
- explain the roles of stakeholders in the application of electrical safety
- embrace electrical technology as a career in society

KEY WORDS

electricity, technology, electrician, technician, hazard, isolation, PPE, regulation, stakeholder, licence.

1. What electrical technology is, and how electricity is used

Electrical technology

Electrical technology is the study and application of electricity: how it is produced, carried, controlled, measured and used, and how the equipment that uses it is made, installed, maintained and repaired. It covers the wires in a building, the machines in a factory, the phone in your pocket and the power station many kilometres away.

Uses of electricity: light (bulbs, streetlights); heat (cookers, kettles, irons, water heaters); motion (fans, pumps, lifts, motors in factories and on farms); communication (phones, radio, television, the internet); computing and data; transport (electric trains and the electronics in every vehicle); health (X-ray machines, ultrasound, refrigerators for vaccines); security (alarms, cameras, electric fences); and money (mobile money, ATMs and shop tills).

In your group, use the library or a digital device to list ten uses of electricity that you see between home and school, and say which form of energy each one produces: light, heat, motion, sound or information. Present your list, and compare it with the other groups.

2. The importance of electrical technology in society

Importance in society

Economic growth: factories, mills, workshops, offices and shops run on electricity, so it creates jobs, raises production and lets small businesses such as welding, tailoring, salons and cyber cafes operate. Education: lights for evening study, computers, projectors and the internet. Health: refrigeration, surgery, laboratories and emergency services. Agriculture: irrigation pumps, milk cooling, egg incubators, cold stores and processing. Communication: phones, radio, TV and the internet connect people and markets. Security: lighting, alarms and cameras make places safer. Daily life: cooking, washing and comfort, with less smoke than firewood or charcoal.

In Kenya, connecting more homes and schools to the national grid and to solar systems is part of national development plans, and modern services such as mobile money rely on electricity in networks and data centres. New skills and careers come with these technologies.

Risks and responsibilities: electricity can kill, burn and start fires; generation may pollute or use up resources; and wasted energy costs money. Society needs trained people to install and maintain equipment safely, and users must save energy and follow safety rules. The benefits are greatest when people are skilled, careful and honest.

3. Careers in electrical technology

Careers

Installation and maintenance: the electrician (wireman) installs and repairs wiring in buildings; the electrical technician installs, tests and maintains larger systems and machines; the electrical technologist and the electrical engineer design systems, manage projects and solve complex problems. Power sector: the lineman builds and repairs power lines; the substation technician runs and maintains substations; the meter technician installs and checks meters; the power plant operator runs generators.

Other paths: solar photovoltaic installer, electronics and phone repair technician, refrigeration and air-conditioning technician, lift technician, security and fire alarm installer, biomedical equipment technician, motor rewinder, industrial automation technician, telecommunication technician, teacher and trainer, and the contractor who owns a business.

Training and licensing: after Senior School, a learner can join a technical and vocational (TVET) institution for a certificate or diploma, a university for a degree, or an apprenticeship, and gain experience. In Kenya, people who do electrical installation work are licensed by the energy regulator, in classes that depend on their qualification and experience, and must follow the wiring regulations. Check the current licensing classes and requirements when planning a career.

4. Career pathways, entrepreneurship and meeting a professional

Pathways and preparation

Prepare for a career by doing well in mathematics, physics and technical subjects; building practical skills through workshop practice, projects and holiday attachments; learning how to read drawings and follow regulations; developing good habits such as honesty, punctuality, safety and respect for customers; and keeping a portfolio of your work.

A small business: an electrician can work for an employer or start a business. A start needs the right licence, a set of tools, a small amount of capital, a good name for honest work and fair prices, and records of jobs and costs. A quotation for a job lists the materials, labour and profit. For example, materials of KSh 2500 and labour of KSh 1500 give a quotation of 2500 + 1500 = KSh 4000.

Meeting a resource person: invite a professional to your class, or visit a workplace (a workshop, a substation, a factory or a building site). Before the meeting, prepare questions: What does your day look like? What training did you need? What are the dangers and how do you stay safe? What do you like or dislike about the job? Listen carefully, take notes, and thank the visitor. Afterwards, write a short report on what you learned.

5. Electrical hazards and the effects of electric shock

Hazards and shock

Hazards: contact with live parts; damaged cables, plugs and equipment; wet or damp places; overloaded sockets and extension leads; poor or missing earthing; overhead and buried power lines; sparks near fuel and gas; and the stored energy in capacitors and batteries. Results include electric shock, burns, falls (a reaction to the shock), fires and explosions.

The current through the body decides the harm, and it depends on the voltage and the body's resistance ($I = V \div R$). Effects (approximate): about 1 mA is felt as a tingle; 10 mA may make it impossible to let go; 30 mA can stop breathing; and 50 mA or more can cause ventricular fibrillation, in which the heart stops pumping properly, and death. Example: with dry skin, the resistance may be about 100000 ohms, so at 240 V the current is $240 \div 100000 = 0.0024$ A, which is 2.4 mA. With wet skin, the resistance may be only 2000 ohms, and the current $240 \div 2000 = 0.12$ A, which is 120 mA: very dangerous.

First aid for electric shock: 1. Do not touch the person while they are in contact with the supply. 2. Switch off the supply at the switch or main, or if you cannot, push the person away with a dry non-conducting object such as a wooden broom handle. 3. Call for help and an ambulance. 4. Check breathing and give first aid, including CPR if you are trained. 5. Treat burns by cooling with clean water and covering loosely. Even a person who seems well after a shock should see a doctor, because the heart may be affected.

6. Safety rules, regulations and protective equipment

Rules and regulations

General rules: work only on jobs you are trained to do; treat every conductor as live until it is proved dead; use the correct tools and equipment in good condition; keep the workplace tidy and dry; report faults and accidents; never work alone on dangerous jobs; never bypass fuses, RCDs or guards; and know the position of the first aid kit, the extinguishers and the exits. Regulations require employers and workers to follow safe practice, and installations to comply with the wiring regulations.

Safe isolation (before working on a circuit): 1. Identify the circuit and switch it off. 2. Lock the isolator off and hang a warning notice, keeping the key with you. 3. Test that the tester works on a known live source. 4. Test the conductors to prove that they are dead. 5. Test the tester again on the known source. Only then start work. Discharge capacitors and take care with batteries and other stored energy.

Protective equipment (PPE): insulated gloves (checked for holes), safety boots with insulating soles, goggles or a face shield for arcs and dust, overalls without loose parts, a hard hat on site, and insulated tools with undamaged handles. Tool care: keep tools clean and dry, stored in their places on a tool board, with damaged ones removed.

Fire: use a carbon dioxide or dry powder extinguisher on an electrical fire, never water, and switch off the supply first if it is safe to do so.

7. Role play: applying safety regulations in the workshop

Practical: role play on safety

Materials: PPE items, insulated tools, a tool board, a first aid kit, a chart of safety signs and dummy equipment with no live supply; groups of four, supervised, no live supply.

Scenes to act out in turn, with one learner as observer using a checklist: 1. Entering the workshop: dressing correctly, putting on PPE and checking it. 2. Collecting tools: checking them for damage, using the tool board and returning them clean. 3. Preparing to work on a circuit: the safe isolation steps with a dummy circuit. 4. Housekeeping: leaving the bench clean, no cables on the floor, no spills. 5. An emergency: a learner is shocked. Switch off, call for help, use a dry insulator, give first aid. 6. A small fire: raise the alarm, switch off, use the right extinguisher, and leave if it grows.

The observer records what was done well and what was missed, using a tick list, and gives kind, honest feedback. Then the groups swap roles, and the class agrees on the five most important rules for their own workshop and displays them on a poster.

Reflection: which rule was the hardest to follow, and why do people ignore safety rules? Write a personal safety pledge and pin it on your workbench.

8. The roles of stakeholders in electrical safety

Stakeholders in electrical safety

Workers: follow the rules, use the PPE and tools provided, work only within their training, report hazards, faults and accidents, and never bypass safety devices. Employers and contractors: provide a safe workplace and equipment, train and supervise workers, supply PPE, keep records, provide first aid and insurance, and follow the law. Owners and users: keep installations maintained, do not overload circuits, and use qualified, licensed people.

Government and agencies: make and enforce laws and standards. In Kenya, for example, the Ministry responsible for energy sets policy; the energy regulator licenses installers and enforces electrical standards; the occupational safety and health authority inspects workplaces under the Occupational Safety and Health Act; the standards body tests and certifies products, so that unsafe goods are kept out; and the power distributor makes sure that connections meet its requirements and educates the public on safety. Confirm the current names and roles of the agencies.

Shared responsibility: safety is not the job of one group. Each stakeholder has a part, and an accident often happens where one of them fails. Example: a market fire may come from an unlicensed person doing the wiring (worker), no inspection (owner, agency), overloaded sockets (user) and no extinguisher (employer).

9. Drawing instruments and simple electrical drawings

Practical: drawing

Materials: a drawing board, a T-square, set squares of 30-60 and 45 degrees, a draughtsman's set, pencils and paper; pairs, supervised.

Use of instruments: fix the paper to the board with tape; slide the T-square along the edge of the board to draw horizontal lines; rest a set square on the T-square to draw vertical lines and lines at 30, 45 and 60 degrees; use the compass for circles and arcs; use a scale rule for measurements; and keep pencils sharp, with a hard pencil for construction lines and a softer one for the outlines. Keep the drawing clean, with a border and a title block giving the title, scale, date and name.

Scale: a plan is drawn smaller than the real building. On a scale of 1:50, every 50 mm of real length is drawn as 1 mm, so a wall of 4000 mm is 4000 ÷ 50 = 80 mm long on the drawing. A room of 5000 mm by 3000 mm is drawn 5000 ÷ 50 = 100 mm by 3000 ÷ 50 = 60 mm.

Task: draw a one-room plan of 5 m by 3 m to a scale of 1:50, mark the door and window, and add symbols for one lamp, one switch and one socket. Then draw a circuit diagram of a battery, a switch and a lamp with proper symbols. These skills are used again when drawing wiring diagrams later.

10. Review: electrical technology as a career, and assessment

Review and presentations

Summary: electrical technology is used in homes, industry, health, agriculture, communication and security; it drives economic and social development; there are many careers at levels from craft to engineering, and training paths through TVET and universities; work with electricity is dangerous, so safety rules, isolation, PPE, licensed people and careful practice are essential; and workers, employers, owners and government agencies each have a role in keeping people safe.

Presentation task: each learner or group chooses one career and prepares a short presentation of three or four minutes with a poster, a slide or a model. It should cover what the person does, the training and licences needed, the tools and safety measures used, where they work, the challenges and rewards, and why it interests the presenter. Use the information from the research, the resource person and the workplace visit.

Assessment: a portfolio holds the list of uses of electricity, the notes on careers and the resource person, the safety role-play checklist, the drawing and the presentation. The teacher assesses with a rubric: content (accurate and complete), safety (applied correctly), communication (clear and confident) and creativity.

Learn • Grow • Build Tomorrow

TRY THESE

1. Define electrical technology.
2. Name four uses of electricity in the home.
3. Give three ways in which electricity helps education.
4. Give two ways in which electricity helps farmers.
5. Name four careers in electrical technology.
6. What is the difference between an electrician and an electrical engineer?
7. State two ways to prepare for a career in electrical technology while still at school.
8. A job needs materials worth KSh 3200 and labour worth KSh 1800. What is the quotation?
9. State three electrical hazards in a workshop.
10. A person of resistance 4000 ohms touches 240 V. What current flows?
11. Why are the conductors tested to prove that they are dead?
12. Why is the tester checked on a known live source before and after testing?
13. Give the first two things to do when a learner is shocked in the workshop.
14. Why should tools be returned to a tool board?
15. State two duties of a worker for electrical safety.
16. State two duties of an employer.

17. What does a scale of 1:50 mean?
18. A wall of 3000 mm is drawn to a scale of 1:50. How long is it on the drawing?
19. State three reasons why electrical technology is important.
20. State the five steps of safe isolation.

TOPIC TEST

T1. Explain why a clinic in a rural area without electricity cannot store vaccines safely.
T2. Explain why saving electricity is good for both a family and a country.
T3. Explain why solar installers are in growing demand in Kenya.
T4. Explain why keeping records of jobs and costs helps a small business.
T5. Explain why a person might fall from a ladder after a small shock, even if it is not fatal.
T6. Explain why the key of the lock on an isolator stays with the person working.
T7. Explain why it is useful to practise emergency actions before an emergency happens.
T8. Explain why buying electrical goods with a mark of quality from the standards body protects the buyer.
T9. Explain why architects and electricians agree on symbols and scales.
T10. Explain how a career in electrical technology could help your community.

Elimu254
Learn • Grow • Build Tomorrow

Strand 1.0 Fundamentals of Electrical Technology | Term 1

1.2 D.C Circuits

WHAT YOU WILL LEARN

By the end of this topic you should be able to:

- describe the properties of resistors in d.c. circuits
- analyse d.c. circuits using circuit laws
- construct resistor networks in d.c. circuits
- troubleshoot d.c. circuits in electrical appliances

KEY WORDS

current, voltage, resistance, ohm, series, parallel, circuit, conductor, insulator, power.

1. Electricity: charge, conductors, insulators and safety

Charge, conductors and insulators

All matter is made of atoms. An atom has a nucleus with positive protons and neutral neutrons, and negative electrons moving around it. In metals some electrons are free to move from atom to atom. When these free electrons are pushed in one direction, we have an electric current. Like charges repel and unlike charges attract. The unit of electric charge is the coulomb (C).

A conductor lets charge flow easily: metals such as copper, aluminium, silver and iron, and also carbon and salt water. An insulator does not: rubber, plastic, glass, dry wood, and dry air. Cables are made of a copper or aluminium conductor covered by plastic insulation. A semiconductor, such as silicon, conducts partly, and is used in electronics.

Safety: an electric shock passes current through the body and can burn, stop the heart and kill; a current of about 30 milliamperes through the chest can be fatal, and the mains at 240 V can easily drive that. Rules: treat every circuit as live until it is proved dead; switch off and isolate before working; use insulated tools; never work with wet hands or on wet floors; do not overload sockets; report damaged cables and equipment; and never touch a person who is being shocked until the supply is off. In class, use only low-voltage supplies.

2. The electric circuit, its symbols and its types

The simple circuit

A circuit is a complete path for current. It needs a source of energy (a cell, battery or generator), conductors to carry the current, a load that uses the energy (a lamp, motor or heater), and usually a control (a switch) and protection (a fuse). Current flows only if the path is complete: a closed circuit. An open circuit has a break, for example a switch off or a broken wire, so no current flows. A short circuit is a low-resistance path across the source, often by accident, which lets a very large current flow and can cause overheating and fire.

Circuit symbols: a cell is a long and a short line; a battery is several cells; a lamp is a circle with a cross; a resistor is a rectangle; a variable resistor is a rectangle with an arrow; a switch is a gap with a lever; a fuse is a rectangle with a line through it; an ammeter is a circle with the letter A; a voltmeter is a circle with V; and earth is a set of three lines that get shorter.

Direction of current: conventional current is taken to flow from the positive terminal of the source, through the circuit, to the negative; the electrons actually move the opposite way, from negative to positive. In this course we use the conventional direction for diagrams and calculations. A circuit diagram shows how parts are connected using symbols, not how they are arranged on the board.