Short-Course

Solar PV System Installation and Maintenance

NTQF Level II

Learning Guide -01

Unit of Competence	**Apply Principles of Photovoltaic system Operation**
Module Title	**Apply Principles of Photovoltaic system Operation**
LG Code	**EIS PIM2 M04 0120 LO1-LG01**
TTLM Code	**EIS PIM2 TTLM 0120v1**

LO 1: Identify Renewable Energy Sources

Instruction Sheet-1	Learning Guide:-10

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

- Basic electricity and electronics
- Identifying and describing types of renewable energy
- Basic working principles of renewable energy
- Applications of renewable energy
- Advantage and disadvantages of renewable energy sources
- Renewable energy plants

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

- Identify and describe types of renewable energy
- Identify basic working principles of renewable energy
- Identify the applications of renewable energy sources
- Identify advantage and disadvantages of renewable energy sources
- Identify components of renewable energy plants

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information Sheet 1, Sheet 2, Sheet 3, Sheet 4, Sheet 5 and Sheet 6 in pages3, 22, 27, 31 and 38 respectively.
4. Accomplish the Self-check 1, Self-check 2, Self-check 3, Self-check 4 Self-check 5 and Self-check 6 in pages 20, 26, 30, 37, 39 and 46 respectively
5. If you earned a satisfactory evaluation from the “Self-check” proceed to Operation Sheet 1in page 47.
6. Do the “LAP test” in page 48.

LO1:-Identify Renewable Energy Sources

Information Sheet-1	Basic Electricity and Electronics

1 Introduction

Electricity is an apparent force in nature that exists whenever there is a net electrical charge between any two objects and is put to use in industrial applications such as: electronics and electric power.

- Electricity:
    - Dynamic electricity is the flow of an electric charge through a conduction point. Dynamic electricity is often referred to as electric current. The biggest difference between dynamic electricity and static electricity is the movement of charges or currents.
- Atom the smallest particle of a chemical element that can exist.
    - It is made up of three parts known as:
    - Protons–positively charged particles
    - Neutrons–particles with no charge
    - Electrons–negatively charged particles

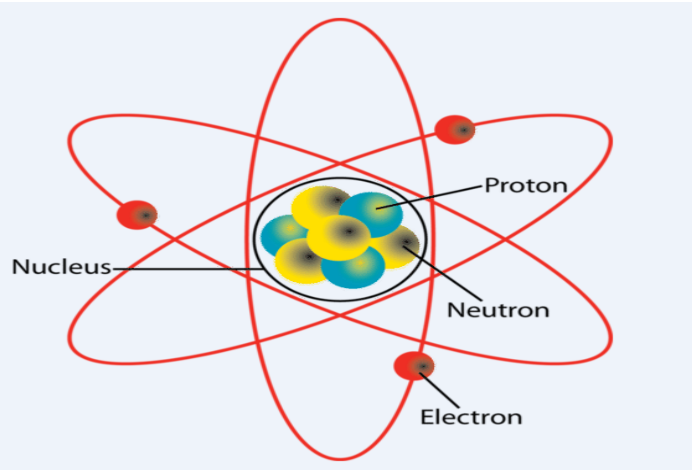


Figure 1:-Atom floating in an electric field

- Conductors
    - Allow the flow of electricity
    - Contain atoms with free electrons one to three electrons in the outer orbit
    - Free electrons are not locked in orbit around the nucleus
    - electrons can be forced to move from one atom to another
    - Copper, gold, and silver are good conductors

- Insulators
    - Resist the flow of electricity
    - Contain atoms with bound electrons five to eight electrons in the outer orbit
    - Bound electrons will not leave their orbit around the nucleus

- Plastic, rubber, and ceramics are good insulators

- Three terms are used in the study of electricity:
  - Current
  - Voltage
  - Resistance

1.1 Current (I)

Current is a measure of the rate of electron flow through a material. Electrical current is measured in units of amperes or "Amps" or "A" for short. This flow of electrical current develops when electrons are forced from one atom to another. One amp is defined as

6.28×10^{18} electrons per second. When current flows in a conductor, heat is produced. This happens because every conductor offers some resistance to current flowing. That is why the amperage flow in a circuit is important, since the more amps flowing, the more heat is produced. Most people notice this heating effect when the cord of any appliance or electrical device heats up after the device has been running for an extended period. Recognizing this heat production is important in specifying wire sizes. When a wire carries more amps than it can handle without overheating, we say it is "overloaded". Overloaded wires can melt the insulation and create shocks or even fires(Source: REEPRO Level 1, 2009)

- Two theories are used to describe direction of current flow:
  - **Conventional current theory**:-states that current flows from positive to negative
  - **Electron theory**:-states that current flows from negative to positive

1.2 Voltage

Voltage is the electrical force that causes free electrons to move from one atom to another. Just as water needs some pressure to force it through a pipe, electrical current needs some force to make it flows. "Volts" is the measure of "electrical pressure" that causes current flow. Voltage is sometimes referred to as the measure of a potential difference between two points along a conductor. Sometimes the symbol E is used for EMF (Electro motive force). (Source: REEPRO Level 1, 2009)

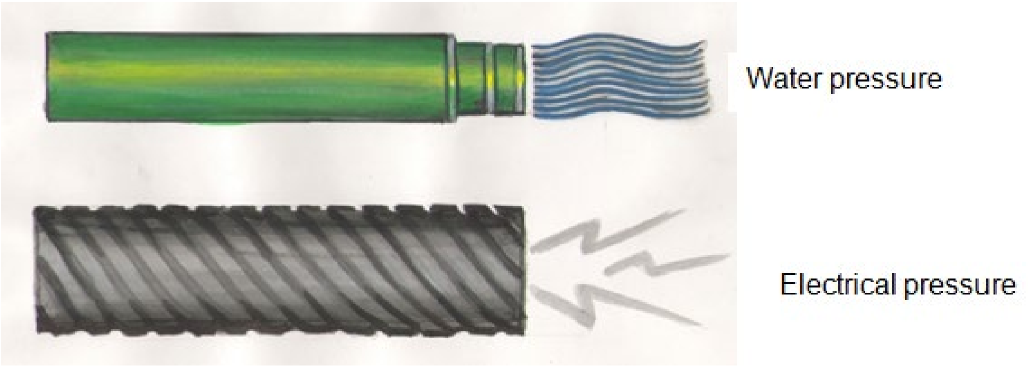


Figure 2: **Similarity of water pressure and Voltage**

1.3 Resistance

Resistance is the opposition to current flow. Every medium has some resistance and the resistance of an object is determined by the nature of the substance, of which it is composed; the dimensions of the object and the temperature. This is known as resistivity. Resistivity is expressed in terms of the ohms resistance per cubic centimetre of the substance at 20° C (68° F). As we know light bulbs, motors, electric heating elements and relay coils all have resistances even though they are just wires.

The electrical resistance of a material is measured in units called "ohms"(Ω). The lower the resistance of a material, the better the material acts as a conductor. For example, copper has a lower electrical resistance than aluminium, copper is a better conductor. We can use a water piping system as an analogy. The resistance in the water pipe to the flow of water comes mainly from the size of the pipe. Rust and corrosion inside the pipe, objects stuckinside the pipe, and the number of bends and fittings all add up to increase the resistance to theflow of water.

The same is true of current flow in an electric circuit. A number of factors determine the resistanceto current flow such as wire diameter, wire length and any impurities in the wire's makeup. Forexample, smaller wires have more resistance than larger diameter wires and longer wires havemore resistance than shorter wires.

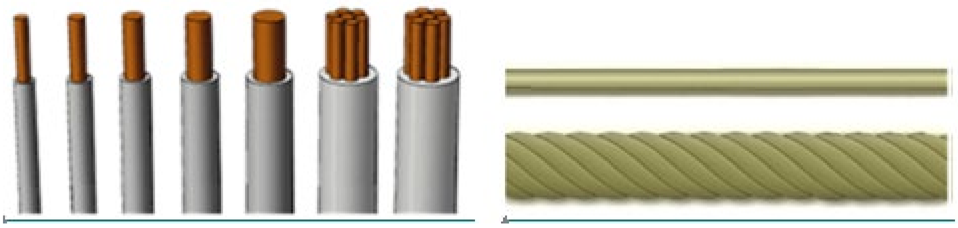


Figure 3: Types of wires/Cable

When electricity flows through any resistance, energy is dissipated in the form of heat. If the heat becomes intense enough, the conductor resistor may actually glow. This is exactly how an incandescent light bulbworks. The filament is made of a material that will resist the current enough to heat up and glow.

The scientific symbol for electrical resistance, which is measured in ohms, is the Greek letter Omega (Ω).Electricians and practical wiring books typically use an "R" to represent resistance.

Factors Affecting the Resistance of a conductor

- Kind of the material-the greatest the number of free electrons present in a substances, the lower the resistance. For example, copper has a lower electrical resistance than aluminium, copper is a better conductor
- Length of the material-Directly proportional with resistance
- Cross sectional area (thickness) -inversely proportional with resistance
- Temperature-Metals generally offer higher resistance at high temperature. Non-metallic substance such as carbon offer lower resistance at high temperature

1.4 Ohm's law

This is the most basic law of current flow, discovered by George Ohm. The law states that the amount of current flowing in a circuit made up of pure resistances is directly proportional to the electromotive force impressed on a circuit and is inversely proportional to the total resistance of the circuit. The relationship of Ohm's law is the behaviour of electric currents I, relating them to voltage V and resistance R.

$V = R \times I$

This is a linear relation. If you double the voltage (V) then for the same value of R you get twice the current. If you want to keep the current the same value after doubling V, you would have to double the resistance (R).

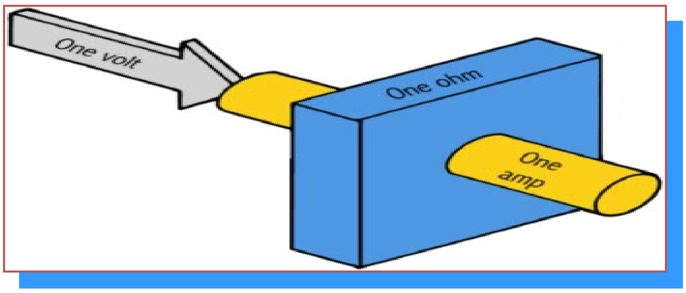


Figure 4 Relation between Voltage, Current and Resistance

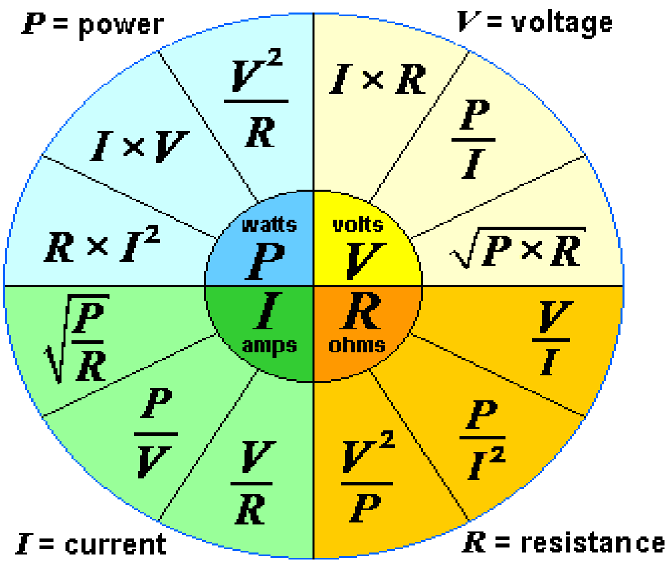


Figure 5 :Ohms law formulas

1.5 Electrical Circuits

An electrical circuit is a path or line through which an electrical current flows. The path may be closed (joined at both ends), making it a loop. A closed circuit makes electrical current flow possible. It may also be an open circuit where the electron flow is cut short because the path is broken. An open circuit does not allow electrical current to flow.

Alternating Current (AC) & Direct Current (DC)

The supply of current for electrical devices may come from a direct current (DC) source or an alternating current (AC) source. In a direct current circuit, electrons flow continuously in one direction from the source of power through a conductor to a load and back to the source of power. Voltage polarity for a direct current source remains constant. DC power sources include batteries and DC generators.

By contrast, an AC generator makes electrons flow first in one direction then in another. In fact, an AC generator reverses its terminal polarities many times asecond, causing current to change direction with each reversal.

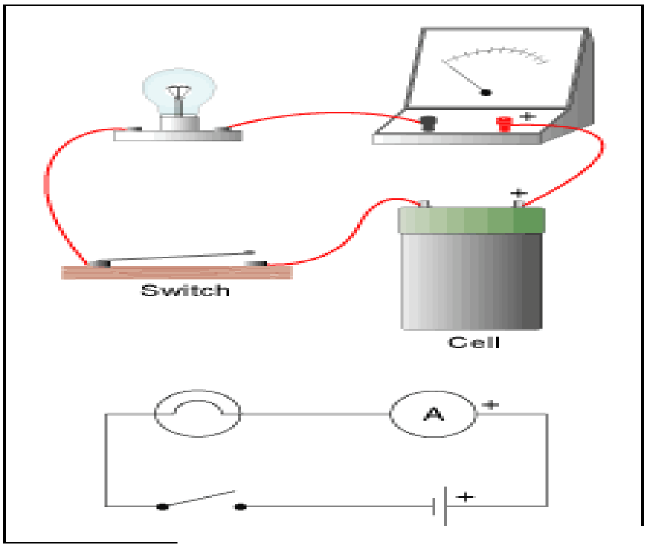


Figure 6: Simple circuit, Source: /www1.curriculum.edu.au

1.6 Types of Electrical Circuits

Based on the connection of loads, electrical circuits are classified in to three:

1.6.1 Series circuit

In series circuit, loads are connected end to end.

- The current is the same at any point in the circuit
  - $I_1=I_2=I_3=...I_n$
- The total resistance is the sum of the individual resistors
  - $R_T=R_1+R_2+R_3....+R_N$
- The applied voltage is equal to the sum of the voltage drops across all the resistors
  - $V_T=V_1+V_2+V_3....+V_N$
- **Advantage**:- Economical, less wire/cable is needed
- **Disadvantage**:- if one of the lamps is broken the whole circuit will be out of operation

1.6.2 Parallel circuit

In a parallel circuit the loads are arranged to allow all the positive terminals to be joined to a single conductor and all the negative one to another conductor so in effect the current travels through different parallel paths. The total resistance of a parallel circuit is the reciprocal of the sum of the reciprocals of each resistor.

In parallel circuits, loads are connected side by side or across the line.

- Total current is the sum of all branch currents
  - $I_T=I_1+I_2+I_3....+I_N$

- equal voltage drops across each load
    - $V_T = V_1 = V_2 = V_3 \ldots\ldots V_N$
- Total resistance(R_T) is computed as
    - Product over sum method

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

- reciprocal of the sum of the reciprocals of each resistor

$1/ R_T = 1/R_1 + 1/R_2 + 1/R_3 + ..1/ R_n$

$$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} .. + \frac{1}{R_N}}$$

- For equal resistors connected in parallel:
    - The value of one resistor is divided by number of branches/resistors
- **Advantages of parallel connections**: if one of the lamps is broken the other circuit part independently operate
- **Disadvantage of parallel connections**:-less-economical because more cables/wire are needed.

1.6.3 Series-parallel circuit

Loads are connected partly in series and partly in parallel

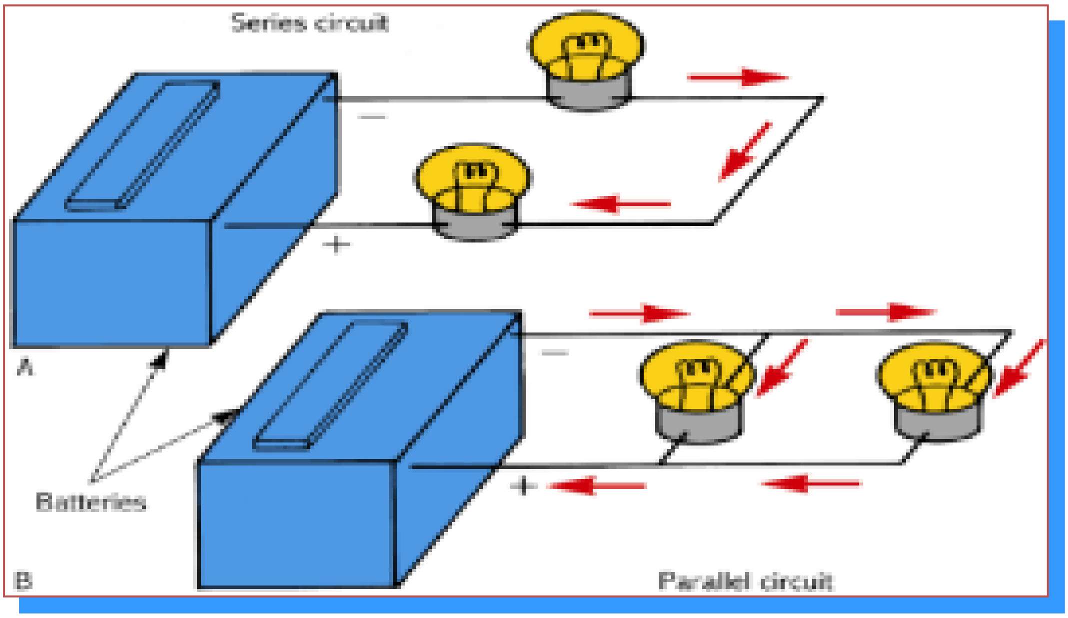


Figure 7: Series & Parallel Connection

- Most important formulas
    - **Voltage(** V) = I × R = P / I = √(P × R) in Volts V
    - **Current (I) = V / R = P / V = √(P / R) in Amperes**

- **Resistance (R) = V / I = P / I2 = V2 / P in ohms Ω**
- **Power (P)** = V × I = R × I^2 = V^2 / R in Watts W

XAMPLE 1: calculate total current (I_T) in the following series connection

Given: V_T=12V, R1=6 Ω, R2=6 Ω Find I?

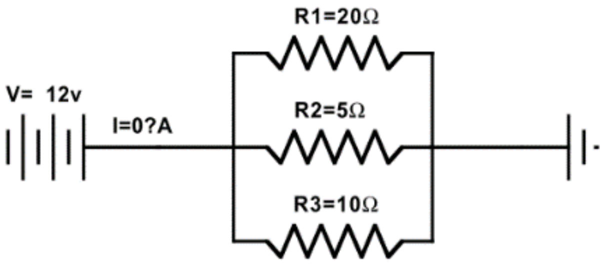
SOLUTION: R_T= R_1+R_2=6+6=12 Ω

I_T =V_T/R_T=12V/12 Ω =1A

Remember that "T" means Total.

EXAMPLE2: calculate total current in the following parallel connection

In a parallel circuit the loads are arranged to allow all the positive terminals to be joined to a single conductor and all the negative one to another conductor so in effect the current travels through different parallel paths. The total resistance of a parallel circuit is the reciprocal of the sum of the reciprocals of each resistor.



Given :

VT=12V, R_1=20 Ω, R_2=5 Ω, R_3=10 Ω

Find I_T:

SOLUTION:

$\frac{1}{Rt}=\frac{1}{R1}+\frac{1}{R2}+\frac{1}{R3}-=\frac{1}{20}+\frac{1}{5}+\frac{1}{10}$=0.05+0.2+0.1=0.35 (1/0.35Ω)

R_t=1/0.35 (1/Ω)=**2.86 Ω ,**

N.B. R_T is always less than even the smallest individual resistance value in the circuit.

Therefore $I_T=\frac{Vt}{Rt}$ = $\frac{12}{2.86}$ = **4.2A**

1.7 Components of Basic Electronic Devices

Electronic devices are simplified as components in which electrical conduction takes place by motions of electrons through them. Components of electronics are divided in to three as shown in the chart below

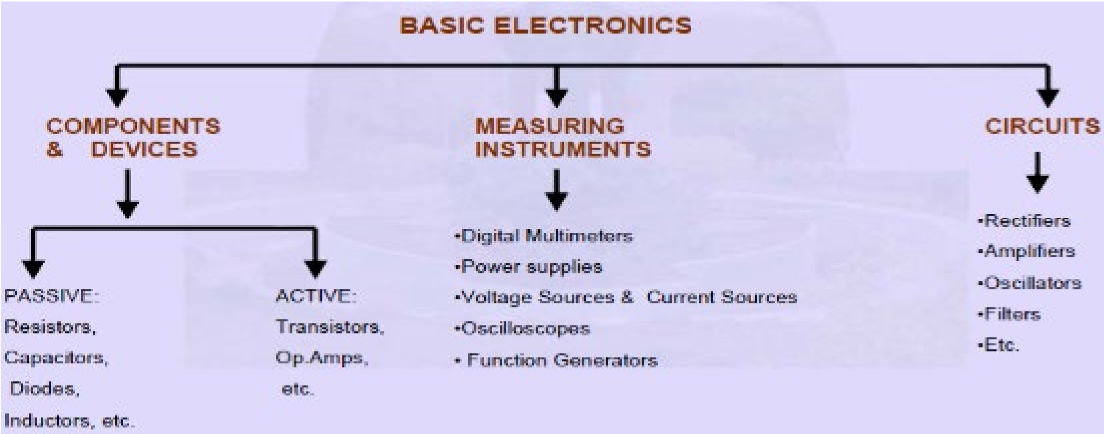


Figure 8: Components of electronics

1.7.1 Passive Components

Typically, anything that doesn't require a bias voltage is a passive component. In other words, any component that isn't a semiconductor is passive. Passive components just have to be connected in the proper circuit pathway to function properly. Common examples of passive components are resistors, capacitors, inductors and transformers.

Are electronic devices that do not automatically amplify the signal or control the presence, flow, or direction of electrical current or voltage by means of an electrical control signal (current or voltage). There are many uses for *passive* electronic components, they are most commonly used in electronic engineering and control systems.

Electronic components carry all types of passive electronic component parts including resistors, capacitors, inductors, potentiometers, transformers, passive transducers, thermistors, thermostats, crystals, oscillators, resonators, fuses, batteries connectors, mechanical relays, switches, wire, and cable.

1.7.2 Resistor

Resistors do exactly what the name sounds like they resist or oppose the flow of electric current through them, causing a voltage drop. Resistance is measured in Ohms and can be measured with an ohmmeter or a multimeter. Resistors are manufactured in various sizes, values and tolerances to meet a wide range of requirements for electronic circuits.

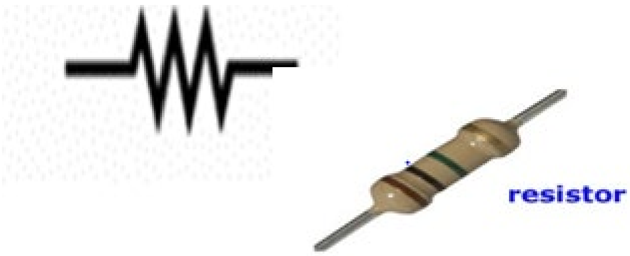


Figure 9: Resistor Symbol and a Resistor

Resistor Colour Code: -An electronic colour code is used to indicate the values or ratings of electronic components, usually for resistors, but also for capacitors, inductors, diodes and others.

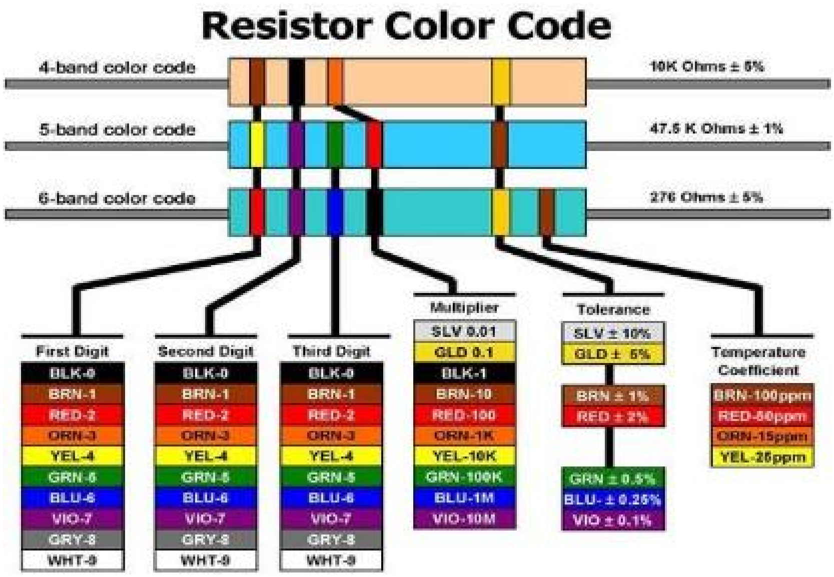


Figure 10: Colour Codes for Resistor

1.7.3 Capacitor

Capacitors temporarily store electricity. How much electricity can be stored is measured in microfarads or uF. Capacitors are also manufactured as different types. Electrolytic capacitors can store a lot of electricity --- values of 470 uF are very common. Ceramic disk capacitors store a lot less electricity and a common value is .01 uF. Capacitors have two conductors separated by a non-conductive surface. Electrons build up on the surface of the conductors, resulting in a static charge. When a capacitor discharges, the electrons are released back into the circuit.

Figure 11: Electrolytic Capacitor and its Symbol

1.7.4 Inductor

An inductor is a coil with or without a ferrous metal core. The inductor is also an electric current storage device, but it functions much differently than a capacitor and operates by storing energy in magnetic fields. Current passing through the coil creates a magnetic field within the coil, which in turn induces an opposing voltage to the current that created it in the first place.

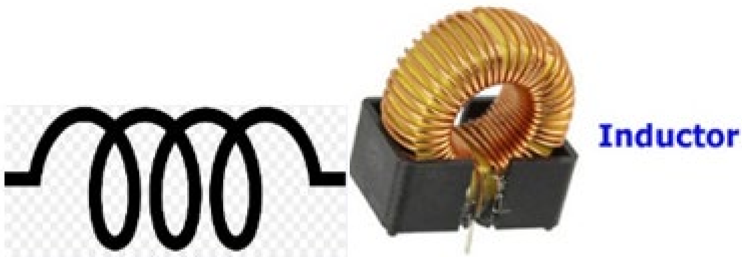


Figure 12: Inductor Symbol and an Inductor

1.7.5 Transformer

Transformers operate only on alternating current and are used to change voltage from one value to another. Transformers are made from two inductors. The primary coil accepts the input voltage and induces a voltage in the secondary coil. The voltage level induced in the second coil is directly related to the number of turns of wire in both coils. Transformers find common use anywhere voltage changes are required such as battery chargers, power supplies, household electronics and power distribution grids.

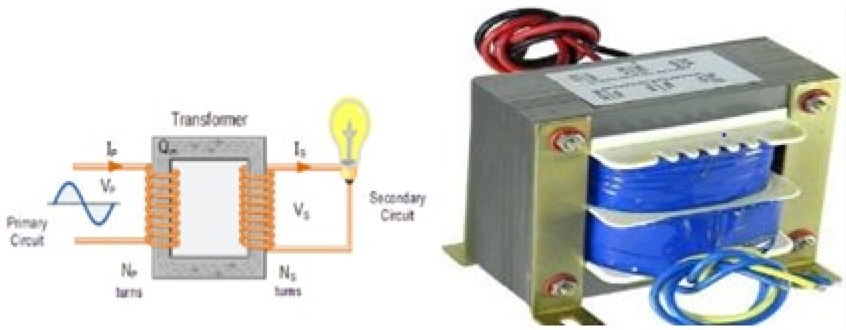


Figure 13: Transformer Symbol and a Transformer

1.7.6 Active Components

Active components require a separate power supply to turn the device on and function. Transistors, operational amplifiers and integrated circuits are examples of active components that require a power supply in order to work .

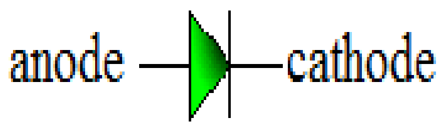
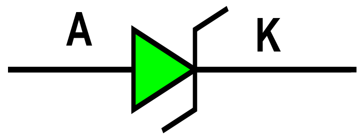
In general, active components require a bias voltage to break the internal barrier and turn them "on." Common examples are diodes, LEDs, transistors and integrated circuits, or chips. These components are sometimes referred to as "digital" components. In most circuits, passive components are combined with active to provide efficient and safe circuit operation.

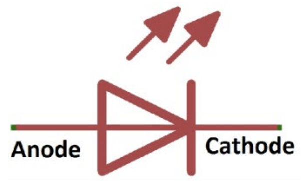
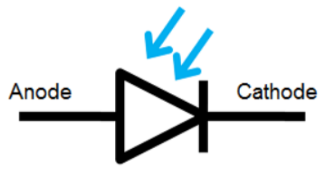
1.7.7 Semiconductor

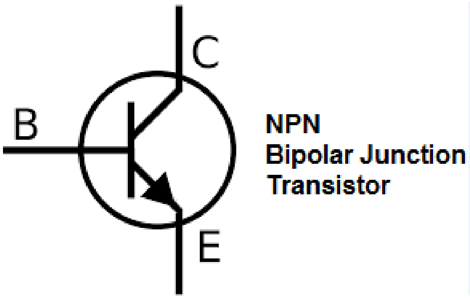
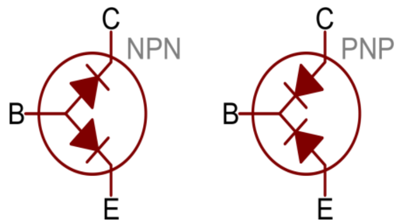
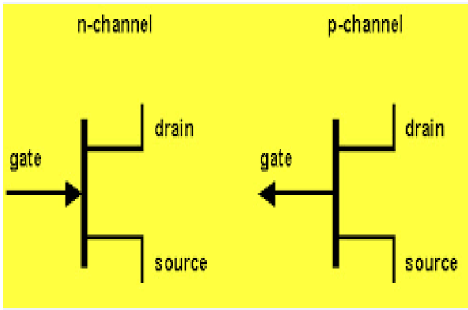
Substances capable of acting as both a conductor and an insulator are called semiconductors. This enables semiconductor devices to control current without mechanical points.

- Semiconductor devices include
    - diodes
    - transistors
    - integrated circuits

Table 1: Describe Electronic Symbols

No.	Semiconductor Name	Description	Symbol
1.	Diode	An “electronic check valve” that allows current to flow in only one direction. • when a diode is forward biased, it acts as a conductor • when a diode is reverse biased, it acts as an insulator	
2.	Zener diode	Passes current in reverse direction to provide a constant voltage reference. Zener diode was designed for limiting the voltage across its terminals in reverse	

No.	Semiconductor Name	Description	Symbol
		bias. This diode is intended to operate at that voltage, and so finds its greatest application as a voltage regulator or voltage reference, utilizing it's so called "reverse breakdown voltage rating." Recall the discussion of diode. Diode operates in forward bias but Zener diode, the normal operation is in reverse bias.	
3.	Light-emitting diode(LED)	A diode that emits light.	
4.	Photodiode	Are intended to sense light (photo detector) & Passes current in proportion to incident light. A photodiode can be used in solar cells, in photometry, or in optical communications.	

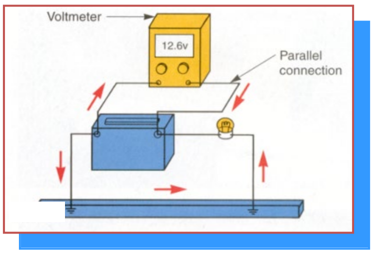
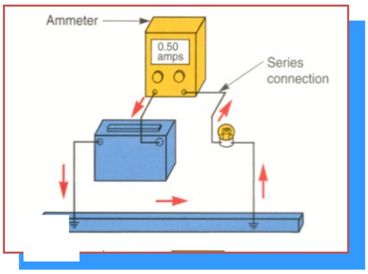
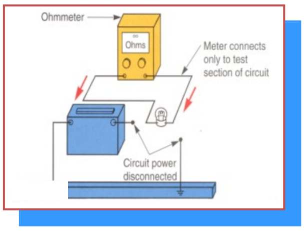
No.	Semiconductor Name	Description	Symbol
5.	Transistor	Allows the control of a high current circuit with a low current circuit and performs the same basic function as a relay. Acts as a remote switch or current amplifier. Operates more quickly than a mechanical device can Has no moving part to wear or deteriorate.	
6.	Bipolar Junction Transistor (BJT)	A semiconductor device constructed with three doped semiconductor regions collector, base and emitter separate by tow p-n junctions	
7.	Field-Effect Transistor (FET)	Electronic device which uses electric field to control the flow of current. FET has three terminals G = GATE, D =DRAIN and S= SOURCE	

The following videos show basic electricity and electronics components.

- https://www.youtube.com/watch?v=mc979OhitAg
- https://www.youtube.com/watch?v=WoN1nou5t1Q

1.8 Measuring Instruments

Table 2:-Electronic Measurement

No.	Instrument	Description	Circuit Connection
1.	Multimeter /VOM	Combines an ohmmeter, ammeter, and voltmeter in one case.	
2.	Voltmeter	Used to measure the amount of voltage in a circuit Connected in parallel with the circuit Voltmeter reading can be compared to specifications to determine whether an electrical problem exists	Voltmeter Connections 
3.	Ammeter	Measures the amount of current in a circuit Connected in series with the circuit All the current in the circuit must pass through a conventional ammeter Inductive ammeters have a special pickup that is clamped around the wire uses the magnetic field around the wire to determine the amount of current in the wire	Ammeter Connections 
4.	Ohmmeter	Measures the amount of resistance in ohms in a circuit or component Connected in parallel with the wire or component being tested	Ohmmeter Connections 

No.	Instrument	Description	Circuit Connection
		Wire or component being tested must be disconnected from power Ohmmeter reading can be compared to specifications to determine if a part is defective	

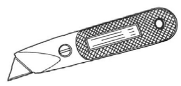
Table 3: Standard basic electrical Units

No	Electrical Parameter	Measuring Unit	Symbol	Description
1	Voltage	Volt	V or E	Electrical Potential **V = I × R**
2	Current	Ampere	I	Electrical Current **I = V ÷ R**
3	Resistance	Ohm(Ω)	R	DC Resistance **R = V ÷ I**
4	Conductance	Siemens (S) or seldomly Mho (℧)	G	Reciprocal of Resistance **G = 1 ÷ R**
5	Capacitance	Farad(F)	C	Capacitance **C = Q ÷ V**
6	Charge	Coulomb(C)	Q	Electrical Charge **Q = C × V**
7	Inductance	Henry(H)	L	Inductance **V_L = -L(di/dt)**
8	Power	Watts(W)	p	Power **P = V × I** or **I^2 × R**
9	Impedance	Ohm(Ω)	Z	AC Resistance **$Z^2 = R^2 + X^2$**
10	Frequency	Hertz(Hz)	f	Frequency **ƒ = 1 ÷ T**

1.9 Necessary tools and equipment

The following tools and equipment are required to perform the tasks mentioned

Table 4:-Hand Tools

No.	Tool	Description	Picture
1.	**Screw drivers**	Used to remove or install screws Available in many shapes and sizes • Standard/Flat • Phillips	
2.	**Long nose/ Combination pliers**	Used to grip, cut, crimp, hold, and bend various parts	
3.	**Diagonal cutter**	Jaw shape allows these pliers to cut items flush with an adjacent surface	
4.	**Electrician knives**	This knife is needed to cut the insulation off of wiring. It is also used to open boxes and cut electrical tape when doing installation.	
5.	**Wire Crimpers**	This tool is used to cut wires, strips wires, and *crimps* lugs and connectors onto wires.	

1.10 OHS hazards and suitable PPE

Occupational health and safety:- is a cross-disciplinary area concerned with protecting the safety, health and welfare of people engaged in work or employment. The goal of all occupational health and safety programs is to foster a safe work environment. As a secondary effect, it may also protect co-workers, family members, employers, customers, suppliers, nearby communities, and other members of the public who are impacted by the workplace environment

1.10.1 Personal Protective Equipment (PPE)

Table 5:-Safety Equipment

No.	equipment	Description	Picture
1	**Hard Hat**	used in workplace environments such as industrial or construction sites to protect the head from injury due to falling objects	
2	**Safety Shoe**	Protective, safety footwear is essential to ensure safe and healthy feet.	
3	**Glove**	It is important to wear gloves when working with hazardous chemicals and Electrical Shocks in working Area	
4	**Safety Belt/Harness**	A safety belt or harness has to be worn as a safety precaution by a person working at a great height. The safety harness has be worn correctly and fixed to an anchor point at the roof	
5	**Fire Extinguisher**	Are commonly sold at hardware stores for use in the kitchen or garage, are pressurized with nitrogen or carbon dioxide (CO_2) to propel a stream of fire-squelching agent to the fire. Fire extinguisher are also commonly used with water and powdered	

1.10.2 First Aid

- **First aid** is the first and immediate assistance given to any person suffering from either a minor or serious illness or injury.
- **First aid** helps ensure that the right methods of administering medical assistance are provided. Knowing how to help a person is just as **important** in emergency situations. It only takes six minutes for the human brain to expire due to lack of oxygen
- First aid is generally performed by someone with basic medical training..

Figure 14: First aid Kit

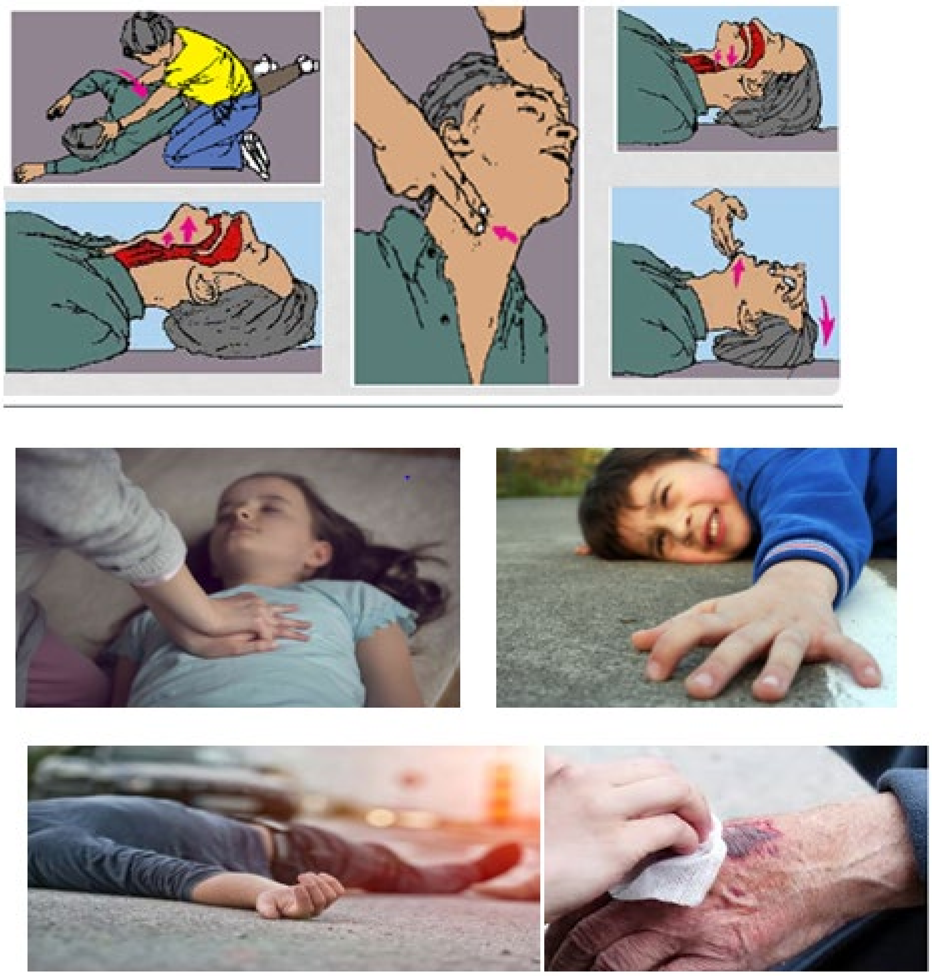


Figure 15: First Aide procedure

Self-Check -1	Written Test

I. Choose the best option & circle the letter of your choice.

1. What is the name for the flow of electrons in an electric circuit?

   A. Voltage B. Resistance C. Capacitance D. Current

2. Which of the following will remain the same in all parts of a series circuit?

   (A) Voltage (B) Current (C) Power (D) Resistance

3. Which instrument would you use to measure resistance?

   A. An ammeter B. A voltmeter C. An ohmmeter D. A wave meter

4. What does an electrical insulator do?

   A. It lets electricity flow through it in one direction

   B. It does not let electricity flow through it

   C. It lets electricity flow through it when light shines on it

   D. It lets electricity flow through it

5. A battery is a source of

   (A) DC voltage. (B) 1 φ AC voltage.

   (C) 3 φ AC voltage. (D) AC or DC voltage.

6. What is the basic unit of electric current?

   A. The volt B. The watt C. The ampere D. The ohm

7. What is the name of the pressure that forces electrons to flow through a circuit?

   A. Magneto motive force, or inductance

   B. Electromotive force, or voltage

   C. Farad force, or capacitance

   D. Thermal force, or heat

8. Which instrument would you use to measure electric current?

   A. An ohmmeter B. A wave meter

   C. A voltmeter D. An ammeter

9. What is the basic unit of electromotive force (EMF)?

A. The volt B. The watt

C. The ampere D. The ohm

10. Which instrument would you use to measure electric potential or electromotive force?

A. An ammeter B. A voltmeter C. A wave meter D. An ohmmeter

11. What limits the current that flows through a circuit for a particular applied DC voltage?

A. Reliance B. Reactance C. Saturation D. Resistance

12. What is the basic unit of resistance?

A. The volt B. The watt C. The ampere D. The ohm

13. What are three good electrical conductors?

A. Copper, gold, mica B. Gold, silver, wood

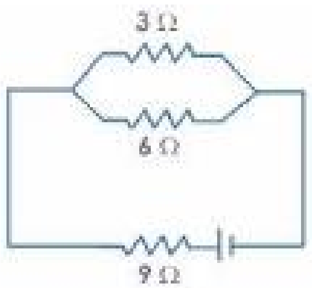
C. Gold, silver, aluminium D. Copper, aluminium, paper

14. What are four good electrical insulators

A. Glass, air, plastic, porcelain B. Glass, wood, copper, porcelain

C. Paper, glass, air, aluminium D. Plastic, rubber, wood, carbon

15. in the figure,



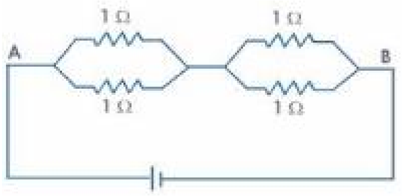
A. 6 Ω , 3 Ω and 9 Ω are in series

B. 9 Ω and 6 Ω are in parallel and the combination is in series with 3 Ω

C. 3 Ω , 6 Ω and 9 Ω are in parallel

D. 3 Ω , 6 Ω are in parallel and 9 Ω is in series

16. The resistance across AB is



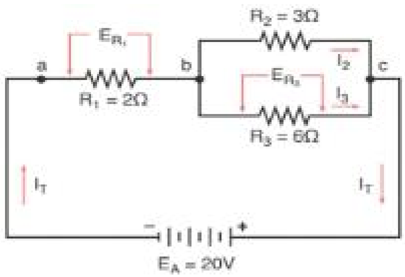
A. 4 Ohm B. 1 Ohm C. 2 Ohm D. 0.5 Ohm

17. Kilowatt-hour is the unit of

A. Potential difference B. Electric power C. Electrical energy D. Charge

18. What is the current through R3 (I3) in the image below?

A. 3.33 B. 1.67 C. 5 D. 6.66



Note: **Satisfactory rating 10 and above points, Unsatisfactory - below 10 points**

Short answer question

Score = ___________
Rating: ____________

Information Sheet-2	Identifying And Describing Types Of Renewable Energy

2 Identifying And Describing Types Of Renewable Energy

2.1 Introduction

- Renewable energy:-
    - is energy generated from natural resources
    - is energy that is generated from natural processes
    - Renewable resources are replenished naturally
    - They are found in unlimited supplies
    - They can never be depleted

On the other hand resources that can be depleted such as petroleum and natural gas are called non-renewable resources

2.2 Identifying and describing types of Renewable Energy Sources

2.2.1 Solar energy

Humans have been harnessing solar energy for thousands of years—to grow crops, stay warm and dry foods. According to the National Renewable Energy Laboratory, "more energy from the sun falls on the earth in one hour than is used by everyone in the world in one year." Today, we use the sun's rays in many ways to heat homes and businesses, to warm water, or power devices. Photo voltaic panels shown in the pictures below convert solar radiation in to electricity

Figure 16: solar Installation

2.2.2 Hydro power

Hydropower relies on water typically fast-moving water in a large river or rapidly descending water from a high point and converts the force of that water into electricity by spinning a generator's turbine blades. Hydropower therefore requires good flow of water and good height difference (termed as head) between the water level and turbine. Hydropower is the main source of electricity in Ethiopia.

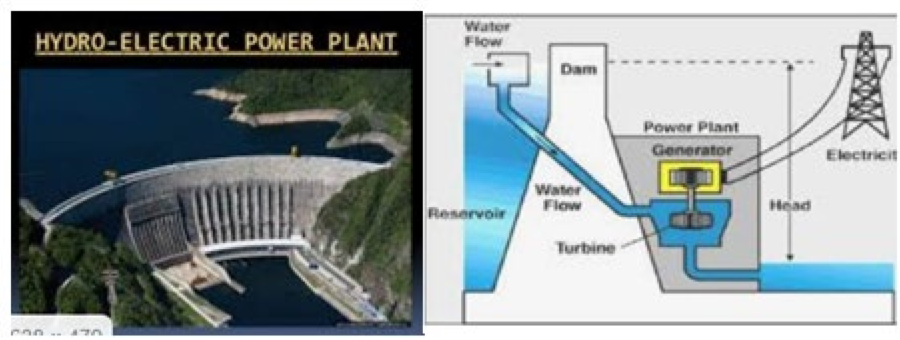


Figure 17: Hydro power Final work

2.2.3 Tidal energy

Tidal power, also called tidal energy, is a form of hydropower that converts the energy of tides into useful forms of power – mainly electricity. Although not yet widely used, tidal power has potential for future electricity generation. Tides are more predictable than wind energy and solar power.

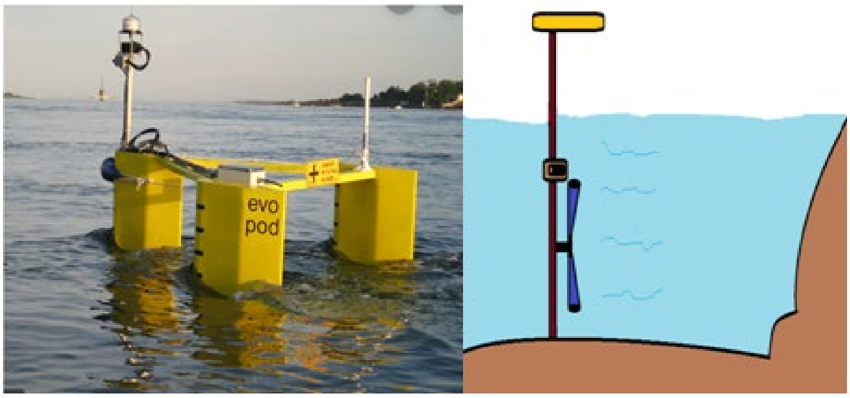


Figure 18: Tidal stream generator

2.2.4 Geothermal heat

If you've ever relaxed in a hot spring, you've used geothermal energy. The earth's core is about as hot as the sun's surface, due to the slow decay of radioactive particles in rocks at the centre of the planet. Drilling deep wells brings very hot underground water to the surface as a hydrothermal resource, which is then pumped through a turbine to create electricity.

Geothermal plants typically have low emissions if they pump the steam and water they use back into the reservoir. There are ways to create geothermal plants where there are not underground reservoirs, but there are concerns that they may increase the risk of an earthquake in areas already considered geological hot spots.

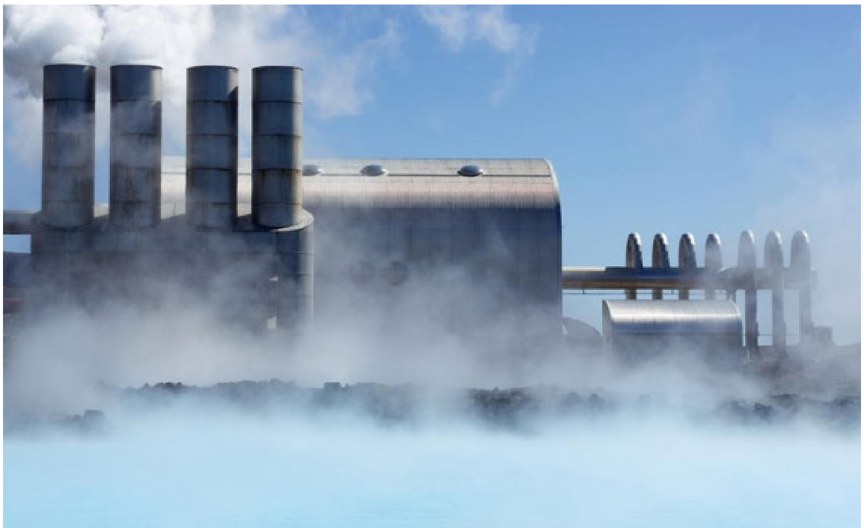


Figure 19: Geothermal heat energy System

2.2.5 Biomass

Biomass energy is organic material that comes from plants and animals, and includes crops, waste wood, and trees. When biomass is burned, the chemical energy is released as heat and can generate electricity with a steam turbine.

Examples of biomass and their uses for energy

- Wood and wood processing wastes—burned to heat buildings, to produce process heat in industry, and to generate electricity
- Agricultural crops and waste materials—burned as a fuel or converted to liquid bio fuels
- Food and wood waste in garbage—burned to generate electricity in power plants or converted to biogas in landfills
- Animal manure and human sewage—converted to biogas.

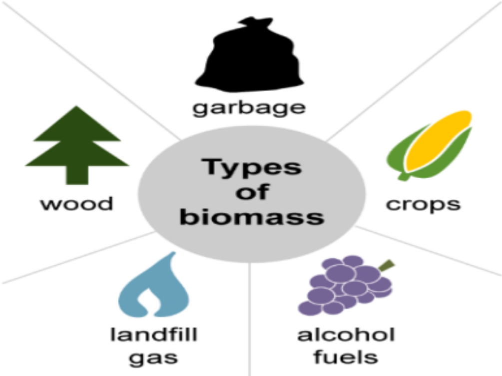


Figure 20: Types of Bio mass

2.2.6 Wind energy:

Wind energy (or wind power) describes the process by which wind is used to generate electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. Mechanical power can also be utilized directly for specific tasks such as pumping water

Wind turbines operate on a simple principle. The energy in the wind turns two or three propeller-like blades around a rotor. The rotor is connected to the main shaft, which spins a generator to create electricity.

Figure 21: Wind Energy

Summary table for renewable energy sources with their respective symbols

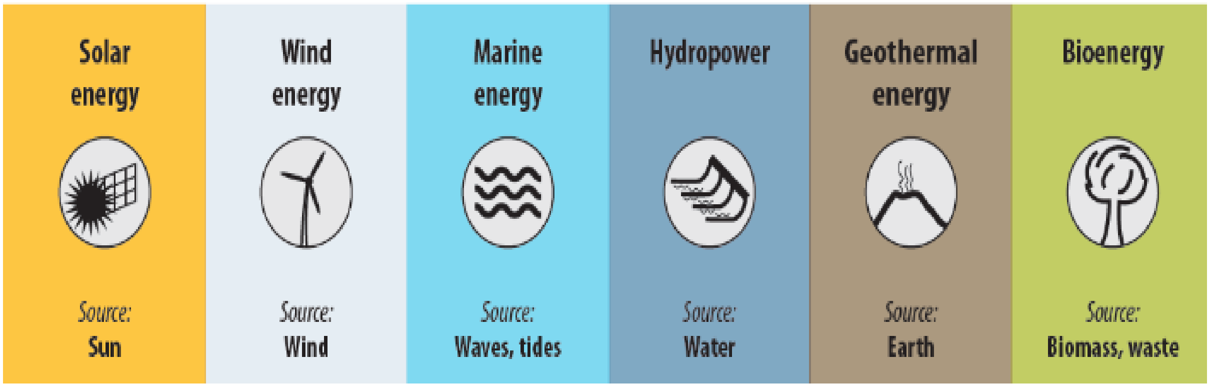


Figure 22: General description renewable Energy

Self-Check -2	Written Test

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

I. Choose the best answer for the following questions below

1. Which one of the following is a renewable resource:
   a) Petroleum b) Natural gas c) Bio mass d) All
2. Energy from organic materials such as plants and animals is
   a) Geothermal b) Natural gas c) Tidal d) None
3. Which one of the renewable resources is widely used to produce electricity in Ethiopia?
   a) Wind energy b) Solar energy c) Hydropower d) Geothermal
4. The machines that convert kinetic energy in the flow air into mechanical power are called
   a) Hydro turbines b) Wind turbines c) Pumps d) All
5. The heat that we use in hot springs comes from
   a) Solar radiation b) Geothermal energy c) Natural gas d) All

***Note:* Satisfactory rating - 3 points Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Short answer questions

Information Sheet-3	Basic Working Principles of Renewable Energy

3 Basic Working Principles of Renewable Energy

3.1 Principles of solar energy

Solar energy is created by light and heat which is emitted by the sun, in the form of electromagnetic radiation. With today's technology, we are able to capture this radiation and turn it into usable forms of solar energy - such as heating or electricity.

Solar energy is the sun's nuclear fusion reactions within the continuous energy generated. Earth's orbit, the average solar radiation intensity is 1,367 W/m^2. Circumference of the Earth's equator is 40,000km, thus we can calculate the energy the earth gets is up to 173,000 TW. At sea level on the standard peak intensity is 1 kW/m^2, a point on the earth's surface 24h of the annual average radiation intensity is 0.20 kW/m^2, or roughly 102,000 TW of energy. Humans rely on solar energy to survive, including all other forms of renewable energy (except for geothermal resources) Although the total amount of solar energy resources is ten thousand times of the energy used by humans, but the solar energy density is low, and it is influenced by location, season, which is a major problem of development and utilization of solar energy.

The technical feasibility and economic viability of using solar energy depends on the amount of available sunlight (solar radiation) in the area where you intend to place solar heaters or solar panels. This is sometimes referred to as the available solar resource. Every part of Earth is provided with sunlight during at least one part of the year.

"Part of the year" refers to the fact that the north and south polar caps are each in total darkness for a few months of the year. The amount of sunlight available is one factor to take into account when considering using solar energy.

There are a few other factors, however, which need to be looked at when determining the viability of solar energy in any given location. These are as follows:

- Geographic location
- Time of day
- Season
- Local landscape
- Local weather

3.2 Principles of wind energy

A windmill converts wind energy into rotational energy by means of its blades. The basic principle of every windmill is to convert kinetic energy of wind into mechanical energy which is used to rotate the turbine of electrical generator to produce electricity.

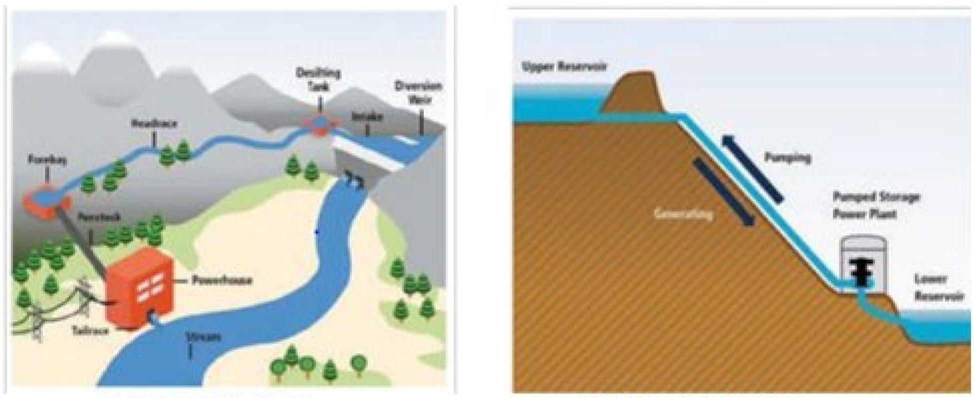
3.3 Principles of hydropower

Hydropower is probably the first form of automated power production which is not human / animal driven. Moving a grind stone for milling first, developed into the driving of an electrical generator. Next to steam it was for long the main power source for electricity. Continual availability does not require any power storage (unlike wind / solar power). It is mainly mechanical hardware. This makes it relative easy to understand and repair-/maintainable. In smaller units its environmental impact becomes neglect-able Head & Flow In order to create electricity from hydropower, two parameters are critical:

- **Flow**; or the minimum amount of water that is constantly available throughout the entire year
- **Head**; the difference in height

These specific conditions limit generalising and standardisation of "how to install hydropower plants". Choosing the right location and planning requires some specific knowledge. With knowledge of water flow and height difference the potential power can be estimated.

Head and flow are the two most important facts of a hydro site. This will determine everything about the hydro system - volume of civil constructions, pipeline size, turbine type and power output. Inaccurate measurements result in low efficiency, high cost and scarcity of power.



a) Run-of-River b) Pump Storage

Figure 23: Hydropower Plant

3.4 Principles of bio energy

Biomass can be converted into energy (heat or electricity) or energy carriers (charcoal, oil, or gas) using both thermo chemical and biochemical conversion technologies. Combustion is the most developed and most frequently applied process because of its low costs and high reliability. However, combustion technologies deserve continuous attention from developers in order to remain competitive with the other options.

3.5 Principles of tidal power

Tidal power harnesses the energy from the tidal force and wave action in order to generate electricity. Unlike other energy flows, it is a predictable source of energy because tides occur at expected time.

Tide or wave is periodic rise and fall of water level of the sea. Tides occur due to the attraction of sea water by the moon. Tides contain large amount of potential energy which is used for power generation. When the water is above the mean sea level, it is called flood tide. When the water level is below the mean level it is called ebb tide.

The arrangement of this system is shown in figure below. The ocean tides rise and fall and water can be stored during the rise period and it can be discharged during fall. A dam is constructed separating the tidal basin from the sea and a difference in water level is obtained between the basin and sea.

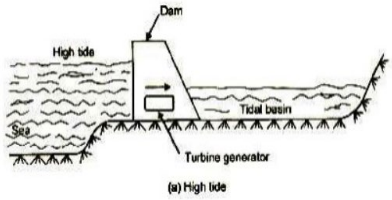


Figure: High tide

Figure 24: High of tidal power

During high tide period, water flows from the sea into the tidal basin through the water turbine. The height of tide is above that of tidal basin. Hence the turbine unit operates and generates power, as it is directly coupled to a generator.

During low tide period, water flows from tidal basin to sea, as the water level in the basin is more than that of the tide in the sea. During this period also, the flowing water rotates the turbine and generator power.

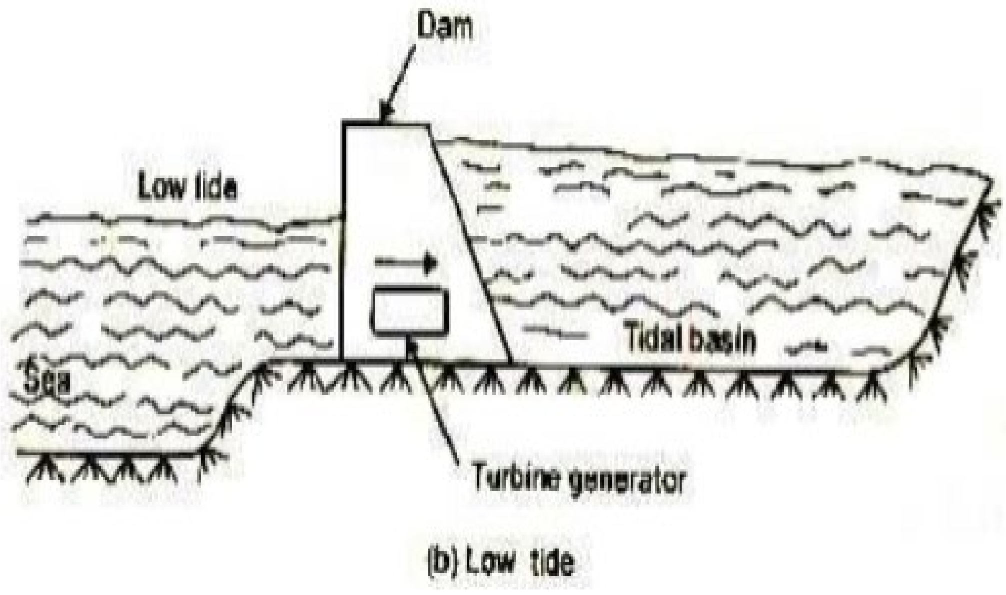


Figure 25: Low tidal power

The generation of power stops only when the sea level and the tidal basin level are equal. For the generation of power economically using this source of energy requires some minimum tide height and suitable site.

Self-Check -3	Written Test

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

Match Colum B to Column A

No	Column A	Column B
1	Geothermal Energy	A. Created by light and heat
2	Hydro power	B. Uses organic materials as source
3	Solar energy	C. uses heat as a prime mover
4	Wind energy	D. converts one kind of energy to rotational energy by its blades
5	Biomass	E. uses falling water

Note:

Satisfactory rating - 3 points

Unsatisfactory - below 3 points

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Short answer question

Information Sheet-4	Applications of Renewable Energy

4 Applications of Renewable Energy

4.1 Application of Solar Energy

Solar energy is utilized mainly in two ways: photovoltaic and thermal applications.

4.1.1 Photovoltaic application of solar energy

The photovoltaic effect (PV) is defined as the generation of electromotive force as a result of the absorption of ionizing radiation. Therefore, by using the photovoltaic effect, electricity can be generated directly from sunlight without going through a thermal process.. Devices that use the PV effect to generate a voltage when sunlight is the source of ionizing radiation are called solar cells.

An individual cell typically produces about 0.5V power with the current directly proportional to the cell's area. The Individual cells are connected in series – parallel combination o meet the voltage, power and reliability requirements of the particular application. . A series-connected set of **solar** cells or modules is called a "**string**".

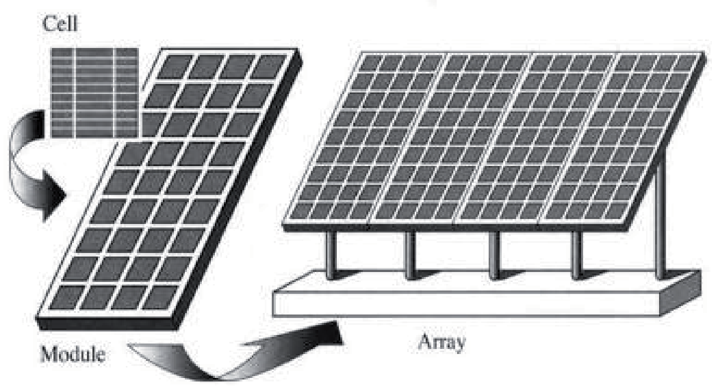


Figure 26: Solar cell, module and array

Some applications for PV systems are lighting for commercial buildings, outdoor (street) lighting, rural households and village lighting, rural small entertainment, health post lighting and vaccine storage, etc. Solar electric power systems can offer independence from the utility grid and offer protection during extended power failures. Solar PV systems are found to be economical especially in the hilly and far flung areas where conventional grid power supply is expensive and hard to reach.

PV tracking systems are alternatives to the fixed, stationary PV panels. PV tracking systems are mounted and provided with tracking mechanisms to follow the sun as it moves through the sky. These tracking systems run entirely on their own power and can increase output by 40%.

Backup systems are necessary since PV systems only generate electricity when the sun is shining. The two most common methods of backing up solar electric systems are connecting the system to the utility grid or storing excess electricity in batteries for use at night or on cloudy days.

4.1.2 Thermal application of solar energy

In solar thermal systems, solar energy can be converted into thermal energy with the help of solar collectors and receivers known as solar thermal devices. Solar energy is used for heating fluid, usually water or air, which can then be used for suitable applications.

The heating process is done by absorbing the solar radiation on an absorber plate and thus heating it. Then this heat is transferred to a circulating fluid for use elsewhere. If the surface area of the exposed sunlight is nearly equal to the surface used for absorbing solar radiation, the device is said to be a non-concentrating type solar collector, for which the most common is the flat plate collector (FPC). An efficient solar collector traps the maximum solar radiation incident on its surface, and converts it to thermal energy for use with minimum losses.

Low-grade solar thermal devices are used in solar water heaters, air-heaters, solar cookers and solar dryers for domestic and industrial application solar water heater. Using the sun's energy to heat water is not a new idea. More than one hundred years ago, black painted water tanks were used as simple solar water heaters in a number of countries. Solar water heating (SWH) technology has greatly improved during the past century. There are a number of service hot water applications. The most common application is the use of domestic hot water systems (DHWS), as depicted in the Figure below. An insulated storage tank holds the hot water. In case of systems that use fluids, heat is passed from the hot fluid to the water stored in the tank through a coil of tubes (heat exchanger)

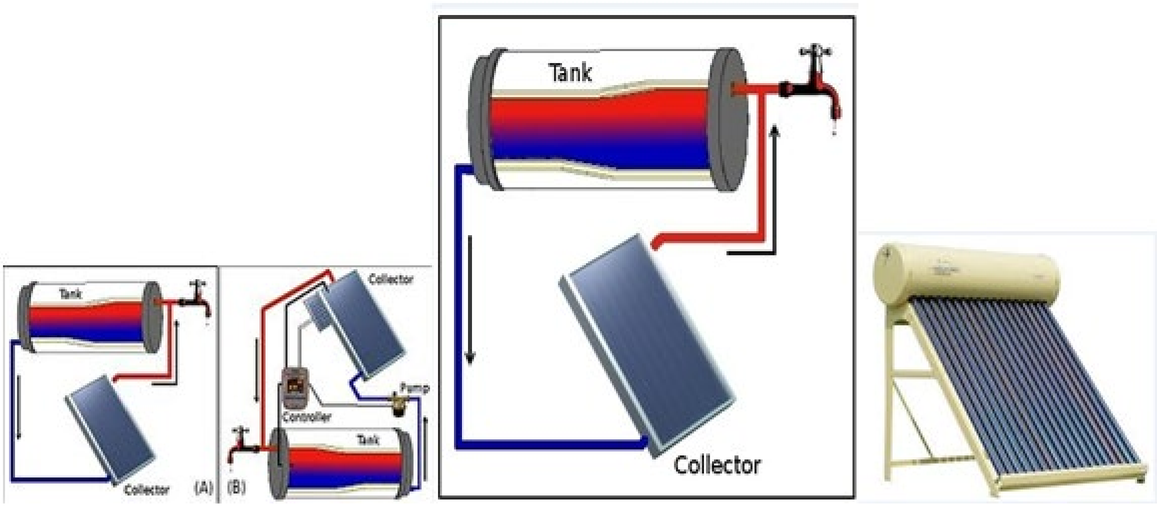


Figure 27: Solar water heater

Solar water heating systems can be either active or passive systems. The active systems, which are most common, rely on pumps to move the liquid between the collector and the storage tank. The passive systems rely on gravity and the tendency for water to naturally circulate as it is heated. Some industrial applications of solar water heaters are Hotels, Textiles, Breweries &Distilleries, etc.

Solar air heating: hot air is needed for drying crops and for warming the area. Solar air heating is the same as for water heating where the fluid is heated while in contact with the surface of the radiation absorber. More specifically, the influence of the collector' s orientation and the heat losses from the blowing of the wind, etc. for the two heating systems are very similar.

Passive heating system

The concept of passive heating systems is the selection of an absorber surface facing the sunlight as to capture an optimal amount of solar energy for a given construction building applications for solar air heating systems include both building ventilation air heating and process air heating.

Systems used for ventilation heating vary depending on the type of building in which the system will be installed (e.g. industrial, commercial or residential).Large quantity of outdoor air is used for process air heating applications, such as for drying agricultural products. Solar systems can also serve as a pre-heater to (high temperature) industrial drying systems.

Solar Cooker is a device, which uses solar energy for cooking, thus saving fossil fuels, fuel wood and electrical energy to a large extent. It is a simple cooking unit, ideal for domestic cooking throughout most of the year except during the monsoon season, cloudy days and winter months.

The box type solar cookers, with a single reflecting mirror, are the most popular. These cookers have proved immensely popular in rural areas where women spend considerable time collecting firewood.

4.2 Application of Bioenergy

There are three fundamental forms of energy in terms of their utilization in our modern lives: heat, mechanical energy and electricity. The use of bioenergy can cover all of these forms of energy requirements.

Heat*:* is generated primarily in combustion systems. For stationary biomass systems that exist solely to generate heat, solid fuels predominate. Wood as a residue or raw material and production residues from farming can be used for heat production with low processing costs for cooking or drying.

Mechanical energy: is required mainly by the transport industry. Bio resources can also be converted in to biofuels for use in cars and agricultural machinery.

Electricity*:* the generation of power (electricity) from bioenergy also makes use of the capabilities of heat and power generation. Systems that generate mechanical energy in combustion engines or in directly and indirectly fired turbines are coupled to electricity generators generated via heat and power-generating machines such as engines.

4.3 Application of Wind Energy

Most modern wind power is generated in the form of electricity by converting the rotation of turbine blades into electrical current by means of an electrical generator. Electricity generating wind turbines can be as small as having capacity in Watts to large scale turbines having capacity in Mega Watts.

In wind mills, wind energy is used to turn mechanical machinery to do physical work, such as crushing grain or pumping water. Recently, wind energy has also been used to desalinate water.

Figure 28: Application of wind energy

Self-Check -4	Written Test

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

Say true or false for the following questions

1. By using PV effect, electricity can be generated directly from sun light without going through thermal process
2. An individual cell in PV can typically produces above 0.5 V
3. Solar water heater is not used for household application
4. Wind energy can be used to desalinate water.
5. In PV system individual cells are connected in series, parallel combination to meet the voltage power and reliability requirement

Note:

Satisfactory rating - 3 points

Unsatisfactory - below 3 points

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ____________

Rating: _____________

Name: ___________________________ Date: ________________

Short answer questions

Information Sheet-5	Advantage and disadvantages of renewable energy sources

5 Advantages and disadvantages of renewable energy sources

The use of renewable energies is the only possibility to electrify the southern hemisphere without destroying the world. The primary advantage of renewable energy resources is no or fewer potentially harmful emissions are released into the atmosphere.. The main disadvantage is that renewable energy sources are mostly volatile, that means they are not continuously available. But this problem can be solved by the use of appropriate storage systems e.g. thermal storage, hydro power plants with pumped storage, battery storage, ice storage and power to gas technology. The following outlines the general advantages and disadvantages of renewable energy resources

Advantages of Renewable Energy

- Pollution free and causes no greenhouse gases to be emitted after installation.
- Reducing dependence on imported fuels
- Creating economic development and jobs in manufacturing and installation
- Renewable clean power is available in different forms: solar, wind, hydropower, bioenergy, tidal power etc.
- sustainable energy supply for the future of the country & the next generation

Disadvantages of Renewable Energy

- Most of the renewable energy sources relatively need large investment
- Many forms of renewable energy are location specific
- Some forms of renewable energy require large space for their application
- Some forms of renewable energy technologies are still under development and are not commercially available

Advantages of solar energy

- Solar energy causes no pollution
- Solar energy can be produced free of charge, no cost for fuel.
- Almost no or low maintenance is required on solar technology is installed
- Solar energy can be used in different forms: thermal or electricity

Disadvantages of solar energy

- Cost: the initial cost of purchasing a solar system is fairly high
- Weather dependent: although solar energy can still be collected during cloudy and rainy days, the efficiency of the solar system drops
- Solar energy storage is expensive
- Uses a lot of space

Self-Check -5	Written Test

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

I. Choose the best answer for the following questions.

1. The main disadvantage of renewable energy resources is

a. Pollution b. Cost c. Space d. Technology development

2. The advantage of solar energy can be

a. Produced free of charge b. Low maintenance c. Pollution free d. All of the above

3. Most of the renewable energy resources are location specific.

a. False b. True

4. One of the disadvantages of solar energy is expensive energy storage.

a. True b. False

5. Employing renewable energy resources reduces dependence on fuels

a. True b. False

Note:

Satisfactory rating - 3 points

Unsatisfactory - below 3 points

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Short answer question

Information Sheet-6	Renewable Energy Plants

6 Renewable Energy Plants

6.1 Geothermal power plant

Geothermal is a thermal power plant, but the steam required for power generation is available naturally in some part of the earth below the earth surface. According to various theories earth has a molten core. The fact that volcanic action taken place in many places on the surface of earth supports these theories.

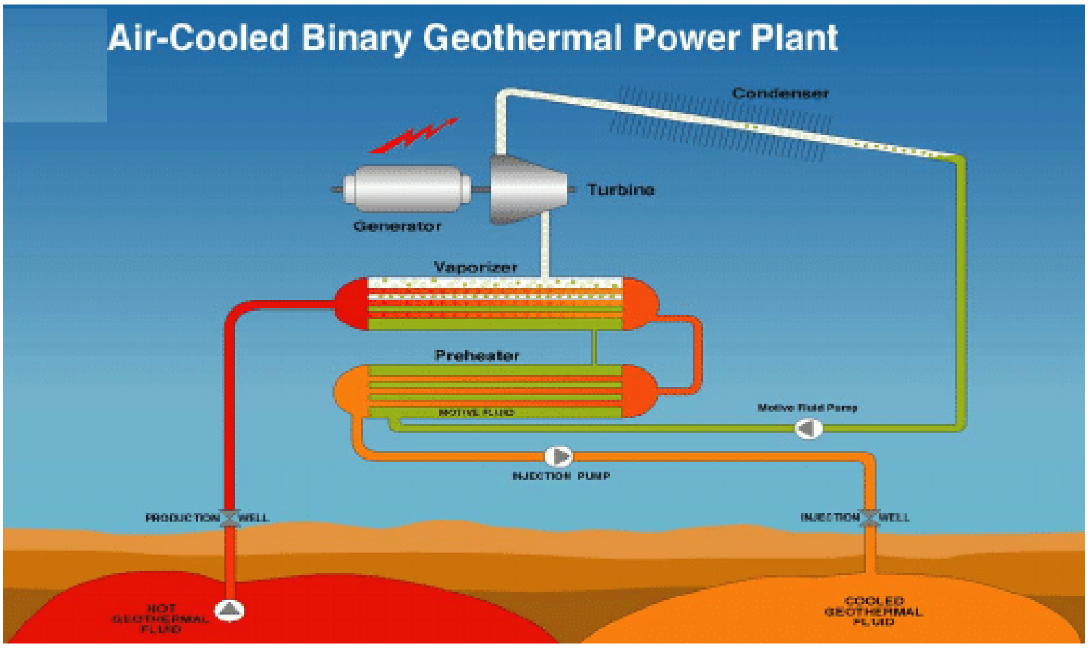


Figure 29: Schematic drawing of Geothermal power plant

Steam well

Pipes are embedded at places of fresh volcanic action called steam wells, where the molten internal mass of earth vents to the atmosphere with very high temperatures. By sending water through embedded pipes, steam is raised from the underground steam storage wells to the ground level.

Separator

The steam is then passed through the separator where most of the dirt and sand carried by the steam are removed.

Turbine

The steam from the separator is passed through steam drum and is used to run the turbine which in turn drives the generator. The exhaust steam from the turbine is condensed. The condensate is pumped into the earth to absorb the ground heat again and to get converted into steam. Location of the plant, installation of equipment like control unit etc., within the source of heat and the cost of drilling deep wells as deep as 15,000 metres are some of the difficulties commonly encountered.

6.2 Tidal power plants

The tidal power plants are generally classified on the basis of the number of basins used for the power generation. They are further subdivided as one-way or two-way system as per the cycle of operation for power generation.

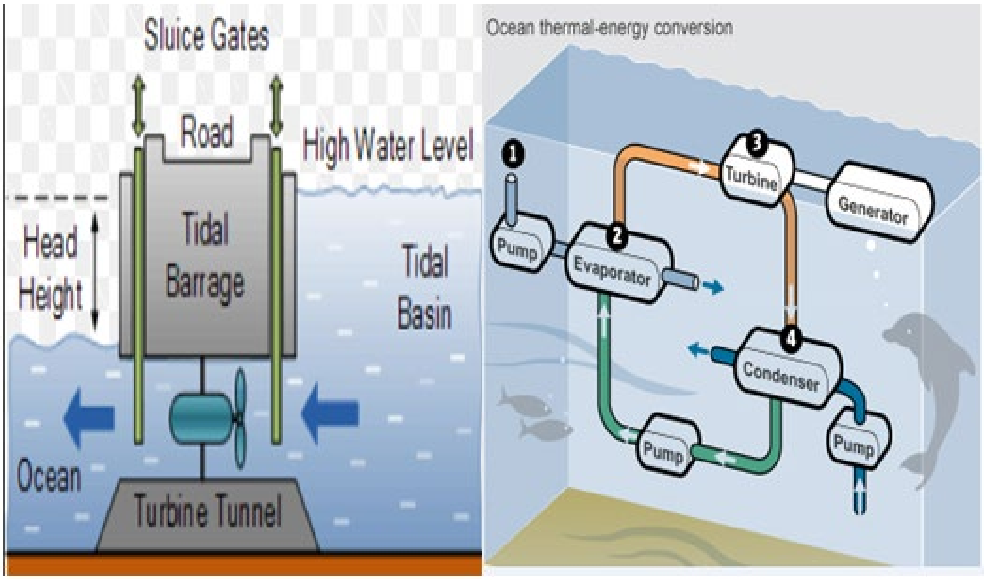


Figure 30: Tidal power plants

6.3 Working principles of different tidal power plants

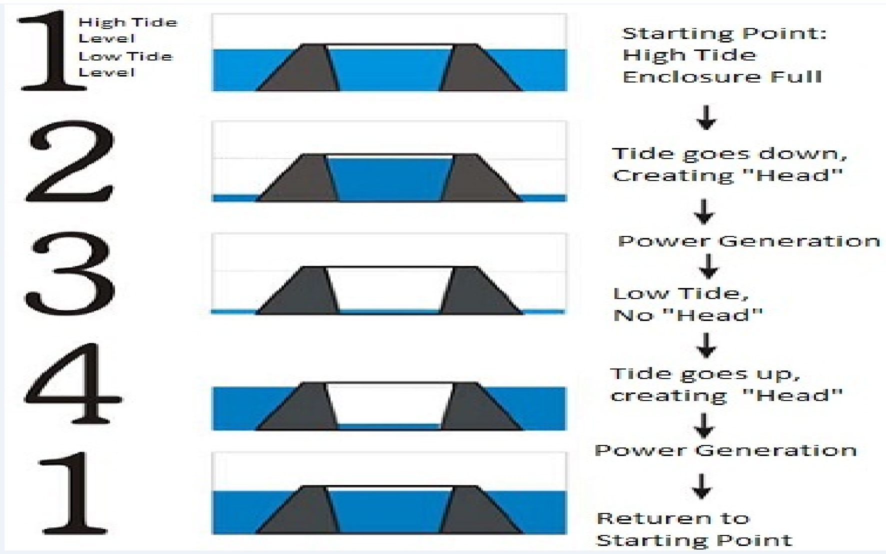


Figure 31: How Tidal **Lagoon Works**

Single basin-one-way cycle

This is the simplest form of tidal power plant. In this system a basin is allowed to get filled during flood tide and during the ebb tide, the water flows from the basin to the sea passing through the turbine and generates power. The power is available for a short duration ebb tide.

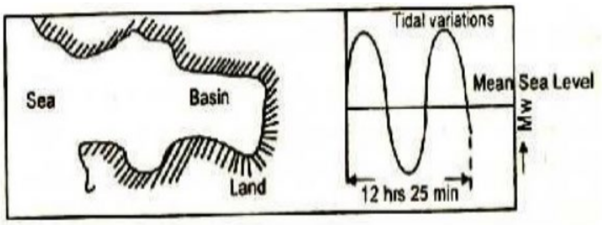


Figure: (a) Tidal region before construction of the power plant and tidal variation

Single-basin two-way cycle

In this arrangement, power is generated both during flood tide as well as ebb tide also. The power generation is also intermittent but generation period is increased compared with one-way cycle. However, the peak obtained is less than the one-way cycle. The arrangement of the basin and the power cycle is shown in figure.

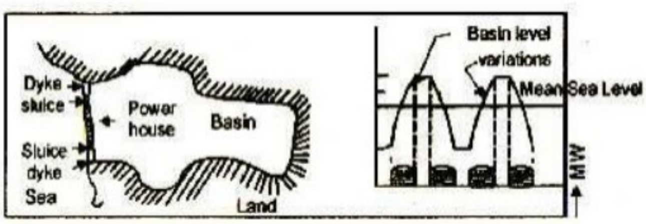
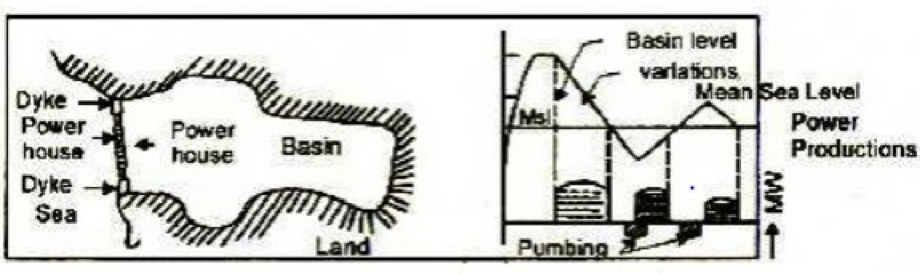


Figure: Single –basin two-way tidal power plant

The main difficulty with this arrangement, the same turbine must be used as prime mover as ebb and tide flows pass through the turbine in opposite directions. Variable pitch turbine and dual rotation generator are used of such scheme.

Single –basin two-way cycle with pump storage

In this system, power is generated both during flood and ebb tides. Complex machines capable of generating power and pumping the water in either direction are used. A part of the energy produced is used for introducing the difference in the water levels between the basin and sea at any time of the tide and this is done by pumping water



into the basin up or down. The period of power production with this system is much longer than the other two described earlier. The cycle of operation is shown in figure.

Double basin type

In this arrangement, the turbine is set up between the basins as shown in figure. One basin is intermittently filled tide and other is intermittently drained by the ebb tide. Therefore, a small capacity but continuous power is made available with this system as shown in figure. The main disadvantages of this system are that 50% of the potential energy is sacrificed in introducing the variation in the water levels of the two basins.

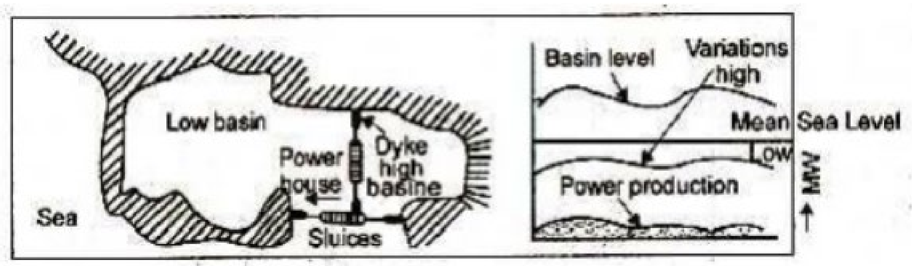


Figure: Double basin, one-way tidal plant.

Barrages

The Tidal barrages are designed to utilize the potential energy created due to the difference in the level (height) of the tidal waves.

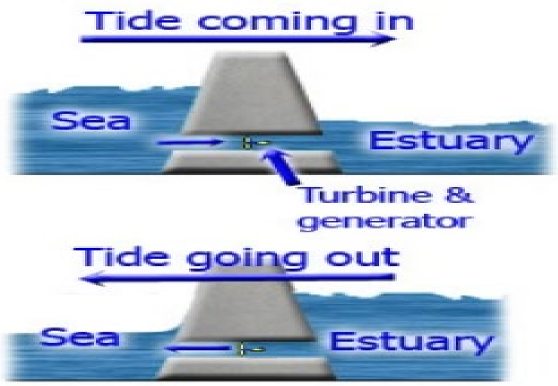


Figure 32:- How Tidal Barrage works

6.4 Wind-Electric Generating power plant

Figure shows the various parts of a wind-electric generating power plant. These are:

- Turbine rotor and hub
- Nacelle: it houses drive train and generator. Drive train includes shafts, gear box, clutch, brake etc. Generator converts the mechanical energy in the rotating shaft into electricity.

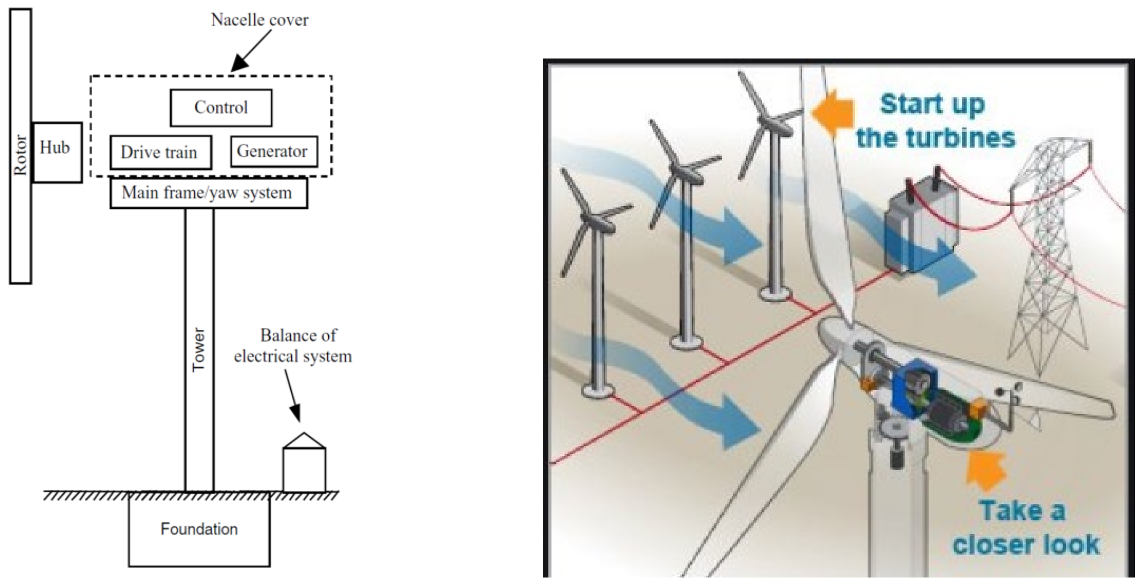


Figure 33:-Supporting tower and its foundation

The most important component is the **rotor**. For an effective utilization, all components should be properly designed and matched with the rest of the components.

The Nacelle performs the following functions:

- It houses the drive train components and generator.
- It also houses any control mechanism incorporated like changing the pitch of the blades and yawing of the turbine to orient the rotor to face the wind. Yawingis facilitated by mounting it on the top of the supporting structure on suitable bearings.

The turbine rotor may be located either upwind or downwind of the tower. In the upwind location the wind encounters the rotor before reaching the tower. In downwind rotors the wind reaches the rotor after reaching the tower. Generally upwind turbines are preferred especially for the large aero generators.

The supporting structure is designed to withstand the wind load during gusts. Its type and height is related to cost and transmission system incorporated. Horizontal axis wind turbines are mounted on towers so as to be above the level of turbulence and other ground related effects.

Types of Wind Machines

Wind turbines (sometimes called aero generators) are generally classified as follows:

- Horizontal axis wind turbines (HAWT).
- Vertical axis wind turbines (VAWT).

Horizontal axis wind turbines

Figure shows a schematic arrangement of horizontal axis turbine. Although the common wind turbine with horizontal axis is simple in principle yet the design of a complete system, especially a large one that would produce electric power economically, is complex. It is of paramount importance that the components like rotor, transmission, generator and tower should not only be as efficient as possible but they must also function effectively in combination.

Figure 34:- Horizontal Axis Wind Turbines

Vertical axis wind turbines. Figure shows vertical axis type wind turbine. One of the main advantages of vertical axis rotors is that they do not have to be turned into the wind stream as the wind direction changes. Because their operation is independent of wind direction, vertical axis machine are called panemones.

Figure 35:- Vertical Axis Wind Turbines

6.5 Hydroelectric power plants

Convert the hydraulic potential energy from water into electrical energy. Such plants are suitable where water with suitable ***head*** is available. The layout covered in this article is just a simple one and only cover the important parts of hydroelectric plant.

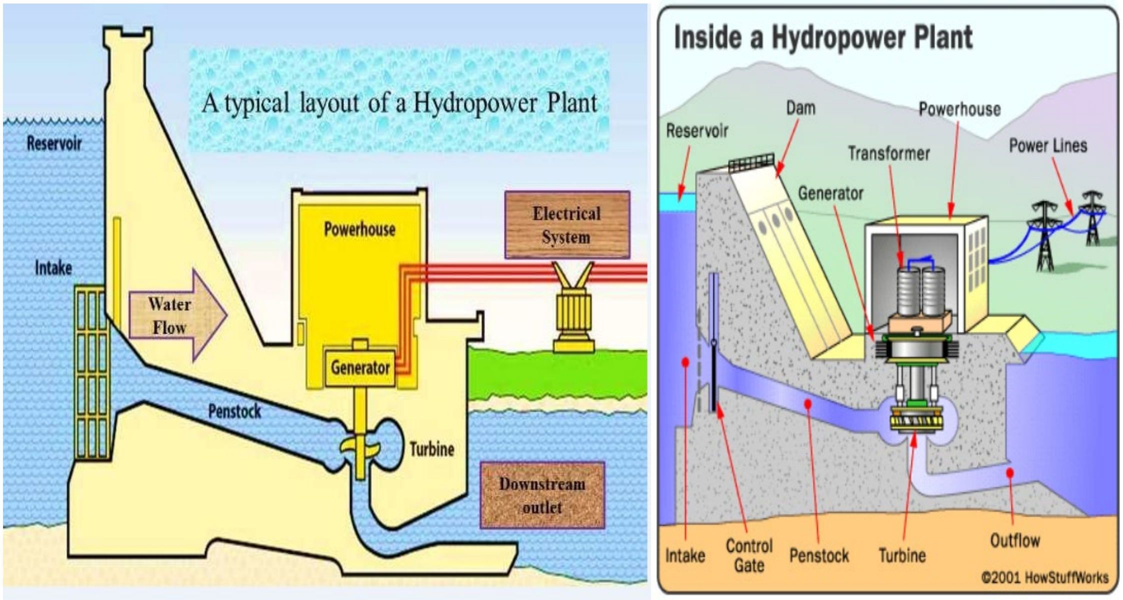


Figure 36:-Typical lay out of Hydropower Plant

Dam

Dams are structures built over rivers to stop the water flow and form a reservoir. The reservoir stores the water flowing down the river. This water is diverted to turbines in power stations. The dams collect water during the rainy season and store it, thus allowing for a steady flow through the turbines throughout the year. Dams are also used for controlling floods and irrigation. The dams should be water-tight and should be able to withstand the pressure exerted by the water on it. There are different types of dams such as arch dams, gravity dams and buttress dams. The height of water in the dam is called *head race*.

Spillway

A spillway as the name suggests could be called as a way for spilling of water from dams. It is used to provide for the release of flood water from a dam. It is used to prevent over toping of the dams which could result in damage or failure of dams. Spillways could be controlled type or uncontrolled type. The uncontrolled types start releasing water upon water rising above a particular level. But in case of the controlled type, regulation of flow is possible.

Penstock and Tunnels

Penstocks are pipes which carry water from the reservoir to the turbines inside power station. They are usually made of steel and are equipped with gate systems. Water under high pressure flows through the penstock. A tunnel serves the same purpose as a penstock. It is used when an obstruction is present between the dam and power station such as a mountain.

Surge Tank

Surge tanks are tanks connected to the water conductor system. It serves the purpose of reducing water hammering in pipes which can cause damage to pipes. The sudden surges of water in penstock are taken by the surge tank, and when the water requirements increase, it supplies the collected water thereby regulating water flow and pressure inside the penstock.

Power Station

Power station contains a turbine coupled to a generator. The water brought to the power station rotates the vanes of the turbine producing torque and rotation of turbine shaft. This rotational torque is transferred to the generator and is converted into electricity.

The used water is released through the *tail race*. The difference between head race and tail race is called gross head and by subtracting the frictional losses we get the net head available to the turbine for generation of electricity.

6.6 Biomass power plants

Biomass power plants range from small biogas plants to large scale electricity generating plants. Biogas plants convert organic materials into biogas through bacteria digestion. While large scale biomass power plants burn the organic materials or waste and generate heat which can drive steam turbines to produce electricity.

Biogas plant

A typical biogas plant consists of the following parts:

- Mixing tank with inlet pipe: this where the organic material is mixed with water and flows into the digester
- Digester: is the main part of the plant where the mixed organic material is digested by bacteria to create the biogas
- Compensating and removal tank: this a tank where the digested material is removed as a slurry
- Gasholder: this is the part of the plant where the biogas is stored
- Gas pipe: the biogas is extracted through the gas pipe for use
- Entry hatch: this is an opening where it is closed in normal operation but may be opened for inspection and maintenance.

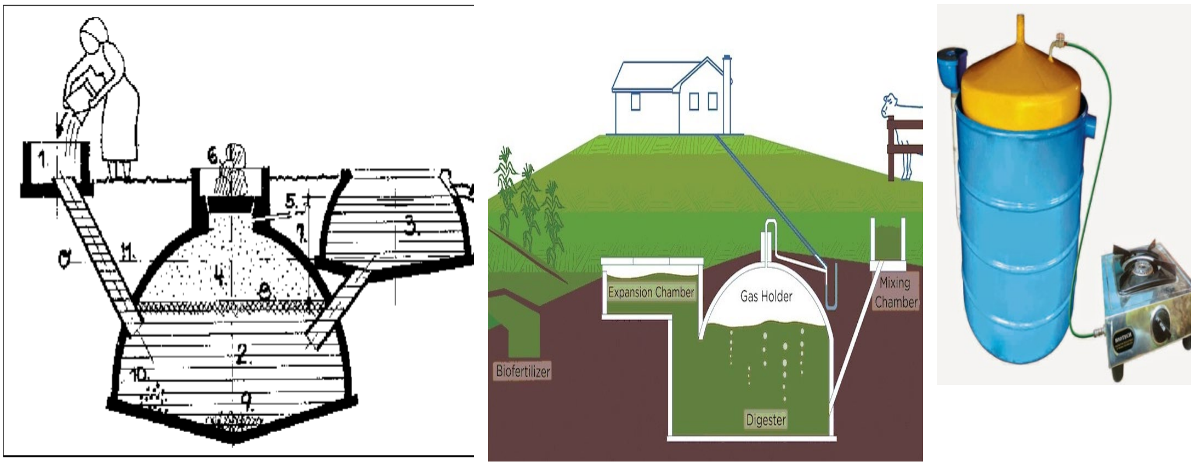


Figure 37:- Fixed Dom Biogas Plant and Biogas stove

The biogas can be then used to:

- Produce electricity and heat by burning it in a combustion engine
- Use it as biofuel e.g. for cars
- Use it for cooking or heating
- Use it as energy storage

Self-Check – 6	Written Test

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

Match the components in column A to their respective power plants in column B

Column A	Column B
_____ 1. Penstock	A. Tidal power plant
_____ 2. Separator	B. Wind power plant
_____ 3. Basin	C. Hydropower plant
_____ 4. Rotor	D. Biogas plant
_____ 5. Digester	E. Geothermal power plant

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Short answer question

Operation Sheet 1	Basic electricity

Operation Title: Procedure to measure current, voltage and resistance in a circuit

Step -1.Wear appropriate personal protective equipment

Step -2. Prepare and plan work place

Step -3 Select appropriate equipment and tools

Step -4 Perform the given project accurately

Step -5 Switches “ON” the multimeter and point selector switch in “Ω” section.

Step -6. Connect the red lead to “V/Ω” and black lead to “COM”

Step -7. Read the given colour code value indicated in Schematic symbol correctly

Step -8. Select the Ohm-scale within the range and turn off the power source

Step -9. Place the black probe of the multi-meter in one terminal of the resistor.

Step -10. Place the red probe of the multi-meter in the other terminal of the resistor.

Step -11 Measure the value each resistor

Step -12 Point selector switch in “V” section.

Step -13 Connect the leads appropriately to the right polarity

Step -14 Measures the voltage drop across each resister by giving voltage source

Step -15 Point selector switch in “A” section and change the lead position properly

Step -16 connect the leads to the right polarity

Step -17Measure current by disconnecting one leg of a resistor inserting the ammeter in series with resistors

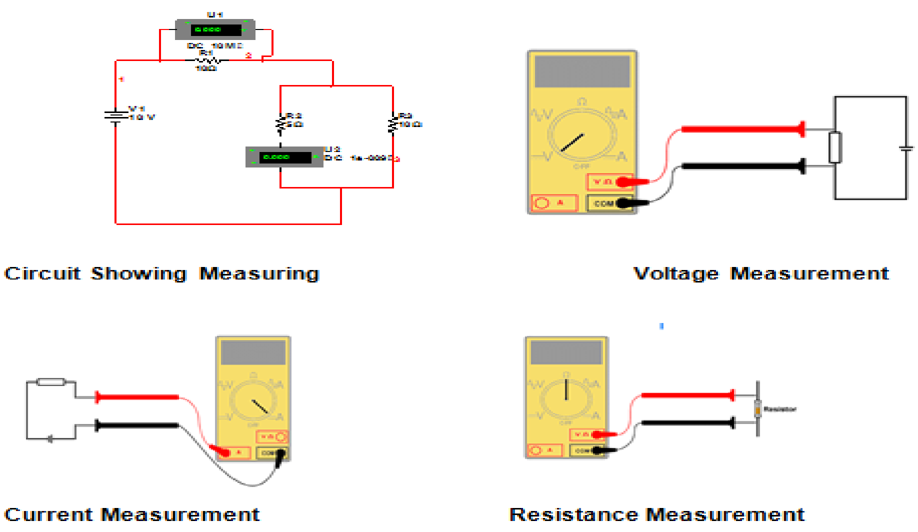


Figure 38:-Ohms Law Circuit Measurement

LAP Test	Practical Demonstration

Name: ______________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Instructions: Given necessary materials, tools and measuring instruments you are required to perform the following tasks within 1 hour.

Task 1. Measure the current, voltage & resister in the circuit.

List of Reference Materials

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8. http://www.susana.org/_resources/documents/default/2-1799-biogasplants.pdf
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