ABOUT THE BOOK....

Energy is the heart of the universe, hence we can't think about the universe without energy. It is one of the most important concepts in the world of science. Use of energy is a part of our life; it is one of the most basic need for human beings. Energy is presents in the universe in a variety of forms, including wind, solar, nuclear, electrical, chemical, hydrogen, mechanical, light, heat, sound, elastic, gravitational, geothermal, tidal, hydroelectric, ocean, biomass, electrostatics, electromagnetic, and nuclear energy.

Energy can be transformed from one kind to another, all observations and experiments suggest that the total amount of energy in the universe never changes. This is also true for an isolated system - a collection of objects that can exchange energy with each other, but not with the rest of the universe. If one form of energy in an isolated system decreases, then another form of energy in the system must increase.

'**Save Energy... Save Nation**' is the key aspect of this book. Which energy source is better for the future? What are the applications of it? The answer of these questions is tried to find by the authors in this book. Also, the goal of the Editor and co-author is to develop a better understanding of every corner of energy to the readers and also to aware of them. The focus on food energy and cosmic energy is one of the highlighted points of this book. Hope that this book fulfils the requirements of students, teachers, and researchers and they will welcome this edition.

ABOUT THE EDITOR...

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THE SCIENCE OF ENERGY

Editor : Dr. C. M. Kale

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ENERGY

Editor
Dr. C. M. Kale

RUSHI PUBLICATION

THE SCIENCE OF ENERGY

• EDITOR •

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We dedicate this book to,

All Real Hero's who are serving

The Entire Nation tirelessly to fight with COVID-19

Author(s)…

Preface...

Humans have always curious insight about the world around us. It is observed that natural things like the Sun, moon, light, air, water, etc are careful. They are always the source of inspiration that lead us to develop and to fulfill our need in day today life. Energy is one of the basic needs for us, without energy it is impossible to survive on the Earth. We have different sources of energy from which we got it, such as, food, sun, wind, sea, earth, etc.

*Considering the importance of energy, I think to work on the concept of energy, so that I have edited this book entitled, '**The Science of Energy'** during the lockdown period due to COVID-19.*

The most important feature of this book is that, all aspects of energy covered a wide sequence of chapters very systematically, so that the interest of the reader will increase and get clear concept of energy.

*At the outset, I would like to place on record my deep sense of gratitude to **Hon'ble Shri. Uttamsingh Pawar saheb (Ex. M.P. India)** for his blessing and love. I take this opportunity to express sincere gratitude to the Principal **Dr. P. P. Sharma** and all staff members of my college for their continuous support.*

*At the same time I take this opportunity to express sincere thanks to my mentor **Prof. K. M. Jadhav** (Senior Professor, Dept. of Physics, Dr. B. A. M. U. Aurangabad) and **Dr. S. J. Shukla**, (Deogiri College, Aurangabad) who inspired me to enhance this opportunity in lockdown period and to do constructive work for our student and society.*

*I express heartfelt thanks to my friend and reviewer Principal **Dr. Ashok Pandit** (Yeshwantrao Chavan College, Sillod), **Dr. Bibhas Dutta** (S. N. College, Labpur, West Bengal), **Dr. Ravindra Dorik** (Vivekanand College, Aurangabad) and **Dr. Chisti Sayd Qadeeruddin** (Dr. Rafiq Zakaria College for women, Aurangabad) for review and for suggestion and corrections in this regards.*

*I express my sincere thanks to the publisher **Dr. Mrs. Surekha S. Lakkas**. She has shown me faith to play the role of editor and hence she published this book in a short span of time.*

*Finally, I thank are due towards my friends **Dr. Santosh Chouthiwale**, **Mr. Vijay Shelke**, and all members of, '**A Group of Science Education'**, who have supported and encourage for editing this book.*

*Lastly, I would like to express my thanks to all **co-authors**, for completion of this reference book and to give beautiful shape to it which is only have been possible because of the spontaneous and continuous support.*

Dr. C. M. Kale

(Editor)

AUTHORS

Acknowledgment...

*We feel great a pleasure to cordially publish and to present this book on Energy entitled. '**The Science of Energy**'. As we know, Science is a vast and fascinating subject that integrates all spheres of life. Science touches every corner of nature and its natural phenomenon. Energy is one of the basic parts of the universe consists of solar energy, wind energy, ocean energy, etc, and other various forms. The main aspect to write this book is to introduce all corners of energy. Today the whole world is now facing challenging problems with energy and its production. The other purpose of this book is too aware of the people about energy crises. '**Save Energy-Save Nation'** is very important because while producing energy it has several advantages and disadvantages so that knowledge of applications of energy is very essential.*

We hope, this book will fulfill all the requirements and you will definitely welcome this edition with satisfaction. In the review of this book, it is written in simple and lucid language with a large number of essential diagrams and equations. Each topic has provided content and split into articles and sub-articles so that even the non-science will able to understand the concept of energy very easily. 'A picture can say a thousand words' so keeping this in mind, a large number of charts, graphs, pictures, table, etc. have been given in this edited book. We are sure you will agree with us that concept is same in all books, the difference lies in the method of presentation only.

*We all co-authors are always grateful to Editor **Dr. C. M. Kale**, who encouraged and motivated us to prepare this book. We are also thankful to Publisher **Dr. Mrs. Surekha S. Lakkas** for her most co-operative, painstaking efforts for creation of this book in a short interval of time with reviewers. All co-authors of, 'A Group of Science Education' are gratefully acknowledges the valuable contribution of the academicians for editing and finalization this book.*

We look forward for feedback and constructive criticism from our users, which we will give due to consideration in future editions. Every care has been taken to keep the book error-free. As there is always a scope for improvement any comment or suggestion will be always acknowledged. We will sure that after reading this book; the reader will develop a special interest in science. We welcome your suggestions and comments for our valued use, especially students and teachers.

We wish our young readers a happy journey to the exciting realm of Physics...!!!

Author(s)

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COSMIC ENERGY

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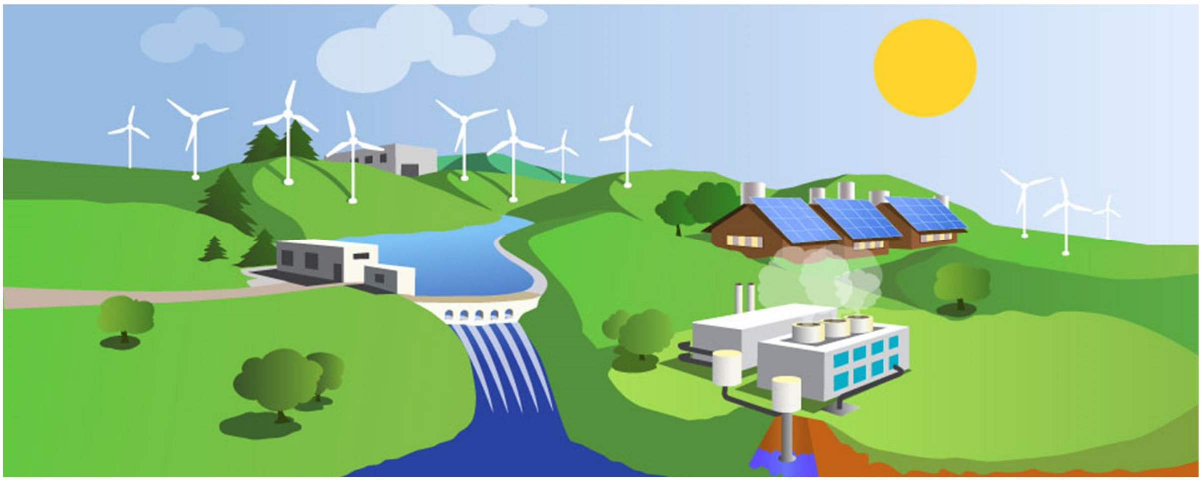
CHAPTER :1

INTRODUCTION TO ENERGY

1.1. INTRODUCTION

The word energy derives from the Greek word, 'energeia' and it was a qualitative philosophical concept, broad enough to include ideas such as happiness and pleasure.



The word **'energy'** is very often used in our daily life. Our day starts with regular activity and for that, we required energy which is taken from food. We need energy everywhere so that from a scientific point of view we give it a definite and precise meaning. Let us consider the examples, when a fast-moving ball hits a stationary wicket, the wicket is thrown away. Also, a bucket full of water lifted from well to a certain height gets the capability to do work. We must have seen that when a raised hammer falls on a nail placed on wood, it drives the nail into the wood. When a rubber cord is stretched by force change its shape. After releasing the force from the rubber cord, then it comes back to its original shape. However, if we press the balloon, it can even explode producing a blasting sound. In all these examples, the objects acquire, through different means, the capability of doing work. An object having the capability to do work is said to possess energy. The object which does the work loses energy and the object on which the work is done gains energy. When this happens, energy is transferred from the former to the latter. The second object may move as it receives energy and therefore does some work. Thus, the first object could do work. This implies that any object that possesses energy can do work.

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1.2. ENERGY TERMINOLOGY

Capacity to do work is called energy. There major areas of energy resources divided into two categories: non-renewable and renewable. Non-renewable energy resources, like coal, nuclear, oil, and natural gas, are available in limited supplies. This is usually due to a long time it takes for them to be replenished. Renewable resources are replenished naturally and over relatively short periods. The major renewable energy resources are solar, wind, water (hydro), biomass, and geothermal. Energy sources are sometimes classified according to characteristics like renewable, traditional, commercial, etc. The terminology is rather ambiguous, as the meaning of the words often depends on the context. Some connotations are given below.

Renewable is generally contrasted with fossil. Renewable is biomass, animate, solar, water and wind energy, as well as geothermal energy. Fossil energy is contained in coal, oil, and natural gas.

Traditional energy is often contrasted with non-traditional energy, and also with new energy. However, what is considered traditional depends on what one is used to. In industrialized societies that are used to fossil fuels, renewable energies like biomass and animate energy are often called traditional. The people are working on new energy sources like wind or solar energy.

New and renewable energy sources are often put together. They exclude fossil and nuclear energy. Commercial energy is contrasted with non-commercial energy, and sometimes with traditional energy. Commercial energy certainly includes energy from fossil fuels that have been monetarized, but also some forms of new and renewable energies which are part of the cash economy. Biomass and some other sources of renewable energy (thermal solar energy) are sometimes considered non-commercial because they are thought to be freely available.


The relation between living things and energy is very close. Life is impossible without energy but we should remember that energy can neither be created nor destroyed it can convert one form to another. The demand by the people for energy day by day is ever increasing. We get energy from the Sun which is the biggest natural source of energy to us. Many of our energy sources are derived from the Sun. We can also get energy from wind, ocean, the nuclei of atoms, the interior of the earth, and the tides. We are trying to find new sources of energy which is beneficial from all aspects. We will shocked by focusing on demand of ehergy in the world. Just look at the report of International Energy Agency (IEA) about daily consuption of energy.

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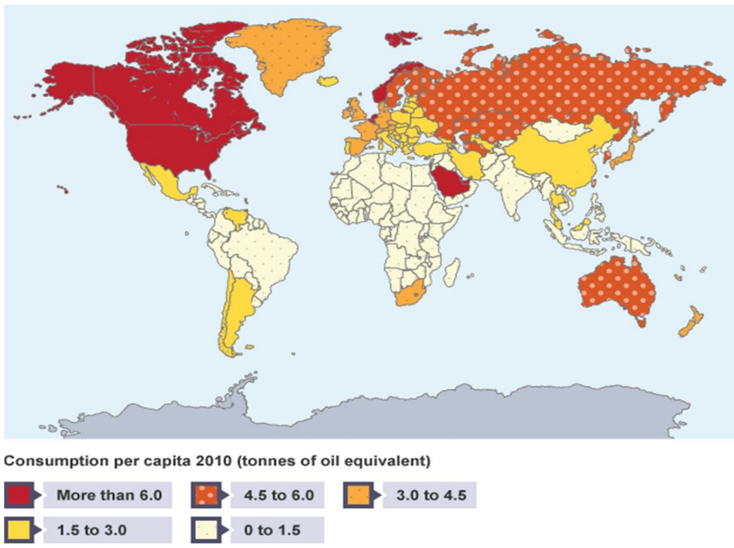
1.3. GLOBAL ENERGY DEMAND

Energy demand is the term used to describe the consumption of energy by human activity. Day by day the energy consumption increases with the increasing number of developing areas. For this development to continue, while maintaining the quality of life, new and renewable energy sources must be found and utilized. Today the demand for energy is more due to vast progress in human life. In the future to fulfill the requirement, the world may be shifting toward renewable energy, but the pace is not fast enough to offset the impacts of worldwide economic expansion and a growing fast population, the International Energy Agency (IEA) warned. The IEA in 2007 predicted that oil, coal, and gas together account for the majority of global primary energy consumption.



Energy consumption per head is a reliable indicator of a country's level of economic development. The map shows the energy consumption per capita in various countries. Energy consumption is highest at the moment in developed countries and with high populations. This is due to a high concentration of industry, high levels of car ownership, and high domestic usage from homes filled with appliances.

1.4. UNIT OF ENERGY

The energy of a body is defined as the capacity of the body to do the work. Energy is a scalar quantity. Energy has the same units and dimensions as those of work. The term energy and work are very close. Work ($w = f \times d$)) has been defined as the product of the force and the displacement. Force is expressed in newton and displacement in meter, the SI unit of work and energy is the newton-meter; also called Joule and the CGS unit is erg.

$$1J = 1Nm.$$

Heat is a form of energy and flows from one body to another due to the difference in temperature. The quantity of heat transferred is often given in calories (cal). One calorie is defined as exactly 4.184 joules. Thus,

$$1 \text{ calorie} = 4.184 \text{ J}$$

One calorie of energy will raise the temperature of 1g of liquid water by 1^oC. A calorie is a non-SI unit, but like the joule, it can be used for any form of energy.

1.4.1. Commercial unit of energy

The unit of energy is joule and it is too small and therefore it is inconvenient to express large quantities of energy. Instead of this, we use a bigger unit of energy called kilowatt-hour (kWh). Suppose a machine uses 1000 J of energy in a second and if this machine is continuously used for one hour, and then it will consume 1 kWh of energy. Thus,

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1 kW h is the energy used by a machine in one hour at the rate of 1000 J/s (or 1kW).

1 kWh = 1kW ×1 h

= 1000 W × 3600 s

= 3600000 J

1 kW h = 3.6 × 106 J.

The energy used in households, industries, and commercial establishments is usually expressed in a kilowatt-hour. The electrical energy used during a month is expressed in terms of 'units'. Here, 1 'unit' means 1 kilowatt-hour.

Table.1: Units of energy

Sr.No.	Unit	Symbol	Equivalent in joule
1	erg	erg	10^{-7} J
2	calorie	cal	4.2 J
3	kilowatt-hour	KWh	3.6×10^{6} J
4	electron volt	eV	$1.6\times10\text{-}^{19}$ J

1.5. THE PRINCIPLE OF CONSERVATION OF ENERGY

The principle of conservation of energy cannot be proved. However, no violation of this principle has been observed. The concept of conservation and transformation of energy into various forms links together various branches of physics, chemistry, and life sciences and correlate them.

Since the universe as a whole may be viewed as an isolated system, the total energy of the universe is constant. If one part of the universe loses energy, another part must gain an equal amount of energy. According to the principle of conservation of energy, the total energy of an isolated system remains constant. Energy may be transformed from one form to another but the total energy of an isolated system remains constant. Energy can neither be created nor destroyed given by the law of conservation of energy.

1.5.1. Law of conservation of energy

The first law of thermodynamics is a version of the law of conservation of energy specialized for thermodynamic systems. It is usually formulated by stating that the change in the internal energy of a closed system is equal to the amount of heat supplied to the system, minus the amount of work done by the system on its surroundings. The law of conservation of energy can be stated like this:

‘The energy can neither be created nor destroyed but it is only converted from one form of energy to another so that total energy in the universe remains constant.'

Consider the example that, the chemical energy stored in a battery and when it connected in a circuit, energy stored in the battery is released to produce electricity. This means that a system always has the same amount of energy unless it's added from the outside. This is particularly confusing in the case of non-conservative forces, where energy is converted from mechanical energy may get transformed into other forms such as heat, light, and sound, but the overall energy does remain the same. Thus, various forms of energy are interrelated and under certain conditions, these may be transformed from one form into another. The device that converts energy from one form to another is a transducer.

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1.6. VARIOUS FORMS OF ENERGY

Luckily the world we live in provides energy in many different forms. Types of energy can be categorized into two broad categories - kinetic energy (the energy of moving objects) and potential energy (energy that is stored). These are the two basic forms of energy. The different types of energy include wind energy, solar energy, thermal energy, radiant energy, chemical energy, nuclear energy, electric energy, motion energy, sound energy, elastic energy, geothermal energy, gravitational energy, etc. Few are brifly discussed below.

1.6.1. Wind energy

Wind energy captures the natural wind in our environment and converts the motion of the air into mechanical energy which is also used to generate electricity. The wind is caused by changes in atmosphere and water bodies by solar radiation. This kinetic energy of the wind can be used to do work. This energy was harnessed by windmills in the past to do mechanical work. The output of a single windmill is quite small; therefore, several windmills are erected over a large area, which is known as wind energy farm.

1.6.2. Solar energy

The energy obtained from the Sun is called solar energy. Sun is a huge source of heat as well as light. The Sun has been radiating an enormous amount of energy, but only a small part of solar energy reaches earth. A maximum amount of energy gets absorbed in the atmosphere. Solar energy collected by a solar panel. India is lucky to receive solar energy for the greater part of the year. It is estimated that during a year India receives the energy more than 5,000 trillion KWh. The solar energy reaching unit area at the outer edge of the earth ís atmosphere exposed perpendicularly to the rays of the Sun at the average distance between the Sun and Earth is known as the solar constant. It is estimated to be approximately 1.4 KJ per sec. per sq. meter or 1.4 KW/m^2.

1.6.3. Sound (Sonic) energy

A sound is a form of mechanical energy that travels through substances in the form of longitudinal waves. It is produced when a force causes an object or substance to vibrate- the energy is transferred through the substance in the form of a wave. The sound vibrations cause waves of pressure that travel through a medium, such as air, water, wood, or metal. This energy is associated with the vibration or disturbance of matter. An example of something that creates sound energy is our voice box. Typically, the sound energy is far less than other forms of energy.

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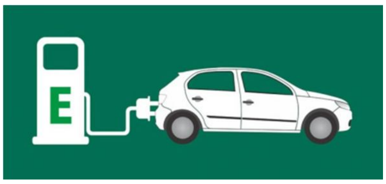
1.6.4. Light (Radiant) energy

Light energy plays a very important role in nature. When light energy enters in eyes and we get the sensation. Light is electromagnetic radiation emitted by hot objects like lasers, bulbs, and the Sun. Light contains photons and when a atoms takes light energy, it results in the production of photons are emitted. The energy is released in the form of a photon and more photons come out as the substance gets hotter. Light travels in the form of a wave when it travels. However, no matter is essential to carry the energy along to travel. Light can travel through space where there is no air. Light energy is very quick and travels faster than anything. The light speed is equal to 186,282 miles per second. Sunlight called white light consists of seven colors which we observerd in rainbow. Luminous energy is the energy that can be seen because it is visible light.

1.6.5. Elastic energy

Elastic energy is energy stored in an object when there is a temporary strain on it - like in a coiled spring or a stretched elastic band. The energy is stored in the bonds between atoms. The bonds absorb energy as they are put under stress and release the energy as when the object returns to its original shape. Elastic potential energy is the energy stored in an elastic object when deformed. In the case of an elastic or spring, you physically pull or push to convert kinetic (movement) energy into elastic potential energy. This is potential mechanical energy that is stored in the configuration of a material or physical system as work is performed to distort its volume or shape. Stretched rubber band, balloon, tube, etc are stores elastic energy.

1.6.6. Electric energy



This is the energy that is from electrical potential energy and it is associated with the way that point charges in a system are arranged. Energy is associated with an electric current. Energy is thus stored in the resulting electrostatic field. Today electricity is a basic need for the human being. We can't do anything without electricity. The flow of electrical current is required for electrical appliances just as, bulbs to glow, fans to rotate, bells to ring, and charging electrical appliances. Laws are governing the attraction and repulsion of charges and currents, which we shall learn a special further topic, 'electric energy' ih this book.

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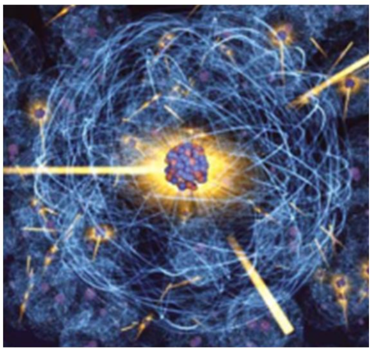
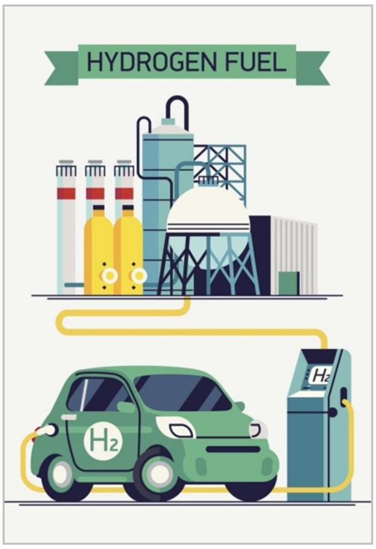
1.6.7. Nuclear energy



Nuclear energy comes from the nucleus of atoms. The energy is released by nuclear fusion (nuclei are fused) or nuclear fission (nuclei are split apart). Nuclear plants use nuclear fission of a radioactive element called uranium to generate electricity. Nuclear power plants and nuclear weapons use nuclear energy. Atom is the smallest part of an element having a nucleus situated at its center. The nucleus contains nucleons and when the nucleus breaks, then energy is released called nuclear energy. Generally, a heavy isotope (such as uranium-235 or plutonium-239) can undergo nuclear chain reaction yielding a vast amount of energy. And also when light nuclei join together emits energy (like sun energy) under nuclear fusion. Using nuclear fusion, the sun converts nuclear energy into available internal energy and keeps the high temperature of the Sun. Sometimes, it is incorrectly referred to as atomic energy.

1.6.8. Hydrogen energy



Hydrogen energy is obtained from hydrogen molecules. Hydrogen is a clean fuel. It is an energy carrier that can be used for a broad range of applications. Also, it could serve as a possible substitute for liquid and fossil fuels. At standard temperature and pressure, hydrogen is a nontoxic, nonmetallic, odorless, tasteless, colorless, and highly combustible diatomic gas with the molecular formula H_2. Hydrogen can be considered as a clean energy carrier, similar to electricity. Hydrogen can be produced from various domestic resources such as renewable energy and nuclear energy. The world is presently experimenting with the dawning of hydrogen energy in all sectors that includes energy production, storage, and distribution.

1.6.9. Chemical energy

Chemical energy stored by molecules can be released as heat during chemical reactions. The chemical energy may also be used to do mechanical work when a fuel burns in an engine or to provide electrical energy through a galvanic cell-like dry cell. Chemical energy is associated with the forces that give rise to the stability of substances. These forces bind atoms into molecules, molecules into polymeric chains, etc. The chemical energy arising from the combustion of methane, cooking gas, wood, or coal burns in air and petroleum is indispensable to our daily existence.

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1.6.10. Mechanical (motion) energy

The mechanical energy of a particle or system is defined as the sum of kinetic energy (K.E.) and potential energy (P.E.). K.E. is always positive, but the mechanical energy may be zero, positive or negative. Negative mechanical energy represents a bound state. This is an energy that is associated with the motion and position of an object. It is the sum of all of the kinetic and potential energy. An example of something that utilizes mechanical energy is a pendulum, turbines, vehicles, crene, etc.

1.6.11. Gravitational energy

Gravitational energy (GE) is the energy of position or place associated with the gravitational field. GE is the potential energy of a physical object with mass has concerning another massive object due to gravity. GE is dependent on the masses of two bodies, their distance apart and the gravitational constant. Every object may have potential energy but gravitational potential energy is only stored in the height of the object. Any time that a heavy object is kept high up, a force or power is likely to be holding it up there. This is the reason why it stays up and does not fall. It is important to note that the heavier the object, the more its potential energy.

1.6.12. Biomass energy

Biomass energy is the use of organic material to generate energy. Biomass is just organic matter - like wood pellets, grass clippings, and even dung. Crops, like sugarcane and corn, can also be used to create biofuels. Plant matter can be regrown, it's a renewable source of energy. Biomass can generate electricity in several ways, but the most common is combustion - burning agricultural waste or woody materials to heat water and produce steam, which spins turbines.

1.6.13. Tidal energy

The moon is revolving around the spinning earth. Tides are the rise and fall of sea levels due to the effects of the gravity exerted by the moon and the sun, and the rotation of the Earth. Tides occur to varying degrees and frequency, depending on location. This phenomenon is called high and low tides and the difference in sea-levels gives us tidal energy. Tidal energy is harnessed by constructing a dam across a narrow opening to the sea. A turbine fixed at the opening of the dam converts tidal energy into electricity.

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1.6.14. Ocean energy

This energy is produced due to the difference in temperature of surface water and water at depth of sea or ocean. The water at the surface of the sea or ocean is heated by the Sun while the water in deeper sections is relatively cold. This difference in temperature is exploited to obtain energy in ocean-thermal energy conversion plants. These plants can operate if the temperature difference between the water at the surface and water at depths up to 2 km is 20 K or more. The warm surface water is used to boil a volatile liquid like ammonia. The vapours of the liquid are then used to run the turbine of a generator. The cold water from the depth of the ocean is pumped up and condenses vapour again to liquid.

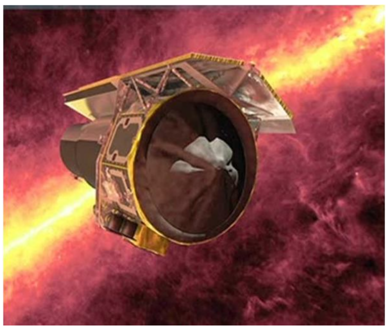
1.6.15. Thermal (Heat) energy

This is an energy associated with the microscopic random motion of particles. Warm bath water stores thermal energy. Thermodynamics is a branch of natural science concerned with heat and its relation to energy and work. One of the very important concepts in a study of thermodynamics is the concept of heat energy. Many sources such as Sun, burning objects, chemical reactions, etc produce thermal energy. It is important to note that energy can be stored within a system and can be transferred from one system to another.

1.6.16. Geothermal energy

Due to geological changes inside the earth, molten rocks formed in the deeper hot regions of earth ís crust are pushed upward and trapped in certain regions called a hot spot. When underground water comes in contact with the hot spot, steam is generated. Sometimes hot water from that region finds outlets at the surface. Such outlets are known as hot springs. The steam trapped in rocks is routed through a pipe to a turbine and used to generate electricity. The energy due to heat (therm) of the earth (Geo) called geothermal energy.

1.6.17. Electromagnetic energy



Electromagnetic energy is a form of energy that is reflected or emitted from objects in the form of electrical and magnetic waves that can travel through space. Examples are radio waves, microwaves, infrared radiation, visible light (all colors of the spectrum that we see), ultraviolet light, X-rays, and gamma radiation. James Clerk Maxwell developed his theory of electromagnetic radiation and showed that light was the visible part of a vast spectrum of electromagnetic waves.

1.6.18. Food energy

Food is any substance normally eaten or drunk by living things. The term food also includes liquid drinks. Food is the main source of energy and of nutrition for animals and is usually of animal or plant origin. Nutrients are chemical substances that are essential for the healthy growth and development of the body. The nutrients present in different food are carbohydrates, fats, proteins, vitamins, and minerals. Our body also required roughage and water to remain healthy.

1.7. GOOD SOURCES OF ENERGY

Whenever work has to be done, energy is needed. This energy is supplied by a source of energy. As we have known different kinds of sources. In our daily lives, we use energy from various sources for doing work. We use diesel or petrol for vehicles, electricity for electrical appliances like the bulb, iron, fan, computer, heater, etc, and chemical energy for cooking food. So we need to know how we select the source needed for obtaining the energy in its usable form. Some sources of energy may be good whereas others may not be good by making use of the following characteristic or qualities of a good source of energy. The good source of energy would be one,

1. Which would do a large amount of work per unit volume or mass,
2. Be easily accessible,
3. Be easy to store and transport,
4. Perhaps most importantly cheap i. e. economical and
5. Which do not cause environmental pollution

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CHAPTER.2

TYPES OF SOURCES OF ENERGY

2.1. INTRODUCTION

Energy is one of the most important components of economic infrastructure. It is the basic input required to sustain economic growth. There is a direct relation between the level of economic development and per capita energy consumption. Simply speaking more developed a country, higher is the per capita consumption of energy and vice-versa. India's per capita consumption of energy is only one-eighth of the global average. This indicates that our country has a low rate of per capita consumption of energy as compared to other countries. We can't think, world without energy. The word energy is used in our everyday life, but in science, it is a definite and precise meaning. Thus, the energy of an object is defined as it is the capacity for doing work. In simple words; energy is the ability to do work. There are many sources of energy i.e. the sun is the biggest source of energy to us many sources are derived from the sun.

Energy is the power we use for transportation, for heat and light in our homes and the manufacture of all kinds of products. A source of energy is one that can provide an adequate amount of energy in a convenient form over a long period. Energy comes from many sources, and to describe these sources. All the sources of energy can be divided into two main categories: Non-renewable sources of energy and Renewable sources of energy. These sources of energy are also known as conventional and non-conventional sources of energy. These two sources of energy: non-renewable and renewable energy are described below.

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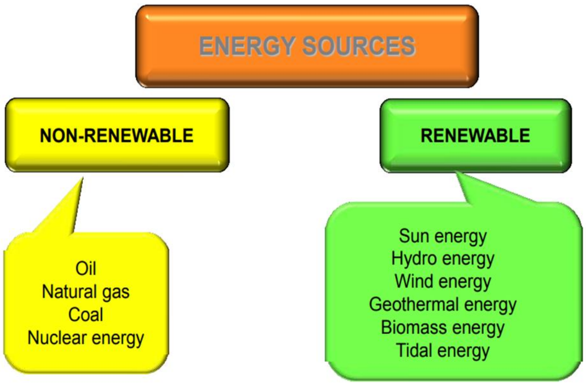
2.2. TYPES OF SOURCES OF ENERGY

Nature is a great source of energy. We use energy from different sources, some sources can exhaust in small time but some sources can't exhaust. Renewable sources can be used again and again throughout their life. They are the energy resources that cannot be exhausted. It is environmentally friendly.

The sources cannot be used again and again as it is limited which can be depleted one day. They are the energy resources that can be exhausted one day. Depending on this property, the types of sources are classified into two categories namely

1. Non-renewable energy sources and
2. Renewable energy sources



2.3. NON-RENEWABLE SOURCES OF ENERGY

Non-renewable energy resources cannot be replaced once they are used up, they will not be restored (or not for millions of years). Non-renewable energy is a source of energy that will eventually run out. Most of the energy we use comes from fossil fuels, such as coal, natural gas, oil, and petroleum. These natural resources are a major source of power for a vast amount of industries-however, there are numerous downsides to non-renewable energy, including their negative environmental impact and the fact they are in limited supply.

Non-renewable energy resources accumulated in nature over a very, very long time and cannot be quickly replaced when exhausted are called non-renewable sources of energy. The non-renewable sources of energy are also called conventional sources of energy. The non-renewable sources of energy like fossil fuels (coal, petroleum, and natural gas) are present in a limited amount in the earth. Once exhausted, they will not be available to us again. Nuclear fuels (like uranium) have been put in the category of non-renewable sources of energy because the nuclear materials which can be conveniently extracted from the earth are limited and hence they will get exhausted one day. Please note that since the non-renewable sources of energy can get exhausted one day, they are also known as exhaustible sources of energy. Another point to be noted is that though nuclear fuels are nonrenewable sources of energy dug out from the earth, they are not the conventional source of energy.

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2.3.1. Coal

Coal is a solid form of fossil fuel that can be classed into three types: lignite, bituminous, and anthracite. Lignite coal is found close to the Earth's surface, making it easy to mine, but it has high sulfur content. Bituminous coal is the most common coal we burn, and it is less polluting than lignite. Anthracite is the highest quality of coal-it is dark and shiny and found deeper in the Earth.

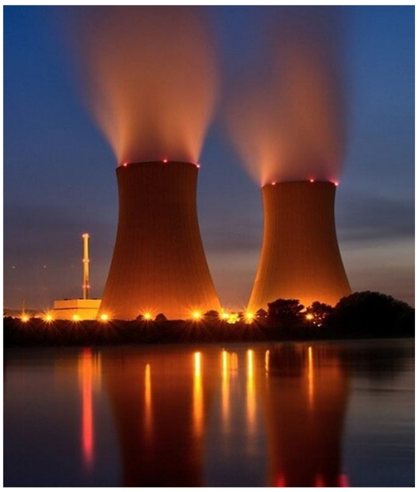
2.3.2. Oil

Oil is a liquid fossil fuel that can be dark brown, yellow, or even green. It is easier to mine once it is found because, being a liquid, it will flow through pipes, which makes it easier for transport. To find the reservoirs of crude oil, scientists must study rocks and landforms to find potential drilling sites. Once a hole is drilled and if the oil is found, it is then piped to the surface. In this form, it is called 'crude oil'. Crude oil is transported to a refinery that heats the oil to different temperatures and sorts out the different types of fuel through a process called fractional distillation

2.3.3. Natural gas

As the name suggests, this is a fossil fuel in the form of a gas (for example, methane and LPG). It is often found under the oceans and near oil deposits. Surveying for natural gas reservoirs is similar to oil exploration. Natural gas is a non-renewable fossil fuel formed from the remains of tiny sea plants and animals that died 300-400 million years ago. Approximately 90% of natural gas is composed of methane, also other gases such as propane & butane.

2.3.4. Nuclear energy



Nuclear energy is released when nuclei of an atom are fused (fusion) or split apart (fission). Nuclear power plants produce electricity through nuclear fission. Nuclear energy comes from the nucleus of atoms. The energy is released by nuclear fusion or nuclear fission. Nuclear plants use nuclear fission of a radioactive element called uranium to generate electricity. The energy is created through a specific nuclear reaction, which is then collected and used to power generators. While almost every country has nuclear generators, there are moratoriums on their use or construction as scientists try to resolve safety and disposal issues for waste.

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2.4. ADVANTAGES AND DIS-ADVANTAGES

2. 4.1. Advantages of non-renewable energy sources

1. The efficiency of the energy source is high
2. This energy source is a well-known source
3. The production expenses are low

2.4.2. Disadvantages of non-renewable energy sources

1. It is not environmentally friendly
2. When used on a longer run, can deplete soon

2.5. RENEWABLE SOURCES OF ENERGY

Renewable sources of energy can be used over and over again. Renewable resources include solar energy, wind, geothermal energy; biomass, and hydropower. They generate much less pollution, both in gathering and production than nonrenewable sources. The resources are used by mankind from the starting of human life. Our ancestors used these resources for lighting purposes, transportation, shelter, cooking, heating, protection from wild animals, etc. Renewable resources are also called as 'Non-Conventional' sources of energy.

Few examples of renewable resources are sun, wind, tidal energy, forests, mountains, soil, water bodies, animals and wildlife resources, atmospheric resources, and many more.

2.5.1. Solar energy

Solar power harvests the energy of the sun by using collector panels to create conditions that can then be turned into a kind of power. Large solar panel fields are often used in the desert to gather enough power to charge small substations, and many homes use solar systems to provide for hot water, cooling, and supplement their electricity. The issue with solar is that while there are plentiful amounts of sun available, only certain geographical ranges of the world get enough of the direct power of the sun for long enough to generate usable power from this source.

2.5.2. Wind energy

Wind power is becoming more and more common. The innovations that are allowing wind farms to appear are making them a more common sight. By using large turbines to take available wind as the power to turn, the turbine can then turn a generator to produce electricity. While this seemed like an ideal solution to many, the reality of the wind farms is starting to reveal an unforeseen ecological impact that may not make it an ideal choice.

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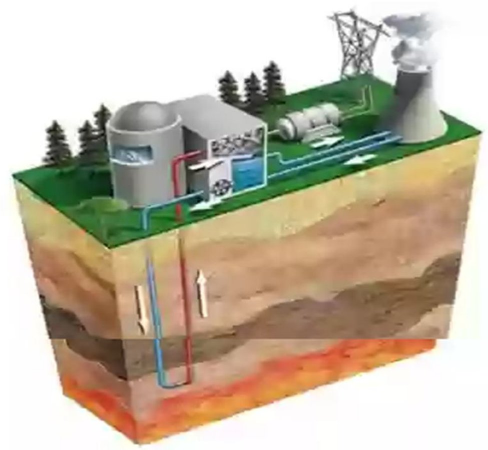
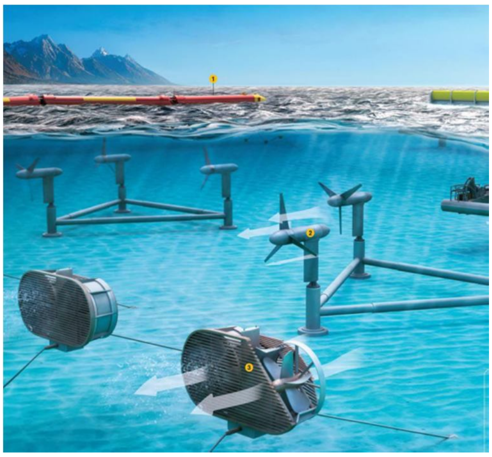
2.5.3. Geothermal energy



Within the Earth, there is a great deal of energy trapped inside molten magma. All of this heat transfers itself to the deep stores of water and air that flow through the Earth. To release the heat and regulate the temperature of the core, the heated water and air are released through vents, which are seen as holes in the crust of the Earth. They form another of the renewable sources of energy, known as geothermal energy. The vents of heated air and steam are used to generate power which is yet another renewable source of energy.

Geothermal energy is completely renewable, reduces dependence on fossil fuels, provides job benefits and significant cost saving. The downside is that it is suitable for a particular region which is normally prone to earthquakes and volcanoes, and may release some harmful gases

2.5.4. Tidal energy



Tidal energy uses the rise and fall of tides to convert the kinetic energy of incoming and outgoing tides into electrical energy. The generation of energy through tidal power is most prevalent in coastal areas. Huge investment and limited availability of sites are a few of the drawbacks of tidal energy. When there is an increased height of water levels in the ocean, tides are produced which rush back and forth in the ocean. Tidal energy is one of the renewable sources of energy and produces large energy even when the tides are at low speed.

2.5.5. Wave energy

Wave energy is produced from the waves that are produced in the oceans. Wave energy is renewable, environment friendly, and causes no harm to the atmosphere. It can be harnessed along coastal regions of many countries and can help a country to reduce its dependence on foreign countries for fuel. Producing wave energy can damage the marine ecosystem and can also be a source of disturbance to private and commercial vessels. It is highly dependent on wavelength and can also be a source of visual and noise pollution.

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2.5.6. Hydroelectric energy

There is a large amount of kinetic energy stored in water. It is available for use when the rivers and streams flow towards the oceans, and the potential becomes greater when they turn into waterfalls. Hydroelectric energy is becoming a common source of electricity production in the 21st century. Most dams that are being built have infrastructure that allows them to capture the energy from the water. The kinetic energy of moving water is then used by hydropower plants to give mechanical energy to turbines which in turn convert it to electrical energy through generators.

It is also seen as a simple and effective way to power regions that are not easily accessible by the regular power grid or simply face a lack of electricity far too often. Being a clean, cheap, and renewable source of energy, a lot of research is being put into efficient utilization of the water resources we have available on the planet. hydropower is renewable, environment friendly, and produces no toxic gases.

2.5.7. Hydrogen energy

Hydrogen is the most common element available on earth as it is available with water and can be a tremendous renewable source of energy to power ships, rockets, marines, vehicles, homes, and industries. Water (H_2O) contains two-thirds of hydrogen but is usually found in combination with other elements. Once it is separated from water, it can be used as a fuel or could be used for generating electricity. Hydrogen Energy is completely renewable, environment friendly, do not leave any toxic emissions.

2.5.8. Biomass energy

Biomass energy is produced from organic material and is commonly used throughout the world. Chlorophyll present in plants captures the sun's energy by converting carbon dioxide from the air and water from the ground into carbohydrates through the process of photosynthesis. When the plants are burned, the water and carbon dioxide are again released back into the atmosphere. Biomass generally includes crops, plants, trees, yard clippings, wood chips, and animal wastes. Biomass energy is used for heating and cooking in homes and as a fuel in industrial production. This type of energy produces a large amount of carbon dioxide into the atmosphere.

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2.5.9. Energy from wood

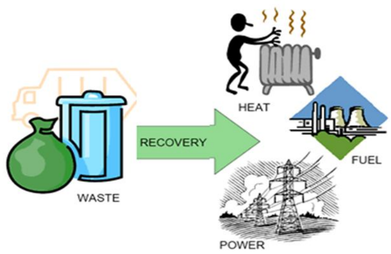
Any energy that comes from using wood as a fuel source may be referred to as wood energy. While the term is not a common one, it accurately describes the fuel source and the benefit. Wood energy was once the dominant source of energy used in the world but has since been replaced by fossil fuels in most areas. Still, many people depend on wood as a fuel source for energy in several different ways.

The most common way to get energy from wood is to burn the material. The heat produced from the fire can be used in several different ways. It can be used as space heating, such as with campfires or fireplaces. Also, it can be used for cooking, or even as a way to produce mechanical energy through the creation of steam, such as in locomotives and some power plants. That steam is then used to power gears or turbines to produce electrical or other forms of energy.

2.5.10. Animal waste

Most of the peoples are used animal waste (dung) as fuel for household purposes. It is a waste product of the digestion process, but not a waste product of the agricultural production system, and has a high value as fertilizer. If dung is widely used as a fuel, the soil fertility will be affected. This change in soil fertility must be compensated with chemical fertilizer, biochar, or others if long-term damages of the soil shall be avoided. Burning dung emits far greater quantities of dioxins and chlorophenols compared to wood, which are damaging to human health. From an energy perspective, the mechanization of dung in a biogas digester is a better alternative, as cow dung contains 50% methane and 30% carbon dioxide by mass converted into biogas.

2.5.11. Energy from urban waste



Nanusable part is called waste material. Urban waste poses a big problem for its disposal. Now it can be used for the generation of power. In Timarpur (Delhi) a power Ration of 3.75 capacities has been set up to generate energy from the garbage. It is a big challenge to make 'waste to best' for budding researchers.

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2.6. ADVANTAGES AND DIS-ADVANTAGES

2.6.1. Advantages of renewable sources of energy

1. Non-conventional sources of energy are considered to be important as they are renewable, pollution-free, availability of them is in abundance, and they are environmentally friendly.
2. These sources of energy are environmentally friendly
3. They are inexhaustible
4. They are easy to operate

2.6.2. Disadvantages of renewable sources of energy

1. Wind energy is one of the non-conventional sources of energy which is expensive and can be a cause of noise pollution
2. Radioactive wastes are produced in nuclear energy

2.7. DIFFERENCE BETWEEN TYPES OF RESOURCES

Renewable Resources	Non-renewable Resources
It can be used again and again	It cannot be used again and again
The energy resources which cannot be exhausted.	The energy resources can be exhausted one day.
It is environment-friendly as the amount of carbon emission is low.	It is not environment-friendly as the amount of carbon emission is high.
These resources are present in unlimited quantities.	These resources are present in a limited quantity only.
The total cost of these resources is low.	The total cost of these resources is comparatively high.
These resources are pollution-free.	These resources are not pollution-free.
The maintenance cost of renewable resources is very high.	The maintenance cost of renewable resources is low.
Requires a large land area for the installation of the power plant.	Requires less land area for the installation of the power plant.
It is sustainable	It is exhaustible
The rate of renewal is greater than the rate of consumption.	The rate of renewal is lower than the rate of consumption.
Sunlight, are example of renewable resources.	Coal, petroleum, natural gases, batteries, are examples of non-renewable resources

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CHAPTER.3

WIND ENERGY

3.1. INTRODUCTION

The wind is a natural phenomenon on the earth which is been created by the difference of air density. It's in simple words ‘an atmospheric air in motion’. Wind energy is a form of solar energy. Wind energy is generated by the movement of air relative to the earth's surface. Wind energy (or wind power) defines the process by which wind is utilized to generate electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. A generator can convert mechanical power into electricity. In prehistoric times, the wind was used to move the sails of the ships. In this chapter, we will see how wind energy is used to generate electricity.

Wind energy captures the natural wind in our environment and translates the air's motion into mechanical energy. The wind is produced by differences in atmospheric pressure. Wind speeds differ founded on geography, landscape, and season. As an effect, there are some locations well-matched for wind energy production than others. In all-purpose, wind speeds are higher near the shoreline and offshore since there are rarer objects like vegetation, mountains, and buildings to slow them down.

The mechanism used to convert air motion into electricity is referred to as a turbine. A turbine is a large structure with several spinning blades. These blades are connected to an electromagnetic generator that generates electricity when the wind rotates the blades.

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A turbine translates the kinetic energy of the wind to beneficial mechanical energy. This energy could be used in mechanical form or turn generator turbines and deliver electricity. Fair like in the hydropower systems, wind energy is harnessed through the conversion of the wind kinetic energy into mechanical energy. Wind power generation means getting the electrical energy by converting wind energy into the rotating energy of the blades and converting that rotating energy into electrical energy by the generator. Wind energy increases with the cube of the wind speed; therefore, wind turbine generators (WTGs) should be installed in the higher wind speed area.

The inventors keep developing electronic devices including controlling systems with knowledge and technologies cultivated from the thermal and hydraulic power plant.

The wind turbines are largely classified into two types- horizontal axis wind turbines and vertical axis wind turbines. Large areas installed with wind turbines, that is, wind farms are increasingly emerging today. The first known wind turbine used to produce electricity is built in Scotland in 1887. The wind turbine is formed by Prof James Blyth of Anderson's College, Glasgow (now recognized as Strathclyde University). Wind energy offers numerous advantages, which clarifies why it's one of the fastest-growing energy sources in the world.

3.2. WIND POWER PRODUCTION

The terms "wind energy" and "wind power" both describe the procedure by which the wind is used to produce mechanical power or electricity. This mechanical power can be used for specific tasks such as crushing grains or pumping water or a generator can convert this mechanical power into electricity. Wind turbines based on a simple principle that, instead of using electricity to make wind-like a fan, conversely wind turbines use the wind to produce electricity. The wind turns the propeller-like blades of a turbine around a rotor, which spins a generator, which creates electricity. The wind is a form of solar energy caused by a combination of three concurrent events:

(a) The sun disproportionately heating the atmosphere

(b) Anomalies of the earth's surface

(c) The revolution of the earth.

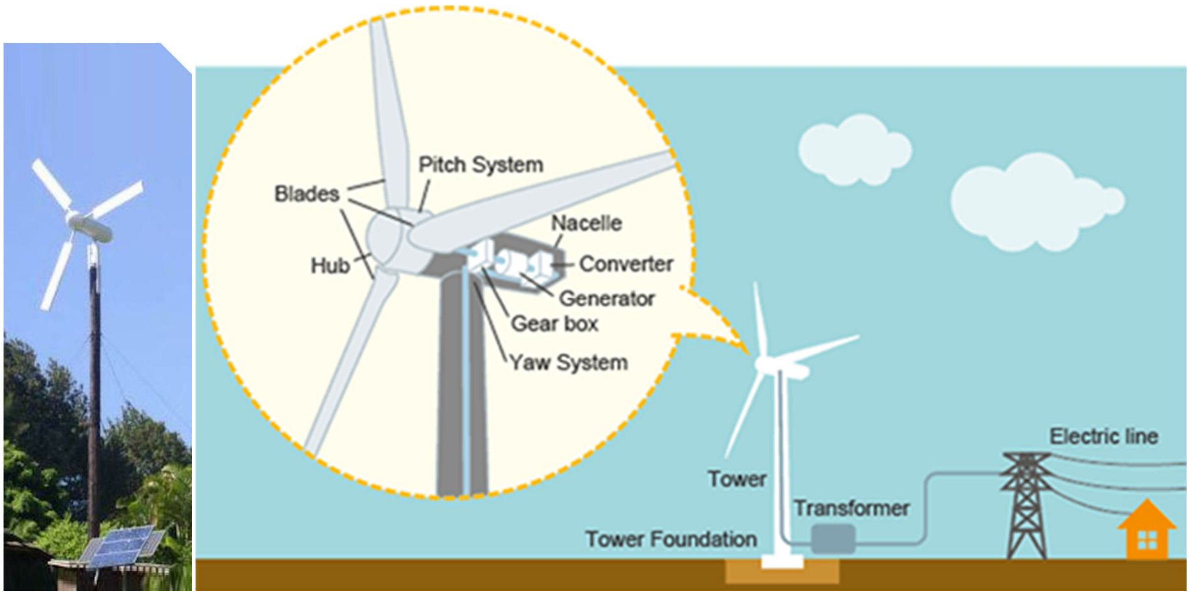

Fig.3.1: General Mechanism of wind energy generation

Wind flow designs and speeds differ significantly across the Windy regions (like the United States) and are modified by bodies of water, vegetation, and changes in topography. Humans use this wind flow, or motion energy, for many purposes: flying a kite, sailing, also even for producing electricity.

Fig.3.1 shows the general working mechanism of the production of wind energy. A wind turbine turns wind energy into electricity using the aerodynamic force from the rotor blades, which work like an airplane wing or helicopter rotor blade. When wind flowing across the blade, the air pressure on one side of the blade decreases. The difference in air pressure across the two sides of the blade creates both lift and drag. The force of the lift is stronger than the drag and this reasons the rotor to spin. The rotor attaches to the generator, either directly (if it's a direct drive turbine) or through a shaft and a series of gears (a gearbox) that speed up the rotation and permit for a physically smaller generator. This translation of aerodynamic force to rotation of a generator creates electricity that can be used for numerous purposes.

3.3. WIND CHARACTERISTICS

There are general characteristics of wind while others are more precise to the place. Some of the site-specific characteristics include:

1. **Mean wind speed**: This evaluates the annual wind yield though it does not give the distributions.
2. **Wind speed distribution**: There are three aspects namely annual, diurnal, and seasonal characteristics. Understanding the wind speed variations and the spread is necessary when choosing a site.
3. **Turbulence**: This is the chaotic movement of wind in unpredictable patterns. Turbulence results from continuously changing properties of wind motion that impact on energy production and fatigue on blades.
4. **Long term fluctuation**: Irregular wind causes unpredictable energy supply. Before a wind turbine is set, the area should be studied for a constant wind flux.
5. **Distribution of wind direction**: This is more significant in the positioning of the blades especially for horizontal axis types.
6. **Wind shear**: Shear is changed in wind direction, speed, or the height at which the maximum velocity occurs.

3.4. WIND SPEED PATTERNS

Wind patterns are important and are often analyzed using a wind spectrum. A high value of the wind spectrum represents a large change in the wind speed at the given time interval. If represented on a graph, the peaks depict turbulences that occur with time.

3.5. WIND SPEED DISTRIBUTION

There are three types of distributions:

1. **Diurnal**: Caused by the difference between temperatures during the day and at night.
2. **Depressions**: Occur with four-day intervals along the coastal region.
3. **Annual**: Distribution is latitude dependent.

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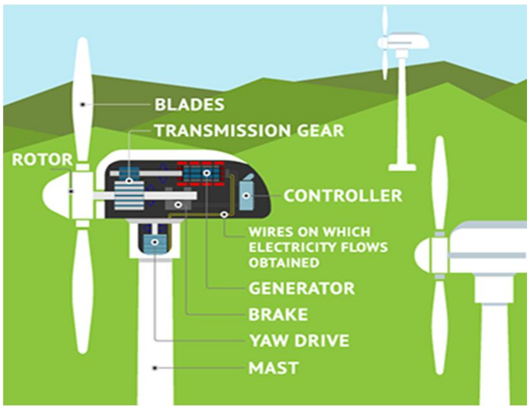
3.6. WINDMILLS

If the mechanical energy is used directly by machineries, such as a pump or grinding stones, the machine is usually called a windmill. The wind flows over windmill blades that are mounted on a rotor, which causes them to lift or turn like an airplane propeller. The blades are connected to a drive shaft that turns a generator to make electricity. This process converts the kinetic energy of the wind into electrical power. For utility-scale wind energy, large numbers of wind turbines are close together to form a wind farm.

3.7. WIND GENERATOR

If the mechanical energy is then converted to electricity, the machine is called a wind generator. There are many different types of generators used today in wind turbines, but the most common types are asynchronous generators. The two types mostly used are the squirrel cage induction generator & the wound rotor induction generator-also known as a doubly-fed induction generator.

3.8. WIND TURBINES



Windmills and wind turbines are different. They both use wind as a resource, but wind turbines are used to generate electricity. A wind turbine is a machine for converting the kinetic energy in wind into mechanical energy. Turbines and generators are equally used in the production of electric power; nevertheless, the turbine converts available energy forms into the rotation while the generator converts rotation into electricity. Two types of modern wind turbines generate electricity

3.8.1. Types of wind turbines

Wind turbines are classified into two general types:

1. Horizontal axis wind turbines (HAWTs) and
2. Vertical axis wind turbines (VAWTs).

A horizontal axis machine has its blades rotating on an axis parallel to the ground. A vertical axis machine has its blades rotating on an axis perpendicular to the ground. There are several available designs for both and each type has certain advantages and disadvantages. However, compared with the horizontal axis type, very few vertical axis machines are accessible commercially.

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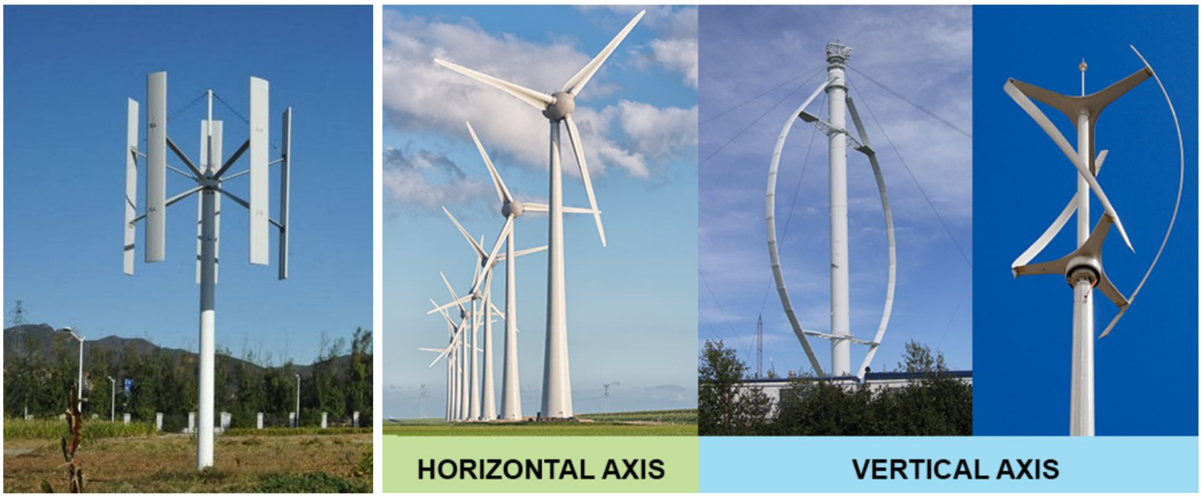

3.8.2. Components of a wind turbine

1. The nacelle contains the key components of the wind turbine, including the gearbox, and the electrical generator.
2. The tower of the wind turbine carries the nacelle and the rotor. Usually, it is an advantage to have a high tower, since wind speeds increase farther away from the ground.
3. The rotor blades capture wind energy and transfer its power to the rotor hub.
4. The generator converts the mechanical energy of the rotating shaft to electrical energy
5. The gearbox increases the rotational speed of the shaft for the generator.

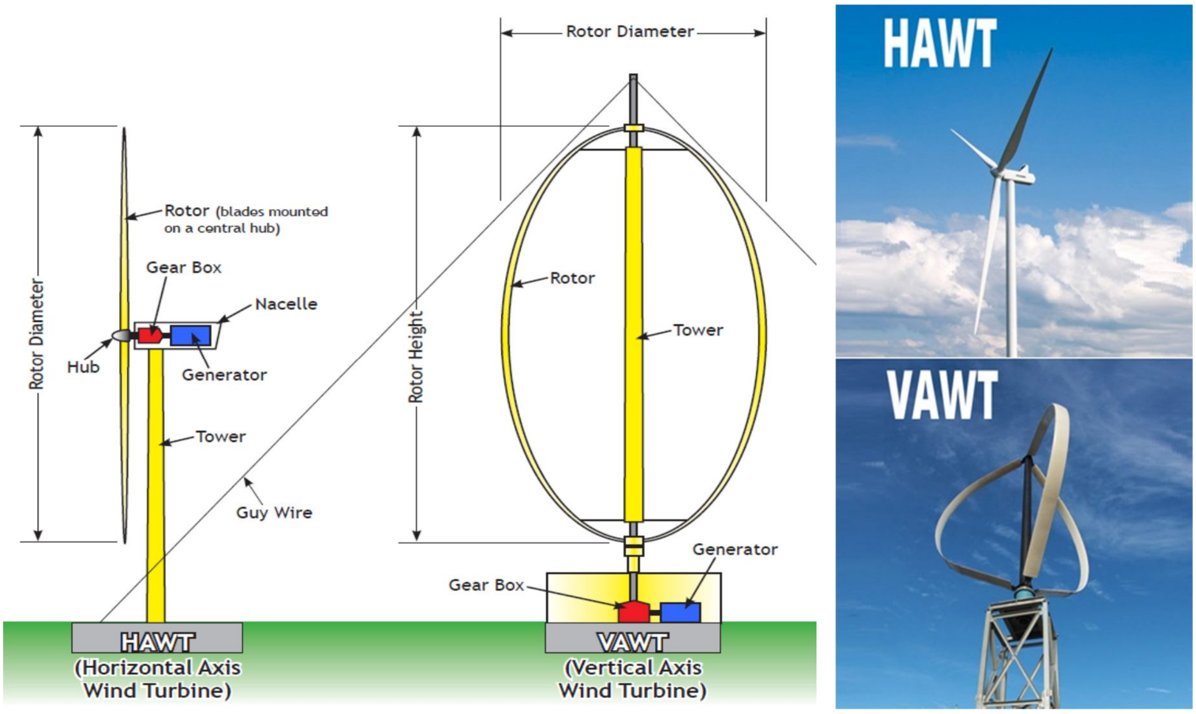

Fig.3.2: Schematics of HAWT and VAWT

Though vertical axis wind turbines have existed for centuries, they are not as common as their horizontal counterparts. The main cause for this is that they do not take benefit of the higher wind speeds at higher elevations above the ground as well as horizontal axis turbines.

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HAWTs are the most commonly used type, and each turbine possesses two or three blades or a disk containing many blades (multibladed type) attached to each turbine. VAWTs can harness wind blowing from any direction and are usually made with blades that rotate around a vertical pole (**Fig.3.2**).

HAWTs are characterized as either high or low solidity devices, in which solidity refers to the percentage of the swept area comprising solid material. High-solidity HAWTs comprise the multibladed types that cover the total area swept by the blades with solid material to maximize the total amount of wind coming into contact with the blades. An example of the high-solidity HAWT is the multibladed turbine used for pumping water on farms, often seen in the landscapes of. Low-solidity HAWTs most often use two or three long blades and resemble aircraft in appearance. Low-solidity HAWTs have a low proportion of material within the swept area, which is compensated by a faster rotation speed used to fill up the swept area. Low-solidity HAWTs are the most commonly used commercial wind turbines as well as the type most often represented through media sources. Those HAWTs offer the greatest in electricity generation and, therefore, are among the most cost-efficient designs used. The Darrieus VAWT, which uses curved blades in a curved arch design, became the most common VAWT in the early 21st century. H-type VAWTs use two straight blades attached to either side of a tower in an H-shape, and V-type VAWTs use straight blades attached at an angle to a shaft, forming a V-shape. Most VAWTs are not economically competitive with HAWTs, but there is continuing interest in of VAWTs, particularly for building wind energy systems.

3.9. ESTIMATING GENERATION

Rendering to Betz's law, the maximum amount of power that a wind turbine can generate cannot exceed 59 percent of the wind's kinetic energy. Given that limitation, the expected power generated from a particular wind turbine is estimated from a wind speed power curve derived for each turbine, usually represented as a graph showing the relation between power generated (kilowatts) and wind speed (meters per second). The wind speed power curve varies according to variables unique to each turbine such as the number of blades, blade shape, rotor swept area, and speed of rotation. To determine how much wind energy will be generated from a particular turbine at a specific site location, the turbine's wind speed power curve needs to be coupled with the wind speed frequency distribution for its site. The wind speed is representing wind speed classes and the frequency of hours per year that are expected for each wind speed class. The data for those histograms are usually provided by wind speed measurements collected at the site and used to calculate the number of hours observed for each wind speed class.

A rough estimate of annual electric production in kilowatt-hours per year at a site can be calculated from a formula multiplying average annual wind speed, swept area of the turbine, the number of turbines, and a factor estimating turbine performance at the site. However, additional factors may decrease annual energy production estimates to varying degrees, including loss of energy because of the distance of transmission, as well as availability (that is, how reliably the turbine will produce power when the wind is blowing). By the early 21st century most commercial wind turbines functioned at over 90 percent availability, with some even functioning at 98 percent availability.

3.10. ADVANTAGES OF WIND ENERGY

1. It's a fresh fuel source. Wind energy doesn't pollute the air like power plants that depend on the combustion of fossil fuels, such as coal or natural gas. It is far more eco-friendly than the burning of fossil fuels for electricity. Wind turbines don't produce atmospheric emissions that cause acid rain or greenhouse effect.
2. Wind turbines can be constructed on existing farms. This significantly benefits the economy in rural areas, where most of the best wind sites are found. Farmers and planters can continue to work the land since the wind turbines use only a fraction of the land. Wind power plant owners make rent payments to the farmers for the use of the land providing landowners with extra income.
3. Wind power is cost-effective. Because the electricity from wind farms is sold at a fixed price over a long period (20+ years) and its fuel is free, wind energy mitigates the price uncertainty that fuel costs add to traditional sources of energy.
4. Wind creates jobs. The wind sector employs several workers and wind turbine technicians for manufacturing, installation, maintenance, and supporting services are one of the fastest-growing jobs across the globe.
5. The wind is a domestic source of energy. Over the past ten years, the wind power capacity of the world has grown 15%/year, & wind is now the largest source of renewable power.
6. It's sustainable. The wind is a form of solar energy. Winds are caused by the heating of the atmosphere by the sun, the rotation of the earth, and the earth's surface irregularities.

3.11. DISADVANTAGES OF WIND ENERGY

1. Constructing turbines and wind facilities is extremely expensive.
2. Some wind turbines cause to generate a lot of noise which can be unpleasant. Two kinds of noise associated with turbines are mechanical noise, which is produced by its equipment such as its gearbox, and aerodynamic noise, which is produced from the movement of air over the blades.
3. Though, this may be an advantage that placing wind turbines in desolate areas, far away from people, but it may also be a disadvantage. The cost of travel and maintenance on the turbines increases and is time-consuming. Offshore wind turbines require boats and can be dangerous to accomplish.
4. The turbine blades may damage local wildlife. Sometimes birds have been killed by flying into the rotors. Most of these problems have been resolved or greatly reduced through technological development or by properly setting wind plants.

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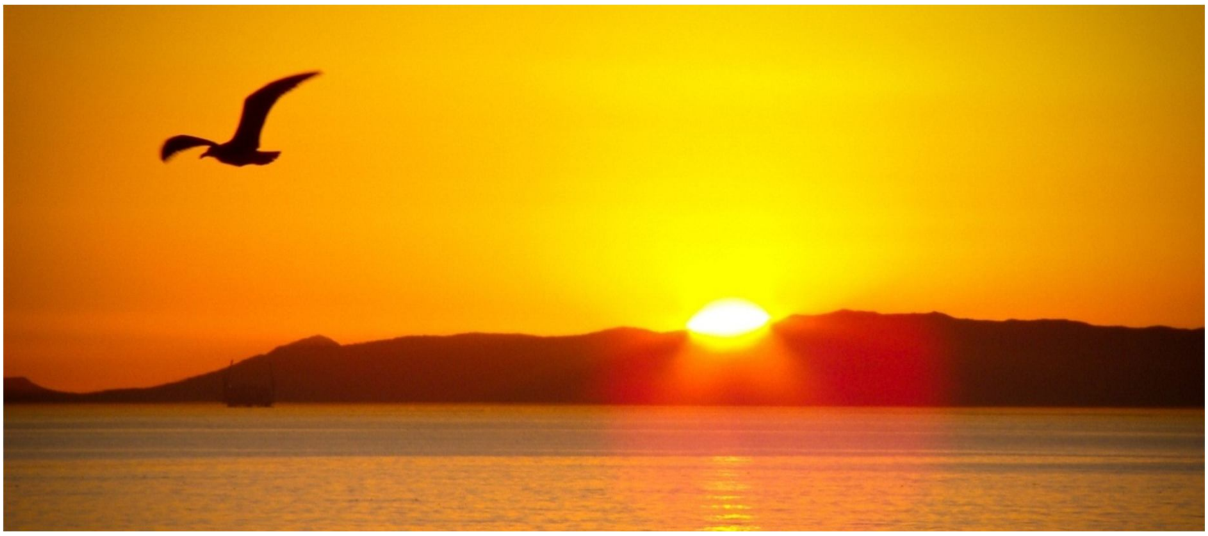
CHAPTER.4

SOLAR ENERGY

4.1. INTRODUCTION

Solar energy is free from all kinds of pollution and available free of cost. Solar energy is the energy obtained by capturing heat and light from the sun. Energy from the sun is referred to as solar energy. Technology has provided several ways to utilize this abundant resource. It is considered a green technology because it does not emit greenhouse gases. Solar energy is abundantly available and has been utilized science long both as electricity and as a source of heat.



The sun is the source of all energy. The sun provides us heat and light energy. The energy obtained from the sun is called solar energy. The nuclear fusion reactions taking place inside the sun keep on liberating enormous amounts of heat and light energy. This heat and light energy are radiated by the sun in all directions in the form of solar energy. The sun has been radiating an enormous amount of energy at the present rate for nearly 5 billion years and will continue radiating energy at that rate for about 5 billion years more. Since the sun is very, very far away, only a small fraction of the solar energy radiated by the sun reaches the outer layer of the earth's atmosphere. About 47% of solar energy which reaches the surface of the earth, the rest of solar energy is reflected into space by the atmosphere and also absorbed by the atmosphere as it comes down through it towards the surface of the earth.

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Solar cells use the energy in sunlight to produce electricity. Thus, a solar cell is a device that converts solar energy (or suns energy) directly into electricity. Since solar energy is also called sunlight energy, so we can also say that a solar cell converts sunlight energy into electrical energy.

4.2. SOLAR CELL

Traditional solar cells are made from silicon; second-generation thin-film solar cells are made from amorphous silicon and third-generation solar cells are being made from a variety of new materials, including solar inks, solar dyes, and conductive plastics

4.2.1. Principle of solar cell

The solar cell is based on the principle of photovoltaic effect, i.e when the light of suitable frequency is incident on it; an emf is produced across its terminal. A solar cell is an electronic device that converts solar energy (sunlight) into electrical energy. Light incident on solar cell produces both current and voltage to generate electrical power. A solar cell works as a source of D.C power.

4.2.3. Construction of a solar cell

A solar cell is usually made from silicon. A complete solar system is made from the solar module. Each solar module is a combination of small solar cells. These solar systems are connected to form a solar array which is used to generate electricity on a large scale.

A simple solar cell (**Fig.4.1)** consists of a sandwich of a 'silicon-boron layer' and a 'silicon-arsenic layer'. The amount of boron and arsenic present in the two silicon layers is, however, very small. A small piece of wire is soldered into the top of the upper layer of the cell and another piece of wire is soldered at the bottom of the lower layer (to tap the current). The solar cell is covered with a glass cover or a transparent plastic cover for protection. When sunlight falls on the surface of the solar cell, it makes the loosely held electrons in the silicon atoms move due to which a current begins to flow in the wires connected to the top and bottom of the solar cell. The strength of current produced depends on the brightness of the light and the efficiency of the solar cell. A potential difference of about 0.5 V is generated between the top and bottom surface of a solar cell. At present, the best designed solar cells can generate 240 W/m^2 in bright sunlight, with a maximum efficiency of about 25%.

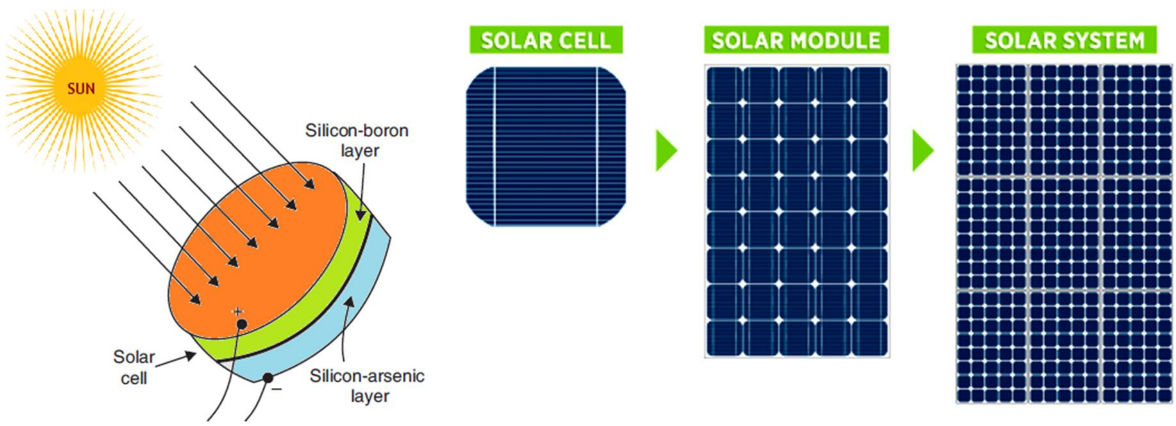

Fig.4.1: Solar cell

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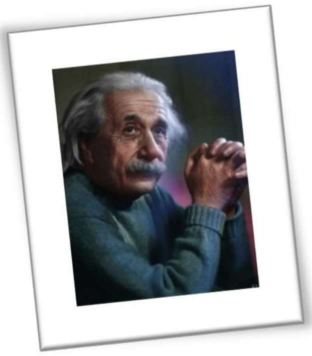
4.3. WORKING OF SOLAR CELL

4.3.1. Principle of working

The working principle of solar cells is based on the photovoltaic effect, i.e. the generation of a potential difference at the junction of two different materials in response to electromagnetic radiation. The photovoltaic effect is closely related to the photoelectric effect, where electrons are emitted from a material that has absorbed light with a frequency above a material-dependent threshold frequency.



Sun is the main source of light energy. Many theories are explaining the concept of light. In 1905, Albert Einstein understood that this effect can be explained by assuming that the light consists of well-defined energy quanta, called photons. The energy of such a photon is given by an equation, $E = h\nu$

Where h is Planck's constant and ν is the frequency of the light. For his explanation and equation of the photoelectric effect, Einstein received the Nobel Prize in Physics in 1921.

4.3.2. Working of solar cell

When suitable light is falling on the upper surface of the solar cell, it generates electron-hole pairs. The upper surface is very thin. Hence the chance of recombination of electrons and holes is reduced. The generated electron-hole pair moves toward the junction. At the junction, they face barrier potential. The barrier potential sweeps the electron from p-region to n-region and holes from n-region top-region

As a result number of holes on the p-side and number of electron on the n-side of the junction increases. The accumulation of the charges develops an emf across the junction it is called photovoltage. When an external load is connected across the solar cell photocurrent (I) flows in the circuit and solar cell behaves like a battery with p-side as positive terminal and n-side as a negative terminal. As shown in **Fig.4.2.**

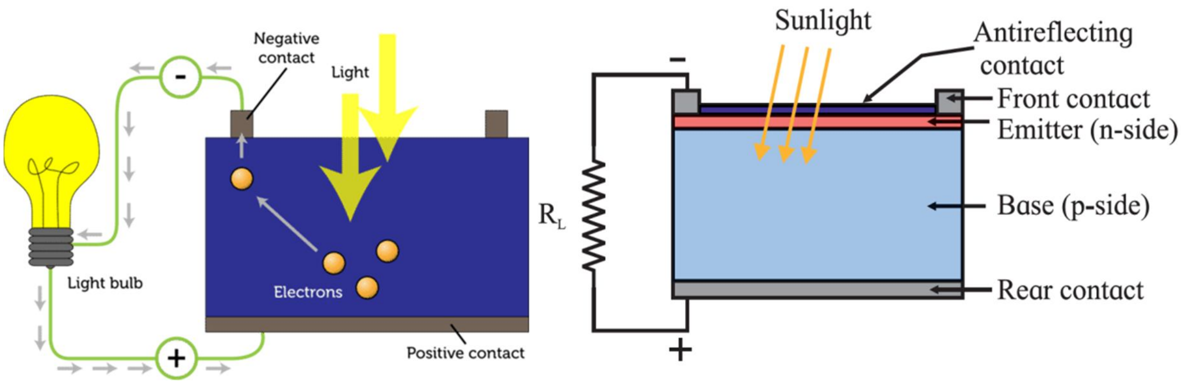


Fig.4.2: Structure of solar cell

4.4. V-I CHARACTERISTIC OF SOLAR CELL

The **Fig.4.3** shows the V-I characteristic of a solar cell. This is drawn in the fourth quadrant because of solar cell supplies current to the load. The power delivered to the load R_L is zero when a load is short-circuited and V_{oc} is the open-circuit voltage when R_L is open.

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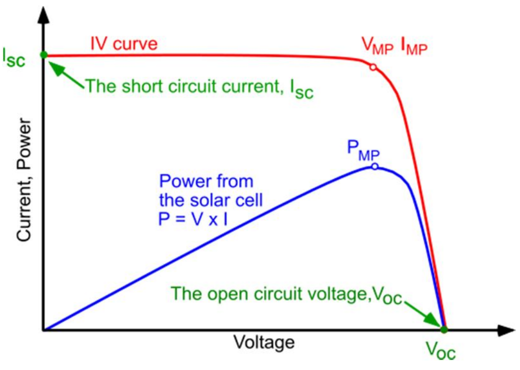

Fig.4.3: V-I characteristic of solar cell

Solar cells are connected in series and parallel to increase the voltage and current capacity respectively. Such a combination of a solar cell is called a photovoltaic array. Hence the array of the cell in series and parallel is used to form a solar panel. Typically one solar cell can generate the photovoltage of 0.5V to 1.2V and power delivered by the solar cell is P=VI.

4.5. ADVANTAGE AND DISADVANTAGE OF SOLAR CELL

Sun is a gift of nature for living things so that they can survive on earth. Using Sun's energy many devices are working. Solar energy has advantages and disadvantages while using it directly or indirectly.

4.5.1. Advantage of solar cell

Solar energy is available everywhere and it is free from pollution and available at low cost. It has many advantages; few of the main advantages of solar cells are;

1. Have no moving parts; hence do not produce noise for electricity generation.
2. They require almost low or no maintenance and work quite satisfactorily without the use of any light focusing device.
3. They can be set up in remote, inaccessible, and very sparsely inhabited areas where the laying of usual power transmission lines is difficult and expensive.
4. Solar energy is free from all types of pollution. Hence use of solar cells gives pollution-free power sources.
5. Solar can be used to heat water, power homes and building, even power cars
6. The life of the solar panel is very high.
7. Creates jobs by employing solar panel manufacturers, solar installers, etc. and in turn, helps the economy
8. The maintenance cost of panels is low. Virtually solar panels work over 30 years

4.5.2. The disadvantage of solar cell

The main disadvantage of solar cells is that they are very expensive. This is due to the following reasons,

1. The special grade silicon needed for making solar cells is expensive.
2. The silver wire used to interconnect solar cells for making solar cell panels is expensive.
3. The entire process of making solar cells is still very expensive. So, the extensive use of solar cells for generating electric power is limited due to their high cost.
4. It has low efficiency convert only about 25 percent of the light energy falling on them into electricity.
5. Require extra elements like batteries, inverters.
6. During the cloudy day the energy cannot be produced and also at night we will not get solar energy.

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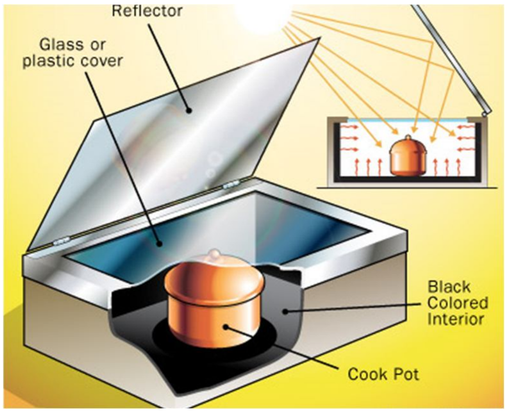
4.6. APPLICATION OF SOLAR CELLS

Solar energy is the cleanest and most abundant renewable energy source available. In this modern era, this energy is useful for personal, commercial, or industrial use. The solar cell has many uses in day to day life; few of them are discussed below,

4.6.1. Solar water heater

In the conventional water heating system, we use LPG or wood stove to heat water. Both release gases pollutants like CO, CO_2. The solar water heater has a solar panel that is made up of solar cells. These are made up of silicon which traps the energy of the sun. The solar water heater is eco-friendly as they use solar energy which is easily available renewable and pollution-free. A solar water heater is a system that utilizes solar energy to heat water. It has a system that is installed on a terrace or open space where it can get sunlight and the energy from the sun is then used to heat water and store it in an insulated tank. The system is not connected to electricity supply and thus does not have an on-off switch, but it uses the sunlight throughout the day to heat the water and store it in the storage tank. Most of the solar water heater on a sunny day can provide heater water at about 68°±5° C temperature. Water from the storage tank can then be used for any application as desired.

Solar water heater



Solar cooker

4.6.2. Solar cooker

The solar cooker is a device that is used to cook food by utilizing the heat energy radiated by the sun. A solar cooker consists of an insulated metal box or wooden box which is painted all black from inside. There is a thick glass sheet cover over the box and a plane mirror reflector is also attached to the box. The food to be cooked is put in metal containers which are painted black from outside. These metal containers are then placed inside the solar cooker box and covered with the glass sheet. Solar cookers concentrate sunlight onto a receiver such as a cooking pan. The interaction between the light energy and the receiver material converts light to heat and this is called conduction. This conversion is maximized by using materials that conduct and retain heat.

Many solar cookers currently in use are relatively inexpensive, low-tech devices, although some are as powerful or as expensive as traditional stoves, and advanced, large-scale solar cookers can cook for hundreds of people. Because they use no fuel and cost nothing to operate. Using stoves and ovens, we can cook food like meat, vegetables, beans, rice, bread, and fruit in just about any way. We can bake, stew, steam, fry, and braise. Using a solar cooker, we can do the same things, but by using sunlight instead of gas or electricity.

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4.6.3. Solar dryer

Solar dryers are devices that use solar energy to dry substances, especially food. Food products such as pickles, chilies, amlas, fish, fruits, and spices tend to have a longer life after they have been dried. Drying is a process that removes moisture and prevents the growth of microorganisms such as bacteria, yeast, etc. Drying also makes food products more sustainable under ambient conditions. Solar drying is environment-friendly and is done using solar dryers. Solar dryers help provide more heat than the atmospheric temperature. In a solar dryer, air enters the drying chamber through the process of natural convection or an external source like a fan, pump, suction device, etc. Air gets heated as it passes through the chamber and then partially cools as it absorbs moisture from the food product placed in the chamber. Then, the humid air is removed by an exhaust fan or chimney.

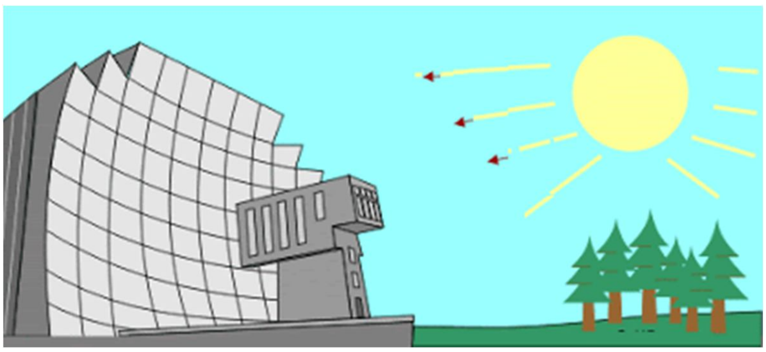
Solar dryer

Solar pump

4.6.4. Solar Pump

The solar pump mainly includes a solar panel, water pump, electric motor, and controller. This pump is electrical, and this pump uses the electricity which is received from the solar panels to work. These panels store energy from the solar. The electric motor manages the current. Solar-pumps are robust, installation is simple, minimum maintenance is necessary, and very expensive when we compare with normal water pumps. Solar-powered pumps run on electricity generated by photovoltaic panels or the radiated thermal energy available from collected sunlight as opposed to grid electricity or diesel run water pumps. Solar-powered water pumps can deliver drinking water as well as water for livestock or irrigation purposes. When the solar energy drops sun rays on the PV panels then the solar panel converts the rays into electrical energy. Then the electrical energy supplies to the electrical motor to operate the pumping system using cables.

4.6.5. Solar furnaces



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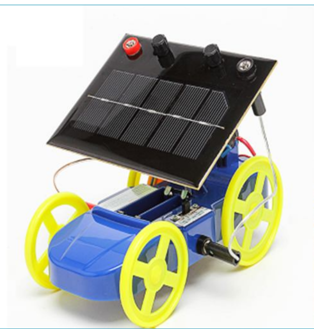
The solar furnace system is widely used in solar thermal power plants. Solar power can be used in many extraordinary ways. One of the most majestic applications of solar thermal energy is the solar furnace. The furnace makes use of a large parabolic reflector concentrating the sun into an area the size of the common cooking pot. The reflector is discrete; 63 individual flat mirrors track the sun in unison and redirect the solar thermal energy towards the crucible. The concentration component of a solar oven works in principle as a lit glass. For technical reasons, however, a hollow or parabolic mirror is used, which concentrates the incident light from the sun at one focal point. The reflective surface of this hub can be from one square meter to several 100 square meters. If larger areas are required, a heliostat field is generally used, in which several flat mirrors assign light to a single point.

4.6.6. Other applications

Ttraffic signal

Solar lamp



Solar toy

Satelite in space

Solar cells are also used for,

1. Providing electricity in artificial satellites and space probes.
2. Providing electricity to remote, inaccessible, and isolated places where normal electricity transmission lines do not exist.
3. The transmission of radio and television programs in remote areas.
4. Providing electricity to 'lighthouses' situated in the sea and to off-shore oil drilling rig platforms.
5. Operating traffic signals, watches, calculators, and toys.
6. Charging battery during day time so that batteries can supply power during the night.
7. Used in light meters.
8. At remote places for supplying power to various electronic equipment from calculator to satellite and space stations.
9. Supply power to traffic signals, in communication stations.
10. In Lux meter to major intensity of light.

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CHAPTER.5

NUCLEAR ENERGY

5.1. INTRODUCTION

The nuclear physics journey is divided into three parts. In the first period, the radioactivity of the nucleus is discovered and ended in 1939 with the discovery of fission by Hahn and Strassman. In 1932, during the Second World War period, nuclear science progressed rapidly due to the discovery of the neutrons by Sir James Chadwick. 1940 to 1969 is the second period which is quite important because there are important developments in practical and theoretical explanations, such as nuclear spectroscopy, reactors, and nuclear models. In 1960 microscopic unifying theory is introduced with a detailed understanding of structure and behavior of protons and neutrons in terms of the fundamental interactions.

Nuclear energy generates from the nucleus of atoms. Atom is the smallest part of an element and the nucleus is situated in the center of an atom. The nucleus contains protons and nucleons. When nucleons break the energy is released this is called nuclear energy. Only heavy isotopes such as uranium 235 and plutonium 239 can go in nuclear reaction and release a large amount of energy. The fusion of light nuclei also emits energy (sun energy). Nuclear energy is clean energy. Nuclear energy, which uses radioactive materials and releases energy, has a variety of applications in electricity generation, medicine, industry, agriculture, as well as in our homes. Nuclear energy is one of the primary sources of energy. If all uranium nuclei in a block take part in a chain reaction, then the energy released would be ~10^6 times larger than in burning coal block of the same size. In a nuclear reactor, energy is controlled.

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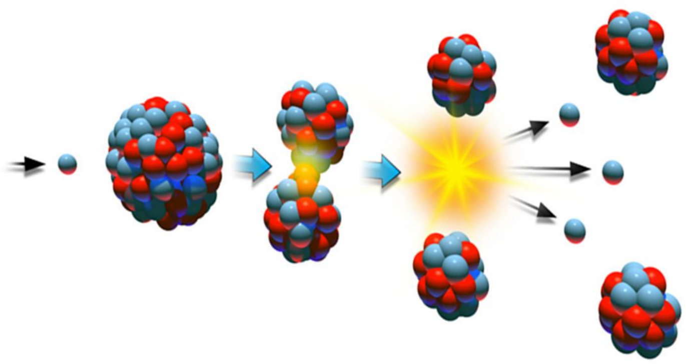
5.2. TYPES OF NUCLEAR ENERGY

5.2.1. Nuclear fission



In 1939 O. Hahn and F. Strassman proved that the product might be in the form of two large fragments called barium and krypton. In the same year, O. R. Frish and L. Meitner used the word fission. Fission is the process that takes place when a heavy nucleus is caused to break down into two equal parts called fission fragments.

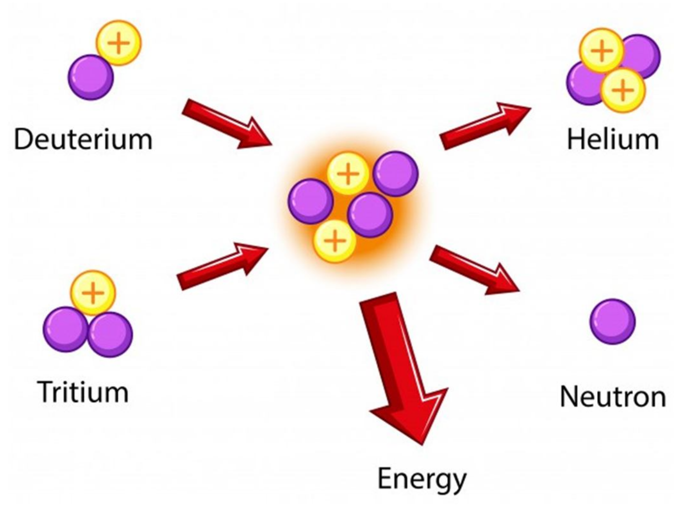
In this process neutron releases with energy. This process also happens when heavy nuclides are bombarded with protons, deuterons, α particles, electrons, and gamma rays. Nuclear fission is one type of nuclear reaction which occurs in heavy atomic nuclei after collision with a neutron. Nucleon undergoes the fission process and it releases energy. Most of the released energy is converting into heat. When uranium is bombarded with neutrons then β active particles are released. This release is in the form of chain

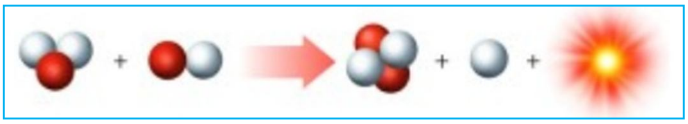
$$^{238}_{92}U + ^{1}_{0}n \rightarrow ^{239}_{92}U \rightarrow ^{239}_{92}X \rightarrow ^{239}_{92}Y \rightarrow \text{etc}$$

Types of Fission

1. Thermal Fission
2. Fast Fission
3. Charged Particle Fission
4. Photo Fission
5. Ternary Fission

5.2.2. Nuclear fusion





An alternative to fission reaction is its reverse process called a fusion reaction. It is the reaction, in which the lighter nuclei fuse and its product is a heavier nucleus. The sum of masses of separate light nuclei is greater than the mass of the nucleus formed by fusion. The fusion process liberates energy. It is a self-sustaining reaction. For light nuclei, the binding energy per nucleon increases with increasing mass number A. The nucleus formed by fusion has greater binding energy per nucleons. Means release of energy is equivalent to lost rest mass.

5.3. CHAIN REACTION

The chain reaction is the process of self-sustaining. Self-sustaining process means once started there is no need for additional agents for further reaction process. Production of neutrons at a constant rate and number of neutrons released per fission ϑ must be sufficiently greater than 1. This is a basic requirement to maintain a chain reaction. Fissionable materials have a constant ϑ. Therefore, beyond human control, there is only one way to reduce neutron loss. Chain reaction with uranium depends on the following six processes.

1. ^{238}U absorbs a neutron and cause fission (its energy is greater than threshold energy)
2. ^{238}U may absorb neutron (without producing fission)
3. ^{235}U may absorb neutron (nucleus causing fission)
4. ^{235}U may absorb neutron (without causing fission)
5. Other materials may absorb neutron without causing fission
6. Escape neutron without being captured

From above, we can see that process (1) and (3) create new neutrons while the rest of the process removes available neutrons from the assembly.

5.4. NUCLEAR REACTOR

A device that releases nuclear energy through fission in a controlled manner is called a nuclear reactor or chain reacting pile. Uncontrolled nuclear reactions are used in nuclear weapons, to achieve rapid and high release of energy. In thermal reactor balance of neutron can be described in terms of cycle. This cycle starts with the fission of ^{235}U nucleus by using thermal neutron. The neutron emission process is fast. Some neutrons having energy greater than the fission threshold for ^{238}U, it causes fission in ^{238}U with an increasing number of fast-moving neutrons. Therefore, the total number of fast-moving neutrons from fission is increased from ϑ to ϑ_E. The value of E is greater than one and called a fast fission factor.

5.4.1. Nuclear reactor design

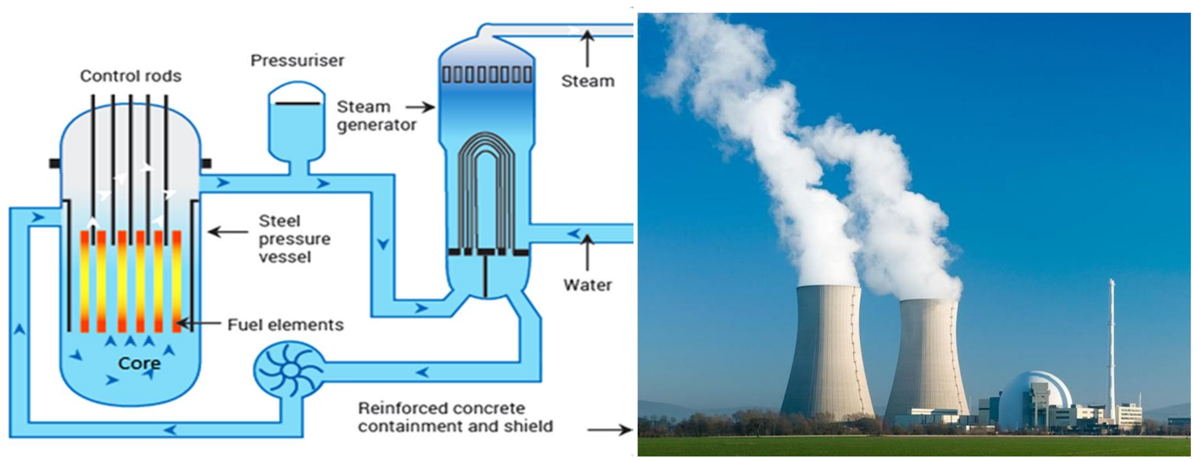


Fig.5.1: Nuclear Reactor System

The number of reactors has been constructed in the world, for various purposes. There are several possible variations in the components and design of reactor systems but the general features for all reactors are common. The nuclear reactor system (**Fig.5.1)** consists of an active core. Nuclear fuel is the main part of the active core, consisting of the fissile

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nuclide. Moderators are used to slowing down, the high energy neutrons liberated in the nuclear fission reaction process.

Fuel moderator core is surrounded by a neutron reflector to reflect neutrons to the core which minimizes the neutron leakage. Coolant is used to remove heat which is generated in the core during the fission process. The amount of energy released in the reactor is converted into electric power. The heat from the coolant is transferred to the working fluid which is used to produce steam or hot gas. Stem or hot gas carried to the turbine. The turbine is connected with a generator to produce electric power. Control rods are inserted into the core to control and maintain a steady-state of operation. These rods have very high neutron absorption capacity. At the exterior part entire reactor is enclosed with shielding. It absorbs the leakage neutrons and gamma rays therefore its intensity is reduced. This reduction is up to that level which can be tolerated by human beings.

Nuclear reactors are classified as,

1. Research reactor

2. Production reactor and

3. Power reactor

5.5. NUCLEAR WASTE

Spent Nuclear fuel is the most important waste of nuclear power reactors. It is composed of uranium 95%, fission products 4% transuranic actinides 1%. Plutonium and other transuranic are responsible for the bulk of long term radioactivity. For the bulk of short term radioactivity fission products are responsible.

1. High-level radioactive waste

High-level radioactive waste which is generated from nuclear power production requires treatment, management, and isolation from the environment. Due to extremely long periods of radioactive waste becomes hazardous to living organisms. They are called as long-lived fission products. In foreign countries spent fuel is treated similarly. While in other countries it is reprocessed and produces a partially recycled fuel known as oxide fuel.

2. Low-level radioactive waste

Low-level radioactive waste is a byproduct of nuclear industries and it is in large volume. Waste may be in the form of clothing, hand tools, water purifier resins, etc. Low-level waste material can be stored on-site until its radiation levels become low. Ones its radiation level becomes low enough then it is disposed of as ordinary waste. Sometimes it may be shifted to a low-level waste disposal site.

3. Waste relative to other types

Radioactive waste is less than 1 % of total industrial toxic waste. This type of waste remains hazardous for long periods. Nuclear power waste materials are less in volume than fossil fuel. Particularly coal-burning plants produce a large amount of toxic. Coal power is more radioactive and releases toxic in the environment.

4. Waste disposal

Waste is mainly stored at respective reactor sites and there are near about 430 locations around the world where radioactive material continuously deposited. Some experts suggest that centralized underground repositories which are well-managed, guarded, and monitored, would be a vast improvement.

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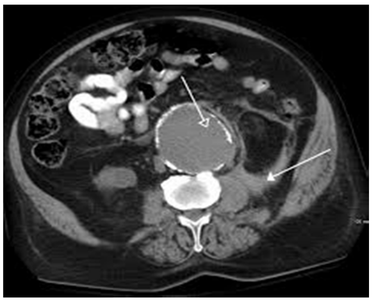
5.6. APPLICATIONS OF NUCLEAR ENERGY

Nuclear energy is a clean, safe, reliable, and competitive energy source. Nuclear energy, which uses radioactive materials, has a variety of important uses in electricity generation, medicine, industry, agriculture, as well as in our homes. Nuclear energy has many applications; few of them are listed below.

1. Electricity Generation

The demand for energy increases with the world's booming population and expanding economy. Nuclear energy is one of the solutions to meet this ever-increasing demand for energy and generates electricity in an environmentally responsible manner. Uranium is used as a fuel in the reactor of a nuclear power plant in the form of generating electricity.



2. Medical applications

There are many applications of radiation in the medical field, ranging from diagnostics to treatment and disease management. Many of these use radioactive elements produced from either reactors or cyclotrons. Themba Laboratory for Accelerator-Based Sciences also provides facilities for the treatment of cancers using neutron and proton therapy.

3. Industrial Applications

Industries use radioactive materials to improve productivity and safety. The applications include fields such as civil engineering, materials analysis, measuring devices, process control in factories, oil and mineral exploration, and checking oil and gas pipelines for leaks and weaknesses. These use directly and indirectly influence our everyday lives. Radioactive materials are used to detect explosives. Radioisotopes are employed in smoke detectors, and as lasting, fail-safe light sources for emergency signs in aircraft and public buildings.

4. Agricultural Applications

In agriculture, radioactive materials are used to improve food crops, preserve food, and control insect pests.

Food irradiation: The use of gamma rays and electron beams in irradiating foods to control disease-causing micro-organisms and to extend the shelf life of food products.

Insect control: Radioisotopes assist in enhancing food production. One method is the control of insects, including the control of screwworms through the Sterile Insect Technique.

5. Archaeological Applications

Archaeological findings can be dated by measuring their natural radioactivity using a technique called carbon dating, which is based on measuring the radiation release profile of the materials. This is a useful tool in geological, anthropological, and archaeological research.

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6. Applications in Consumer Products

One of the most common uses of radioactive materials in the home is smoke detectors. These devices contain tiny amounts of radioactive material which makes the detectors sensitive to smoke.

7. Environmental Applications

Radioactive materials are used as tracers to measure environmental processes, including the monitoring of silt, water, and pollutants. They are used to measure and map effluent and pollution discharges from factories and sewerage plants, and the movement of sand around harbors, rivers, and bays. The radioactive material used for such purposes have short half-lives and decay to background levels within days.

5.7. NUCLEAR POWER PLANTS

India's production of nuclear power consists of three stages

1. Development and operation of ^{235}U fuelled thermal reactors used for the generation of power and production of Plutonium.
2. Plutonium fuelled Fast Breeder Reactor (FBRS) used for generation of power and production of ^{233}U
3. Uranium 233 / Thorium fuelled reactors

There are a total of six nuclear power plants in India at present. These nuclear power plants are located at **1. Tarapur** in Maharashtra, **2.Rana Pratap Sagar** near Kota in Rajasthan, **3.Kalpakkam** in Tamil Nadu, **4.Narora** in Uttar Pradesh, **5.Kaprapur** in Gujarat, and **6.Kaiga** in Karnataka.

Table 5.1: List of Nuclear Power Plants in India

Sr.No	Name of the Power Station	State	Operator	Total capacity
1.	Tarapur Atomic Power Station	Maharashtra	NPCIL	1,400
2.	Kakrapar Atomic Power Station	Gujarat	NPCIL	440
3.	Kudankulam Nuclear Power Plant	Tamil Nadu	NPCIL	2,000
4.	Kaiga Nuclear Power Plant	Karnataka	NPCIL	880
5.	Madras Atomic Power Station	Tamil Nadu	NPCIL	440
6.	Rajasthan Atomic Power Station	Rajasthan	NPCIL	1,180
7.	Narora Atomic Power Station	Uttar Pradesh	NPCIL	440

5.8. URANIUM MINING AND MILLING

Uranium deposits in the form of rocks around the world. The mined rock is crushed and leached to dissolve out the uranium. The precipitated solution is then as the uranium oxide U_3O_8 which is also called yellowcake. Most of the uranium ore is mined in openly by underground mines. The uranium content of the ore is only 0.1 % to 0.2 % therefore; large amounts of ore have been mined to get the uranium. In the 1980s on the world market, the

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prices of uranium go on decreasing. Uranium mining is the process of extraction of uranium ore from the underground. The quantity of ore required to produce a tone of the product, whether it be copper or uranium, using open-pit or underground mining depends primarily on the average grade of the ore and can range from 10 to 1 000 tones (average grades of 10% to 0.1%). Thus, the volume of tailings that results from milling this ore is large. For example, over its lifetime, the Shirley Basin mine in the United States produced 9460 tons of uranium from ore with an average grade of 0.145%.

5.9. ADVANTAGES AND DISADVANTAGES OF NUCLEAR ENERGY

5.9.1. Advantages of nuclear energy

The advantages of nuclear energy are:

1. It produces a large amount of useful energy from a very small amount of nuclear fuel (like uranium-235).
2. Once the nuclear fuel (like uranium-235) is loaded into the reactor, the nuclear power plant can go on producing electricity for two to three years at a stretch. There is no need for putting in nuclear fuel again and again.
3. it does not produce gases like carbon dioxide which contribute to the greenhouse effect or sulfur dioxide which causes acid rain

5.9.2. Disadvantages of nuclear energy

The disadvantages of nuclear energy are:

1. The waste products of nuclear fission reactions (produced at nuclear power plants) are radioactive which keeps on emitting harmful nuclear radiation for thousands of years. So, it is very difficult to store or dispose of nuclear wastes safely. Improper nuclear waste storage or disposal can pollute the environment.
2. There is the risk of accidents in nuclear reactors (especially the old nuclear reactors). Such accidents lead to the leakage of radioactive materials which can cause serious damage to the plants, animals (including human beings), and the environment.
3. The high cost of installation of nuclear power plants and the limited availability of uranium fuel make the large scale use of nuclear energy prohibitive

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CHAPTER.6

ELECTRICAL ENERGY

6.1. INTRODUCTION

When you turn on a light switch, the light that fills your room isn't magic, its electrical energy. Electrical energy is an important concept in science, yet one that is frequently misunderstood. Electrical energyis produced by the movement of electrons along with an electric current. The energy which is caused by the movement of the electrons from one place to another such type of energy is called electrical energy. In other words, electrical energy is the work done by the moving streams of the electrons or charges. Electrical energy is the form of kinetic energy because it produces by the movement of the electrical charges. The faster the electrons are moving, the more electrical energy they carry. We can use the analogy of a ball being thrown at a window. The ball represents an electric charge and if the ball is not thrown very fast, then it may simply not have enough energy to break the window. The faster the ball travels the more energy it has and it then has the ability to break the window. Electrical energy is basically generated the same way regardless of the starting form of energy. Electrical energy commonly moves through a wire in an electrical circuit.

Energy is the ability to do work or apply force to move an object. In the case of electrical energy,the force is electrical attraction or repulsion between charged particles. Electrical energy may be either potential energy or kinetic energy, but it is usually encountered as potential energy, which is energy stored due to the relative positions of charged particles or electric fields. With electrical energy, it's helpful to think of an on/off

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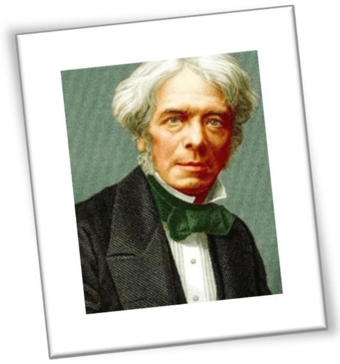
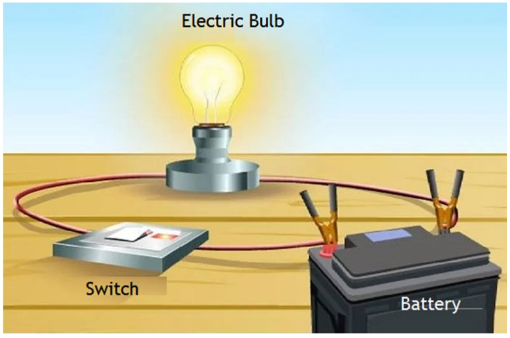
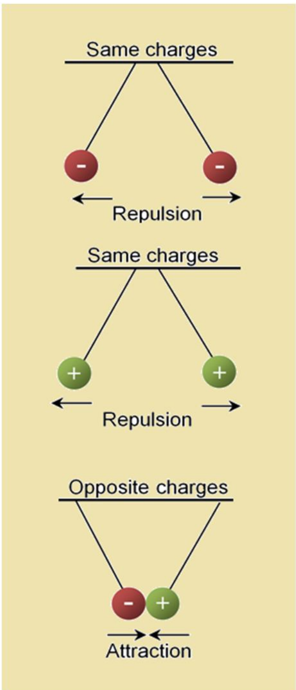
switch. When the switch is off, the electrical energy is stored as potential energy. When the switch is on, electrical energy is being used as kinetic energy. You can also think of a battery: when it is not in use, it is potential energy. When it is powering an item, it is kinetic energy. The movement of charged particles through a wire is called current or electricity.

There is also static electricity, which results from an imbalance or separation of the positive and negative charges on an object. Static electricity is a form of electrical potential energy. If sufficient charge builds up, the electrical energy may be discharged to form a spark,which has electrical kinetic energy.By convention, and the direction of an electric field is always shown pointing in the direction a positive particle would move if it was placed in the field. This is important to remember when working with electrical energy because the current carrier is an electron, which moves in the opposite direction compared with a proton.





6.2. HOW ELECTRICAL ENERGY WORKS?



British scientist Michael Faraday discovered a means of generating electricity as early as 1820. He moved a loop or disc of conductive metal between the poles of a magnet. The basic principle is that electrons in copper wire are free to move. Each electron carries a negative electrical charge. Its movement is governed by attractive forces between the electron and positive charges (such as protons and positively-charged ions) and repulsive forces between the electron and like-charges (such as other electrons and negatively-charged ions). In other words, the electric field surrounding a charged particle (an electron, in this case) exerts a force on other charged particles, causing it to move and thus do work. Force must be applied to move two attracted charged particles away from each other.Any charged particles may be involved in producing electrical energy, including electrons, protons, atomic nuclei, cations (positively-charged ions), anions (negatively-charged ions), positrons (antimatter equivalent to electrons), and so on.

6.3. UNITS OF ELECTRICITY

The SI unit of potential difference or voltage is the volt (V). This is the potential difference between two points on a conductor carrying 1 ampere of current with the power of 1 watt. However, several units are found in electricity (**Table. 6.1**), including:

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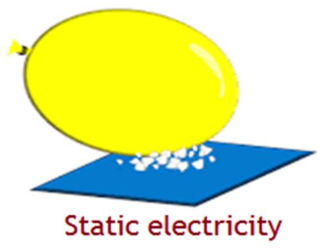
Table. 6.1: Units of electrical energy

Sr. No.	Unit	Symbol	Quantity
1	Volt	V	The potential difference, voltage (V), an electromotive force (E)
2	Ampere (amp)	A	Electric current (I)
3	Ohm	Ω	Resistance (R)
4	Watt	W	Electric power (P)
5	Farad	F	Capacitance (C)
6	Henry	H	Inductance (L)
7	Coulomb	C	Electric charge (Q)
8	Joule	J	Energy (E)
9	Kilowatt-hour	kWh	Energy (E)
10	Hertz	Hz	Frequency (f)

6.4. TYPES OF ELECTRICITY

There are two types of Electricity, Static Electricity, and Current Electricity. Static Electricity is made by rubbing together two or more objects and making friction while Current electricity is the flow of electric charge across an electrical field.

6.4.1. Static electricity



Static electricity is when electrical charges build up on the surface of a material. It is usually caused by rubbing materials together. The result of a build-up of static electricity is that objects may be attracted to each other or may even cause a spark to jump from one to the other. For Example, rub a balloon on wool and hold it up to the wall. Before rubbing, like all materials, the balloons and the wool sweater have a neutral charge. This is because they each have an equal number of positively charged subatomic particles (protons) and negatively charged subatomic particles (electrons). When you rub the balloon with the wool sweater, electrons are transferred from the wool to the rubber because of differences in the attraction of the two materials for electrons. The balloon becomes negatively charged because it gains electrons from the wool, and the wool becomes positively charged because it loses electrons.

6.4.2. Current electricity

Current is the rate of flow of electrons. It is produced by moving electrons and it is measured in amperes. Unlike static electricity, current electricity must flow through a conductor, usually copper wire. In electricity, the current is a measure of the amount of

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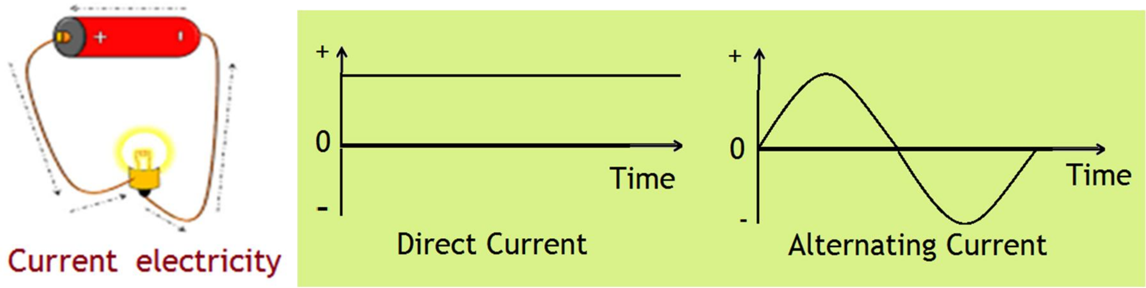
energy transferred over a period of time. That energy is called a flow of electrons. One of the results of the current is the heating of the conductor. When an electric stove heats up, it's because of the flow of current. There are different sources of current electricity including the chemical reactions taking place in a battery. The most common source is the generator. A simple generator produces electricity when a coil of copper turns inside a magnetic field. In a power plant, electromagnets spinning inside many coils of copper wire generate vast quantities of current electricity.There are two main kinds of electric current, Direct current (DC) and Alternating current (AC).



Direct Current (DC): It is an electrical current that flows consistently in one direction. Flashlight, Wall clock, Radio, etc. appliance running on batteries is direct current.Direct current is like the energy you get from a battery.

Alternating Current (AC): It is a type of electrical current, in which the direction of the flow of electrons switches back and forth at regular intervals or cycles. Current flowing in power lines and normal household electricity that comes from a wall outlet is alternating current. Alternating current is like the plugs in the wall.

6.5. ENERGY RESOURCES

In this global era, scientists are in search for the production of more electrical energy by means of different resources to meet the needs of society. The vast majority of electricity generated by using primary energy resource is hydropower, fossil fuel, and nuclear fuel. Secondary resources for the production of electricity are; solar, wind, geothermal, etc.Electrical energy is produced using mechanical and heats energy, and so on. The lightning in thunderstorms is pure electricity generated by the water molecules. We are unable to utilize this electrical energy as it would not meet the current needs of the world because clouds may not form this energy in abundance.

The electrical energy depends on the resources that are used to produce energy. It's is produced in power plants of various types. These plants use different energies to work proficiently. In simple words, we can say that other energies that are used to generate electrical energy serve the purpose of electrical energy resources.

Depending on these resources, they can be renewable or non-renewable. Natural resources such as fossil fuels, gasoline, natural gas, oil, and petrol and so on, that is burnt to produce heat energy and as a result, helps to run a turbine which in turn produces electrical energy. These are non-renewable resources of electrical energy. Renewable resources include wind energy, solar energy, and geothermal energy, and so on.Following is the list of best energy resources to produce electrical energy.

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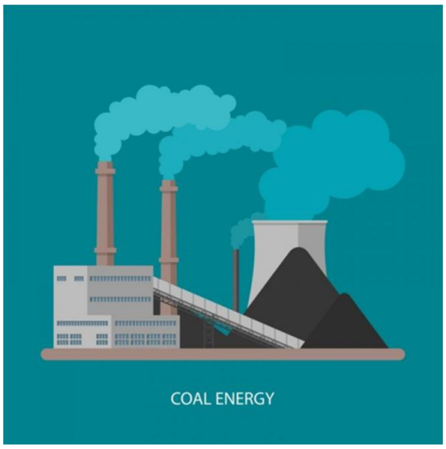
6.5.1. Wind

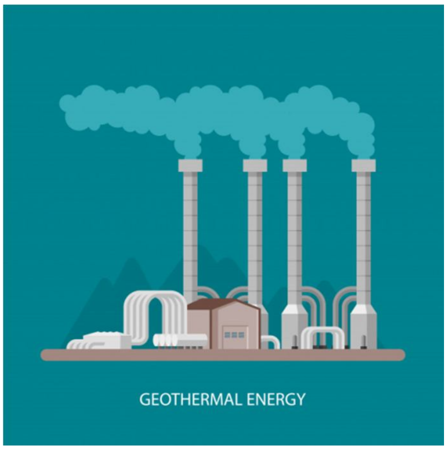
Wind turbines are used for the production of electrical energy. Wind turbines convert kinetic energy to generate mechanical power. The turbine is connected to a generator that generates electrical energy. The generator uses the motion of the shaft to make rotor work. The electromagnetic induction is created by rotor thus generates electricity. This producedenergy then goes through transformers to transfer it successfully over long distances. It is the best and cheapest source of electrical energy but requires large area for its stations.

6.5.2. Coal



Energy from coal can be utilized for the production of electricity. It is a non-renewable source of electrical energy. But it is a cheap resource for the production of electrical energy. A steam engine is used to burn coal under high pressure. The steam of coal is then flowing in the turbine which turns the generator to work as result electricity is produced. Turbines spin the generator at 3,600 revolutions per minute. This makes 20,000 volts of AC electricity. Coal energy causes pollution in the environment but clean coal and clean power plants have been introduced to reduce pollution.

6.5.3. Geothermal



Geothermal energy steam plays a key role. This steam comes from the hot reservoirs of water found a few miles under the surface of the earth. The steam is used for the activation of the turbine. The types of geothermal power plants are:

a) Dry steam power plant: In these power plants the steam underneath Earth's surface is derived directly through pipes. It is then used to run generator units.

b) Flash steam power plant: Geothermal reservoirs contain water of different temperatures.Some are really hot that is nearer to lava and some are moderate.Flash steam power plants use the water with temperatures that are greater than 360 degrees. Under the influence of its own pressure, the water rises up to the well.Water boils up and is converted into steam is then used for the production of electricity.

c) Binary steam power plant: These are the power plants that use water with lower temperatures. The temperature may be between 225 to 360 degrees. These plants use the heat from geothermal energy to boil organic compound which has a low boiling point. By the use of a heat exchanger, the vaporization of the working fluid is done. This turns the turbine. Geothermal energy is a renewable resource of energy to produce electrical energy.

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6.5.4. Nuclear

By the splitting of uranium nuclear energy is generatedis known as fission. It produces heat and this heat generates steam. Steam is used by a turbine to run generators and as a result, electricity is produced. It is the cleanest energy source of electricity as it does not emit carbon dioxide and it does not generate any greenhouse gas emissions.It is generally a more expensive type of plant for energy production. It does not pollute the environment as other energy resources.

6.5.5. Natural gas

For the production of electricity, natural gas is widely used all over the world. The natural gas power plant consists of gas engines and combustion engines. Fossil fuels are used in these combustion chambers. They are burned to release hot gasses. These hot gases are used to run the generators which produce electricity. 30-33 % of energy is used to produce electricity.Due to the advancement in technology these natural gas power plants have gained popularity. It is costly than non-renewable resources like wind& geothermal energy.

6.6. EXAMPLES OF USE OF ELECTRICAL ENERGY

6.6.1. Residential uses

A significant amount of the total electricity produced globally is used for household purposes. Here are some examples of everyday objects that use electrical energy. It is used for computing, water heating, television, refrigeration, cooking, lighting, washing machine, cell phone, laptop, air conditioning system, microwave, vacuum cleaner, and car battery among others.Electricity keeps your food cold, your house warm, and your lights on.

6.6.2. Industrial uses

Industries also use huge amounts of electricity to power a diverse range of manufacturing processes. Due to a surge in industrial activities, industrial consumption of electricity has gone up sharply in the past few decades. In some manufacturing processes, electricity is used to increase the temperature of components in order to achieve the desired product shape. While some industrial facilities build their own power generation plants, others rely on supply from utilities.

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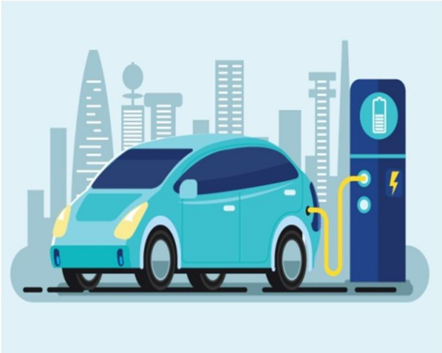
6.6.3. Transportation



Electricity is widely used by public mass transit systems and by electric vehicles across the world. Electricity is used as fuel by railway networks in many countries. Electricity is also used to charge batteries for electric vehicles. As many countries frame policies to contain environmental pollution caused by the burning of fossil fuels in transportation, vehicles run on batteries are gaining prominence. Electricity has a major contributor to transportation.

6.6.4. Commercial buildings

Electricity finds its vast usage in commercial buildings that include offices, hospitals, schools, police stations, hotels, and shopping malls, among others. It is used for lighting, heating, ventilation, and air conditioning. A large amount of electricity is currently being used for street lighting in almost every country. Medical facilities require a continuous supply of electricity. Electricity use is estimated to increase the most in residential and commercial buildings due to growth in personal incomes and rising urban migration in countries.

6.7. HOW TO CALCULATE YOUR ELECTRIC BILL?

To calculate our electric bill, we need to figure the energy usage inour home. In an ideal world, estimating our electricity usage would be as easy as looking at an itemized grocery receipt. To get a truly accurate accounting of the energy consumption of our home, we need to use some modern technology. But we may be able to calculate some decent estimates using some simple, old fashioned arithmetic.To estimate electricity we need three figures: the wattage of the appliance, the average number of hours we use it per day and the price wewere kilowatt-hour (kWh) of electricity.

Our kWh rate is printed right on our electric bill, and the average daily use is easy enough to figure. To determine the wattage of an appliance, look for a label, which is usually in an inconspicuous place like the back or bottom of the device. Once we have our data, we calculate the cost of use with this formula:

1. Multiply the device's wattage by the number of hours the appliance is used per day
2. Divide by 1000
3. Multiply by your kWh rate

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CHAPTER.7

CHEMICAL ENERGY

7.1. INTRODUCTION

The growth, success, and prosperity of human civilization and the use of energy for the same have advanced together. Energy growth is immediately linked with well-being and prosperity throughout the globe. For developing nations, the need for reliable and affordable energy is more essential. It supports financial growth, social progress, and not merely builds a better quality of life but even save lives. In these countries reliable energy supports the expansion of industries, modern agriculture, increase trade, and improved transportation. These are the building blocks that help people escape poverty and create higher lives. For developed nations, reliable and affordable energy enables the products and services that enrich and extends life. Energy powers computers, transportation, communications, medical equipment and contributes much more.

Energy does not have a mass nor a volume or shape. Thus, energy is very difficult to recognize. However, energy is everywhere. We simply defined energy is the capacity to do work. Energy is an exclusive driving force for all physical and chemical changes and manifests itself into various forms like kinetic energy, mechanical energy thermal energy, chemical energy, light energy, electrical energy, sound energy and, nuclear energy. Energy is a prominent idea in all of the scientific disciplines, universally beneficial for describing and explaining a range of phenomena. Indeed, most educators agree that an understanding of

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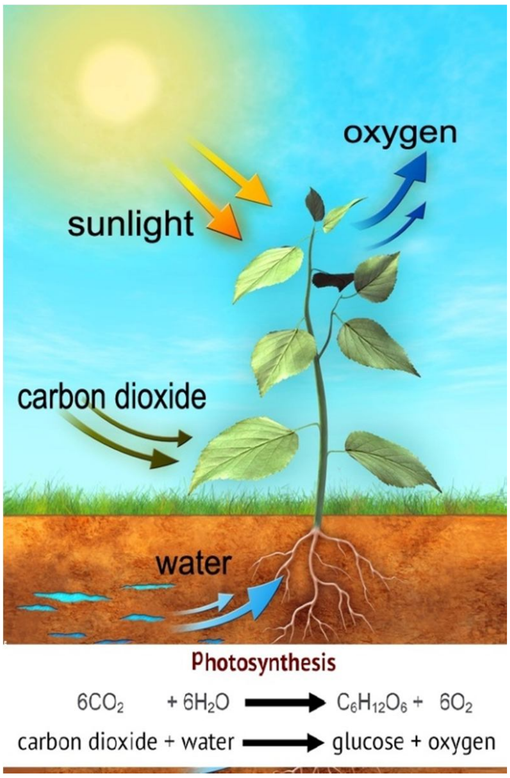
energy and energy modification is crucial both for science, technology, engineering, and mathematics students and scientifically knowledgeable citizens. In this chapter our main objective is to realize what is Chemical energy? Explore its importance and discuss our day to day encounters with it.

7.2. WHAT IS CHEMICAL ENERGY?

We are aware that energy is essential to life and all living organisms. Chemical energy is the most widely used type of energy in the world, as it is crucial to the existence of humans and the natural world. Chemical energy is stored in the bonds of chemical compounds, like atom and bonds. This energy is released during the chemical reactions, often in the form of heat; such reactions are called exothermic reactions. Usually, once chemical energy has been released from a substance that substance is transformed into a completely new substance. Some reactions that require inputs of energy to occur are endothermic. Reactions that require an input of heat to proceed may reserve some of that energy as chemical energy in newly formed bonds.

7.2.1. Understanding the chemical energy

Chemical energy reflects itself into the bond making and bond breaking during a chemical reaction. The law of conservation of energy states that energy is neither created nor destroyed it is simply transformed from one form to another. This means the total energy of the universe always constant. Chemical reactions and chemical energy associated with them also follow it strictly. This can be illustrated as follows, breaking chemical bond require energy while forming chemical bond release energy. The more energy that's released when a bond forms, the more stable that bond is. These bonds are stable because the same amount of energy must be put into these bonds to break them again. Hence, energy is conserved.



The Sun directly or indirectly is the ultimate source of all the energy available on Earth. Photosynthesis is the fundamental reaction that serves as the source of energy for all living organisms on the surface of the Earth. In photosynthesis, solar energy of the Sun is absorbed and converted into chemical energy in the form of food with the help of CO_2, H_2O and, chlorophyll pigment. Food synthesized through photosynthesis is served as a source of chemical energy. The chemical energy stored in digested food is released by the respiration process. Respiration is the biological oxidation of complex organic food into simple substances with the release of energy. This released energy is immediately converted into a metabolically usable form of chemical energy that is energy-rich wonder molecule ATP (Adenosine triphosphate). ATP is credited as the currency of energy in the living world. This chemical energy of

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ATP is the body used to perform different functions and converted into heat and mechanical energy. Urey and Miller's experiment in 1953 provided critical evidence that the hidden chemical energy in nucleotides and amino acids worked as building blocks for the first living organisms might have been formed on primordial Earth. Indeed, this discussion cleared that chemical energy is a key player for creating, maintaining, and sustaining life on Earth.

7.2.2. Examples of chemical energy

The very first energy source is Sun, providing light and heat to us. The role of solar energy is unparalleled in the phenomenon of photosynthesis. Here, trapped solar energy converted into chemical energy and provides meals to the entire living world.

The act of control of fire by early humans evidences at 1.7 million years ago which was a turning point in the technological evolution of human beings. The burning of fire is a combustion process i.e. oxidation reaction. It is an exothermic reaction in which stored chemical energy is made available in the form of heat and light. Chemical energy stored in wood, straw, and dried dung was served as our main source of fuel for heating and cooking from ancient times.

Before the industrial revolution, our energy needs were modest. But, later the scenario was changed dramatically and energy demand goes on increasing steadily. Fossil fuels like coal, petroleum, and natural gas are some most energy-rich molecules that exist evidently on Earth. These are hydrocarbon compounds that were formed with time from plants and animals that lived, died, and buried hundreds of millions of years ago. Coal is the most promising chemical fuel for industry and electricity generation at power stations. Even today the bulk of our electricity is generated by burning coal at thermal power stations. Here chemical energy in coal is unlocked into heat, light, and electrical energy.

With the invention of the automobile and the spread of electricity, our society's need for energy and its use has changed forever. Today most of the energy consume from hydrocarbons, where crude oil is the most dominant source of transportation fuel. We use petroleum products like petrol, diesel to power our vehicle where chemical energy stored in and converted into heat, electrical and mechanical energy.

Chemical energy not only used to run our vehicle but also apply to protect us from mishap. It is used in vehicle airbags. **Airbags** are activated by a chemical reaction inside the bag. During an accident a sensor gets activated and turns on an electrical circuit, in response then sodium azide gets ignited.

The reaction that occurs generates nitrogen gas, which fills the bag at an exceptionally rapid rate and protects us from upcoming danger. Natural gas is another fossil fuel we used

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for energy purposes. It is aggregate of many gases including propane, butane, ethane, O_2, N_2, and H_2S but it is made up of methane gas. When we burnt natural gas it gives off heat energy that is stored in the gas molecules.

Chemical energy not only used for fulfilling our energy requirements but also to entertain us. In India, we cannot imagine any Diwali and marriage celebration without firecrackers. Firecrackers are used for the celebration of the lighting ceremony. Gunpowder, which is 75% potassium nitrate, 15% charcoal, and 10% sulfur is at the heart of firecrackers. Here chemical energy expresses itself in the form of light, heat, and sound energy.

Chemical explosives like Tri Nitro Toluene (TNT) usually have less potential energy than fuels, but their violent rate of energy release produces great blast. The chemical energy released as a heavy dose of light, heat, and noise.

One of the most fascinating natural applications of chemical energy lies in the phenomenon of bioluminescence. Fireflies produce a chemical reaction inside their bodies that allows them to light up. This type of light production is called bioluminescence. When oxygen combines with calcium, ATP, and the chemical luciferin in the presence of luciferase, a bioluminescent enzyme, a ‘cold light’ is produced without a lot of energy is being lost as heat.

The use of cells and batteries is unquestionable. They are widely used in vehicles, to power torches, laptops, mobiles and show many more applications. Instead of burning fuels such as petroleum or coal or natural gas to produce steam for electrical turbines, electrochemistry can be used to generate electricity directly from chemical reactions, therefore, heading off the waste of energy and the pollution that comes from combustion. This technique is particularly appealing for use in portable energy sources and vehicles. The electrochemical cell acts as a device in which simultaneous oxidation and reduction reaction take place and used to convert the chemical energy into electrical energy, which can be utilized for commercial purposes. Need to invent rechargeable batteries which might be realistic for vehicles that have electric-powered motors instead of gasoline engines. Advances in both fundamental and applied chemistry are in chemical engineering to achieve these goals.

Our energy choices and decisions impact Earth's natural systems, so we must pick out our energy assets carefully. The fossil fuels we are using cause pollution. The day will soon dawn when all fossil fuels will be exhausted. Hence, proposed some green energy resources like biofuel, is a source of energy extracted from the plant. The combustion of which does no longer emit greenhouse gases.

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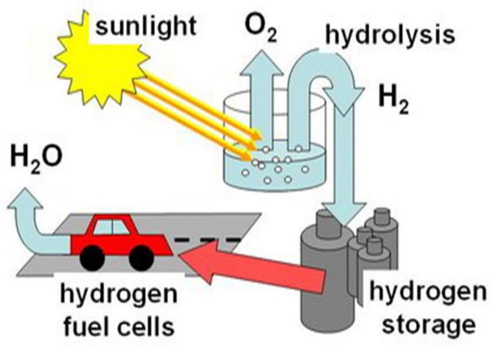
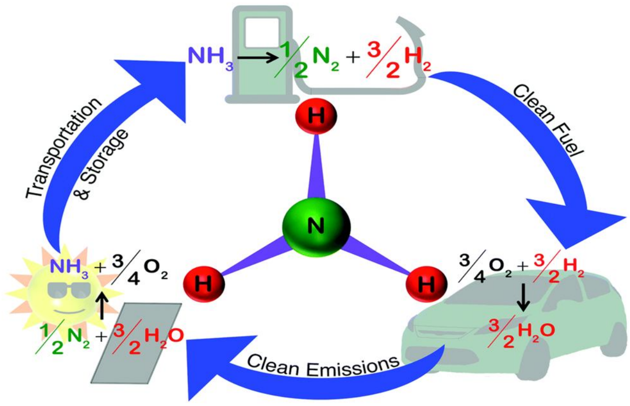
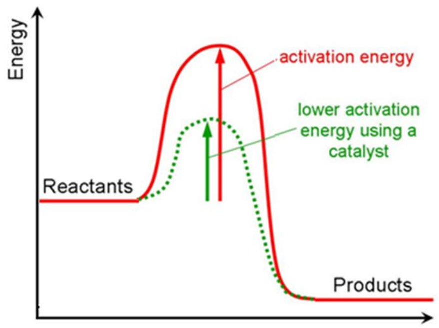




Thousands of years of collective learning have enabled us to tap new forms of energy and have encouraged an ever-increasing appetite for resources that can fuel further innovations. Meanwhile, we are trying to minimize pollution and conserve resources for future generations. In the future, it will join electricity as an important energy carrier since it can be made safely from renewable resources and emit zero carbon footprints. It will also use as a fuel for zero CO_2 emission vehicles, to heat rooms, offices, and fuel aircraft. For the future, ammonia is proposed to be future fuel. It is essentially nonflammable and liquid at room temperature. The system for its transportation and storage is already placed. It can be generated from renewable sources and can be applied for electricity generation as a clean source of energy without CO_2 emission.

7.3. CATALYST



The role of catalyst in any chemical transformation cannot be neglected. A catalyst increases the rate of the chemical reaction by decreasing the amount of activation energy. Hence, we can save energy input and time to carry transformation. In summary, chemical energy makes its ubiquitous presence in the world's energy supply. It is so readily available and is found in nearly everything we use.At the same time meeting, the growing call for energy in a safe and environmentally responsible manner is a key challenge. Researchers need to join with experts from other disciplines to invent new ways to generate and transport energy for human use and provide for the needs and aspirations of a growing population in a sustainable manner. We are committed to people and the environment for making positive contributions. Humans will always need energy, and chemical energy and chemists will continue to play a central role in learning how to produce energy and use it.

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CHAPTER.8

HYDROGEN ENERGY

8.1. INTRODUCTION

Hydrogen is a modest element. An atom of hydrogen consists of only one proton and one electron. It's also the most plentiful element in the universe. Despite its simplicity and large quantity, hydrogen doesn't occur naturally as a gas on the Earth-it's always combined with other elements. Water is a combination of hydrogen and oxygen (H_2O). Like electricity, hydrogen is an energy carrier, meaning it can store and deliver energy in an easily usable form to consumers. Hydrogen is also found in many organic compounds, notably the hydrocarbons that configuration many of our fuels, such as natural gas, gasoline, methanol, and propane. Hydrogen is also found in biomass, which includes all plants and animals. Hydrogen can be separated from hydrocarbons through the application of heat-a process known as reforming. Currently, most hydrogen is made this way from natural gas. An electrical current can also be used to separate water into its components of oxygen and hydrogen. This process is known as electrolysis. Some algae and bacteria, using sunlight as their energy source, even give off hydrogen under certain conditions.

Although hydrogen is the most abundant element in the universe, it does not naturally exist in its elemental form on Earth. Pure hydrogen must be produced from other hydrogen-containing compounds, such as fossil fuels, biomass, or water. Each production method requires various sources of energy. Researchers are developing a wide range of technologies

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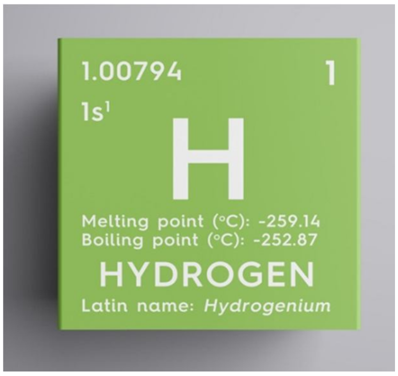
to produce hydrogen in economical, environmentally friendly ways so that we will not need to rely on anyone's energy resources. The great potential for diversity of supply is an important reason why hydrogen is such a promising energy carrier.

The overall challenge to hydrogen production is cost reduction. For transportation, hydrogen must be cost-competitive with conventional fuels and technologies on a per-mile basis to succeed in the commercial market place.



Hydrogen is high in energy, yet an engine that burns pure hydrogen produces almost no pollution. NASA has used liquid hydrogen since the 1970s to propel the space shuttle and other rockets into orbit. Hydrogen fuel cells power the shuttle’s electrical systems, producing clean byproduct-pure water, which the crew drinks.

In the future, hydrogen could also join electricity as an important energy carrier. Renewable energy sources, like the sun and wind, can’t produce energy all the time. Produce electric energy and hydrogen, which can be stored until it’s needed. Hydrogen can also be transported (like electricity) to locations where it is needed. Hydrogen Fuel Initiative to accelerate the research and development of hydrogen, fuel cell, and infrastructure technologies that would enable hydrogen fuel cell vehicles to reach the commercial market...

8.2. CURRENT USE OF HYDROGEN

The United States currently produces about nine million tons of hydrogen per year. This hydrogen is used primarily in industrial processes including petroleum refining, petrochemical manufacturing, glass purification, and fertilizers. It is also used in the semiconductor industry and for the hydrogenation of unsaturated fats in vegetable oil.

Only a small fraction of the hydrogen produced in the United States is used as an energy carrier, most notably by the National Aeronautics and Space Administration (NASA). This could change, however, as our nation’s leader’s look to increase our energy security by reducing our dependence on imported oil and expanding our portfolio of energy choices. Hydrogen is the optimum choice for fuel cells, which are extremely efficient energy conversion devices that can be used for transportation and electricity generation. But, currently, hydrogen is not renewable since about 95% is produced by steam reforming of natural gas.

8.2.1. Natural gas reforming

Natural gas contains methane (CH_4) that can be used to produce hydrogen via thermal processes including steam methane reforming and partial oxidation.

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8.2.2. Steam methane reforming

Hydrogen can be produced via steam reforming of fuels including gasoline, propane, and ethanol. But about 95% of the hydrogen produced in the United States today is made via steam methane reforming, in which high-temperature steam is used to produce hydrogen from a methane source such as natural gas. The methane reacts with steam in the presence of a catalyst to produce hydrogen, carbon monoxide, and a relatively small amount of carbon dioxide. The carbon monoxide and steam are then reacted using a catalyst to produce carbon dioxide and more hydrogen. This is called the 'water-gas shift reaction.' In the final process step, called 'pressure-swing adsorption' carbon dioxide and other impurities are removed from the gas stream, leaving essentially pure hydrogen.

8.2.3. Partial oxidation

In partial oxidation, the methane and other hydrocarbons in natural gas are reacted with a limited amount of oxygen that is not enough to completely oxidize the hydrocarbons to carbon dioxide and water. With less than the stoichiometric amount of oxygen available for the reaction, the reaction products contain primarily hydrogen and carbon monoxide, again with a relatively small amount of carbon dioxide and other compounds. The product gas is often referred to as synthesis gas from which hydrogen can be separated for use.

Partial oxidation initially produces less hydrogen per unit of the input fuel than is obtained by steam reforming of the same fuel. As in steam reforming, to maximize the amount of hydrogen produced, partial oxidation usually includes a water-gas shift reaction to generate additional hydrogen from the oxidation of carbon monoxide to carbon dioxide by reaction with water.

8.2.4. Gasoline

Most of the hydrogen produced today is made from natural gas in large, central facilities. Although natural gas reforming is relatively mature compared to other hydrogen production technologies, the capital equipment, and operation and maintenance costs associated with distributed natural gas reforming must be reduced to make hydrogen cost-competitive with the conventional fuels we use today.

Gasification is a thermal process that converts coal or biomass into a gaseous mixture of hydrogen, carbon monoxide, carbon dioxide, and other compounds by applying heat under pressure and in the presence of steam. Adsorbers or special membranes can separate the hydrogen from this gas stream, and additional hydrogen can be generated by reacting the carbon monoxide in a separate unit with water.

8.2.5. Coal

Coal is an abundant and relatively inexpensive domestic resource. It is important to note that hydrogen can be produced directly from coal via gasification, rather than by using coal-generated electricity to produce hydrogen. The carbon dioxide created as a by-product of coal gasification can be captured and sequestered so that the process results in near-zero greenhouse gas emissions. Coal gasification research, development, and demonstration activities seek to ensure that coal can produce clean, affordable, reliable and efficient electricity and hydrogen in the future

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8.3. HYDROGEN FUEL APPLICATIONS

Hydrogen is an ideal replacement for fossil fuels such as coal, oil and natural gas in furnaces, internal combustion engines, turbines, and jet engines.

Today, environmental pressures mean that hydrogen research and development efforts are focussing on hydrogen as an alternative fuel to power our mobility and transportation needs. In electrified vehicles, for example, it is used to run fuel cells that convert hydrogen efficiently (back) to electricity. The application spectrum of fuel cells is vast. They have the potential to replace conventional power generators such as combustion engines or even large batteries in cars, buses, forklift trucks, submarines, and backup and power plants. Learn more about hydrogen H_2 - as a fuel.

8.3.1. Passenger cars

Along with battery electric vehicles, hydrogen-powered fuel cell passenger cars are the only zero-emission alternative drive option for motorized private transport. About 10 years ago petrol engine prototypes were still being tested with hydrogen as an alternative energy and low-emission fuel. These were vehicles with modified bivalent engines, which could run on both petrol and hydrogen.

Owing to the fuel, hydrogen-powered internal combustion engines not only achieve somewhat higher efficiencies than in petrol operation, but they also emit much lower levels of pollutants. Although hydrogen is a clean fuel with excellent physicochemical properties, it has been unable to gain acceptance as a fuel for motorized road transport. For passenger cars, the focus is now almost entirely on hydrogen-powered fuel cells as a source of drive energy.

8.3.2. Hydrogen-powered buses

Buses in the public transport network are the most thoroughly tested area of application for hydrogen and fuel cells. Although hydrogen was initially still used in buses with internal combustion engines, bus developers are now concentrating almost entirely on fuel cell electric buses (FCEB). The use of small FCEB fleets is being promoted in urban areas as a way of contributing to technological development and to clean air policy.

Fuel cell buses have now reached a high level of technical maturity, although they are not yet in series production. Fuel cell buses now have a range of 300 to 450 km and so offer almost the same flexibility as diesel buses in day-to-day operations. While some older municipal buses still consume well over 20 kg of hydrogen (rather than 40 liters of diesel) per 100 km, newer fuel cell buses now use only 8 to 9 kg per 100 km, giving FCEBs an energy efficiency advantage of around 40 % as compared with diesel buses.

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8.3.3. Material handling vehicles

Fuel cell industrial trucks, like forklifts or towing trucks (airports), are especially suitable for indoor operation because they produce no local pollutant emissions and only low noise emissions. Fuel cell vehicles have advantages over battery-operated industrial trucks in terms of refueling. Instead of having to replace the battery, the trucks can be refueled within two to three minutes. They take up less space and are cheaper to maintain and repair.

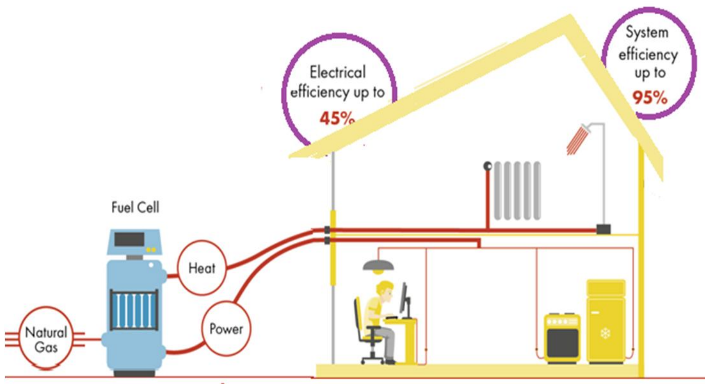
Fuel cell industrial trucks allow for uninterrupted use and are therefore particularly suitable for multi-shift fleet operation in material handling. In the case of larger industrial truck fleets in multi-shift operation, moderate cost reductions can be achieved in comparison to battery technology, and productivity in material handling can also be increased.

8.3.4. Electricity generation

A fuel cell combines hydrogen and oxygen to produce electricity, heat, and water. Fuel cells are often compared to batteries. Both convert the energy produced by a chemical reaction into usable electric power. Emergency generator sets are used for maintaining operation in the event of lengthy power outages. In such cases, the switchover from the mains power supply is usually (briefly) interrupted.

In comparison to conventional thermal power plants, hydrogen fuel cells have much higher electrical efficiencies of up to 60 %, even for small plants. This is advantageous from an energetic perspective since a lot of high-value electricity and little heat is produced.

8.3.5. Domestic energy



If, in addition to the generated electricity, the heat that is produced is also used, the process is referred to as combined heat and power (CHP). The fuel cell will produce electricity as long as fuel (hydrogen) is supplied, never losing its charge. Fuel cells are a promising technology for use as a source of heat and electricity for buildings and as an electrical power source for electric motors propelling vehicles. Fuel cells operate best on pure hydrogen. But fuels like natural gas, methanol, or even gasoline can be reformed to produce the hydrogen required for fuel cells. Some fuel cells even can be fueled directly with methanol, without using a reformer. Probably the biggest advantage of fuel cells over thermal power processes is the direct electrochemical conversion during electricity and heat generation and the associated higher electrical efficiency. In combined mode, i.e. electrical and thermal, fuel cells can achieve efficiencies of up to 95 %. The electrical efficiency is up to 45 %.

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8.3.6. Hydrogen bomb

The hydrogen bomb consists of heavy isotopes of hydrogen called deuterium (2H) and tritium (3H) along with an element lithium-6 (6Li). The detonation (or explosion) of the hydrogen bomb is done by using an atom bomb. When the atom bomb is exploded, then its fission reaction produces and releasing an enormous amount of heat energy in a few microseconds. This energy destroys life and property.

A hydrogen bomb is based on the thermo-nuclear fusion reactions of heavy hydrogen atoms to produce helium atoms. A hydrogen bomb is an uncontrolled nuclear fusion process. Thus, the source of energy of a hydrogen bomb is the same as that of the sun's energy, the only difference being that the sun's energy supports life on earth, whereas the energy of the hydrogen bomb destroys life on earth! Please note that a hydrogen bomb is much more powerful than an atom bomb.

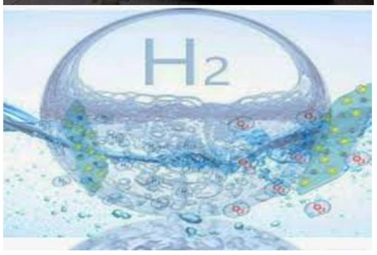
8.4. ADVANTAGES AND DISADVANTAGES OF HYDROGEN ENERGY

Hydrogen is a clean fuel that, when consumed in a fuel cell, produces only water. Hydrogen is an energy carrier that can be used to store, move, and deliver energy produced from other sources. Today, hydrogen fuel can be produced through several methods. The hydrogen energy has some advantages and also disadvantages. Few of them are listed below

8.4.1. Advantages of hydrogen energy

1. It is a renewable energy source and bountiful in supply.
2. It is practically a clean energy source.
3. Hydrogen energy is nontoxic.
4. It is far more efficient than other sources of energy.
5. It is used for powering space ships.

8.4.2. Disadvantages of hydrogen energy



1. It is expensive and it is difficult to store.
2. Hydrogen is very hard to move around
3. It is not easy to replace existing infrastructure
4. It is highly flammable.
5. Hydrogen energy cannot sustain the population.

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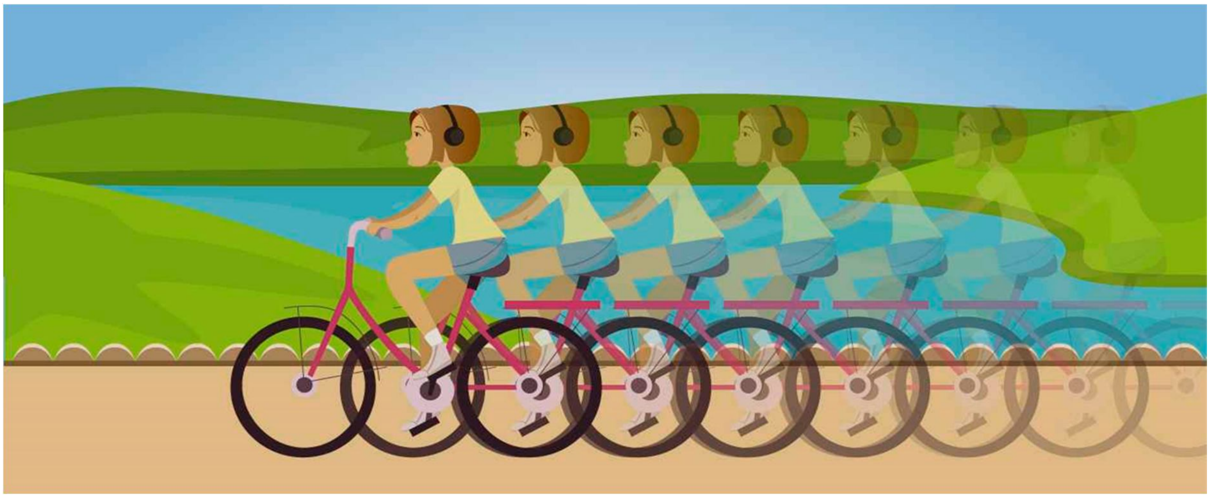
CHAPTER.9

MECHANICAL ENERGY

9.1. INTRODUCTION

The concept of Energy in physics is explaining about the capacity for doing work. Energy obtained in various forms such as potential, kinetic, thermal, electrical, chemical, nuclear, or other. The energy obtained by motion or positions of the body called motion energy sometimes is also called mechanical energy. The rest bodies have no motion but mot zero mechanical energy. Mechanical energy plays a very important role in human life because it is the process of transfer from one form to another. We use energy always from the beginning of the day. While cycling, we use chemical energy taken from food and convert to mechanical energy. Many machines can convert energy from one phase to another phase.



The mechanical energy generally divides into two main categories i. e. Kinetic energy due to motion and potential energy due to the position of a body. The mechanical energy is the sum of the kinetic energy, or energy of motion, and the potential energy, or energy stored in a system because of the position of its parts. The mechanical energy is constant in a system that has only gravitational forces or in an otherwise idealized system-that is one lacking dissipative forces, such as friction and air resistance, or one in which such forces can be reasonably neglected. Thus, a swinging pendulum has its greatest kinetic energy and least potential energy in the vertical position, in which its speed is greatest and its height is least; it has its least kinetic energy and greatest potential energy at the extremities of its swing, in

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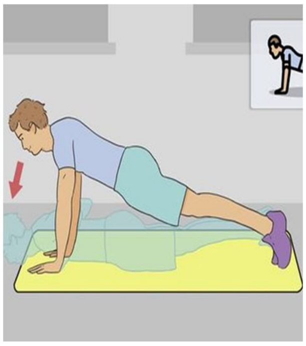
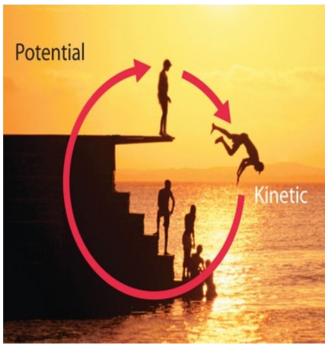
which its speed is zero and its height is greatest. As the pendulum moves, energy is continuously passing to and fro between the two forms. Neglecting friction at the pivot and air resistance, the sum of the kinetic and potential energies of the pendulum, or its mechanical energy, is constant. The mechanical energy of the system is diminished at the end of each swing by the tiny amount of energy transferred out of the system by the work done by the pendulum in opposition to the forces of friction and air resistance. The mechanical energy of the Earth-Moon system is nearly constant as it is rhythmically interchanged between its kinetic and potential forms. When the Moon is farthest from Earth in its nearly elliptical orbit, its speed is least. Its kinetic energy has become least, and its potential energy is greatest. When the Moon is closest to Earth, it travels fastest; some potential energy has been converted to kinetic energy.

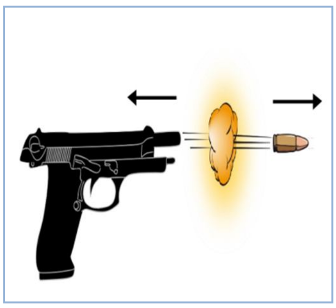
9.2. MECHANICAL ENERGY

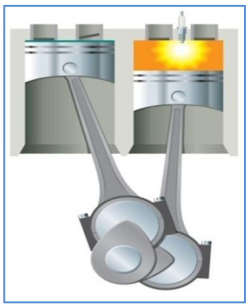
Mechanical energy is the energy possessed by an object due to its motion or its position. Well, that seems simple enough, but the energy is the ability to do work, where work is the movement of an object when a force is applied to it. For example, a person doing push-ups is doing work by applying force to the floor. Since the floor doesn't typically move, the person will move away from the floor.



Moving train, a sewing machine, spring motion, etc possess mechanical energy. Mechanical energy is the energy possessed by an object due to its movement or position. In other words, an object possesses mechanical energy when it can do work due to its position or motion. Mechanical energy can take the form of either kinetic energy, which is energy due to an object's motion, or potential energy, which is stored energy due to an object's position. A moving object can do work. An object moving faster can do more work than an identical object moving relatively slow. A moving bullet, spring in a clock, a rotating wheel, a piston moves up and down can do work. The bullet pierces the target, objects in motion possess energy. We call this motion energy or mechanical energy.



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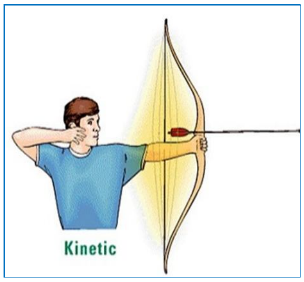
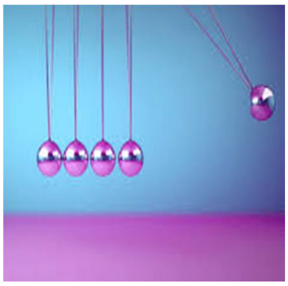
9.2.1. Kinetic energy

Kinetic energy is a form of energy that an object or a particle has because of its motion. If work, which transfers energy, is done on an object by applying a net force, the object speeds up and thereby gains kinetic energy. Kinetic energy is a property of a moving object or particle and depends not only on its motion but also on its mass. The kind of motion may be a translation (or motion along a path from one place to another), rotation about an axis, vibration, or any combination of motions. Windmill convert wind energy by moving with blades of a turbine with high-speed winds. The mechanical energy of the moving air gives the air particles the ability to apply a force and cause a displacement of the blades. As the blades spin, their energy is subsequently converted into electrical energy




9.2.1.1. Kinematical equations

Let us now express the kinetic energy of an object in the form of an equation. Consider an object of mass, 'm' moving with a uniform velocity, 'u'. Let it now be displaced through a displacement's' when a constant force, 'F' is the acts on it in the direction of its displacement. The work done, W is the product of F and s. The work done on the object will cause a change in its velocity. Let its velocity change from u to v. Let 'a' be the acceleration produced. According to the kinematical equation of motion; the relation between initial velocity- u and final velocity-v, uniform acceleration-a, and displacement-s is given by,

$$v^2 = u^2 - 2as$$

$$\therefore \quad s = \left(\frac{v^2 - u^2}{2a}\right)$$

But, F = ma. Thus, we can write the equation for work done due to force.

$$W = F \cdot S$$

$$W = ma \cdot \left(\frac{v^2 - u^2}{2a}\right) = \frac{1}{2} m \left(v^2 - u^2\right)$$

If the object is starting from its stationary position, that is u = 0, then

$$W = \frac{1}{2} mv^2$$

It is clear that the work done is equal to the change in the kinetic energy of an object. If u = 0, the work is done will be half of mv^2.

Thus, the kinetic energy possessed by an object of mass m and moving with uniform velocity v is,

$$E_k = \frac{1}{2} mv^2 \qquad \text{- - - (1)}$$

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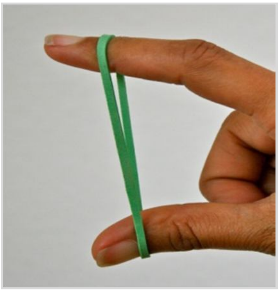
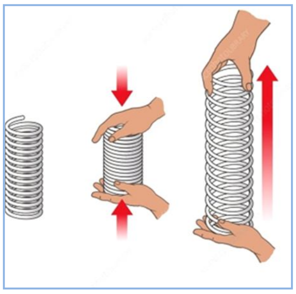
9.2.2. Potential energy

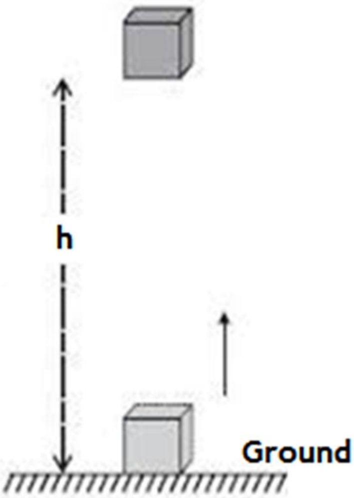
Potential energy is an energy that an object has because of its position relative to other objects. It is called potential because it has the potential to be converted into other forms of energy.

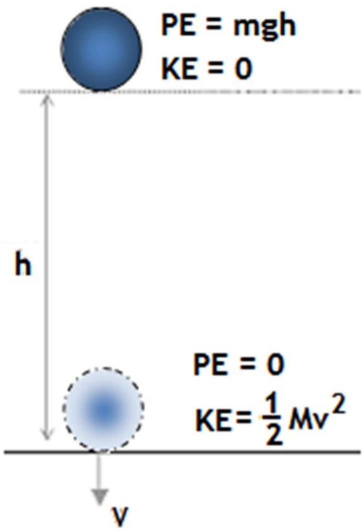
The energy transferred to an object is stored as potential energy if it is not used to cause a change in the velocity or speed of the object. You transfer energy when you stretch a rubber band. The energy transferred to the band is its potential energy. You do work while winding the key of the toy car. The water stored in damp is in the form of potential energy and the flow converts it into kinetic energy. The potential energy possessed by the object is the energy present in it by its position or configuration. The stretched or compressed spring stored inside energy is elastic energy is stored as potential energy. Water stored in a dam has potential energy.






An object increases its energy when raised through a height. This is because work is done on it against gravity while it is being raised. The energy present in such an object is the gravitational potential energy. The gravitational potential energy of an object at a point above the ground is defined as the work done in raising it from the ground to that point against gravity. It is easy to arrive at an expression for the gravitational potential energy of an object at a height.





Consider an object of mass, ‘m’. Let it be raised through a height, ‘h’ from the ground. The minimum force ‘F’ required to raise the object is equal to the weight of the object, ‘mg’. The object gains energy equal to the work done on it. Let the work done on the object against gravity be ‘W’, given by,

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Work is done, W = force × displacement

$$W = mg \times h$$

Since work done on the object is equally tough, energy equal to mgh units is gained by the object. This is the potential energy (E_p) of the object.

$$E_p = mgh \qquad \text{- - - (2)}$$

9.2.3. Total mechanical energy

Mechanical energy is the sum of kinetic energy and potential energy possessed by an object that is used to do a particular work. In other words, it describes the energy of an object because of its motion or position or both.

If E_k and E_p refer the kinetic and potential energies of the body respectively, its mechanical energy E_{Mech} is given by,

$$E_{Mech} = E_k + E_p$$

From equation (1) and (2), we get,

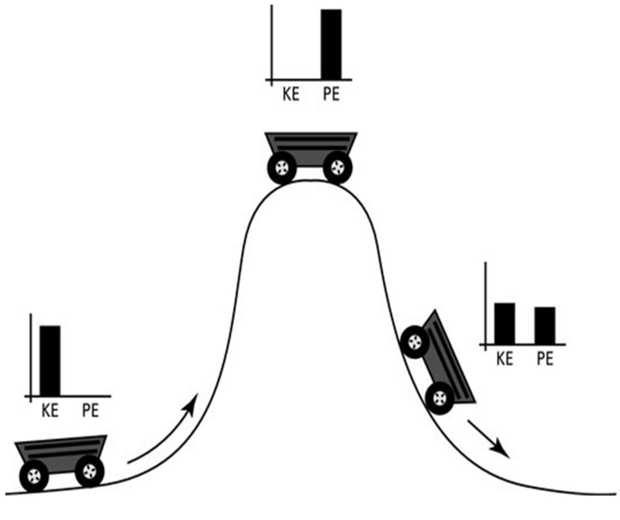
$$E_{Mech} = \frac{1}{2}mv^2 + mgh \qquad \text{- - - (3)}$$

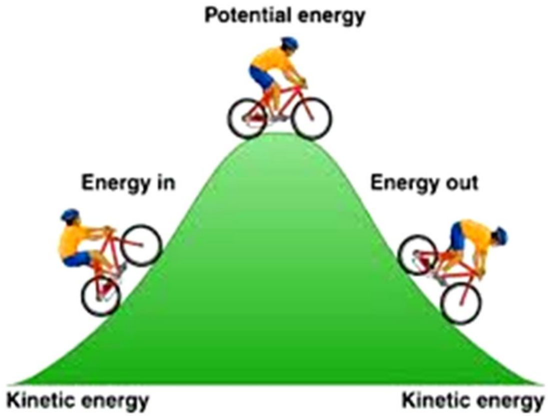
Where m is mass of the object, v is the velocity of the moving object, g is the acceleration due to gravity and h is the height of the object from the ground.

9.3. CONSERVATION OF MECHANICAL ENERGY

The principle of the conservation of mechanical energy states that the total mechanical energy in a system remains constant as long as the only forces acting are conservative forces. According to the law of conservation, energy neither be created nor be destroyed it can only be converted from one form to another; the total energy before and after the transformation remains the same.

The law of conservation of energy is valid in all situations and for all kinds of transformations. In physics, if you know the kinetic and potential energies that act on an object, then you can calculate the mechanical energy of the object. Imagine a roller coaster car traveling along a straight stretch of track. The car has mechanical energy because of its motion kinetic energy. Imagine that the track has a hill and that the car has just enough energy to get to the top before it descends the other side, back down to a straight and level track.





At the top of the hill, the car is pretty much stationary, so whereas all its kinetic energy is has been converted to potential energy. As the car begins its descent on the other side of the hill, the potential energy begins to be converted back to kinetic energy, and the car gathers speed until it reaches the bottom of the hill. Back at the bottom, all the potential energy the car had at the top of the hill has been converted back into kinetic energy.

An object's mechanical potential energy derives from work done by forces, and a label for particular potential energy comes from the forces that are its source. For example, the roller coaster has potential energy because of the gravitational forces acting on it, so this is often called gravitational potential energy.

The initial total mechanical energy of the car is

$$E_{Mech1} = \frac{1}{2} m v_1^2 + mgh_1 \qquad \text{- - - (4)}$$

The final total mechanical energy of the car is

$$E_{Mech2} = \frac{1}{2} m v_2^2 + mgh_2 \qquad \text{- - - (5)}$$

Equate equation (4) and (4) we get

$$E_{Mech1} = E_{Mech2}$$

$$\frac{1}{2} m v_1^2 + mgh_1 = \frac{1}{2} m v_2^2 + mgh_2 \qquad \text{- - - (6)}$$

The equation (6) represents the principle of conservation of mechanical energy. The principle says that if the network done by non-conservative forces is zero, the total mechanical energy of an object is conserved.

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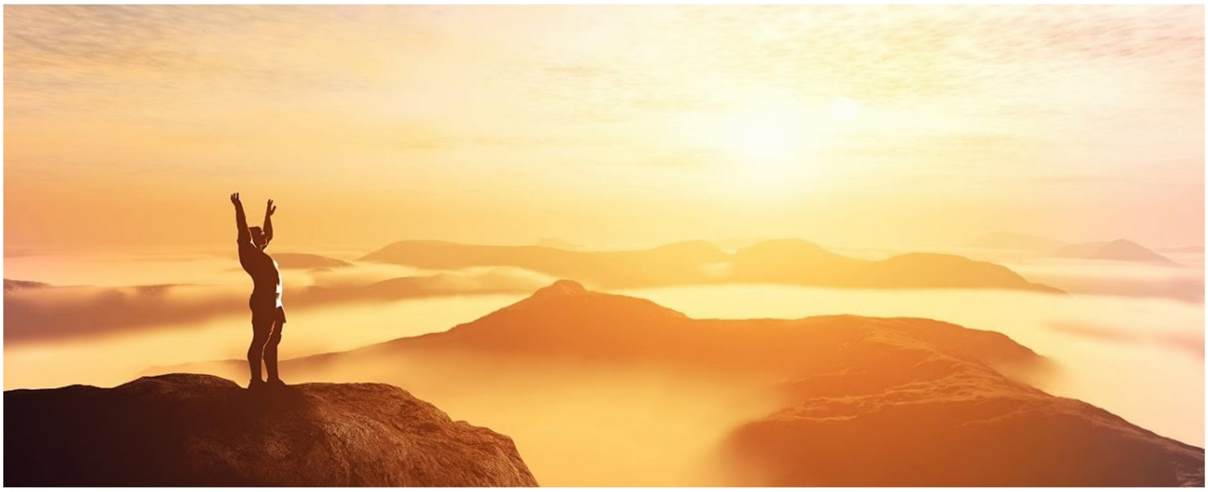
CHAPTER.10

LIGHT ENERGY

10.1. INTRODUCTION

Light is a form of energy andlight energy converts one form to another form of energy. There are numerous instances, we canrealize in our routine life carrying light energy like a lightened candle,stars, and other luminous objects, flashlight, fire, kerosene lamp,electric bulb, etceach act as a different source of light. Even a burning candle is an illustration of light energy. There are two types of light sources, i.e. natural source and artificial source. The sun is the biggest natural source of light energy.



Light is the basis for plants and animals for their existence on earth. Light is required for human beings to maintain a complete eminence of life and is one of the foremost uses of energy that is often for electricity. Homelighting extends a person's day and allows for many relaxations and economic opportunities after the sun sets to provide sunlight. People often get light from kerosenelamps in undeveloped countries and a variety of lightbulbs in developedcountries (like LED, CFL, and incandescent light bulbs).Light energy is used to assist us with seeing either normally utilizing the sun or fire, or with artificial objects like candles or lights. Light energy is additionally used by plants, which catch the light energy from the sun and exploited it to create their food by the photosynthesis procedure. Sun is the biggest source of light and heat energy. The light reaches in from the sun to us within a very short interval of time.

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10.2. WHAT IS LIGHT?

Light is technically any form of radiant energy but is almost always occupied to mean visible radiant energy. Humans can see only a fraction of this energy which is recognized as visible light. This visible radiant energy range is between 380 nm to 750 nm. **Fig.10.1.** display saminor portion of the total electromagnetic spectrum, which is known asthe visible spectrum.

Light is a type of electromagnetic radiation, which implies it has electric fields and magnetic fields vibrating to and fro quickly as a wave. Because of the strangeness of quantum mechanics, light is made of little massless particles called photons. The electromagnetic spectrum is the entire distribution of electromagnetic radiation according to frequency or wavelength.**Fig. 1**shows different types of electromagnetic radiation radiating from the sun, including gamma rays, X-rays, ultraviolet rays, infrared rays, microwaves, radio-waves, and cosmic rays. Various kinds of radiant energy from the sun have been distinguished within the electromagnetic spectrum and the variation between wavelength points to the amount of energy that is carried by them.

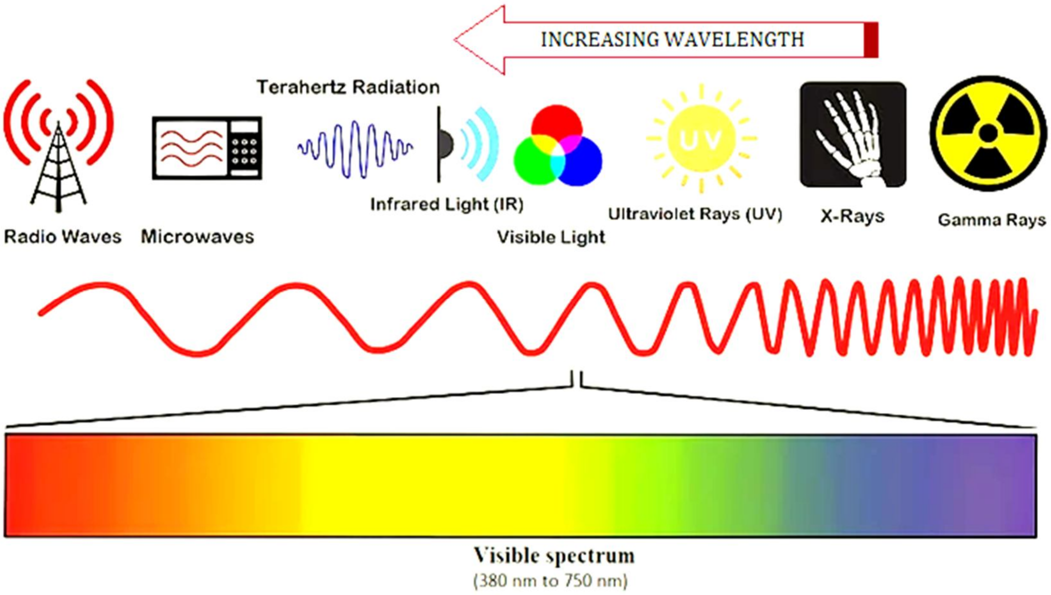

Fig. 10.1: The electromagnetic spectrum

10.3. NATURE OF LIGHT

Light energy is a form of electromagnetic (EM) radiation. Light contains photons, which are delivered when object molecules acquire thermal energy. Light vitality is a type of electromagnetic radiation of a wavelength, which can be seen by the normal eye. It is a kind of kinetic energy. Light energy travels in the form of waves. Light energy is very fast–in fact, nothing travels faster than light. Light is made up of photons, which resemble tiny packets of energy. When an object's atoms heat up, photons are formed by the movement of atoms. The hotter the object, the more photons will be created. The electrons find excitement from the heat and result in earning extra energy. The energy is released in the form of a photon and more photons come out as the substance gets hotter. A photon is the lowest discrete quantity or quantum of electromagnetic radiation. It is the fundamental unit of all light. Light voyages in the form of a wave. However, no matter is required to carry the energy to travel along. This is the cause of why light can travel through space where there is no air. This is not the case with sound waves since they have to travel through solids, liquids, or gas.

Characteristics of light waves to understand light waves, it is important to understand the basic wave motion itself. Water waves are sequences of crests (high points) and troughs (low points) that move along the surface of the water.

An electromagnetic wave is made of an electric field and a magnetic field that alternately gets weaker and stronger. The directions of the fields are at right angles to the direction the wave is moving, just as the motion of the water is up and down while a water wave moves horizontally. In an electromagnetic wave, electric and magnetic field vectors are perpendicular to each other and simultaneously are perpendicular to the path of propagation of the wave. This nature of electromagnetic waves is known as transverse nature, as shown in the following **Fig.10.2.**

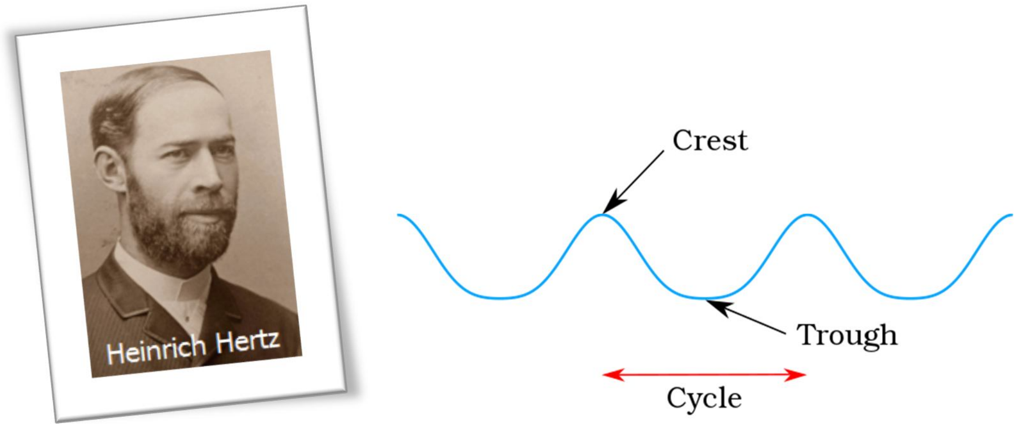

Fig.10.2: Transverse nature of electromagnetic (EM) wave

A crest is a point on a superficial wave where the displacement of the medium is at an extreme. A trough is the reverse of a crest, so the minimum or lowest point in a cycle. The distance between the peaks of a wave is known as the wavelength. Wavelengths are measured in units of length -meters when dealing with light, wavelengths are in the order of nanometers (1×10^{-9} m). The number of peaks that will travel past a point in one second is termed as the frequency of the light wave. Frequency is measured in cycles per second. The term given to this is Hertz (Hz) named after the 19th century discoverer of radio waves - Heinrich Hertz. 1 Hz is equal to 1 cycle per second.

10.4. PROPERTIES OF LIGHT

Light energy is very quick and travels faster than anything. The speed of light in a vacuum is expressed as, $c = 2.99 \times 10^{8}$ m/s. Light travels in a vacuum at a continual speed, and this speed is considered a universal constant. It is imperative to note that speed changes for light traveling through a non-vacuum medium, for example, air (0.03% slower) or glass (30.0% slower). For most purposes, we might characterize the light in terms of its magnitude and direction. In a vacuum, the light will travel in a straight line at static speed, carrying

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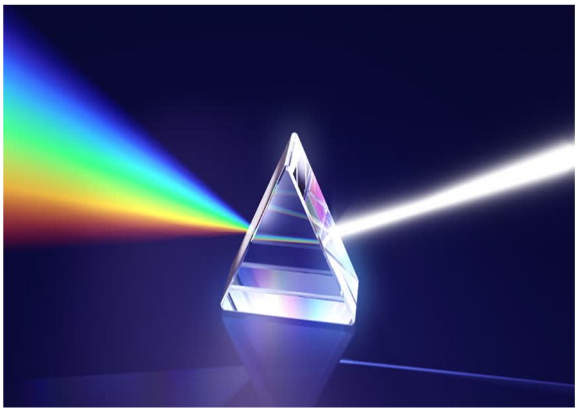
energy from one place to another. Two foremost characteristics of light interacting with a medium are: it is deflected when traveled from one medium to another (called refraction). Also, it can be bounced off a surface (i.e. reflection). The field of detection and measurement of light energy is called radiometry. Light is bent with various kinds of lenses for several purposes (in eyeglasses, microscopes and telescopes, in projectors as in a movie theater, etc.).



Light is a form of energy that is why photovoltaic cells can harness the primary energy flow of sunlight to generate electricity called solar energy. The speed of light varies when it passes from the material into another. The ratio of the speed of light in a vacuum to its speed in a given material is called the refractive index. The study of light and the interaction of light with matter is called optics. The ray optics is known as geometrical optics and wave optics is known as physical optics. The light exhibits different phenomena's when interacted with diverse kinds of matters viz. reflection, refraction, interference, dispersion, scattering, total internal reflection, diffraction, and polarization.

10.5. DIFFERENT THEORIES OF LIGHT

The query about the nature of light, whether light is a wave or particle has a fascinating and elongated history. Different theories of light were put forward by several scientists. In the 17thera two debated theories of the nature of light were proposed, the wave theory and the corpuscular theory. The Dutch physicist, mathematician, and astronomer Christiaan Huygens (1629-1695) proposed a wave theory of light. He supposed that light was a longitudinal wave and that this wave was spread through a hypothetical medium named 'aether' also called luminiferous ether. Since, light can pass through a vacuum and travels very fast Huygens had to propose somewhat strange properties for the ‘aether’: for example; it must exist in all space and it is weightless and unseen. For this reason, many scientists were unconvinced of his theory. In between 1672-1690, Newton proposed the simplest corpuscular theory of light. He believed that light was traveling from a source in small particles called corpuscles and this opinion was believed for over centuries. At the time, some of the experiments performed on light theory, both the wave theory and particle theory, had some unexplained miracle. Newton could not enlighten the phenomenon of light interference, this forced Newton's particle theory in favor of the wave theory. This difficulty was due to the unexplained phenomenon of light polarization, inventors were familiar with the fact that wave motion was parallel to the direction of wave travel, not perpendicular to the direction of wave travel, as light does.

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Thomas Young (1803) investigated the interference of light waves by shining light through a screen with two equally placed slits, the light emerging from the two slits, spread out according to the Huygens principle. Ultimately the two wave fronts will interfere with each other if a screen was positioned at the point of the overlapping waves; the construction of light and dark fringes was detected. Well along in 1815, Augustin Fresnel reinforced Young's experiments with mathematical formulations. The quantum theory put forward by Max Planck in 1900 joint the wave theory and the particle theory and exposed that light can sometimes behave like a particle and sometimes like a wave. Max Planck presented the existence of a light quantum, a finite packet of energy that rests on the frequency and velocity of the radiation. Albert Einstein 1905 put forward an explanation for the problem of remarks made on the nature of light having characteristics of both wave and particle theory. After studies of Planck on the emission of light from hot bodies, Einstein recommended that light is composed of tiny particles called photons and each photon has energy, $E= h\nu$. Light theory branches into the physics of quantum mechanics, which was hypothesized in the twentieth century. As a result of quantum mechanics, this gave the proof of the dual nature of light and therefore not strangeness.

As proposed by Einstein, light is composed of small packets of energy i.e. photons. The purpose that photons can travel at light speeds is because they have no mass and therefore, Einstein's notorious equation $E=mc^2$ cannot be used. Another formula formulated by Planck is used to designate the relation among photon energy and frequency - Planck's constant (h) - 6.63×10^{-34} Joule-Second.

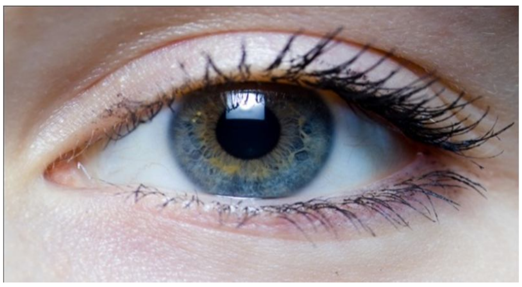
$$E = h\nu \quad \text{or} \quad E = \frac{hc}{\lambda}$$

Where, E is the photonic energy in Joules, $h$is Planks constant and ν is the frequency in Hz.

10.6. USES OF LIGHT ENERGY

Light energy is a type of kinetic energy, which can transfer from one place to another place in the form of electromagnetic waves. Light energy can be converted into so many forms like solar energy, heat energy, chemical energy, etc. Light energy received by the earth is used in different ways by converting it into a required medium. There are so many daily lives, commercial and scientific uses of light energy, and some of them are listed below:

10.6.1. Vision



When light falls on eyes then we get a sensation of light. Any creature can view the objects around them owing to the existence of eyes. But these might be unusable without light. The eyes receive the image when light falls on it and the information is sent to the brain. Hence, light allows us to see the objects around us.

10.6.2. Colours

The whole world is beautiful due to the colours and all these colors are possible due to light. The light comprises many spectra and each spectrum has a distinct colour which is mainly specified as VIBGYOR. The formation of the rainbow is as a result of the dispersion, refraction, and internal reflection of sunlight by tiny water droplets.

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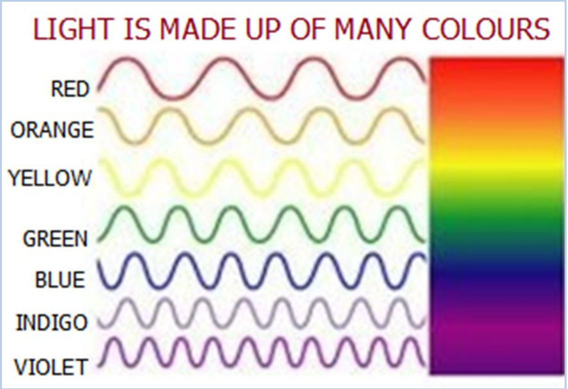
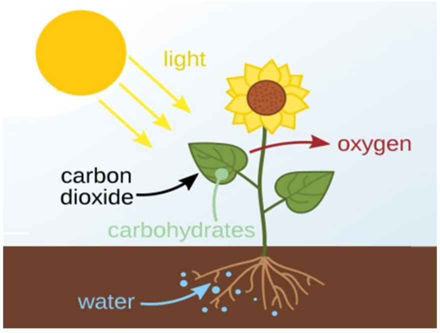


10.6.3. Food

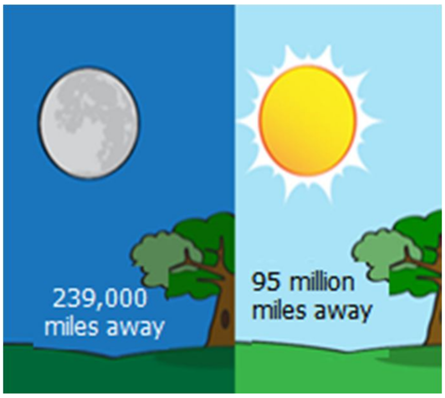


Light is the solitary source of food generation for all living creatures. Every organism is dependent on light for their energy and food except a few chemotrophic bacteria. Light energy is also used by plants, which employs the light energy from the sun and uses it to produce their food recognized as a photosynthesis process. The plants with the help of sunlight, water, and carbon dioxide make their food.

10.6.4. Solar energy

Light energy can be used to generate a huge power which is possible through solar energy and solar energy can also be converted into heat energy for different distillation purposes. Solar energy refers to capturing the energy from the sun and afterward converting it into electricity. We can then use that electricity to light up our homes, streets, electrical appliances, power our batteries and machines as well. The energy of light from the sun can be gathered to solar panels and can be used for domestic uses since it is facile eco-friendly and cost-effective also.

10.6.5. Measurement of speed and distance



Light is used to measure the speed and distance because it is the only source that man can calculate accurately with high precision when the distance and speed are cannot be calculated in normal ways. The calculations depend upon the light speed as introduced by Albert Einstein. He proves that light has also affected by gravitational force. The light changes its direction according to the gravitational force. Depending upon the gravitational force speed also changes, explained by Albert Einstein in the theory of Relativity.

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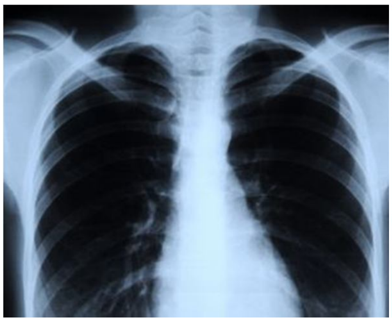
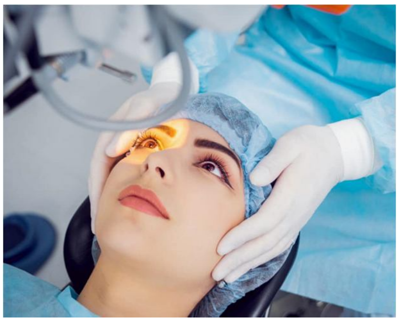
10.6.6. Medical applications

In 1903 Niels Ryberg Finsen (Nobel Prize winner in Medicine) originated the usage of light therapy to cure the lupus patients. Typically, he had used focused beams of UV light to treat patients with lupus vulgaris (a form of TB that affects the skin, particularly on the neck and face). Light therapy is used to bring down the level of bilirubin newborn babies infected by jaundice. Light and optical instruments have made reflective effects on current medicine, with several lasers and optical devices being presently used in clinical practice to assess health and treat disease. Several instruments termed endoscopes are used for observing internal body organs and cavities.

Nowadays there are various advantages of UV light for medical usage, including germicidal applications such as water purification, air, and surface treatment. Procedures include sewage treatment, swimming pools and spa therapy, air ventilation systems in hospitals and workplace buildings, odor controller, sterilization, removal of volatile organic compounds, and industrial wastes. UV light provides health benefits with these applications in addition to medical phototherapy lamps, tanning lamps, and much more. UV air sterilization encourages healthy environments.

When light is absorbed, its energy generally appears as heat. This property is the basis for the use in medicine of infrared light to heat tissues. Likewise, the heat formed by laser beams is utilized to "weld" a detached retina to the back of the eyeball and to coagulate small blood vessels in the retina. The laser is routinely used in clinical medicine only in ophthalmology. The use of the optical microscope in the pathology laboratory is as common as the use in the clinic. The most aware use of X-ray light is to inspect for fractures (broken bones), dental issues, and also be used to kill cancer cells.

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CHAPTER.11

HEAT ENERGY

11.1. INTRODUCTION

The words 'hot and cold' are commonly used in our day to day life. These two words are nothing but the two sides of the same coin. Neither human beings nor flora and fauna can survive without heat or cold. For example, let us take a cup of hot tea and a cold drink. The moment we dip our finger in the cup of hot tea, we immediately take it back, same the case when we try to hold an ice cold cool drink bottle. Why is this so? This is so because in both cases, the hotness or coldness differs from that of our body.

When two bodies at different temperatures are placed in contact, the hotter body cools down and the colder body warms up. Energy is thus transferred from a body at a higher temperature to a body at a lower temperature when they are brought in contact. The energy being transferred between two bodies or between two adjacent parts of a body as a result of temperature difference is called heat. Thus, heat is a form of energy. It is energy in transit whenever temperature difference exists. Once it is transferred it becomes the internal energy of the receiving body. It should be clearly understood that the word ‘heat’ is meaningful only as long as the energy is being transferred. Thus, expansions like ‘heat in a body’ or ‘heat of a body’ are meaningless.

Heat always flows from a hot body to a cold body not in the reverse direction, till the temperature of both bodies becomes the same or constant. So, we have to need to understand the concept of the transfer of heat.

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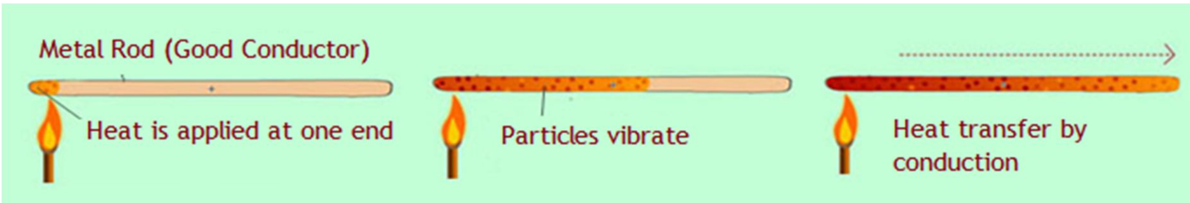
11.2. HEAT TRANSFER

Heat can be transferred from one place to another by three different modes namely, conduction, convection, and radiation.

11.2.1. Conduction

It is a process by which heat flows from the hot end to the cold end of the solid body without there being any net movement of the particles of the body.

Heat passes through solids by conduction only. When one end of the metal rod is placed in a flame while others held in hand, the end being held becomes hotter and hotter, although it is not itself in direct contact with the flame. We say that heat has been conducted from hot end to cold end. Heat conduction can be visualized as the result of molecular collisions. As one end of the object is heated, then the molecules of the object vibrate faster and faster. As they collide their slow-moving neighbors, they transfer some of their energy to these molecules still farther down the object. Thus the energy of thermal motion is transferred by molecular collision down the object. The transfer of heat continues until the two ends of the object are at the same temperature. This method of heat transfer is called conduction.



Those solid substances which conduct heat easily called good conductors of heat. Silver, Copper, Aluminum, etc, and all metals are good conductors of heat. In general good conductors of heat are also good conductors of electricity. Those substances which do not conduct heat easily are called heat conduction of heat such as, wood, rubber, cloth, air; paper, etc. are bad conductors of heat are also bad conductors of electricity.

11.2.1.1. Thermal conductivity

The thermal conductivity of a solid is measure of the ability of the solid to conduct heat through it. The greater the thermal conductivity of a solid, the greater is its ability to conduct heat through it and vice-versa. To study conduction is more detail, suppose that one end of the metal rod is heated as shown in **Fig.11.1**.

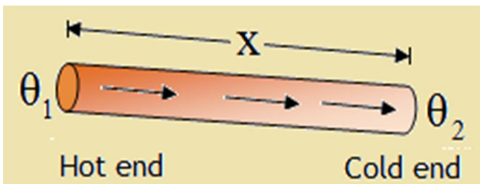


Fig.11.1

The heat flows by conduction from the hot end to the cold end. As a result, the temperature of every section of the rod starts increasing. Under this condition, the rod is said to be in the variable state. After some time, the temperature at each section of the rod becomes steady i.e. constant. Note that the temperature of each cross-section of the rod is constructed but not the same. This is called a steady-state condition. Under steady-state

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conditions, the temperature at the points within the rod decreases uniformly with distance from the hot end to the cold end. The fall of temperature with the distance between the ends of the rod in the direction of the flow of heat is called a temperature gradient.

$$\text{Temperature gradient} = \frac{\theta_1 - \theta_2}{x}$$

Where, θ_1 is the temperature of the hot end of a rod, θ_2 is the temperature of cold end and x is the length of the rod.

11.2.1.2. Application of thermal conductivity

Thermal conductivity is the rate at which heat passes through a specified material, expressed as the amount of heat that flows per unit time through a unit area with a temperature gradient of one degree per unit distance. Thermal conductivity depends on materials and it is different for different materials. Different substances have different coefficients of thermal conductivity. This fact has many practical applications in daily life and we shall discuss a few of them by way of illustration.

1. Cooking utensils are made of metals but provided with handles of bad conductors. Since metals are good conductors of heat, heat can be easily conducted through the base of the utensils. The handles of utensils are made bad conductors of heat (e.g., wood, ebonite, etc.) because they will not conduct heat from the utensils to your hand.
2. Quilts are filled with fluffy cotton. Cotton is a bad conductor of heat and trapped air in it is a still worse conductor. So it provides good heat insulation i.e. it does not allow the heat to flow from our body to the surrounding. As a result, our remains warm.
3. When hot water is poured in a beaker of thick glass, the beaker cracks. When we pour hot water in a glass beaker, the inner surface of the glass expands on heating. Since glass is a bad conductor of heat, the heat from the inside does not reach the outside surface quickly. Hence the outer surface does not expand and the glass cracks.
4. Thick walls are used in the construction of cold storage rooms. Brick is a bad conductor of heat so that it reduces the flow of heat from the surroundings to the rooms. Still better heat insulation is obtained by using the hollow bricks. Air being a poorer conductor than a brick, it further checks the conduction of heat from outside.
5. To prevent ice from melting, it wrapped in gunny bags. A gunny bag is a poor conductor of heat and reduces the heat flow from outside to ice. Moreover, the air filled in the interspaces of gunny bags, being a very bad conductor of heat, further checks the conduction of the heat from outside.
6. Woolen clothes are warm because they have fine pores filled with air. Wool and air are bad conductors of heat. Therefore, woolen clothes check the heat conduction from the body to the surroundings and thus keep the body warm in winter.
7. An icebox is a double-walled box. The space between the walls is packed with insulators like cork powder, sawdust, etc. Since these materials are bad conductors of heat from outside.
8. In cold countries, windows have two panes of glass with a thin layer of air in between. Since air is a bad conductor of heat, it checks the conduction of heat from the room to the surroundings. For the same reason, the windows of air-conditioned railway coaches have double glass panes with an air layer in between the two panes.

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11.2.2. Convection

The process by which heat is transmitted through a substance from one point to another due to the actual bodily movement of the heated particles of the substance is called convection. In liquid and gases, heat is transmitted by convection because their molecules are quite free to move about. Let's discuss the heat transfer by convection in liquids and gases.

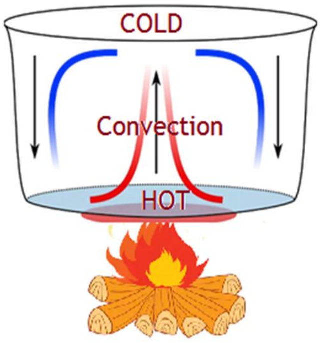

Fig.11.2

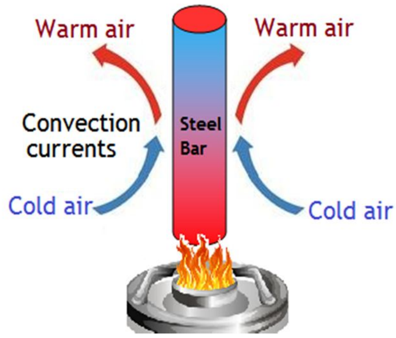

Fig.11.3

Consider water being heated in the vessel as shown in **Fig.11.2**. The water at the bottom of the vessel is heated first and its density decreases i.e. water molecules at the bottom are separated quite apart. These hot molecules have high kinetic energy and rise upward while the cold molecules come down to take their place. Thus each molecule at the bottom gets heated and rises then cools and descends. This action sets up the flow of water molecules called convection currents. The convection currents transfer heat to the entire mass of water. Note that the transfer of heat is by the bodily movement of heated molecules.

In **Fig.11.3**, the molecules of air in contact with the hot steel bar get more energy and rise upward. As the hot air moves upward, it is replaced by cooler air which, in turn, also warm up. Thus a continuous current of air is set up around the hot bar, removing its heat by convection. We say that convection currents are set up in the air surrounding the bar.

11.2.2.1. Free and forced convection

1. When a hot body is in contact with air under ordinary conditions as shown in **Fig.11.3**, it removes heat from the body by a process called free or natural convection. Thus the air of the room removes the heat of glowing incandescent lamps by free convection.
2. The convection process can be accelerated by employing a fan to create a rapid circulation of fresh air. This is called forced convection. Heat transfer by forced convection is used in most electric motors for efficient cooling.

11.2.2.2. Applications of convection

The mechanism of heat transfer by convection is utilized in many engineering applications. Two such applications are given below by way of illustration:

1. **Heating of rooms:** The mechanism of heating a room by a heater is entirely based on convection. The air molecules in immediate contact with the heater are heated up. These air molecules acquire sufficient energy and rise upward. The cool air at the top being denser moves down to take their place. This cool air is in turn heated and moves upward. In this way, convection currents (see **Fig.11.4**) are set up in the room which transfers heat at different parts of the room.

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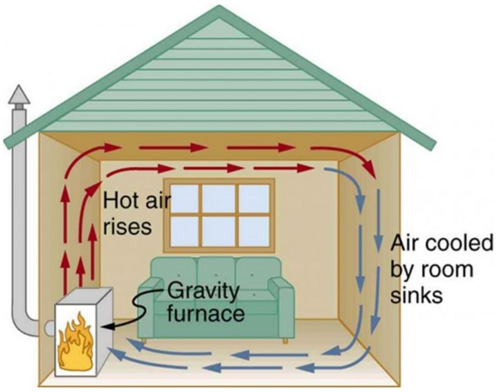


Fig.11.4

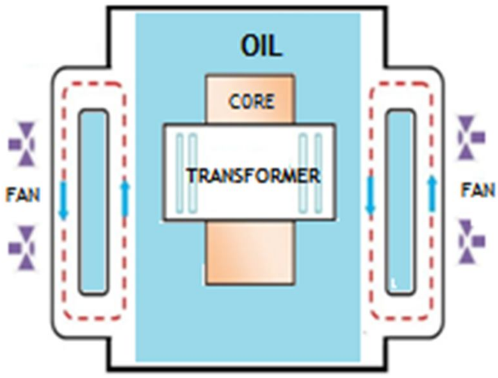
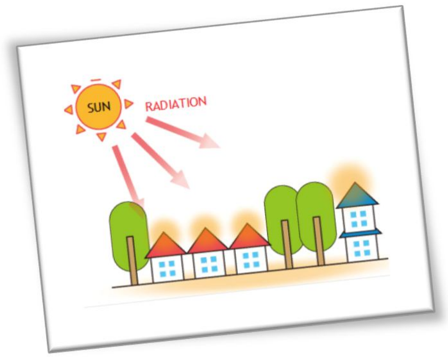


Fig.11.5

2. **Cooling of the transformer:** Due to currents flowing in the windings of the transformer enormous heat is produced. Therefore the transformer is always kept in the tank containing oil (transformer oil). The oil in contact with the transformer body heats up, creating convection currents that follow the path as shown in **Fig.11.5.** The warm oil comes in contact with the cooler tank, gives heat to it, and descends to the bottom. It again warms up to rise upwards once again. This process is repeated again and again. The heat of the transformer body is thus carried away by convection to the tank. The tank, in turn, loses its heat by convection to surrounding air.

11.2.3. Radiation



The transfer of heat from one place to another in a straight line with the speed of light without heating the intervening medium is called radiation. For transfer of heat by radiation, molecules are not needed i.e. medium is not required. The fact that earth receives large quantities of heat from the sun shows that the heats can pass-through space between the sun and the atmosphere that surrounds the earth. The transfer of heat by radiation has the same properties as light.

A natural question arises as to how heat transfer occurs in the absence of medium (i.e. molecules). All objects pass thermal energy due to their temperature. The rapidly moving molecules of a hot body emit waves (called electromagnetic waves) that travel in straight lines with the velocity of light. These are called thermal radiations. These carry energy with them and transfer it to the low-speed molecules of a cold body on which they fall. This increases the molecular motion of the cold body and its temperature rises. Thus the transfer of heat by radiation is a two-fold process; the convection of thermal energy into waves and reconversion of waves into thermal energy by the body on which they fall.

11.2.3.1. Thermal radiation

The radiant energy emitted by a body solely on account of its temperature is called thermal radiation. All objects above 0K emit thermal radiation continuously. This radiation spans a continuous range of wavelengths and the distribution of energy amongst these wavelengths depends upon the temperature of the emitter and nature of the radiating surface of emitter. At temperatures below about 1000^0C, the energy is associated almost entirely with

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infrared wavelengths (8×10^{-7}m to 4×10^{-4}m). When infrared radiation falls on the skin, it gives the sensation of warmth. It is what we usually have a mind when we speak of heat or thermal radiation and it is the main component of radiation from a hot body. When thermal radiation is incident on a body, some of the radiation may be reflected, some transmitted and some may be absorbed and produce a heating effect.

11.2.3.2. Properties of thermal radiation

Thermal radiation, like light, is electromagnetic radiation. Therefore, it has all the general properties of electromagnetic waves.

1. Thermal radiation can travel through a vacuum. The thermal radiation reaches earth after passing through a vacuum between the sun and the atmosphere.
2. Thermal radiation travel in a straight line. If an obstacle is kept between the source of heat and the receiver, the thermal radiation is cut off in the shadow region of the obstacle.

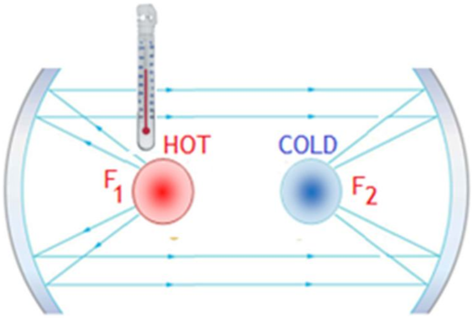

Fig.11.6

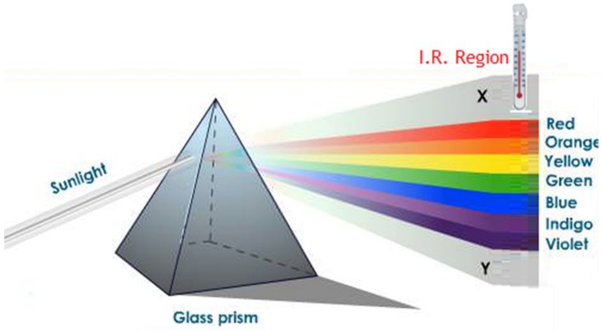

Fig.11.7

3. Thermal radiation obeys the laws of reflection. We can show the reflection of thermal radiation by two concave mirrors set up as shown in **Fig.11.6**. At the focus (F_1) of one mirror, we place an iron ball heated to just below redness. At the focus (F_2) of the other mirror, we put the bulb of a thermometer covered with lampblack to make it a good absorber. The mercury raise in the steam of the thermometer. If the move either the bulb or the ball away from the focus, the mercury falls back; the bulb has been therefore receiving heat from the ball by reflection at the two mirrors.
4. Thermal radiation can be refracted. **Fig.11.7** shows the refraction of sunlight by the prism. The spectrum of the sunlight can be explored by a sensitive thermometer whose bulb is blackened. The rise of mercury will be maximum in the infrared region. This shows that sun rays consist of thermal radiation as well as light.
5. Thermal radiation travels with the speed of light. During the solar eclipse, we do not get heat and light of the sun. Once the solar eclipse is over, we get both heat and light simultaneously. This shows that thermal radiation is equal to the speed of light.
6. Thermal radiation does not heat the medium through which it passes. If a piece of paper is placed at the focus of the convex lens and the sun rays are incident on the lens, then the paper is placed at the focus of the convex lens and the sun rays incident on the lens, the paper is burnt. However, the lens does not become hot.
7. Thermal radiation obeys inverse square law i.e. the intensity of radiation at a point is inversely proportional to the square of the distance from the point source of radiation.
8. They exhibit the phenomena of interference, diffraction, and polarization.

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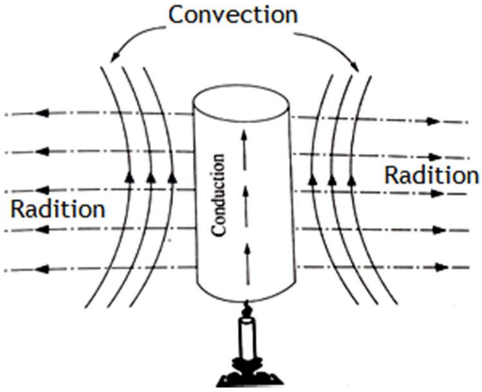
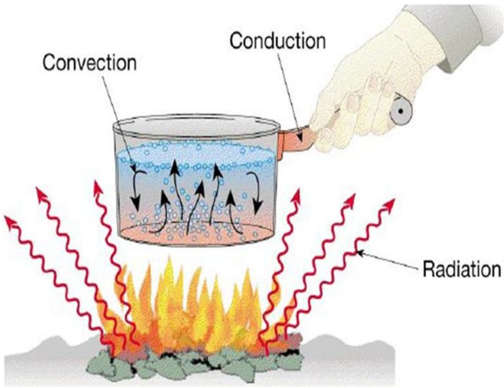
11.3. COMPARISON OF CONDUCTION, CONVECTION, AND RADIATION





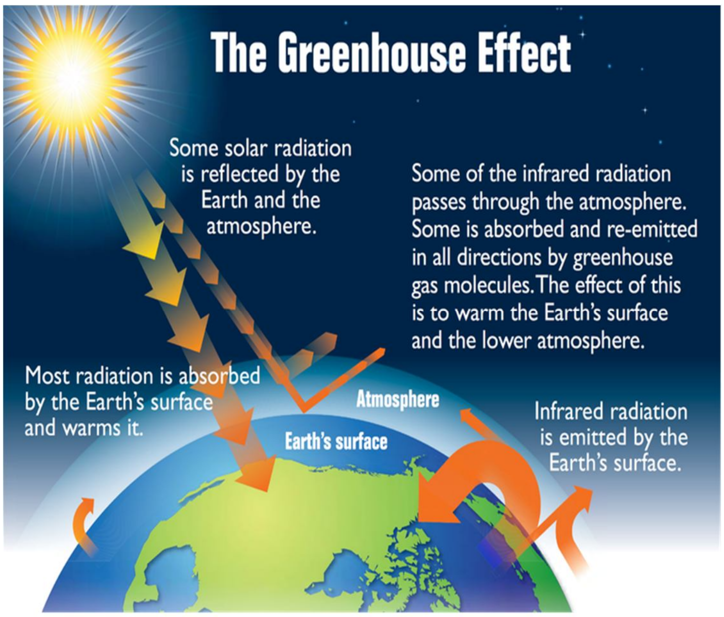
The figure shows heat transfer by conduction, convection, and radiation. The steel bar is heated by conduction. However, the bar loses heat by convection and radiation. The following **Table.11.1** describes the comparison between conduction, convection, and radiation.

Table 11.1: Comparison between conduction, convection, and radiation.

Particular	Conduction	Convection	Radiation
Material medium	Essential	Essential	Not essential
Molecules	Do not leave their mean position	Move bodily from one place to another	The medium does not play any part
Transfer of heat	Can be in any direction along any part	Only vertical upward	In all directions in straight lines.
Speed of transfer of heat	Slow	Rapid	Fastest (3×10^8m/s)

11.4. APPLICATION OF HEAT TRANSFER

11.4.1. Greenhouse effect



The ability of the atmosphere to capture and recycle energy emitted by the Earth's surface is the defining characteristic of the greenhouse effect. The heat of the sun penetrates the atmosphere and warms the Earth's surface. The warmed Earth radiates this heat back into the atmosphere. The gases surrounding the atmosphere such that carbon dioxide, methane, nitrous oxide, and water vapors absorb some of the radiated heat and send it back to the Earth. This trapping of heat from the sun by the

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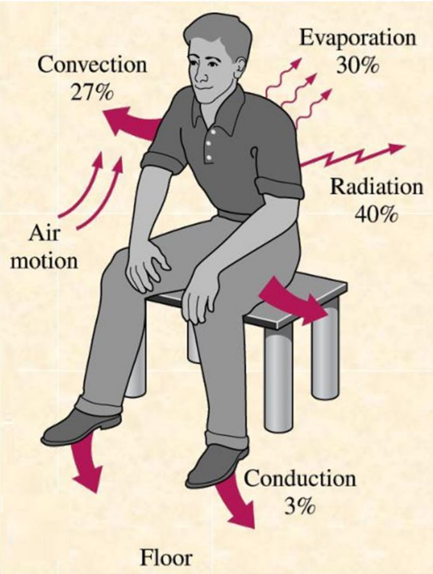
excess of carbon dioxide and other gases present in the atmosphere is known as the greenhouse effect. The gases involved in the phenomenon are called greenhouse gases. This phenomenon is called the greenhouse effect because a similar concept is used in a greenhouse, where plants that require protection from preventing the heat from escaping. The percentage of greenhouse gases, especially methane and carbon dioxide, has been steadily increasing in the atmosphere.

Causes of global warming

Global warming may cause many problems for human life, plants, and animals. Due to global warming ice caps are melting faster, sea level is rising and the weather pattern is changing, common coastal cities are at the risk of getting submerged. The increase in the greenhouse effect results in the expansion of deserts.

11.4.2. Heat transfer in the human body



The principles of heat transfer in the human body to determine how the body transfers heat. Heat is produced in the body by the continuous metabolism of nutrients which provides energy for the systems of the body. The human body must maintain a consistent internal temperature to maintain healthy bodily functions heat transfer by convection is driven by the movement of fluids over the surface of the body. This convective fluid can be either a liquid or a gas. For heat transfer from the outer surface of the body, the convection mechanism is dependent on the surface area of the body, the velocity of the air, and the temperature gradient between the skin and the ambient air. The normal temperature of the body is approximately 37 °C. Heat transfer occurs more readily when the temperature of the surroundings is significantly less than the normal body temperature.

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CHAPTER.12

SOUND ENERGY

12.1. INTRODUCTION

Every day we hear sounds from various sources like humans, birds, bells, machines, vehicles, televisions, radios, etc. A sound is a form of energy that produces a sensation of hearing in our ears. There are also other forms of energy like mechanical energy, heat energy, light energy, etc. The principle of conservation of energy, states that we can neither create nor destroy energy. We can just change it from one form to another. In our daily activity, we hear and produce sound from different sources.

A sound is a form of energy that is produced when an object vibrates. The sound vibrations cause waves of pressure that travel through a medium, such as air, water, wood, or metal. Sound energy travels out like waves in all directions. Sound energy is a form of mechanical energy. Sound waves are longitudinal waves. Sound energy is typically not used for electrical power or for other human energy needs because the amount of energy that can be gained from the sound is quite small. We can use sound energy to learn about our surroundings. The simplest and most obvious use of sound energy is for hearing. Humans can hear frequencies between about 20 Hz to 20,000 Hz. Sound energy is usually measured by its pressure and intensity, in special units called pascal and decibels. Sometimes, loud noise can cause pain to people. This is called the threshold of pain. This threshold is different from

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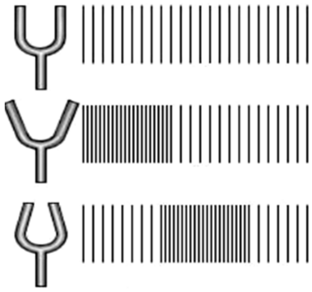
person to person. For example, teens can handle a lot of higher sound pressure than elderly people, or people who work in factories tend to have a higher threshold pressure because they get used to loud noise in the factories.

12.2. PRODUCTION OF SOUND

When we set the objects into vibrations they produce sound. Vibration means a kind of rapid to and fro motion of an object. The sound of the human voice is produced due to vibrations in the vocal cords. Sound is produced due to the vibration of objects. For example:

1. When you clap, a sound is produced
2. Stretched strings of a guitar vibrate to produce sound.
3. When the membrane of a tabla is struck, it vibrates to produce sound.
4. Set a tuning fork into vibration produces sound waves.

12.3. PROPAGATION OF SOUND

The traveling of sound is called propagation of sound. The matter or substance through which sound is transmitted is called a medium. It can be solid, liquid, or gas. Sound cannot travel in a vacuum. Sound moves through a medium from the point of generation to the listener. When an object vibrates, it sets the particles of the medium around it vibrating. The particles do not travel all the way from the vibrating object to the ear. A particle of the medium in contact with the vibrating object is first displaced from its equilibrium position. It then exerts a force on the adjacent particle. As a result of which the adjacent particle gets displaced from its position of rest. After displacing the adjacent particle the first particle comes back to its original position. This process continues in the medium until the sound reaches your ear. The disturbance created by a source of sound in the medium travels through the medium and not the particles of the medium.

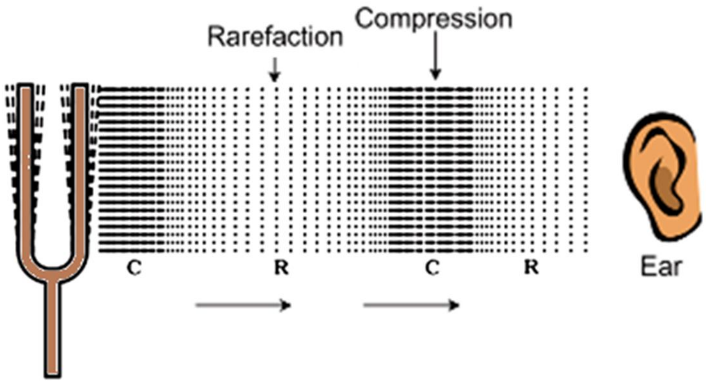


Fig.12.1: Compression and rarefraction of sound wave

A wave is a disturbance that moves through a medium when the particles of the medium set neighboring particles into motion. They in turn produce similar motion in others. The particles of the medium do not move forward themselves, but the disturbance is carried forward. This is what happens during propagation of sound in a medium; hence sound can be visualized as a wave.

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Sound waves are characterized by the motion of particles in the medium and are called mechanical waves. Air is the most common medium through which sound travels. When a vibrating object moves forward, it pushes and compresses the air in front of it creating a region of high pressure. This region is called a compression (C) and it starts to move away from the vibrating object. When the vibrating object moves backward, it creates a region of low pressure called rarefaction (R) shown in **Fig. 12.1**. As the object moves back and forth rapidly, a series of compressions and rarefactions are created in the air. These make the sound wave that propagates through the medium. Compression is the region of high pressure and rarefaction is the region of low pressure. The pressure is related to the number of particles of a medium in a given volume. More density of the particles in the medium gives more pressure and vice versa. Thus, propagation of sound can be visualized as a propagation of density variations or pressure variations in the medium.

12.4. CHARACTERISTICS OF A SOUND WAVE

Sound waves have the following characteristics:

1. Wavelength
2. Frequency
3. Time period
4. Amplitude
5. Speed

A sound wave in graphic form is shown in the following **Fig. 12.2.**

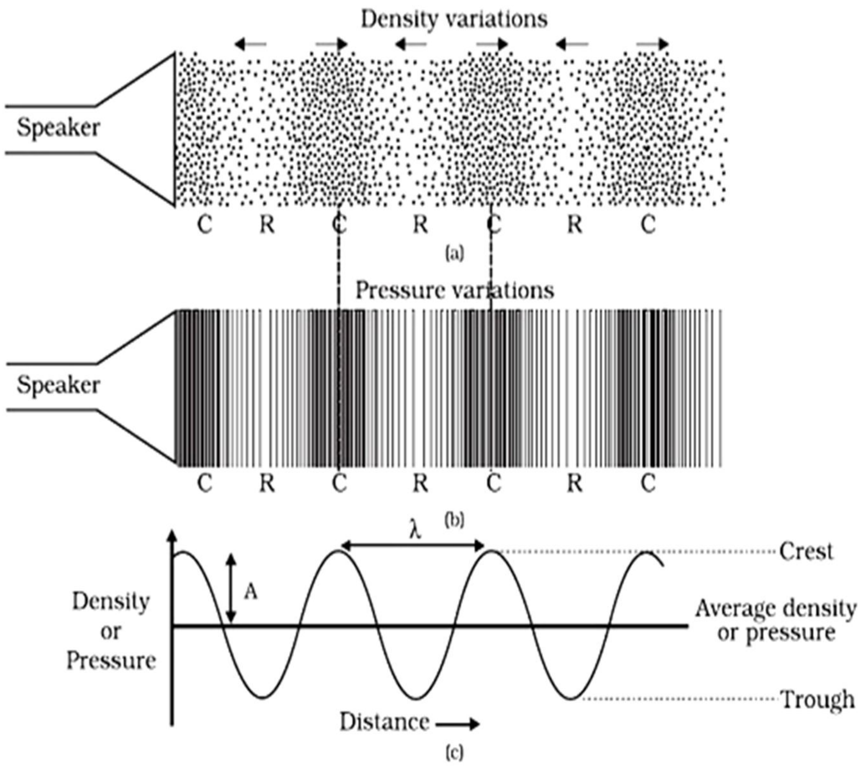

Fig. 12.2: Propagation of the sound wave

A sound wave in graphic form is shown in Fig.12.2 (c), which represents how density and pressure change when the sound wave moves in the medium. The density as well as the pressure of the medium at a given time varies with distance, above and below the average

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value of density and pressure. Fig.12.2 (a) and Fig.12.2 (b) represent the density and pressure variations, respectively, as a sound wave propagates in the medium.

Compressions are the regions where particles are crowded together and represented by the upper portion of the curve in Fig.12.2 (c). The peak represents the region of maximum compression. Thus, compressions are regions where density as well as pressure is high. Rarefactions are the regions of low pressure where particles are spread apart and are represented by the valley, that is, the lower portion of the curve in Fig.12.2(c). A peak is called the crest and a valley is called the trough of a wave.

The distance between two consecutive compressions (C) or two consecutive rarefactions (R) is called the wavelength, as shown in Fig.12.2(c), The wavelength is usually represented by λ (Greek letter lambda). Its SI unit is a meter (m).

Frequency tells us how frequently an event occurs. Suppose you are beating a drum. How many times you are beating the drum per unit time is called the frequency of your beating the drum. We know that when sound is propagated through a medium, the density of the medium oscillates between a maximum value and a minimum value. The change in density from the maximum value to the minimum value, again to the maximum value, makes one complete oscillation. The number of such oscillations per unit time is the frequency of the sound wave. If we can count the number of the compressions or rarefactions that cross us per unit time, we will get the frequency of the sound wave. It is usually represented by ν (Greek letter, nu). Its SI unit is hertz (symbol, Hz). The time taken by two consecutive compressions or rarefactions to cross a fixed point is called the time period of the wave. In other words, we can say that the time taken for one complete oscillation in the density of the medium is called the time period of the sound wave. It is represented by the symbol T. Its SI unit is second (s). Frequency and time period are related as, $\nu = 1/T$.

A violin and a flute may both be played at the same time in an orchestra. Both sounds travel through the same medium, that is, air and arrive at our ear at the same time. Both sounds travel at the same speed irrespective of the source. But the sounds we receive are different. This is due to the different characteristics associated with the sound.

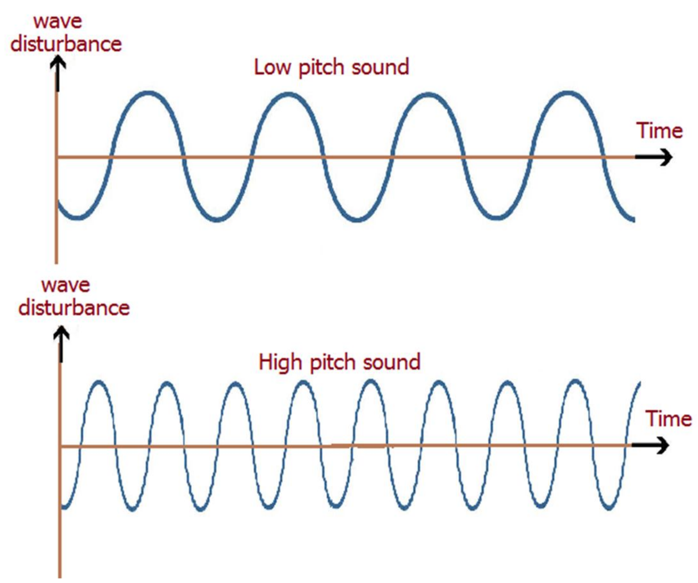

Fig.12.3: Low pitch and high pitch sound

Pitch is one of the characteristics. The faster the vibration of the source, the higher is the frequency and the higher is the pitch, as shown in **Fig. 12.3.** Thus, a high pitch sound corresponds to more number of compressions and rarefactions passing a fixed point per unit time. Objects of different sizes and conditions vibrate at different frequencies to produce sounds of different pitch. The magnitude of the maximum disturbance in the medium on either side of the mean value is called the amplitude of the wave, as shown in **Fig.12.3.**

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The loudness or softness of a sound is determined basically by its amplitude. The amplitude of the sound wave depends upon the force with which an object is made to vibrate.

If we strike a table lightly, we hear a soft sound because we produce a sound wave of less energy (amplitude). If we hit the table hard, we hear a loud sound. Loud sound can travel a larger distance as it is associated with higher energy. A sound wave spreads out from its source. As it moves away from the source its amplitude as well as its loudness decreases. The sound which is more pleasant is said to be of rich quality. A sound of a single frequency is called a tone. The sound which is produced due to a mixture of several frequencies is called a note and is pleasant to listen to. Noise is unpleasant to the ear and music is pleasant to hear and is of rich quality.

12.5. SPEED OF SOUND IN DIFFERENT MEDIA

Table.12.1: Speed of sound in different media at 25 °C

State	Substance	Speed in m/s
Solids	Aluminium	6420
	Nickel	6040
	steel	5960
	Iron	5950
	Brass	4700
	Glass (Flint)	3980
Liquids	Water (Sea)	1530
	Water (distilled)	1498
	Ethanol	1207
	Methanol	1103
Gases	Hydrogen	1284
	Helium	965
	Air	346
	Oxygen	316
	Sulphur dioxide	213

Sound propagates through a medium at a finite speed. Sound travels with a speed that is much less than the speed of light. The speed of sound depends on the properties of the medium through which it travels. The speed of sound in a medium depends on the temperature of the medium. The speed of sound decreases when we go from solid to a gaseous state. In any medium, as we increase the temperature the speed of sound increases. The speeds of sound at a particular temperature of 25 ºC in various media are listed in **Table.12.1**. The distance traveled by a wave in one second is called the speed of the wave. Its S.I. unit is meters per second (m/s).

$$\text{Speed} = \frac{\text{Distance travelled}}{\text{Time taken}}$$

$$\therefore \text{v} = \frac{\lambda}{\text{T}} \quad \therefore \text{ v} = \lambda \nu \qquad (\text{As } 1/\text{T} = \nu)$$

$$\therefore \text{Velocity} = \text{Wavelength} \times \text{Frequency, is called the wave equation.}$$

12.6. NORMAL FREQUENCY RANGE

The audible range of human ear is 20 Hz and 20,000 Hz, i.e., the human ears can hear only those waves whose frequency lies between 20 Hz and 20,000Hz. Sounds with frequencies above the realms of human ears are called ultrasound and those below are called infrasound. Though a ‘normal’ audible range for loudness is from 0 to 180dB, anything over 85dB is considered damaging. The human auditory frequency-intensity curve is shown below

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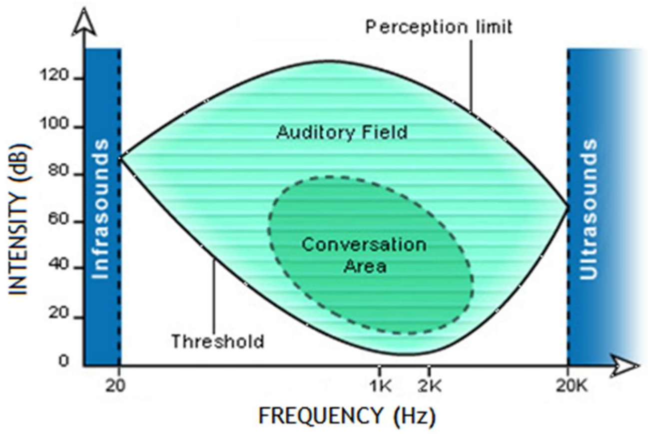
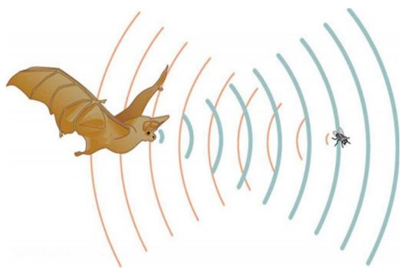


The human auditory field (green) is limited by the threshold curve (bottom) and a curve giving the upper limit of sound perception (top). At each frequency, between 20 Hz and 20 kHz, the threshold of our sensitivity is different. The best threshold (at around 2 kHz) is close to 0 dB. It is also in this middle range of frequencies that the sensation dynamics are the best (120 dB). The conversation area (dark green) demonstrates the range of sounds most commonly used in human voice perception; when hearing loss affects this area, communication is altered.

12.7. USES SOUND ENERGY

12.7.1. Reflection of sound

Bouncing back of sound waves from the surface of solid or liquid is called reflection of sound. The angle of incident wave and reflected wave to the normal is equal. Reflection of sound is used in many devices. Such as; megaphone, loudspeaker, bulb horn, stethoscope, hearing aid, soundboard, etc. Loudspeaker, Megaphone, and bulb horn are devices used to send the sound in the desired direction without spreading the sound all around.




Megaphone


Bulb horn

In Animals

Many animals use sound energy for communicating within them selves, for example, bats don't have eyesight so they produce and make use of ultrasonic waves to find the obstacles in their paths. Elephants can also communicate through infrasonic waves.

12.7.2. Medical field

Sound waves are used when performing ultrasound treatment, which is mainly used to cure major cancers and tumors these ultrasound waves cure the tumor cells of the cancer

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patient without any feeling of physical pain. Ultrasound tests are also used on pregnant women to detect many structural and functional abnormalities in a foetus. Ultrasound may also aid in the detection of heart disease, tumors, gallstones, and other disorders. The Electrocardiograph (ECG), sonography, etc work on sound energy.

Stethoscope

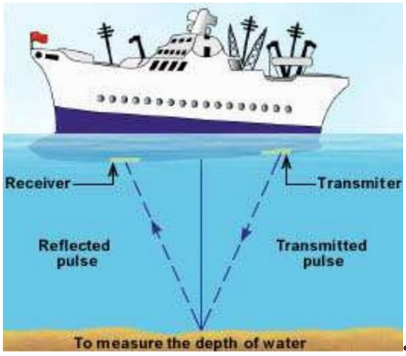
A stethoscope is used to hear the sounds of internal organs of a patient; for diagnostic purposes. It works on the laws of reflection of sound. In a stethoscope, the sound is received by chest piece and sent to the earpieces by multiple reflecting through a long tube. Doctors diagnose the condition of an organ of the human body by hearing the sound using the stethoscope.

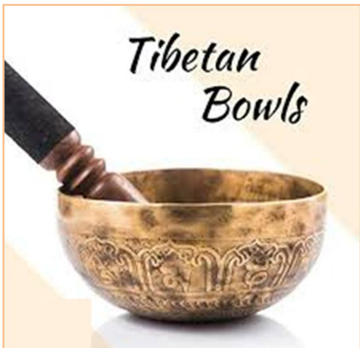
12.7.3. Industry

Ultrasound sound waves are used to detect flaws or cuts over machinery parts in Industries. Ultrasound is also used in Industries to measure the thickness of metal pipes.

Shipping Industry

SONAR (**SO**und **N**avigation **A**nd **R**anging) Sonar devices are used mainly to locate fishes, enemy ships, submarines, and underwater obstacles through the use of ultrasound. It is also used in exploring minerals and petroleum, oil-bearing rock formations under the water.





Music industry

In instruments and amplifiers, here a large amount of sound energy is produced and being used. It's been proved that particular music forms are used in healing the body like music from Tibetan bowls can remove stress and body pain.

In Science

Scientists have invented whistles and other devices that produce ultrasound. An ultrasonic transducer converts electric energy into ultrasonic waves. These waves can also be converted into electric energy by transducers. One way to use the sound wave in science is a sonar wave. A sonar wave uses a sound wave to see how far or deep something is. This is mainly used for underwater research.

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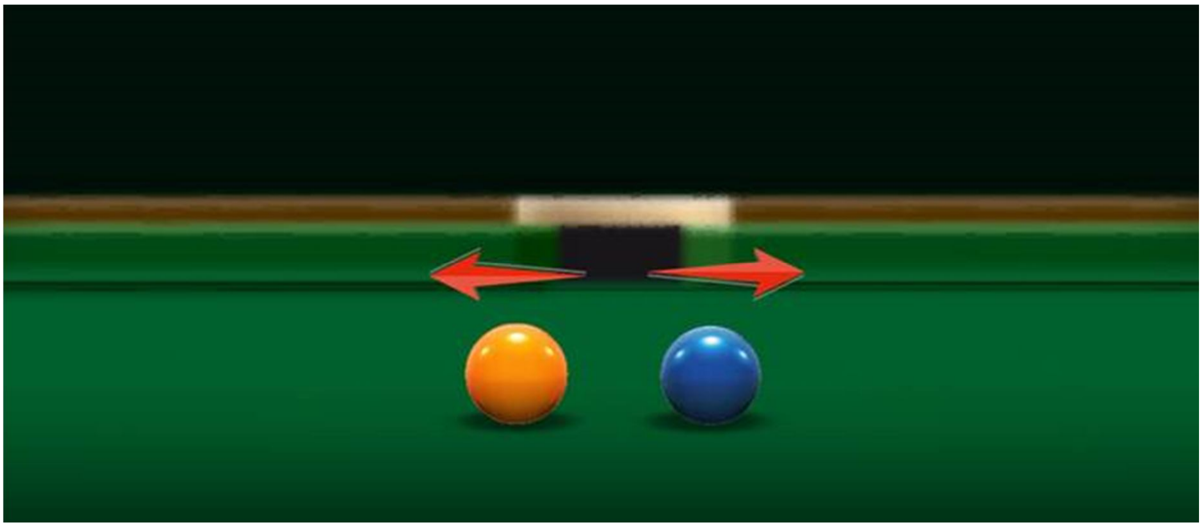
CHAPTER.13

ELASTIC ENERGY

13.1. INTRODUCTION

The dimension of a rigid body can be changed by pulling, pushing, twisting, or by compressing them. When the force is applied to the body; then there may change in shape or size or both. The body such as rubber cord, spring, rubber ball, etc temporary deformed by applying force and regain its original dimension after removing applied force is an elastic body and the property is called elasticity, but the body such as mud, wax, putty, etc changes permanently by applying force is the plastic body. The deformation produced in a body is due to the relative motion of the molecules in a body.

When an external unbalanced force is applied to a body, it gets deformed due to the relative displacement of the molecules. If the deforming forces acting on the body are removed, the body acted upon by internal restoring forces developed within the body which try to restore its original dimension.



‘The property by which material bodies regain their original dimension (Shape size or both) and after removal of deforming force is called elasticity’. In another way, we can define, 'The property possessed by a material body by which it opposes to change in its shape or size or both and regain its original dimension as soon as deforming forces are removed is called elasticity'

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Elastic energy is the mechanical potential energy stored in the configuration of a material or physical system as it is subjected to elastic deformation by work performed upon it. Elastic energy occurs when objects are impermanently compressed, stretched, or generally deformed in any manner.

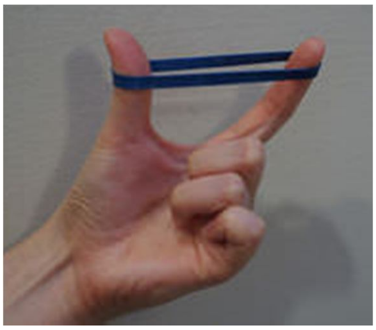



Consider an example of a rubber sponge; balloon, rubber ball, spring, etc shows the property of elasticity. When deforming force is applied then there is a change in dimension and after removing the deforming forces it regains its original dimension. So, the deforming force produces deformation of the body, after removing deforming forces the body gets the original dimension; this is property of elasticity.

The elastic properties of a body are described in terms of concepts like stress and strain. When the body is deformed, internal restoring forces are set up within the body trying to restore to its original dimensions. They are directly proportional to the applied force. The energy stored inside the body is called potential elastic energy.

13.2. ELASTIC POTENTIAL ENERGY

Elastic energy is the potential mechanical energy stored in the configuration of a material or physical system as work is performed to distort its volume or shape. Potential energy is stored in an object due to shape is called elastic potential energy. This energy results when an elastic object is stretched or compressed. The farther the object is stretched or compressed, the greater its potential energy is. A point will be reached when the object can't be stretched or compressed anymore. Then it will forcefully return to its original shape. The energy stored in an elastic band when is it is stretched or compressed. Their elasticity gives them the potential to return to their original shape. For example, the rubber band has been stretched, but it will back to its original shape when released. Springs like the handspring have elastic potential energy when they are compressed or released.



Elastic potential energy is energy stored as a result of applying a forced to deform an elastic object. The energy is stored until the force is removed and the object springs back to its original shape, doing work in the process. The deformation could involve compressing,

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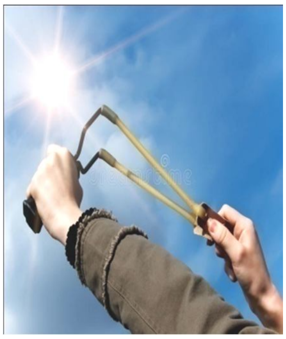
stretching, or twisting the object. Many objects are designed specifically to store elastic potential energy, such as, the coil spring of a wind-up clock, an archer's stretched bow, a bent diving board, the twisted rubber band which powers a toy airplane, etc. These examples of potential energy described indicate the movement or the potential to move is called mechanical energy. The energy is potential as it will be converted into kinetic.

There are many other examples of elastic energy conversions between elastic potential energy and kinetic energy. The law of conservation of energy is a law of science that states that energy cannot be created or destroyed, but only changed from one form into another or transferred from one object to another. The law of conservation of energy can be seen in these everyday examples of energy.


Elastic potential energy $\leftrightarrow$ kinetic energy $\leftrightarrow$ Elastic potential energy

Kinetic energy is energy in an object because of its motion. For example, a slingshot, a bow, rubber band that is stretched has elastic potential energy, because when released, the stored potential energy converted into kinetic energy.

13.3. HOOKE'S LAW

Robert Hookes (1635-1703) measured the strain in the different materials by subjecting them to different values of stress. The relation between stress and strain is called Hook's law. The materials obey Hooke's law are termed as elastic or Hookean materials.

'Within the elastic limit, the stress is directly proportional to strain.

$$\text{Stress } \alpha \text{ strain, (within the elastic limit)}$$

$$\text{Stress} = \text{M}\,(\text{strain})$$

$$\text{M} = \frac{\text{Stress}}{\text{Strain}}$$

This constant' is called 'modulus of elasticity' or 'elastic constant'. It measures the strength of elastic energy stored in the material due to its shape, size, length, volume, etc.

13.4. MODULUS OF ELASTICITY

An elastic modulus also known as modulus of elasticity is a quantity that measures an object or substance's resistance to being deformed elastically when a stress is applied to it. The ratio of stress to strain is called modulus of elasticity of a material. It is denoted by'.

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$$\therefore\ M = \frac{\text{Sterss}}{\text{Strain}}$$

If stress is measured in Pascals, then since the strain is a dimensionless quantity, the units of M will be Pascals as well. Specifying how stress and strain are to be measured, including directions, allows for many types of elastic moduli to be defined.

There are three kinds of elastic constant namely,

1. Young’s modulus (Y)
2. Bulk modulus. (K)
3. Modulus of rigidity (η)

13.4.1. Young’s modulus (Y)

The modulus of elasticity corresponding to the change in length called Young’s modulus is named after a British Physicists Thomas Young’s (1733-1829). It is also called elasticity of length. Young's modulus measures the resistance of an elastic material and typically used for characterizing a rod or wire. The value of Y depends on the nature of the material. The material has a large value of Y, it resists the elastic deformation and large stress is required to produce small strain.

13.4.2. Bulk modulus (K)

The modulus of elasticity corresponding to the change in volume is called bulk modulus. Or Bulk modulus is defined as the ratio of volume stress to volume strain. It is also called volume elasticity and it is denoted by K. It describes volumetric elasticity or the tendency of an object to deform in all directions when uniformly loaded in all directions; it is also defined as volumetric stress over volumetric strain and is the inverse of compressibility. The bulk modulus is an extension of Young's modulus to three dimensions.

13.4.3. Modulus of rigidity (η)

The modulus of rigidity (η) is corresponding to change in the shape of the body. Modulus of rigidity is defined as the ratio of the shearing stress to shearing strain. It is also called, the elasticity of shape. It is denoted by ‘η’. The modulus of rigidity or modulus of rigidity describes an object's tendency to shear (the deformation of shape at constant volume) when acted upon by opposing forces. The shear modulus is part of the derivation of viscosity.

In physics, you can examine how much potential and kinetic energy is stored in the spring when you compress or stretch it. The work you do compress or stretching the spring must go into the energy stored in the spring. That energy is called elastic potential energy or simply elastic energy.

One more phenomenon related to elastic energy is Poisson’s ratio (σ). It is named after Simeon Denis Poisson

13.4.4. Poisson’s ratio (σ)

If the load is applied to the free end of the wire, the wire gets elongated. At the same time, there is a decrease in its diameter; the observation shows that longitudinal extension is accompanied by lateral contraction. This lateral contraction depends on the nature of the body and is proportional to its size, direction as well as stress. This proportional change is called lateral strain.

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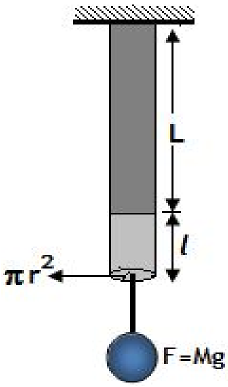
13.5. EXPRESSION FOR ELASTIC ENERGY

During the elongation of wire, work is done on it by the applied force. This work is stored in the wire in the form of potential energy. This energy is called strain energy. Strain energy is defined as elastic potential energy gained by a wire during elongation by stretching force.

Expression



Suppose that a wire of length 'L' and cross-sectional area, '$A = \pi r^2$' is elongated by gradually increasing the load (i.e. stretching force) the magnitude 'F'. Let 'l' be the extension produced in wire, during elongation. When elongation for a given load is complete, then,

$$\therefore \text{Youngs modulus}, Y = \frac{\text{Longitudinal stress}}{\text{Longitudinal strain}} = \frac{FL}{A\,l}$$

$$\therefore F = \frac{YA\,l}{L}$$

The magnitude of the force is not constant but changes from 0 to F during elongation of the wire. Let f be the force and x be the corresponding elongation then we can write,

$$\therefore f = \frac{YA\,x}{L}$$

Let, 'dw' be the work done for further small extension (i.e. displacement) 'dx' is given by.

Work done (dw) = Force (f) × Displacement (dx)

$$\therefore dw = \left(\frac{YA\,x}{L}\right)\cdot dx$$

The total work performed during the extension from x= 0 to x=l obtained by integrating dw,

$$w = \int dw = \int_0^l dw$$

$$\therefore w = \int_0^l \left(\frac{YAx}{L}\right) dx = \frac{YA}{L}\int_0^l x\,dx$$

$$= \frac{YA}{L}\left[\frac{x^2}{2}\right]_0^l = \frac{YA}{L}\left[\frac{l^2}{2} - \frac{0}{2}\right]$$

$$= \frac{YA\,l^2}{2L} = \frac{1}{2}\times\left[\frac{Y\times A\times l}{L}\right]\times l$$

$$= \frac{1}{2}\times F\times l$$

$$\text{Work done} = \frac{1}{2}\times(\text{load})\times(\text{extension})$$

Work is stored in the form of elastic energy called strain energy.

$$\text{Hence, strain energy} = \frac{1}{2}\times \text{Load}\times\text{Extension}$$

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13.6. APPLICATION OF ELASTIC ENERGY

Store elastic potential energy in many mechanical devices. This energy can be used in many ways since the material can remain in its compressed or stretched state for extended periods without dissipating energy. Some of the applications are given below.

1. Guitars

String instruments are a popular instrument people use to make sounds and tunes. String instruments, such as guitars and ukuleles rely on elastic potential energy to produce their sound. The strings on guitars are pulled taut and transform elastic potential energy into kinetic energy and sound energy through vibrations when their strings are strummed or plucked. The sounds are then amplified inside the hollow chamber found in guitars.

2. Shock absorbers

A spring is used to store elastic potential energy in many mechanical devices (like the shock absorbers in cars). This energy can be used in many ways since the spring can remain in its compressed or stretched state for extended periods without dissipating energy.

3. Production of Rubber

Rubber is a natural elastic material. It has good elastic property so that it is used in many applications. The rubber is extracted from the sap of the rubber tree. By chemical process, it is used in tire and tubes of vehicles. Due to the elastic phenomenon of rubber, the vehicles are safely driven on road. Baloon, sponge, band, ball, etc are made from rubber. The elastic energy is stored depends on its softness or hardness of the material.

4. Entertainment

A pogo-stick is a device in which a person jumps on a stick that has a spring within the core of it. The spring compresses as the person's weight acts on it thus storing elastic potential energy. However, when the person jumps, the force that the person does to the ground in combination with the conversation of potential energy to kinetic energy, as the spring stretches is enough to propel the person into the air. Many toys work on the phenomenon of elastic energy.




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5. Construction

Elastic behavior of material used in the design of bridges, constructions of homes and malls, in machinery, in industry, and so on. Bridges are designed for convenience and withstand a load of traffic, bridges may be of suspension type of arched type. Suspension type bridges support its load through the tension in cable and compression in towers whereas an arched bridge in which support load primarily through compression. Elasticity used in the thickness of ropes in cranes is decided based on elastic behavior of material of the rope along with the factor of safety.

13.7. NATURE USE ELASTICITY

In physics, elastic energy refers to the energy released when a spring elongates. When a spring is compressed it stores energy that can be used later, at this point the spring contains elastic potential energy. Kangaroo's hind legs work like springs, compressing and elongating, storing and releasing elastic energy in the process. In the kangaroo example, however, the kangaroo does not need to do work to elongate the springs that are their hind legs gravity takes care of that.

Kangaroos are an impressive animal whose unique usage of elastic energy allows them to move at high speeds for long distances and makes the models of efficiency in the animal kingdom.

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CHAPTER.14

GRAVITATIONAL ENERGY

14.1. INTRODUCTION

The earth can be imagined to be a sphere made of a large number of concentric spherical shells with the smallest one at the center and the largest one at its surface. A point outside the earth is obviously outside all the shells. Thus, all the shells exert a gravitational force at the point outside just as if their masses are concentrated at their common center according to the result stated in the last section. The total mass of all the shells combined is just the mass of the Earth. Hence, at a point outside the earth, the gravitational force is just as if its entire mass of the earth is concentrated at its center.

A body falls from a certain height, it attracted to earth with a force called gravitational force. Gravitational energy is the potential energy associated with gravitational force, as work is required to elevate objects against Earth's gravity. The potential energy due to elevated positions is called gravitational potential energy, and is evidenced by water in an elevated reservoir or kept behind a dam. If an object falls from one point to another point inside a gravitational field, the force of gravity will do positive work on the object, and the gravitational potential energy will decrease by the same amount.

The presence of the atmosphere around the earth is due to gravity. We observe that planet like our earth rotating around the sun and the satellite like our moon rotating around the earth. Earth exists a force of attraction on the moon. Similarly, the motion of the planet around the Sun suggests that, the existence of the force of attraction between sun and planet.

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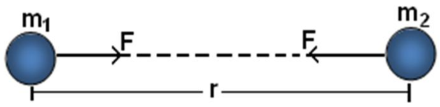
Everyone knows that a body when thrown upwards, it falls back to the earth's surface, this is because of the earth attracts everybody in its surrounding, the property of attraction between any two bodies is called gravitation and the force of attraction between then is called gravitational force.

14.2. NEWTON'S LAW OF GRAVITATION

Sir Isaac Newton was the first scientist to precisely define the gravitational force, and to show that it could explain both falling bodies and astronomical motions. Newton's law of gravitation gives the gravitational force between any two material objects.

Newton's universal law of gravitation states that every particle of matter attracts every other particle of matter in the universe with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.



Let m_1 and m_2 be masses of the two particles and r is the distance between them, and F is the force of attraction,

Mathematically we write,

$$F = G\frac{m_1 m_2}{r^2}$$

G is the constant of proportionality called the constant of gravitation. The value of G is $6.67408 \times 10^{-11}\ m^3\ kg^{-1} S^{-2}$.

14.3. GRAVITATIONAL POTENTIAL ENERGY

The gravitational potential energy of an object is defined as the energy possessed by an object rase to a certain height against gravity.

We know that the potential energy as being the energy stored in the body at its given position. If the position of the particle changes on account of forces acting on it, then the change in its potential energy is just the amount of work done on the body by the force.

When a body of mass is moved from infinity to a point inside the gravitational influence of a source mass without accelerating it, the amount of work done in displacing it into the source field is stored in the form of potential energy.

We know that the potential energy of a body at a given position is defined as the energy stored in the body at that position. If the position of the body changes due to the application of external forces the change in potential energy is equal to the amount of work done on the body by the forces.

Under the action of gravitational force, the work done is independent of the path taken for a change in position so the force is conservative. Besides, all such forces have some potential in them.

The gravitational influence on a body at infinity is zero; therefore, potential energy is zero, which is called a reference point. The force of gravity is conservative and we can calculate the potential energy of a body arising out of this force, called the gravitational

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potential energy. Consider points close to the surface of the earth, at distances from the surface much smaller than the radius of the earth. In such cases, the force of gravity is practically a constant equal to mg, directed towards the center of the earth. If we consider a point object having mass m and it is situated at a height h from the surface of the earth

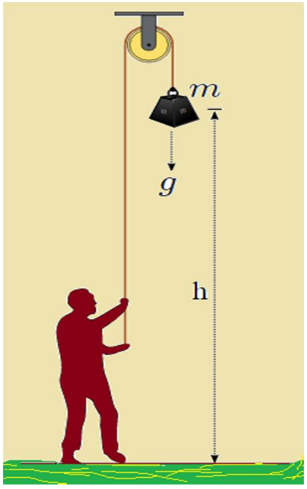

Fig. 14.1

Consider an object of mass, 'm' being lifted through a height 'h' against the force of gravity as shown in **Fig.14.1**. The object is lifted vertically by a pulley and rope, so the force due to lifting the box and the force due to gravity, F_g are parallel. If 'g' is the magnitude of the gravitational acceleration, we can find the work done by the force on the weight by multiplying the magnitude of the force of gravity, F_g, times the vertical distance, h, it has moved through. This assumes the gravitational acceleration is constant over the height h. The equation for gravitational potential energy (GPE) Ug is,

$U_g = F_g \cdot h$

$U_g = m \cdot g \cdot h$

Where, m is the mass in kilograms, g is the acceleration due to gravity (9.8 on Earth), h is the height above the ground in meters. Gravitational potential energy measured by kg m^2/s^2

If the force were to be removed, the object would fall back down to the ground and the gravitational potential energy would be transferred to the kinetic energy of the falling object. The interesting fact about gravitational potential energy is that the zero is chosen arbitrarily. In other words, we are free to choose any vertical level as the location where h=0. For simple mechanics problems, a convenient zero point would be at the floor of the laboratory or the surface of a table. In principle, however, we could choose any reference point-sometimes called a datum. The gravitational potential energy could even be negative if the object were to pass below the zero points. This doesn't present a problem, though; we just have to be sure that the same zero points are used consistently in the calculation. Gravitational potential energy depends on height and also on the mass of an object.

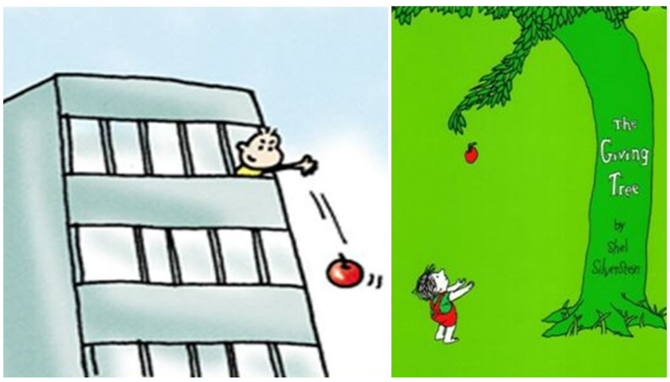

Fig.14.2

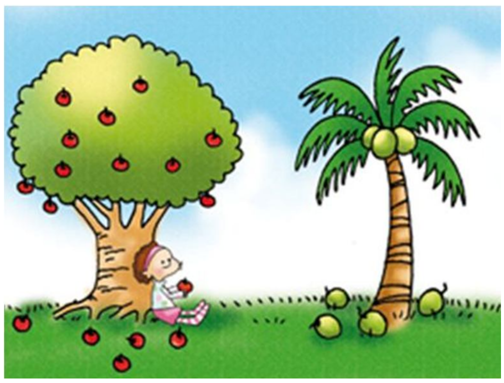

Fig.14.3

If two objects have the same mass but are at different heights, the object is at a greater height, will have more gravitational potential energy, **Fig.14.2**. Also if the objects are at the same height from the ground, the objects have greater mass have more gravitational potential energy, **Fig.14.3**.

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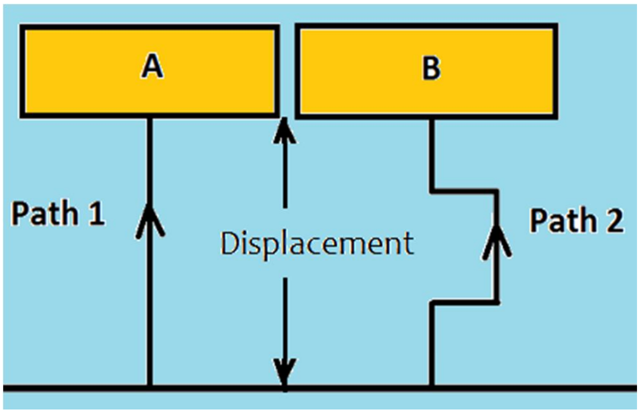

Fig.14.4

The gravitational energy does not depend upon the distance traveled by the object, but the displacement i.e., the difference between the initial and the final height of the object. Hence, the path along which the object has reached the height is not taken into consideration. In the example shown above, the gravitational potential energy for both the blocks A and B will be the same as shown in **Fig.14.4.**

14.4. REFERENCE LEVELS FOR GRAVITATIONAL POTENTIAL ENERGY

The reference level is important for gravitational potential energy, it's important to choose a location at which to set that energy equal to zero. The choice is completely arbitrary because the important quantity is the difference in potential energy, and this difference will be the same regardless of the choice of zero levels. However, once this position is chosen, it must remain fixed for a given problem. While it's always possible to choose the surface of Earth as the reference position for zero potential energy, the statement of a problem will usually suggest a convenient position to use.

Consider a book at several possible locations, as shown in the adjacent picture. When the book is at A, a natural zero level for potential energy is the surface of the desk. When the book is at B, the floor might be a more convenient reference level. Finally, a location such as C, where the book is held out a window, would suggest choosing the surface of Earth as the zero levels of potential energy. The choice, however, makes no difference: Any of the three reference levels could be used as the zero levels, regardless of whether book is at A, B, or C.

14.5. EXAMPLE OF GRAVITATIONAL ENERGY IN ACTION

Gravitational energy is the energy associated with gravity. It is the energy stored in an object due to its height above the Earth. It is also the potential energy stored by an object because of its higher position compared to a lower position. Gravity is a force that tries to pull two objects toward each other. Gravity holds everything close to this planet. Trees, water, animals, buildings, and the air we breathe are all held here by gravity. The planets, their moons, and the stars in the universe have gravity. Even our bodies have gravity. The Earth's gravity is far stronger than our own so we don't notice the gravity our bodies have. The Earth's tides are caused by the moon's gravitational pull on the oceans. Systems can increase gravitational energy as mass moves away from the center of the Earth or other objects that are large enough to produce significant amounts of gravity (like our Sun, the planets, and stars).

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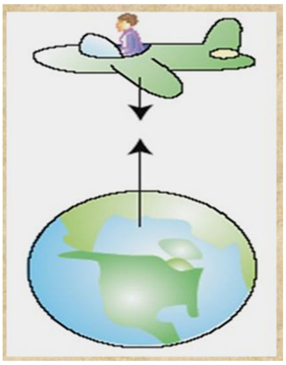
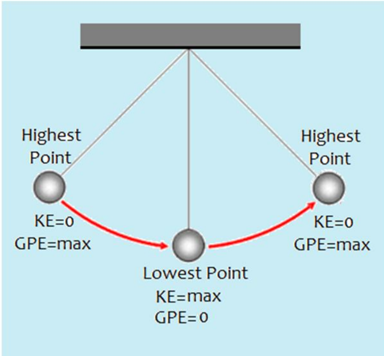
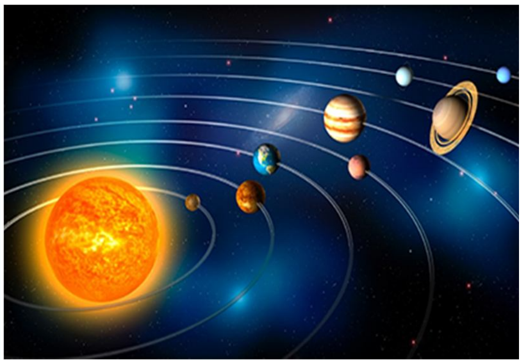
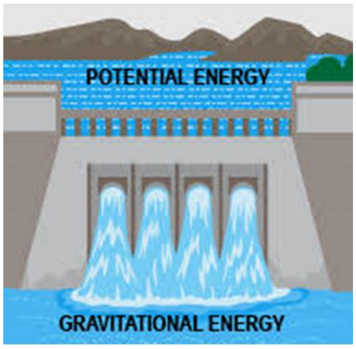





The airplane's stored energy is due to its elevated position in a region where there is gravity. This type of potential energy is called gravitational potential energy. A pendulum is a simple machine for transferring gravitational potential energy. When the bob is at the highest point of its swing, it has no kinetic energy (KE), but its gravitational potential energy (GPE) is at a maximum. As the bob swings downwards, the bob's KE is at a maximum and its GPE is at a minimum. Our planetary system works on gravitational potential energy.

Further examples are a large boulder at the edge of a cliff, roller coasters, a skateboard on the top of a ramp. Water atop a dam has gravitational potential energy, but the water did not get into its position at the top of a dam without some agent doing work. The Earth, the Sun, planets, and stars all produce significant amounts of gravity.

14.6. GRAVITATIONAL BINDING ENERGY

Gravitational binding energy is the minimum energy that must be added to a system for the system to cease being in a gravitationally bound state.

We know that if a particle of mass m placed on the earth is given energy $\frac{1}{2}mu^{2} = \frac{GmM}{R}$ or more, it finally escapes from earth. The minimum energy needed to take the particle infinitely away from the earth is called the binding energy of the earth-particle system. Thus, the binding energy of the earth-particle system is $\frac{GmM}{R}$

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CHAPTER.15

GEOTHERMAL ENERGY

15.1. INTRODUCTION

Geothermal is a renewable source of energy in the form of heat at the interior of the Earth. The detailed study of geothermal phenomenon begins in the 19th century. The interior of the earth consists of different physical, chemical conditions, and composition. Depends on physical, chemical conditions, and composition the energy is released in the form of heat from the interior of the earth called geothermal energy. The temperature (heat) is increased with respect depth of the earth. Even in the crust part of the earth heat is present in large amounts in inexhaustible form. The heat is dissipated from the interior of the earth and transfer toward the surface of the earth.

The temperature of the earth increases concerning depth therefore there is a heat gradient (geothermal gradient) that exists between different layers of the earth (Average 30^{0}C/Km) in the lithosphere. There are several places in the interior of the earth where the geothermal gradient in above-average value. In most of those places, the rocks are found to be in the molten form called 'magma'. When this 'magma' erupted on earth's surface it gets solidify by cooling and releasing energy in the form of heat.

The heat can be extracted from hot spots (where magma exist) using heat carrier and can be utilized for different applications. The heat carrier transfers heat from beneath (interior) of the earth to the surface of the earth. The heat is transfer through heat carrier by

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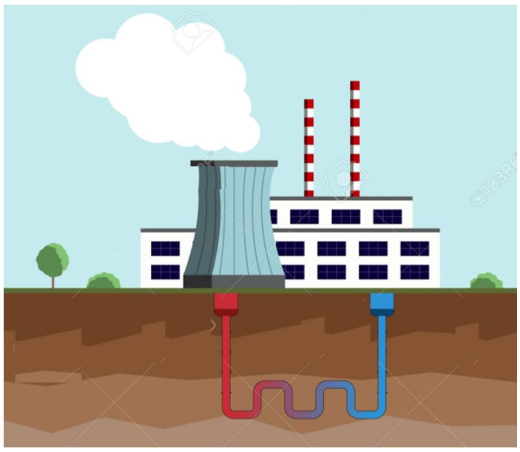
conduction, convection, and radiation. Generally, geothermal fluid e.g. rainwater penetrated through drilling hole. When the water in contact with hot rocks get heated and accumulated in reservoirs. The reservoirs are at high pressure and temperature under the beneath of the surface of the earth. The reservoirs are the most important part of the geothermal field. The reservoirs are generally covered with impermeable rocks so it does not allow hot fluids (magma) to come easily on the surface of the earth. By drilling, we can extract hot fluids from the interior and collect geothermal energy (heat).

The geothermal energy i.e. earth's heat is the amount of heat released from the interior of earth on the surface of the earth in the unit area in a unit time. The S.I. unit of geothermal energy is milliwatt/m^2. The geothermal energy (heat) varies from place to place and also with respect time in the same place.



In the interior of the earth, heat is produced mainly due to the presence of radioactive substances such as Thorium, Uranium, and Potassium. These radioactive substances decay by transforming parent atom into a daughter atom by releasing energy in the form of heat. The average heat flows from the interior of the earth to space is 50 to 70 mW/m^2, worldwide (the heat striking from the sun on the earth is 342 Watts/m^2).

15.2. THE EARTH ACTS AS A HEAT ENGINE (GEOTHERMAL ENERGY SOURCE)

Earth is formed approximately 4.5 billion years ago measured by the radioactive decay method. At the beginning when earth formation starts the earth is very hot then earth cooled by emitting heat. The earth is a very dynamic object because many activities are happening on the surface and at the interior of the earth like volcanos, earthquake, plate tectonic movement, etc. during this geological process the energy is released in the form of heat on the surface of the earth called as geothermal energy. The presence of volcanoes at the interior of the earth is the most important source of heat.

15.2.1. Origin of geothermal energy

Earth is formed by accretion of solar nebula when dust and gases are collided and aggregated. This aggregated material consists of light minerals like silicates which formed the uppermost layer of the earth called the crust. The heavy minerals like iron accumulated and formed the central part called the core of the earth. The middle layer is called a mantle. The thickness of the mantle part is about 2890 km. The mantle part tends to be composed of Silicate minerals, Oxides, and other high-density minerals which as a small atomic radius like

Magnesium (Mg), Calcium (Ca), Titanium (Ti), Aluminum (Al) etc. Due to the accretion process of the earth the pressure and temperature of the interior increase.

The primary solar nebula also consists of some radioactive elements. When radioactive elements decay it transform from parent to daughter by releasing energy in the form of heat. There are several radioactive processes possible like alpha decay, beta decay, gamma decay, and electron capture. When emitted particles are colliding with surrounding atoms then the kinetic energy of the particle gets to transform into heat and which is increases the local temperature at that place.

The accretion and radioactive heating temperature and pressure of the interior of earth increases and when it is more than the melting point of iron then iron is get melted. The density of iron is more than silicates therefore it is migrated toward the center of the earth. This migration process also contributes to increasing the temperature of the interior of the earth. When iron is migrated toward the center it is transformed from higher gravitational potential to lower gravitational potential by releasing gravitational potential energy.

At the beginning (i.e. up to the age of the planet was 30 million years) the core of the earth is in liquid form. The earth is slowly cooled and forms a solid inner core with a liquid outer core. The solid inner core has a radius up to 1221 Km and outer core extended up to 3480 Km, the temperature of the inner core is up to 5700Kelvin and the outer core is up to 4000Kelvin, because of high pressure at the mantle. The mantle accommodates a large number of atoms per unit volume. Therefore, the mantle part rarely accommodates large radius atoms like Uranium (U), Thorium (Th), Rubidium (Rb), Potassium (K), etc. i.e. it is excluding large atomic radii. The part floating on mantle called the crust.

There are two types of crust

1. Oceanic crust -Thickness of the oceanic crust is up to 6 to 10 Km.
2. Continental crust - Thickness of the continental crust is up to 30 to 60 Km.

Oceanic crust is formed from convection activities happening at the mantle part. The oceanic crust formed from magma continuously coming from the mantle. Therefore, radioactive atoms are rarely formed in oceanic crust. The continental crust consists of lower density minerals which are incompatible with a mantle. Therefore, radioactive minerals like U, Th, Rb, K can easily suit in the continental crust. The abundant amount of radioactive elements is found in continental crust compared to the mantle and oceanic crust. Therefore, continental crust is a global reservoir of radioactive minerals. Nearly 60 percent of heat exists in continental is due to radioactive activities happening in the continental crust.

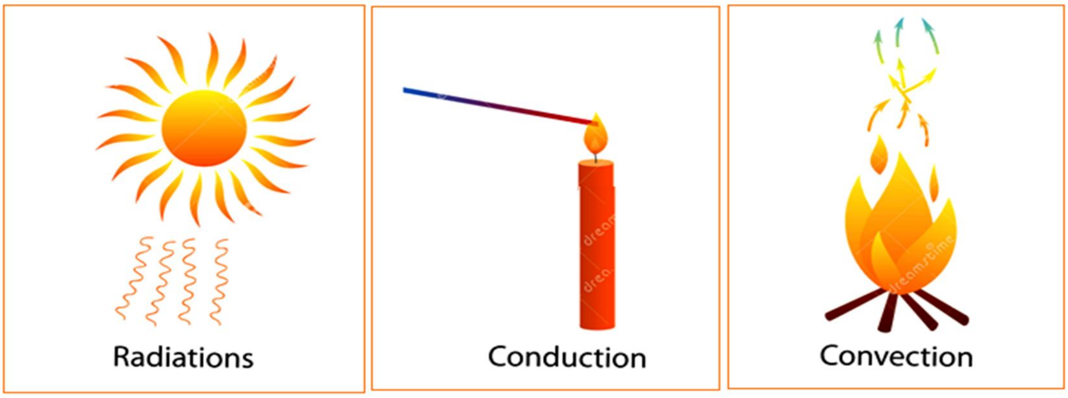
15.2.2. Different ways to transfer heat in the earth

The heat cannot hold at a point where it is generated. Heat always transfers from one place (hotter body)to other (cooler body). There are three major mechanisms through which heat is transfer from one place to another.

1. Radiation, **2.** Conduction, and **3.** Convection

1). Radiation

Heat transfer from one place to another by radiating thermal photons. The thermal photons are similar to light photons. The wavelength of the thermal photon is higher than the light photon in the infrared region of the EM spectrum. The heat transfer due to radiation is very small because most of the earth's materials opaque to infrared radiation.



2). Conduction

The transfer of heat is due to direct physical contact. This is a diffusion process in which heat transfer without transforming mass. The atoms of the material contribute to the transfer of the heat from one atom to another without moving. Here due to thermal energy the atomic vibrational energy changes and transfers the heat from one place to another.

3).Convection

In conduction heat is transferred from one place to another without a moment of mass. However, in some places, hotter material moves from a hot region to a cold region by carrying heat along with it. Therefore, convection is a combination of transfer of heat by mass movement as well as by heat conduction.

15.2.3. Plate tectonic movement and distribution of geothermal energy resources

In 1921, the theory of plate tectonic movement i.e. continental drifts firstly studied by Alfred Wegner. The part of the crust floating on a semi-molten layer called the asthenosphere. When the earth was formed and solidify all continental crusts are together. But due to convection current loops formed at the asthenosphere, the single continental crust gets divided into several parts called continental plates. These continental plates are moving away from or towards each other or transforming with each other called plate tectonics.

During the second war, the geologist appointed to search for hidden places or to detect submarines. They have done oceanic surveys and found that the middle part of the ocean is not deep they exist some mountains called mid-oceanic ridge. On either side of the oceanic ridge, the symmetric magnetic anomalous pattern is observed. They predicted that 'magma' continuously erupted at the mid-ocean ridge and spread uniformly on both sides of the mid-ocean ridge. This upwelling of 'magma' from the mantle is due to convection current loops formed in the asthenosphere. The upward flow of hot magma from mantle balanced by down welling flow of old crust part at the region called a subduction zone.

Depends on the direction of convection current loops at mantle (asthenosphere) there are three types of plates movement is possible i) Divergence ii) Convergence iii) transformation. As we noted the convection is the transfer of heat by conduction as well as due to flow of mass. Very high heat flow from the interior (mantle) to the surface of the earth take place at the spreading center. The subduction zone is the region of very low heat flow because in this region downwelling moment takes place and cooler material subducts into the mantle. In addition to this, there are some geothermally important locations called hot spots.

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Hot spots are places where magma continuously flows from the mantle to the surface for tens of millions of years to present.

Hence three areas in the earth are important for the distribution of geothermal energy reservoirs. Those areas are spreading centers, hot spots, and subduction zone. Among these three locations, the hot spots are important for geothermal energy sources. Iceland and Hawaii are two main locations on the earth in which hot spots exist.

15.3. USES OF GEOTHERMAL ENERGY

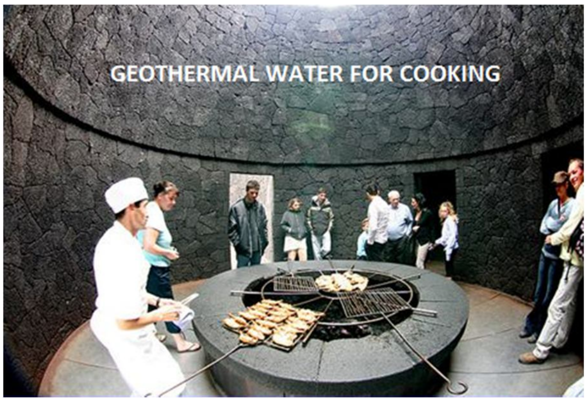
Geothermal hot water can be used for many applications that require heat. Its current uses include heating buildings (either individually or whole towns), raising plants in greenhouses, drying crops, heating water at fish farms, uses for cooking, heat pump, and several industrial processes, such as pasteurizing milk.

15.3.1. Directly heated water from the ground

a) The directly heated water from geothermal resources directly uses to household purposes like bathing, washing, etc. The steam generated from heated water used to warm buildings. Geothermal resources also used to heat swimming pools, aquaculture ponds, spas, etc.

b) The direct geothermal energy uses for cooking, drying fruits, vegetables.

c) The geothermal energy uses for milk sterilization.



15.3.2. Electric power generation

Geothermal energy can use to generate electricity. The electricity from geothermal energy can be produced by using the following three methods. i.e. power plants can have operated in three different ways.

A]. Dry steam operation method

In this method, the steam is generated from the ground impose on the turbine. Then the turbine operates an electrical generator. The following **Fig.15.1** shows dry steam geothermal power plant.

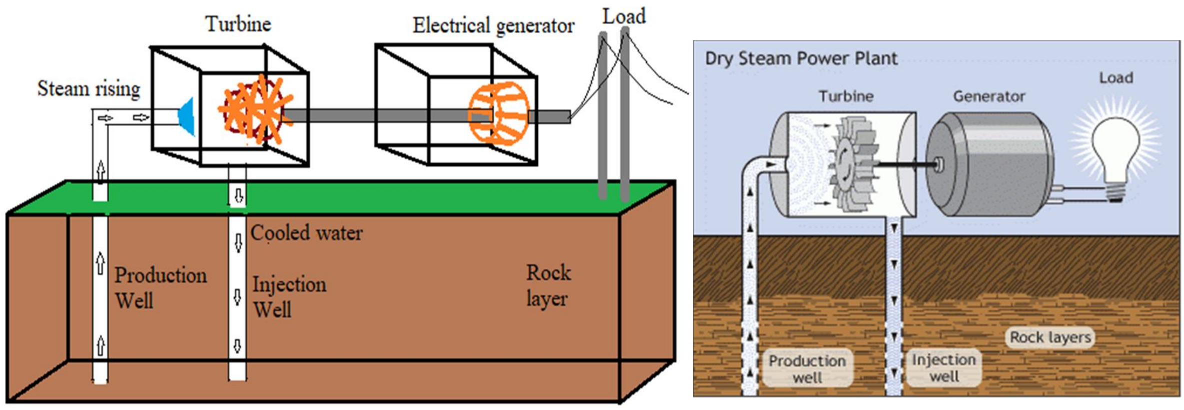


Fig.15.1: Dry steam geothermal power plant

B]. Flash steam operation method

In this method, the highly pressurized with high-temperature water extracted from the ground through the pipe and it is collected into the tank on the surface of the earth called flash tanks. The pressure of the water suddenly decreases and produces water steam. The steam generated uses to operate the turbine and generator. **Fig.15.2** shows flash steam geothermal power plant.In this method wet steam (i.e. a mixture of steam and hot water) extracted from the ground to operate the turbine - electrical generation process.

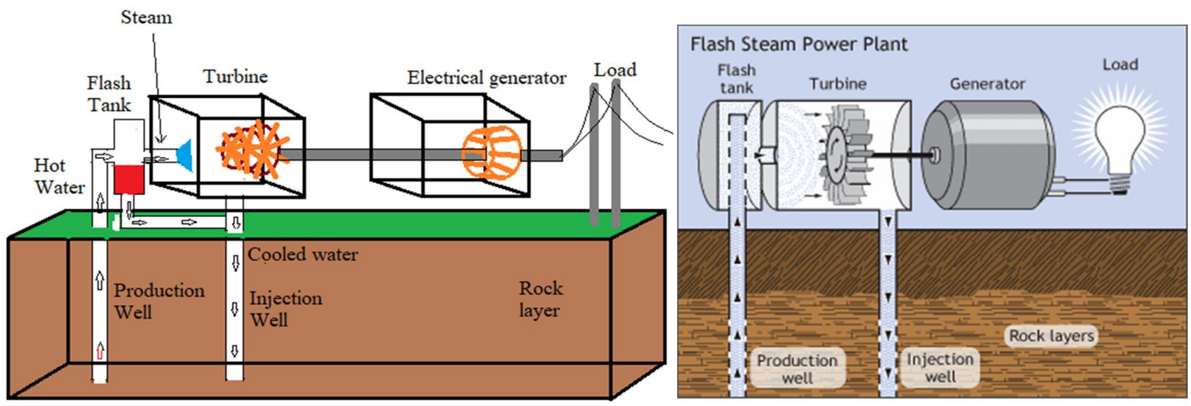


Fig.15.2: Flash steam geothermal power plant

15.3.3. Geothermal heat pumps (GHPs)

In the lithosphere, the rocks and groundwater found at the temperature are in between 5 to 30^{0}C. The temperature of the lithosphere (crust) is constant up to 10 to 16 ^{0}C within the depth of 6 meters from the surface of the earth. Most of the geothermal heat pumps (GHPs) are constructed within this depth. In the summer season, the warm air can be transfer into the ground under the building. In the winter season, the temperature of the building decreases below-ground temperature. Therefore, heat from ground uses for warming purposes in the winter season.

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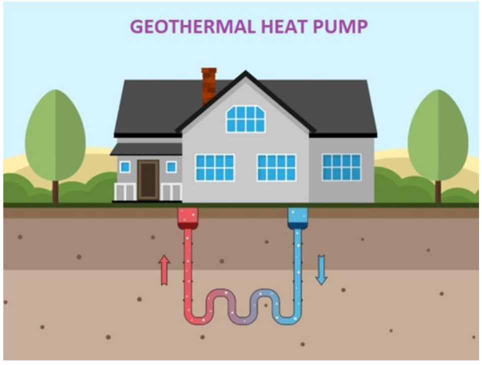
GHPs consist of a heat exchanger and pump. The fluid is circulating through pipes that transfer heat from ground to air or vice versa. Generally, the fluid used to circulate through the pipe is water. GHP is efficient and has less power consumption. It saves electricity up to 25-50 percent. It produces less pollution. It reduces greenhouse gas emissions up to 72 percent compared to electric resistance heating method or air conditioning system.



15.4. ADVANTAGES AND DISADVANTAGES OF GEOTHERMAL ENERGY

15.4.1. Advantages of geothermal energy

1) GE is a renewable source of energyand it is a lifelong till the earth is destroyed.
2) GE is more environmentally friendly compared to conventional energy sources like coal, fossil fuels. It emits less CO_2 and other hazardous gases compared to fossil fuels.
3) Geothermal is a more sustainable and reliable source of energy compared to other renewable sources like wind and solar energy. This source is available at any time does not depends on environmental or weather conditions.
4) We can utilize whole reservoirs in the interior of the earth then geothermal energy has huge potential to provide energy worldwide.
5) GE is a naturally occurring source of energy that does not require any fuel.
6) Now a day lots of modifications and technologies are used to improve the geothermal energy process. The worldwide numbers of geothermal energy project are increases and rapid evolution take place.

15.4.2. Disadvantages of geothermal energy

1) GE is available at a specific location. Geothermal plants built in those areas where accessible energy is available. We built plants at those places where hot spots are found. Therefore, geothermal energy is location restricted.
2) GE plants do not emit greenhouse gases directly into the environment but it is stored under the interior of the earth. These gases will release in the atmosphere during digging or mining. There is a slight side effect on environment.
3) At digging places of the geothermal energy plants, there is an alteration of earth structure which may cause earthquakes.
4) For the sustainability of geothermal energy, there is a need to pump geothermal fluid faster than it is depleted into the heat reservoirs.

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CHAPTER.16

HYDRO ENERGY

16.1. INTRODUCTION

Earth is a beautiful planet in our solar system. The beauty of the earth is due to only water on its surface. If we look at the picture of the earth is taken from space appear blue. The blue colour is due to 71% of the earth's surface is covered with water. Almost all the water on the earth is contained in the seas and oceans, rivers, lakes, ice caps, as groundwater and the atmosphere. The quantity of water that exists on our planet, roughly 97.5 % is saltwater and less than 2.5 % is fresh water. Water is a gift of nature and we should use it for many purposes. Out of the many applications of water, one is to generate electricity, the electricity generated by using water is called hydroelectricity.

Hydropower (hydro meaning water) is an energy that comes from the force moving water. The fall and movement of water is part of a continuous natural cycle called the water cycle. Hydroelectric energy, also called hydroelectric power or hydroelectricity, is a form of energy that harnesses the power of water in motion-such as water flowing over a waterfall-to generate electricity. Hydroelectric energy is a form of renewable energy that uses the power of moving water to generate electricity.

Water energy can be defined as the energy that is derived from water, generally through its motion. A common example of water energy is hydroelectricity, which derives power from the water that flows over dams. Another important example of water energy is the energy known as tidal energy. The kinetic energy of flowing water is often referred to as

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hydraulic energy. This hydraulic energy is converted into mechanical energy, and then into electrical energy. The hydroelectric power generator is shown in the following **Fig.16.1.**

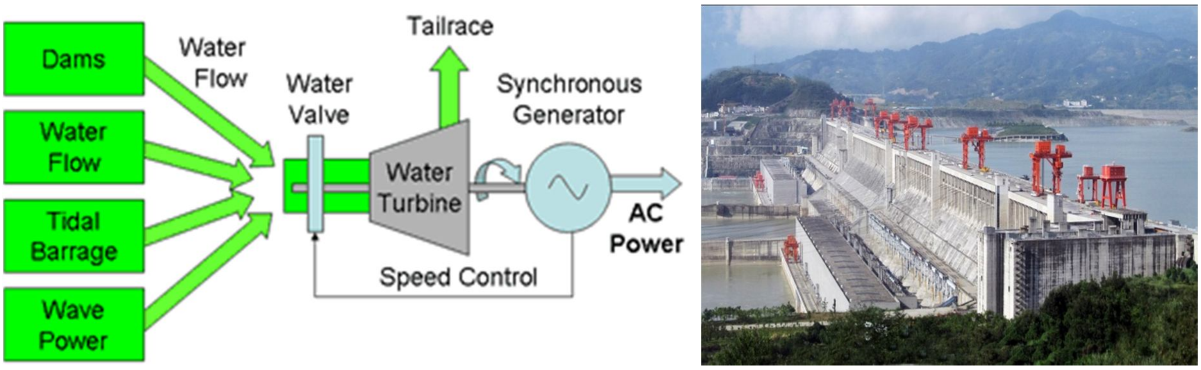


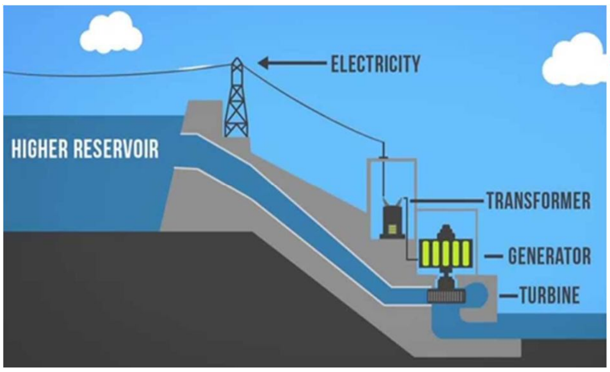
Fig. 16.1: Hydroelectric power generation

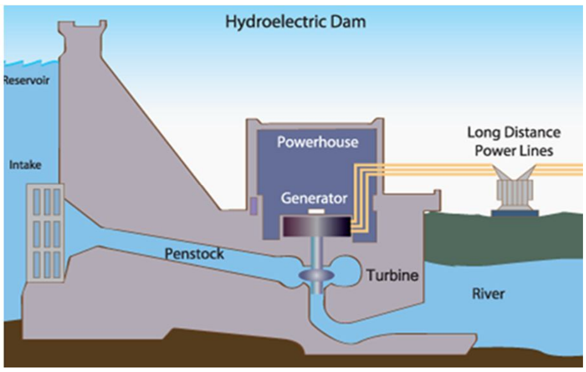
Typically, water energy is harnessed by making a large volume of water flow from a higher altitude to a lower altitude. Water energy is a clean, renewable source of energy. For conversion of water energy to electrical energy, we have to know the basic term related to it.

Turbines: A turbine is a rotatory mechanical device that extracts kinetic energy in various forms and converts it into useful work. It uses a dynamo to convert this mechanical energy into electrical energy. Various uses of this have been implemented in power plants where the shaft of the dynamo is made to rotate.

Hydropower plants: Another traditional source of energy is from the kinetic energy of flowing water or harnessing the potential energy of water falling from a height. The falling or flowing water moves the turbine, which with the help of a dynamo converts mechanical energy into electrical energy. Hydropower plants are usually constructed near dams or waterfalls.

Dams or reservoir: A dam is a barrier that impounds water or underground streams. The water is ejected upon requirement by the power plant to generate hydroelectricity.





Hydroelectricity refers to the generation of electrical power by the use of hydropower. Hydropower here mainly is the gravitational force of falling water. This does not use any water in energy production. The flow of the water from a height causes the rotation in the turbines, but more on that later. Coming back to hydroelectricity, it is the most widely used form of renewable energy accounting for 3% of the world's total energy consumption. The cost of hydroelectricity is relatively low, giving it a competitive edge as a source of energy. The average cost of electricity for a large hydropower plant is very less. The production of hydroelectricity in the hydro-power plant is described below.

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16.2. HYDRO-POWER PLANT (OR HYDROELECTRIC POWER PLANT)

A power plant that produces electricity by using flowing water to rotate a turbine (which drives the generator), is called hydro-power plant or hydroelectric power plant. The electricity produced by using the energy of falling water or flowing water is called hydroelectricity. A hydro-power plant produces electricity as follows. Rain falling on the high ground in hilly areas is flows down like rivers.

To produce electricity, a high-rise dam 'D' is built to stop the flowing river water (**Fig.16.2**). Due to this, a large lake or reservoir 'R' builds up behind the dam. As more and more water collects in the reservoir, the level of water behind the dam rises to a large height. In this way, the kinetic energy of the flowing river water is converted into the potential energy of water stored behind the dam. Thus, the water stored behind a tall dam has a lot of potential energy due to its great height.

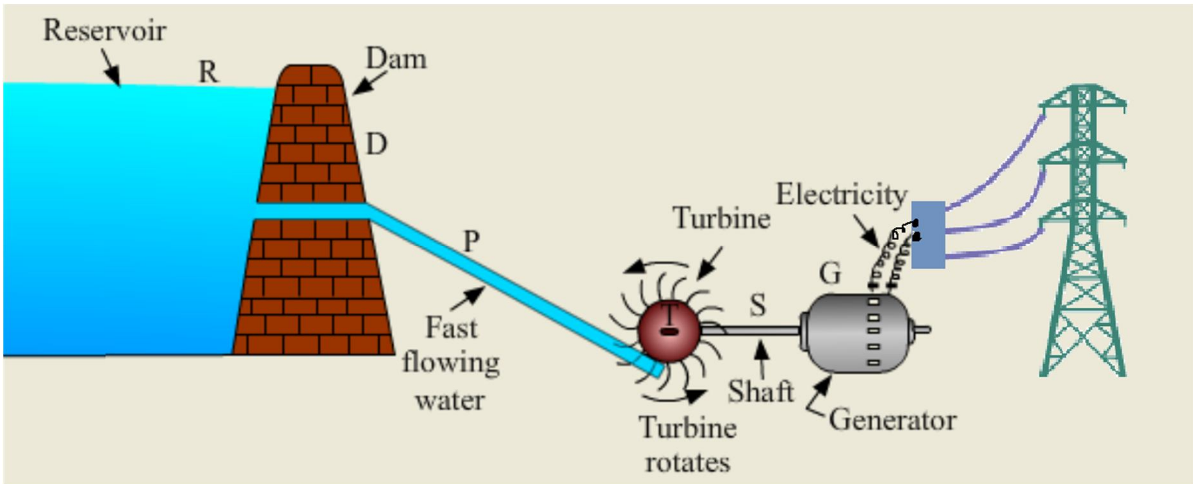

Fig. 16.2: Hydroelectric power plant

The sliding gates at half the height of the dam are opened to allow some of the stored water to escape. This water is taken through pipe 'P' to the turbine 'T' installed at the bottom of the dam. Since the waterfalls down through a large height from the dam, it flows very fast (its potential energy is changed into kinetic energy). A high-pressure jet of fast-flowing water pushes on the blades of the turbine with a great force and makes the turbine rotate rapidly. The turbine is connected to the generator through its shaft 'S'. When the turbine rotates, its shaft also rotates and drives the generator. The generator produces electricity.

Dam and Reservoir

Inside a hydroelectric power plant

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When the hydroelectric generator works and produces electricity, water flows out of the dam continuously and the level of water in the reservoir falls slowly. The reservoir is filled up again by the rainwater brought in by the rivers. Water in the dam reservoir needed for generating electricity is refilled each time it rains; therefore, hydroelectric power is a renewable source of energy. It will never get exhausted. Another point to be noted is that water to the turbine is taken from a point midway up the dam (see **Fig.16.2**) so that the generators continue to work even if the water level in the reservoir falls below normal.

A hydro-power plant converts the potential energy of water stored in the reservoir of a tall dam into electric energy. The dams for generating hydroelectricity can be built only in a limited number of places, usually in the hilly areas or at the foothill (where the water can fall from a considerable height). At present, of the total electric power generated in our country, almost one-fourth is contributed by hydroelectricity.

16.2.1. Factor affecting on hydropower plant

The amount of electricity a hydropower plant produces depends on two factors:

How Far the Water Falls:

The farther the waterfalls, the power is greater. Generally, the distance that the waterfall is depends on the size of the dam. The higher the dam, the farther the waterfalls and the more power it has. Scientists would say that the power of falling water is directly proportional to the distance it falls. In other words, water falling twice as far has twice as much as energy.

Amount of Water Falling:

More water falling through the turbine will produce more power. The amount of water available depends on the amount of water flowing down the river. Bigger rivers have more flowing water and can produce more energy. Power is also directly proportional to the river flow. A river with twice the amount of flowing water as another river can produce twice as much energy.

16.3. ADVANTAGES AND DISADVANTAGES OF HYDROELECTRICITY

16.3.1. Advantages of generating hydroelectricity

The advantages of using the energy of flowing water for the generation of electricity are the following.

1. The generation of electricity from flowing water does not produce any environmental pollution. Hydropower is fueled by water, so it's a clean fuel source, meaning it won't pollute the air like power plants that burn fossil fuels, such as coal or natural gas.
2. Flowing water is a renewable source of electric energy that will never get exhausted. The energy generated through hydropower relies on the water cycle, which is driven by the sun, making it a renewable power source, making it a more reliable and affordable source than fossil fuels that are rapidly being depleted.
3. Hydroelectric power is a domestic source of energy, allowing each state to produce their energy without being reliant on international fuel sources.
4. Impoundment hydropower creates reservoirs that offer a variety of recreational opportunities, notably fishing, swimming, and boating. Most water power installations

are required to provide some public access to the reservoir to allow the public to take advantage of these opportunities.

5. Some hydropower facilities can quickly go from zero power to maximum output. Because hydropower plants can generate power to the grid immediately, they provide essential back-up power during major electricity outages or disruptions.
6. In addition to a sustainable fuel source, hydropower efforts produce several benefits, such as flood control, irrigation, and water supply.

16.3.2. Disadvantages of generating hydroelectricity

The production of hydroelectric power by constructing high-rise dams on rivers has certain problems associated with it. Some of these are given below.

1. Large areas of agricultural land, a vast variety of flora and fauna (plants and animals) as well as human settlements (or villages) get submerged in the water of the reservoir formed by the dam. Due to this many plants and trees are destroyed, animals get killed and many people are rendered homeless. This creates the problem of satisfactory rehabilitation of the people displaced from the dam site.
2. Large eco-systems are destroyed when land is submerged under the water of the reservoir of a dam. The construction of a dam on a river also disturbs the ecological balance in the downstream area of the river. For example, due to the construction of a dam, there are no annual floods in the river. And because of this, the soil of the downstream region does not get nutrient-rich "silt". This decreases the fertility of the soil in the downstream area and finally the crop yields also decrease.
3. Due to the construction of a dam on the river, the fish in the downstream area do not get sufficient nutrient materials due to which the production of fish decreases rapidly (because the fish nutrients remain trapped in the reservoir formed by the dam).
4. The vegetation which is submerged underwater at the dam site rots under anaerobic conditions and produces a large amount of methane which is a greenhouse gas (and hence harmful for the environment). The opposition to the construction of Tehri Dam on the river Ganga and Sardar Sarovar Project on the river Narmada are due to such problems. So, before deciding to generate hydroelectricity by constructing high-rise dams on rivers, it is necessary to consider its long-term effects on the environment and social life carefully. The energy of flowing water is called hydro-energy. The energy of flowing water (or hydro-energy) is an indirect source of solar energy. This is because it is the solar energy that recirculates water in nature in the form of the water cycle. It is this water which then flows in the rivers and makes water-energy available to us.

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CHAPTER.17

TIDAL ENERGY

17.1. INTRODUCTION

The development of living things on earth can't be possible without energy. As we know that the demand for electricity on an electrical grid varies with the time of day. We should think about the sources of energy which is energy is renewable and sustainable among the energy available in the universe. Many of the energy like solar energy, wind energy, thermal energy, tidal energy, etc are the main sources of energy. Tidal Power buildings were built as early as the 9th Century throughout Europe. This building was built in Ohalo, Portugal circa 1280. The history of tidal energy is one that goes further back in time than huge numbers of us may understand. In all actuality, we have since quite a while ago comprehended the intensity of streaming water. In this chapter, the focus is kept on tidal energy which is a clean source of energy.

The supply of electricity from a tidal power plant will never match the demand on a system. But, due to the lunar cycle and gravity, tidal currents, although variable, are reliable and predictable and their power can make a valuable contribution to an electrical system that has a variety of sources. Tidal electricity can be used to displace electricity which would otherwise be generated by fossil fuel-fired power plants, thus reducing emissions of greenhouse and acid gasses.

Tidal power has been used hundreds of years ago in many applications but the concept of producing electricity from tides is relatively new and remains untapped in many countries. The energy is renewable and sustainable. Compared to other forms of renewable

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energies, tidal energy carries more potential because it is predictable. The energy from the nature-the sun, the breeze, waves, tides, and so forth can be changed over into a usable structure. One of these inexhaustible wellsprings of energy is tidal energy. Tides are the waves caused because of the gravitational draw of the moon and sun. This structure up and subsiding of waves happens two times every day causes tremendous development of water. Tidal energy is the usage of the varieties in ocean level caused essentially by the gravitational impact of the moon, joined with the turn of the Earth.


Tidal energy is a manageable asset, which offers numerous advantages and just a couple of disadvantages. Most importantly, Tidal energy is a clean sustainable asset that is more productive than wind energy because of the thickness of water and more effective than sun-powered energy because of its high ~80% transformation proficiency. Tides are likewise more unsurprising than wind energy and sunlight based energy, along these lines progressively dependable. Tidal energy is viable at low tidal speeds, which means that the turbines can turn more slowly, minimizing impacts on local ecosystems. It very well may be a less exorbitant asset, both as far as development and support costs, contrasted with other sustainable power sources. Tidal energy delivers no carbon dioxide, ozone-depleting substances, or waste.

17.2. FORMATION OF TIDE

Tides are a regular phenomenon. They can be anticipated over months and years ahead of time. This is the reason the energy from this gigantic development of water can be tackled and changed over into a usable type of energy. The energy got from the ascent and fall of tides is known as the tidal energy. Tidal energy (tidal power) is typical hydroelectric energy that takes advantage of the tides to generate electricity. The gravitational forces between the moon and sun with the rotation of the earth yield massive tides in our oceans and we can harness that energy to produce electricity.

The gravitational forces of the sun and the moon combined with the rotation of the earth result in an alternate rise and fall of the sea levels. At one particular place, it usually occurs twice on a lunar day. The rise of the sea level is called the high tide, whereas the fall is called the low tide. When the earth and moon's gravitational field are in a straight line, the influences of these two fields become very strong and causing millions of gallons of the water flow towards the shore resulting in the high tide condition. Likewise, when the moon and earth's gravitational fields are perpendicular to each other, the influences of these fields become weak causing the water to flow away from the shore resulting in a low tide condition. The alignment of the Sun and Moon on the tides is shown in **Fig.17.1.**

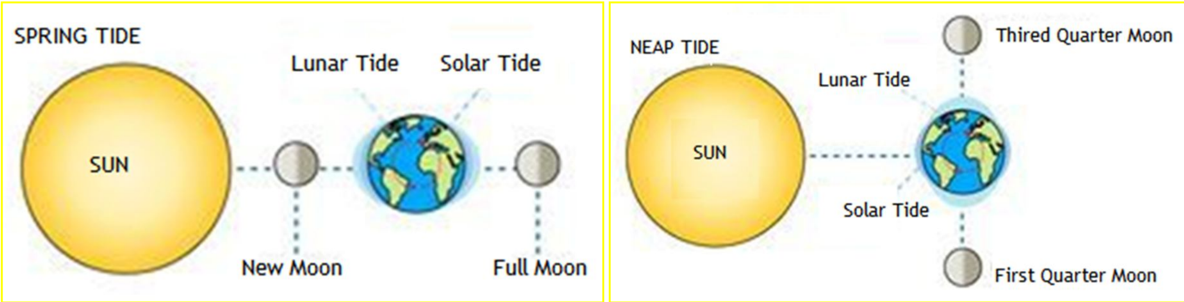

Fig. 17.1: Alignment of the Sun and Moon

When the moon is perfectly aligned with the earth and the sun, the gravitational pull of the sun and the moon on the earth becomes much stronger and the high tides much higher and the low tides much lower during each tidal cycle. This condition occurs during the full or new moon phase. Such tides are known as spring tides. Similarly, another tidal situation emerges when the gravitational pull of the moon and sun are against each other canceling their effects. This results in a smaller difference between the low and high tides due to the smaller pulling action on the seawater, thereby resulting in weak tides. These weak tides are known as neap tides. Neap tides occur during the quarter moon phase.

17.3. WORKING OF TIDAL ENERGY

17.3.1. Tidal turbines

Tidal turbines use similar technology to wind turbines, although their blades are much shorter and stronger, so a good way to think of them is as underwater windmills.

17.3.2. Tidal barrages

This system involves constructing a barrage at the tidal basin or inlet. The barrage is in the form of a tidal reservoir with sluice gates and tunnels underneath to allow water to flow through. Turbines are installed which need an enormous force of tides to turn them and activate the generator to produce electricity. See the picture below which illustrates the structure of the tidal barrage system is shown in **Fig.17.2** (a).

The efficacy of tidal barrage in producing electricity depends on the vertical height difference between the low and high tides. The distance should at least be 10 feet. This falling

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and rising of seawater turn the giant turbines underneath by flowing through them in either direction. Tidal barrages are very similar to the dams in hydroelectric plants, except that they are much larger as they are built across an estuary or bay.

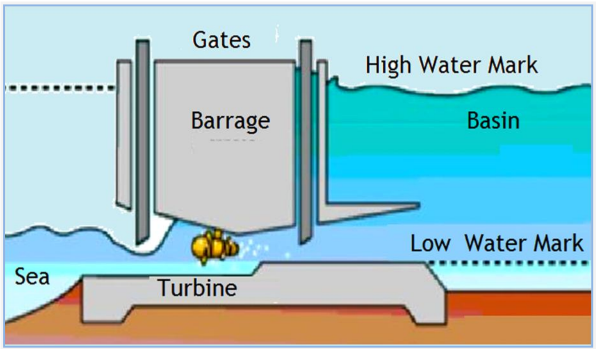


Fig. 17.2 (a): Tidal Barrages

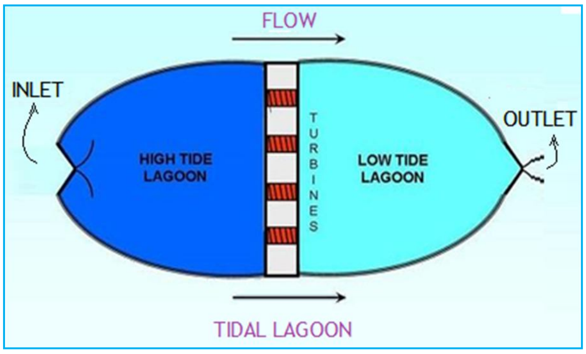


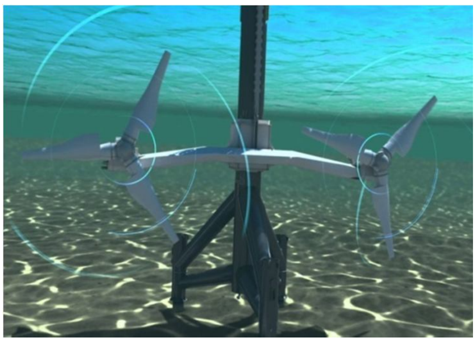
Fig. 17.2 (b): Tidal lagoon

17.3.3. Tidal lagoons

These are the smallest versions of barrages and are available at affordable costs. The structures are also built alongside the ocean and they are filled by the rising of tides and emptied by the falling of tides. When this happens, water can be directed through the turbines which will turn and activate the generator to produce electricity.

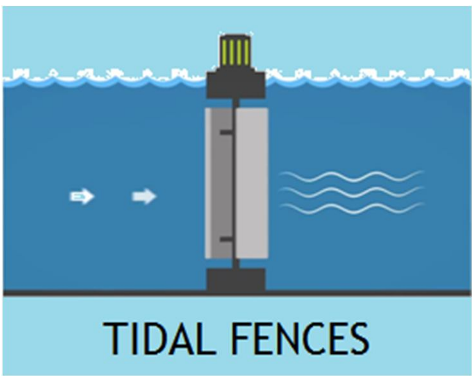
Tidal Lagoons is shown in **Fig.17.2** (b) are similar to barrages but have a much lower cost and impact on the environment. A tidal lagoon is a power station that generates electricity from the natural rise and fall of the tides. Tidal lagoons work in a similar way to tidal barrages by capturing a large volume of water behind a man-made structure which is then released to drive turbines and generate electricity.

17.3.4. Tidal stream (Turbines)



With this system, turbines are installed beneath the seawater instead of building a separate structure as in tidal barrages. These turbines are similar to wind turbines but are much larger because of the higher energy density of seawater compared to air. Storms do not affect tidal turbines just like wind turbines because they are installed below the surface. However, they have small diameters and higher speeds.

17.3.5. Tidal fences



Tidal fences are also forms of tidal energy. They encompass vertical-axis turbines attached to the structure and water is forced through them which will then produce electricity. One of the main challenges is to transport tidal energy from underneath the sea to the grid and eventually to households. Other developing technologies seek to turn tidal energy into hydrokinetic energy which uses the same method of turbines beneath the sea.

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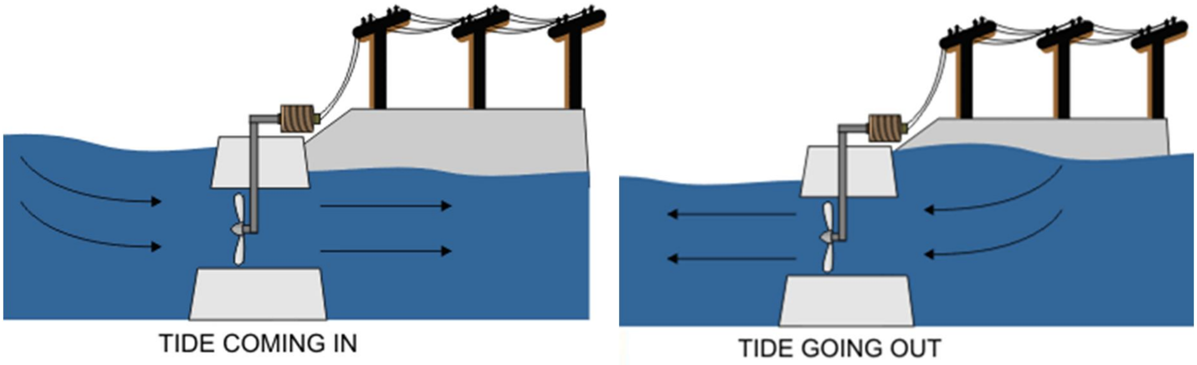
17.4. TIDAL ENERGY APPLICATIONS

There are many uses of tidal energy, and many uses are still being unfolded since the concept is still under development. The common tidal energy examples include electricity production, milling of grains, and energy storage like hydropower

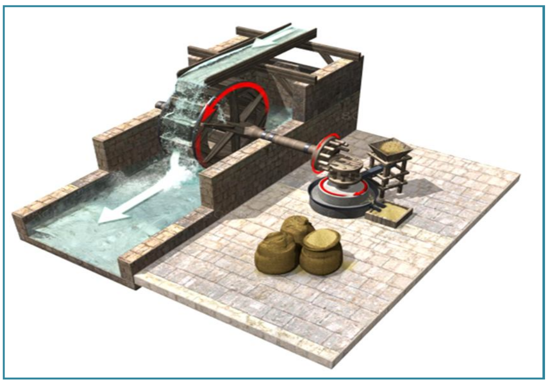
17.4.1. Tidal electricity production

Tidal electricity generation works as the tide comes in and again when it goes out. The turbines are driven by the power of the sea in both directions.



Tidal barrages or dams are constructed across a narrow opening to the sea. Water rushes into the dam when the sea level rises. This moves the blades of the turbines which are attached at the opening of the dam. This results in the generation of electricity. Electricity production through tidal energy is the main application that is harnessed and planned to be improved. France is the first country to leverage on this application by constructing the world's first tidal plant in 1966 with a capacity of 240 MW and 24 turbines. Other countries such as Canada, India, and China have followed suit to harness this power in producing electricity for the end-user. Tidal energy is predictable and powerful even though it is only active for about 10 hours a day.

17.4.2. Milling of grain



For many years ago in history, this application has been common. Much the same way as windmills, the tidal power is used to process grains. The tidal mill impacted the way workers did their jobs in the mills. They were able to produce the same grain without having to do as much work. This invention also provided a cleaner source of energy at the time, which made people want to use tidal mills more.

17.4.3. Energy storage

Just like hydropower, tidal power can be used to store energy for later use. Tidal barrages can be configured to store energy, but this is a concept under development. The storage equipment has maximum maintenance and cost so that energy storage is the main problem after the generation of electricity from any source.

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17.5. ADVANTAGES AND DISADVANTAGES OF TIDAL ENERGY

Like all other renewable and non-renewable energy sources, tidal energy is bound to advantages and disadvantages. The good thing is that its advantages outweigh its disadvantages hence it is a sustainable energy source.

17.5.1. Advantages of tidal energy

1. It is renewable and sustainable
2. No greenhouse gas emissions because only water is used to produce electricity
3. Tidal Energy is clean
4. Inexpensive to operate and maintain
5. Low noise because it is absorbed by water since the turbines are installed beneath the water
6. Tidal power is predictable
7. Does not compromise the movement of ships
8. Government is subsidizing the tidal energy projects

17.5.2. Disadvantages of tidal energy

1. The energy depends on the strength of tides which is also dependent on the gravitational effects of the sun and moon on earth
2. The energy is intermittent. It is only active for about 10 hours a day.
3. Expensive capital costs to install the tidal power plant
4. It can affect sea life
5. It requires giant turbines due to high-energy-density and these turbines are expensive.
6. Maintenance is cumbersome since the turbines are installed underneath the seawater
7. Requires very long cables to transport electricity to the grid
8. It cannot be installed anywhere. It requires strong tides in designated streams
9. Infrastructure can be damaged by strong currents

Tidal energy has the potential for future power age. Tidal energy has endured because of the moderately significant expense and constrained accessibility of destinations for development. Be that as it may, because of the ongoing innovative advancements demonstrating that the financial and natural expenses can be brought down to serious levels, there is by all accounts a brilliant future for Tidal energy age.

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CHAPTER.18

OCEAN ENERGY

18.1. INTRODUCTION

The well-known usage of affordable electricity converted from ocean waves would be a tremendous achievement. Besides that the wave energy converting technology would be particularly interesting, it also would have several important benefits to society, such as:

- It is another sustainable and endless energy source, which could significantly contribute to the renewable energy mix. In general, increasing the amount and diversity of the renewable energy mix is very beneficial as it increases the availability and reduces the need for fossil fuels.
- Electricity from wave energy will make countries more self-sufficient in energy and thereby less dependent on energy import from other countries.
- It will contribute to the creation of a new sector containing, innovation and employment.
- Electricity from an ocean wave can be produced offshore, which thereby does not require land nor has a significant visual impact.

As the world energy needs will keep on increasing while the fossil fuel reserves are depleting, wave energy will become of significant importance. The demand for it will start when its price of electricity will be right and will then only increase with time.

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18.2. WHAT IS OCEAN ENERGY?

Oceans water movement creates a vast store of kinetic energy (energy in motion) in the various forms of renewable energy viz wave energy, tidal energy, ocean current energy, salinity gradient energy, and ocean thermal gradient energy which can be harnessed to generate electricity.

18.2.1. Types of ocean energy

1. **Tidal Energy**
   Like conventional hydroelectric dams, power plants are built on river estuaries and hold back huge amounts of tidal water twice a day which generates electricity when released. India is expected to have 9,000 MW of tidal energy potential.
2. **Wave Energy**
   This is generated by the movement of a device either floating on the surface of the ocean or moored to the ocean floor.
3. **Current Energy**
   It is very similar to the wind above the oceans. Underwater turbines, large propellers tethered to the seabed, are moved with the marine currents to generate electricity.
4. **Ocean thermal energy**
   It is obtained from the temperature difference (thermal gradients) between ocean surface waters and deep ocean waters.

18.3. OCEAN THERMAL ENERGY

A very large area of sea is called an ocean and a sea. The water at the surface of an ocean gets heated by the heat of the sun and attains a higher temperature than the colder water at deeper levels in the ocean. So, there is always a temperature difference between the water 'at the surface of the ocean' and 'at deeper levels.' The energy available due to the difference in the temperature of water at the surface of the ocean and deeper levels is called ocean thermal energy (OTE). The ocean thermal energy can be converted into a "usable form" of energy like electricity.

18.3.1. Ocean thermal energy plant

The devices used to harness ocean thermal energy are called Ocean Thermal Energy Conversion power plants or OTEC power plants. Ocean thermal energy conversion produces energy from temperature differences in ocean waters. A temperature difference of 20°C (or more) between the surface water of the ocean and deeper water is needed for operating OTEC power plants. Ocean thermal energy conversion (OTEC) is a process or technology for producing energy by harnessing the temperature differences also called thermal gradients between ocean surface waters and deep ocean waters. Energy from the sun heats the surface water of the ocean. In tropical regions, surface water can be much warmer than deep water. This temperature difference can be used to produce electricity and to desalinate ocean water. Ocean Thermal Energy Conversion systems use a temperature difference (of at least 77° Fahrenheit) to power a turbine to produce electricity.

Ocean energy is a continuous source of energy. The conversion of ocean energy to electrical energy is shown in the following **Fig.18.1.**

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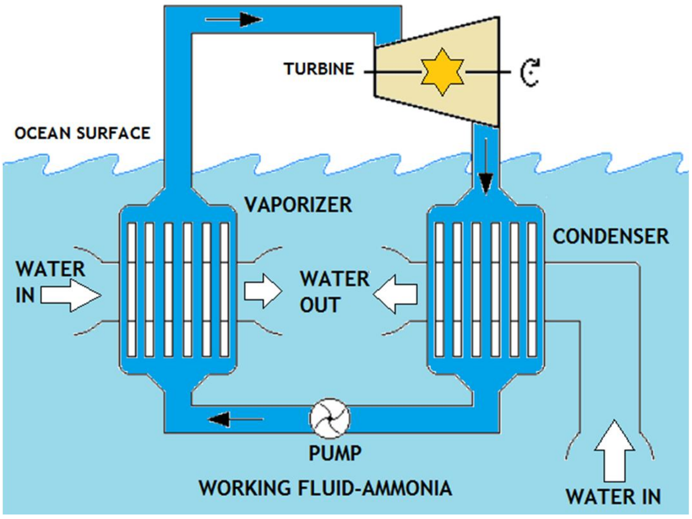

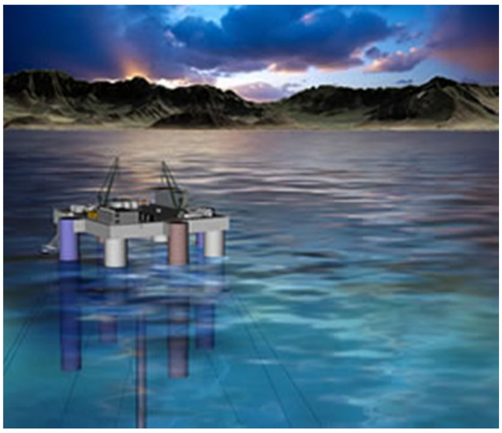

Fig. 18.1: Ocean thermal energy conversion system

An OTE plant generates power without the need for burning fossil fuels. We **know** that this system only requires the temperature difference in the ocean water to produce power. Ocean thermal electric conversion takes in warm water and uses it to boil propene. **I**t does not burn the **propene;** instead only raises its temperatures to enable it to boil. This boiling propene then runs the turbine which in turn generates electricity. This generated power gets transported through an underwater cable to land. The cold deep water gets pumped up by a pipe and used to cool and condense the boiling propene. The propene goes back to boiling, and the cycle renews.

In one type of OTEC power plant, the warm surface water of the ocean is used to boil liquid-like ammonia or a chlorofluorocarbon. The high-pressure vapors of the liquid (formed by boiling) are then used to turn the turbine of a generator and produce electricity. The colder water from the deeper ocean is pumped up to cool the used up vapors and convert them again into a liquid. This process is repeated again and again.

OTEC systems using seawater as the working fluid can use the condensed water to produce desalinated water. The amount of energy created is dependent on the amount of water available to cool or heat the working fluid. Since seawater temperature does not change rapidly, the power output is stable and the prediction of potential power generation is more reliable than many other renewable sources. The seawater pumped in for use at an OTEC plant can be used for many different applications, offsetting the cost of initial pipeline investment. A great advantage of the ocean thermal energy is that it can be used continuously 24 hours a day throughout the year. Another advantage is that ocean thermal energy is a renewable source of energy and its use does not cause any pollution. Please note that wave energy and ocean thermal energy are the two forms in which solar energy manifests itself in oceans. Another point to be noted is that though the energy potential from the sea is very large its large scale exploitation is difficult at the moment.

Physicist Jacques-Arsène d'Arsonval of France first proposed the idea in 1881. The development has been intermittent since, but in response to the recent growth in interest in renewable energy, development has increased in countries such as the United States, France, China, and Japan.

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18.4. THERMODYNAMIC EFFICIENCY

A heat engine gives greater efficiency when running with a large temperature difference. In the oceans, the temperature difference between surface and deep water is greatest in the tropics, although still a modest 20 to 25 °C. It is therefore in the tropics that OTEC offers the greatest possibilities. OTEC has the potential to offer global amounts of energy that are 10 to 100 times greater than other ocean energy options such as wave power. OTEC plants can operate continuously providing a base current supply for an electrical power generation system.

The main technical challenge of OTEC is to generate significant amounts of power efficiently from small temperature differences. It is still considered an emerging technology. Early OTEC systems were 1 to 3 percent thermally efficient, well below the theoretical maximum 6 and 7 percent for this temperature difference. Modern designs allow performance approaching the theoretical maximum Carnot efficiency.

18.5. OTEC WORKING CYCLES

Cold seawater is an integral part of each of the two types of **Ocean thermal energy conversion** systems mainly closed-cycle, and open-cycle.

18.5.1. Open cycle

In the open cycle, warm seawater can be used as the working fluid. When the surface seawater is flashed evaporated it is pumped into a vacuum chamber to produce a spray of the liquid. Making the pressure of the chamber less than the saturation pressure of the spray of the water, it starts to boil. The steam that is produced passes through the turbine to generate electricity. The steam later condensates using the cold seawater and is not returned to the evaporator. This condensation process can be done using two methods: spray cold seawater over the steam or in a surface condenser in which the steam and the cold water do not enter in contact with each other, producing desalinated water. If the condensation is done using the spray method the mix of steam and cold water is discharged back to the ocean, as shown in the following **Fig.18.2.**

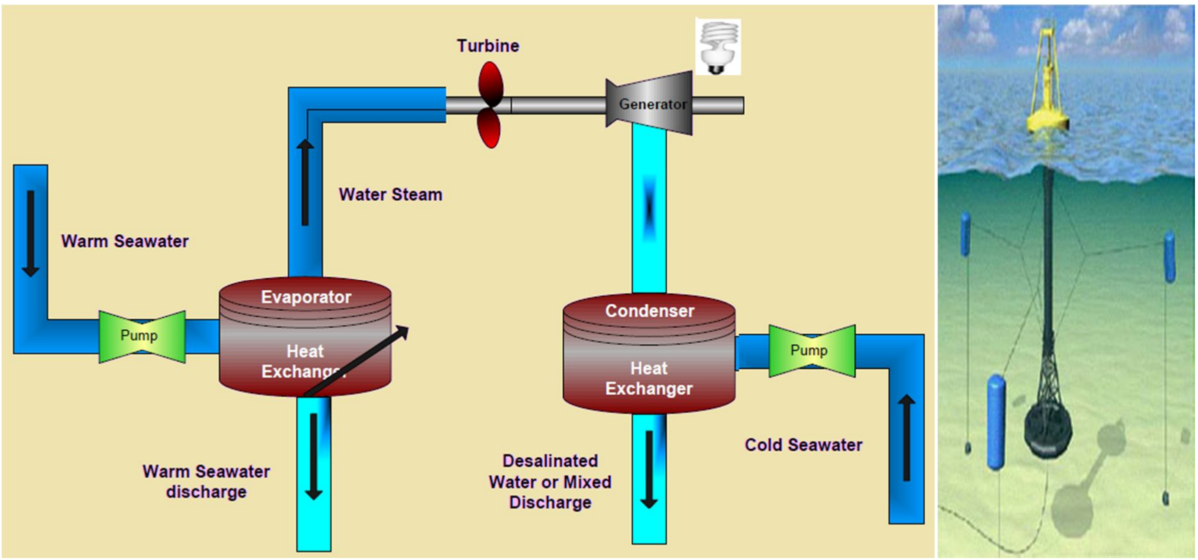

Fig.18.2: The OTEC open cycle

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18.5.2. Closed cycle

In the OTEC closed-cycle, two working fluids work to complete the cycle. First, it is necessary to use warm seawater to vaporize a second working fluid such as ammonia, propane, or a Freon-type refrigerant. This second working fluid will flow through an evaporator (heat exchanger). The high-pressure steam that is produced moves a turbine that is connected to a generator that produces electricity. After the steam moves the turbine, it is condensate using the cold seawater that is pumped from the depths and is pumped back to the evaporator to start the cycle. The turbines that are used in the closed cycle are usually smaller than the ones use in the open cycle because the density and operating pressure of the second working fluid are higher, as shown in **Fig.18.3.**

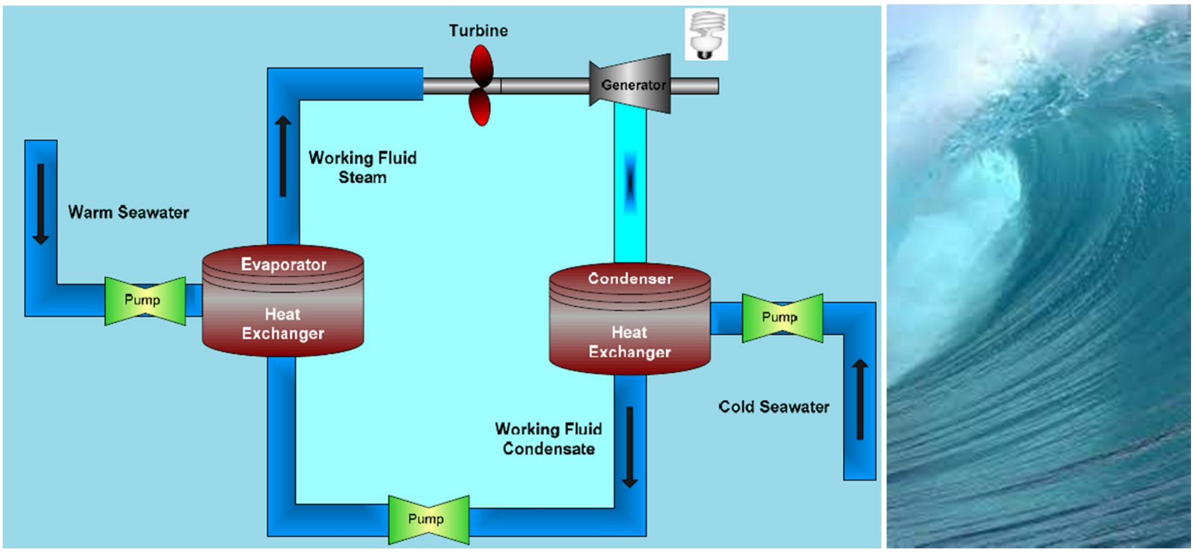

Fig.18.3: The OTEC closed cycle

18.6. APPLICATIONS OF OCEAN THERMAL ENERGY CONVERSION-OTEC

Ocean thermal energy is used for many applications, including electricity generation. Aside from the generation of electricity, it has been proposed that OTEC plants could assist ocean-based industries, such as aquaculture, refrigeration and air conditioning, desalinated water crop irrigation and consumption as well as mineral extraction through the use of the fresh and chilled water byproducts. OTEC has important benefits other than power production.

1. **Air conditioning**

   Air conditioning can be a byproduct. Spent cold seawater from an OTEC plant can chill freshwater in a heat exchanger or flow directly into a cooling system.

2. **Soil agriculture**

   OTEC technology also supports chilled-soil agriculture. When cold seawater flows through underground pipes, it chills the surrounding soil. The temperature difference between plant roots in the cool soil and plant leaves in the warm air allows many plants that evolved in temperate climates to be grown in the subtropics.

3. **Desalination**

   An OTEC plant that generates 2-MW of net electricity could produce about 4,300 cubic meters (14,118.3 cubic feet) of desalinated water each day.

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4. **Mineral extraction**

   An OTEC plant that generates 2-MW of net electricity could produce about 4,300 cubic meters (14,118.3 cubic feet) of desalinated water each day.

In our India, we possess excellent thermal gradients and some of the best sites in the world for harnessing OTEC power India has a potential of exploiting 80,000 MW of OTEC based power. Some of the coastal regions of Tamil Nadu and Andhra Pradesh provide excellent sites for OTEC plants.

18.7. ADVANTAGES AND DISADVANTAGES OF OTEC

Most of us may be aware that about 70 percent of water covers the earth's surface. Water is a source of life and without it, we would not survive and in a world where we almost cannot survive without electricity, the need for more supply of energy grows with each passing day. The problem which arises is that most of our nations produce energy from the traditional burning of fossil fuels. By looking at the advantages and disadvantages of ocean thermal energy, we might change this view.

18.7.1. Advantages of OTEC

1. OTEC uses clean, renewable, natural resources.
2. OTEC plant will not produce carbon dioxide and other polluting chemicals.
3. OTEC can produce freshwater and electricity which is most significant in islands.
4. The source of electricity from OTEC will reduce the complete state dependency on imported fossil fuels.

18.7.2. Disadvantages of OTEC

1. Capital investment is very high. Due to the small temperature difference between the surface water and deep water, the conversion efficiency is very low about 3-4%. The low efficiency of these plants coupled with high capital cost and maintenance cost makes them uneconomical for small plants.
2. OTEC produced electricity at present would cost more than electricity generated from fossil fuels at their current costs.
3. OTEC must be located where the temperature difference of 20˚C occur a year around.
4. Ocean depths must be available fairly close to shore-based facilities for economic.
5. No energy company will put money in this project because it had been tested in a very small scale.
6. Construction of OTEC plants in coastal waters causes localized damage to marine ecosystems.

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CHAPTER.19

BOI-MASS ENERGY

19.1. INTRODUCTION

The dead parts of plants and trees and the waste material of animals are called biomass. Biomass is the organic matter which is used as a fuel to produce energy. Biomass includes wood, agricultural wastes, and cow-dung. Biomass contains chemical energy in the form of carbon compounds. Dried biomass like wood is the oldest source of heat energy which is still widely used as fuel for domestic purposes. Biomass is another form in which solar energy manifests itself. This is because all the plants and trees which provide biomass used the sun's energy to grow. Even the animal wastes like cow-dung are given by cattle consuming plant food made with the help of sunlight energy. Since fuels like wood, agricultural wastes, and cow-dung are all plants and animal products, so they are called biomass (or biofuels). Note that biomass is a renewable source of energy because it is obtained from plants or animals which can be produced again and again.

Biomass is a gift from nature for living things. Biomass refers to the organic material that is used for the production of energy called bio-energy. This energy production process is referred to as Bioenergy. Biomass is primarily found in the form of living or recently living plants and biological wastes from industrial and home use. ‘Waste to Best’ is doing with the help of the production of bio-energy. The wastage from nature used for the production of energy contains mainly wood, animal waste, plant waste, etc.

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19.2. WOOD IS BIOMASS

When wood is burnt, heat is produced. So, wood has been used as a fuel for a long time, wood that is burnt as a fuel is called firewood. Wood is a renewable source of energy. Wood is obtained by cutting down the trees. Now, if we can ensure that enough trees are planted in place of cut down trees, then a continuous supply of firewood can be obtained. The traditional use of wood as fuel has many disadvantages. So that charcoal is a better option for the production of heat energy.

Wood can be converted into a much better fuel called charcoal. Charcoal can be prepared when the wood is burnt in a limited supply of air, then water and other volatile materials present in it get removed and a black substance 'charcoal' is left behind. Thus, wood minus volatile material is charcoal. Charcoal is mainly carbon (C) and used as a fuel for domestic purposes. It is a better fuel than wood.

19.3. COW-DUNG IS BIOMASS

Cow-dung is also known as 'cattle dung' or 'animal dung' or just 'dung'. Cow-dung is the 'excreta' of cattle such as cows and buffaloes, etc. Cow-dung is usually semi-solid. In our villages, dried cow-dung cakes have been traditionally used as a fuel for cooking food. When cow-dung cakes are burnt, they produce heat. This heat is used for cooking food, etc. It is, however, not good to burn cow-dung directly as a fuel

Since there are many disadvantages in using cow-dung as a fuel directly, it is better to prepare biogas (or gobar gas) from cow-dung. This gas can then be used as a smokeless fuel. After extracting the biogas, the spent cow-dung can be used as manure because it still

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contains all the 'nutrient elements' which were present in it initially. Only the organic matter of cow dung is decomposed and converted into biogas. The other elements like nitrogen and phosphorus, etc., remain intact. In this way, nutrients like nitrogen and phosphorus can be returned to the soil in the form of manure.

19.4. BIOGAS

Biogas is not a single gas. It is a mixture of methane, carbon dioxide, hydrogen and hydrogen sulfide. The major constituent of biogas is methane, which is an extremely good fuel. Biogas contains up to 75 percent of methane gas which makes it an excellent fuel. Biogas is produced by the anaerobic degradation of animal wastes like cow-dung or plant wastes, in the presence of water. The calorific value of methane is high. This degradation is carried out by anaerobic micro-organisms called anaerobic bacteria in the presence of water but in the absence of oxygen. Cow-dung and plant wastes contain a lot of complex carbon compounds like carbohydrates, proteins, and fats. The anaerobic bacteria degrade these carbon compounds to form methane gas, which is the main constituent of biogas. Some other gases like carbon dioxide, hydrogen, and hydrogen sulfide are also formed. Cow-dung is known as 'Gobar' is in Hindi laguage. Biogas is popularly known as 'gobar gas', because it is prepare by cow-dung. Now we discuss a biogas plant or gobar-gas plant.

19.5. BIOGAS PLANT

Three main types of simple biogas plants can be distinguished

1. Balloon plants
2. Fixed-dome plants
3. Floating-drum plants

Generally people used Fixed-dome plants for the production of energy and manure.

Structure of a biogas (gobar gas) plant

The biogas plant is a dome-like structure made of bricks and cement. It consists of the following five compartments.

1. **Mixing tank:** Present above the ground level.
2. **Inlet chamber/tank:** The mixing tank opens underground into a sloping inlet chamber.
3. **Digester:** The inlet chamber opens from below into the digester. The digester is a huge tank with a dome-like ceiling that has an outlet with a valve for the supply of biogas.
4. **Outlet chamber/tank:** The digester opens from below into an outlet chamber.
5. **Overflow tank:** The outlet chamber opens from the top into a small overflow tank

Principle: Biogas is produced as a result of anaerobic fermentation of biomass in the presence of water.

The biogas plant consists of a dome-like structure. Organic material such as discarded food residue, fats, sludge, cow dung, etc. are mixed with water and fed to the digester through the inlet pipe as shown in the figure.

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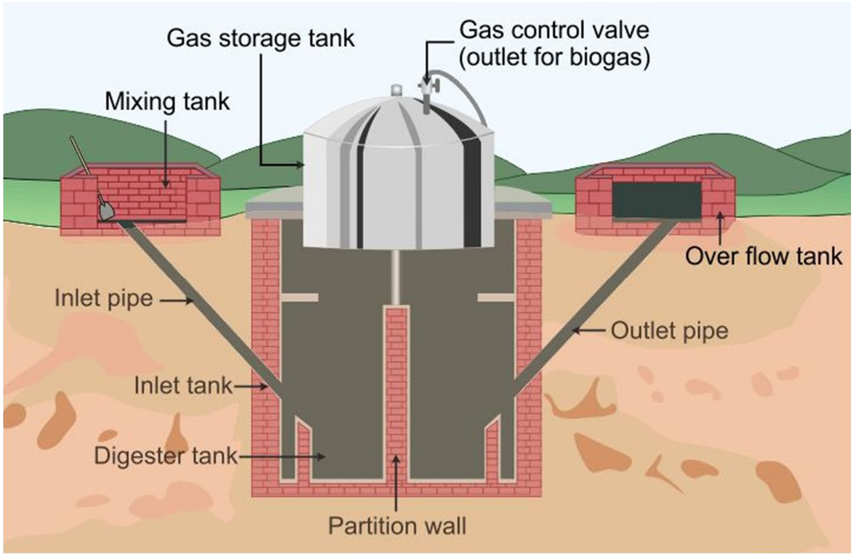

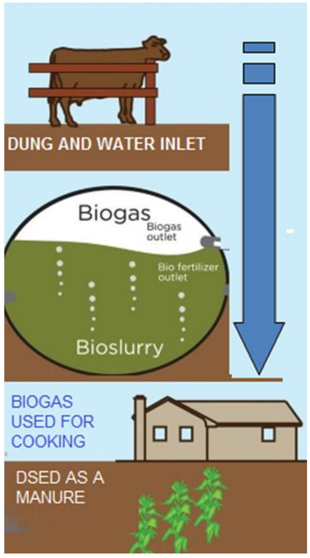

Working of biogas plant

1. The forms of biomass are mixed with an equal quantity of water in the mixing tank.
2. This forms the slurry. The slurry is fed into the digester through the inlet pipe.
3. When the digester is partially filled with the slurry, the introduction of slurry is stopped and the plant is left unused for about two months.
4. During these two months, an anaerobic bacterium present in the slurry decomposes or ferments the biomass in the presence of water.
5. As a result of anaerobic fermentation, biogas is formed, which starts collecting in the dome of the digester.
6. As more and more biogas starts collecting, the pressure exerted by the biogas forces the spent slurry into the outlet pipe.
7. From the outlet pipe, the spent slurry overflows into the overflow tank.
8. The spent slurry is manually removed from the overflow tank and used as manure.
9. The gas valve connected to a system of pipelines is opened when a supply of biogas is required.
10. To obtain a continuous supply of biogas, a functioning plant can be fed continuously with the prepared

19.6. USES OF BIOGAS

Biogas is a renewable source of energy. Since India has a large population of cattle and other farm animals to provide animal dung, therefore, biogas can become a steady source of energy in our rural areas.

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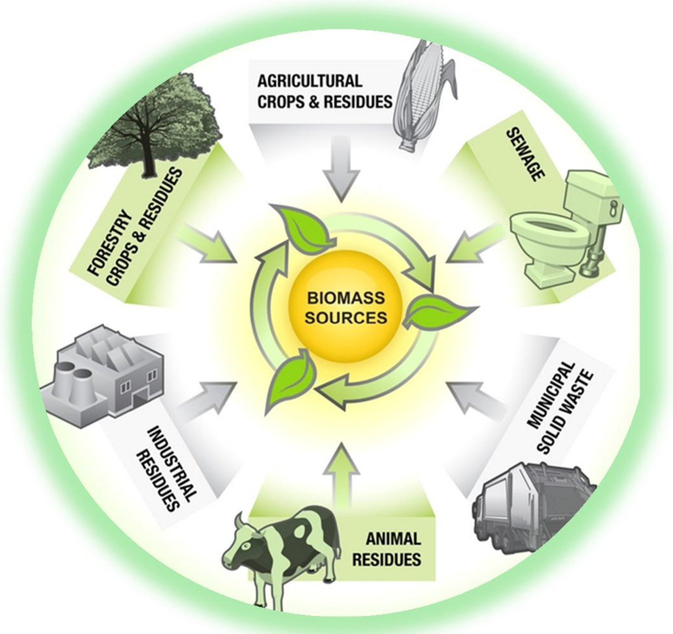
The important uses of biogas are given below

1. Biogas is used as a fuel for cooking food. When biogas is burned, it produces a lot of heat. This heat is used for cooking food and for other domestic heating purposes.
2. Biogas is used as a fuel because it is cheaper than most common fuels.
3. Biogas is also used for lighting.
4. Biogas is used as fuel to run engines. At many places, the engines of water pumping sets used for irrigation are run on biogas, instead of diesel.
5. Biogas is used for producing electricity.

19.7. BIOMASS AND ENVIRONMENT

Biomass is an integral part of Earth's carbon cycle. The carbon cycle is the process by which carbon is exchanged between all layers of the Earth: atmosphere, hydrosphere, biosphere, and lithosphere. The carbon cycle takes many forms. Carbon helps regulate the amount of sunlight that enters the Earth's atmosphere. It is exchanged through photosynthesis, decomposition, respiration, and human activity. Biomass is the material derived from plants that use sunlight to grow which include plant and animal material such as wood from forests, material left over from agricultural and forestry processes, and organic industrial, human, and animal wastes. Biomass energy is a type of renewable energy generated from biological such as, anaerobic digestion or thermal conversion of biomass resources. Biomass comes from a variety of sources which include:



1. Wood from natural forests and woodlands
2. Forestry plantations
3. Forestry residues
4. Agricultural residues such as straw, stover, cane trash, and green agricultural wastes
5. Agro-industrial wastes, such as sugarcane bagasse and rice husk.
6. Animal wastes
7. Industrial wastes, such as black liquor from paper manufacturing
8. Sewage
9. Municipal solid wastes (MSW)
10. Food processing wastes

Biomass conversion systems reduce greenhouse gas emissions in two ways. Heat and electrical energy is generated which reduces the dependence on power plants based on fossil fuels. Biomass energy plants are highly efficient in harnessing the untapped sources of energy from biomass resources and help in the development of rural areas.

19.8. ADVANTAGES AND DIS-ADVANTAGES OF BIOMASS ENERGY

Biomass energy is a growing source of energy around the world. It can be produced from many types of organic matter and the product can be used to provide a cleaner alternative to traditional electricity and transportation fuel sources.

However, there are advantages and disadvantages associated with biomass energy.

19.8.1. Advantages of biomass energy

1. Biomass is a clean, renewable energy source. Its initial energy comes from the sun, and plants can regrow in a relatively short amount of time. Trees, crops, and municipal solid waste are consistently available and can be managed sustainably.
2. If trees and crops are sustainably farmed, they can offset carbon emissions when they absorb carbon dioxide through respiration. In some bioenergy processes, the amount of carbon that is re-absorbed even exceeds the carbon emissions that are released during fuel processing or usage.
3. Many biomass feedstocks, such as switch grass, can be harvested on marginal lands or pastures, where they do not compete with food crops.
4. Unlike other renewable energy sources, such as wind or solar, biomass energy is stored within the organism and can be harvested when it is needed.

19.8.2. Disadvantages of biomass energy

1. If biomass feedstocks are not replenished as quickly as they are used, they can become non-renewable. A forest, for instance, can take hundreds of years to re-establish itself. This is still a much, much shorter period than a fossil fuel such as peat. It can take 900 years for just a meter (3 feet) of peat to replenish itself.
2. Most biomass requires arable land to develop. This means that land used for biofuel crops such as corn and soybeans are unavailable to grow food.
3. Forested areas that have matured for decades can sequester more carbon than newly planted areas. Therefore, if forested areas are not sustainably cut, re-planted, and given time to grow and sequester carbon, the advantages of using the wood for fuel are not offset by the trees' regrowth.
4. Most biomass plants require fossil fuels to be economically efficient. An enormous plant under construction near Port Talbot, Wales, for instance, will require fossil fuels imported from North America, offsetting some of the sustainability of the enterprise.
5. Biomass has a lower “energy density” than fossil fuels. As much as 50% of biomass is water, which is lost in the energy conversion process. Scientists and engineers estimate that it is not economically efficient to transport biomass more than 160 kilometers (100 miles) from where it is processed. However, converting biomass into pellets can increase the fuel’s energy density and make it more advantageous to ship.
6. Burning biomass releases carbon monoxide, carbon dioxide, nitrogen oxides, and other pollutants. If these pollutants are not captured and recycled, burning biomass can create smog and even exceed the number of pollutants released by fossil fuels.

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CHAPTER.20

ENERGY FROM FOSSIL FUEL

20.1. INTRODUCTION

Remains or vestiges or traces of plants and animals of the past are called fossils. These remains of the organisms from past geological ages remain preserved in sedimentary rocks either as actual or as impressions, cast, or molds. The word fossils derived from the Latin word fossils which mean 'to dig up' in earlier studies, therefore a large number of things dug out of earth's crust were called fossils. These things also included minerals and rocks beside the remains of plants and animals.

The plants and animals which died millions of years ago were gradually buried deep in the earth and got covered with sediments like mud and sand, away from the reach of oxygen of the air. In the absence of oxygen, the chemical effects of pressure, heat, and bacteria, converted the buried remains of plants and animals into fossil fuels like coal, petroleum, and natural gas. It should be noted that the buried remains of large plants were converted into coal whereas those of small plants and animals were converted into petroleum and natural gas.

20.2. FOSSIL FUELS

Fossil fuel is formed from the buried remains of plants and animals throughout millions of years. Coal, petroleum, and natural gas are examples of fossil fuels. Since fossil fuels are obtained from nature, they are referred to as natural resources.

The natural resources divided into two types

1. Inexhaustible natural resources
2. Exhaustible Natural resources

Inexhaustible resources (such as sunlight and air) of which there is an unlimited supply. The examples of fossil fuel are coal, petroleum, and natural gas, forests, and wildlife. Fossil fuel is a fuel formed by natural processes, such as anaerobic decomposition of buried dead organisms, containing organic molecules originating in ancient photosynthesis that release energy in combustion. Natural fuel such as coal or gas, formed in the geological past from the remains of living organisms.

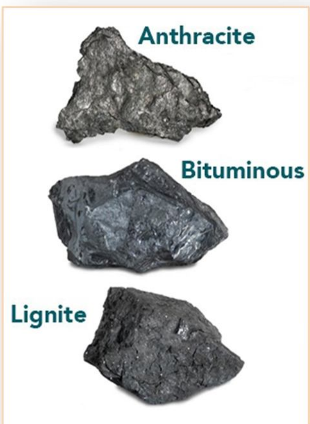
The four types of fossil fuels are coal, petroleum, natural gas, and Orimulsion the Coal, crude oil, and natural gas are all considered fossil fuels because they were formed from the fossilized, buried remains of plants and animals that lived millions of years ago. Because of their origins, fossil fuels have high carbon content. Fossil fuels are found underground, trapped in deposits surrounded by layers of rock. Coal beds typically lie 200 to 300 feet below the surface.

20.3. COAL

Coal is generally black or brownish-black colour, depending on carbon content. It is mostly carbon with variable amounts of other elements; chiefly hydrogen, sulfur, oxygen, and nitrogen. Coal is a combustible black or brownish-black sedimentary rock, formed as rock strata called coal seams.

It is generally accepted that most coals formed from plants that grew in and adjacent to swamps in warm, humid regions. Material derived from these plants accumulated in low-lying areas that remained wet most of the time and were converted to peat through the activity of microorganisms. Under certain conditions, this organic material continued to accumulate and was later converted into coal. Much of the plant matter that accumulates on the surface of Earth is never converted to peat or coal because it is removed by fire or organic decomposition. Hence, the vast coal deposits found in ancient rocks must represent periods during which several favorable biological and physical processes occurred at the same time.

20.3.1. Types of coal



The main three types of Coal

1. **Anthracite:** It has a carbon content of around 86 % or higher and is regarded as the highest grade of coal it is mainly used in heating.
2. **Bituminous coal:** It has a carbon content of around 70-86 % and is mainly used for power generation and for manufacturing another fuel called coke.
3. **Lignite:** It has a carbon content of around 60-70 % and is regarded as the lowest grade of coal, is mainly used for power generation.

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Coal was formed from the remains of plants that grew in warm, humid swamps 300 to 400 million years ago. Coal is processed further to obtain useful materials such as coke, coal tar, and coal gas.

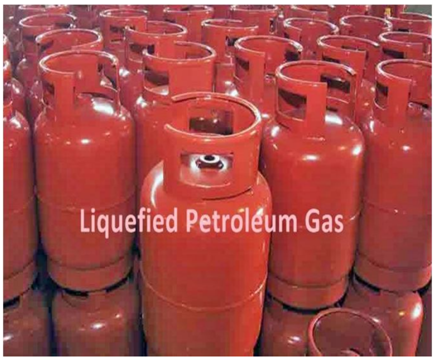
20.4. PETROLEUM

Petroleum is a naturally occurring liquid found beneath the earth's surface that can be refined into fuel. Petroleum is a fossil fuel, meaning that it has been created by the decomposition of organic matter over millions of years. Petroleum is a naturally occurring, yellowish-black liquid found in geological formations beneath the Earth's surface. Petroleum or crude oil is a complex mixture of solid, liquid and gaseous hydrocarbons. Petroleum and natural gas were formed from the marine organisms that died millions of years ago.

Petroleum is a complex mixture of hydrocarbons that occur in Earth in liquid, gaseous, or solid form. The term is often restricted to the liquid form types of unrefined petroleum include asphalt, bitumen, crude oil, and natural gas

Petroleum is a fossil fuel that is found in geological formations beneath the Earth's surface. It includes crude oil, natural gas plant liquids, liquefied refinery gases, and refined petroleum products such as gasoline and diesel. It has been used as fuel for our transport, a fuel to generate electricity to light our homes, run factories and machines, the raw material to produce fertilizer to increase food production and produce plastic which is used in a wide range of things we use in daily life.

20.4.1. Petroleum gas



Liquefied petroleum gas or liquid petroleum gas (LPG or LP gas), is a flammable mixture of hydrocarbon gases used as fuel in heating appliances, cooking equipment, and vehicles. Liquefied petroleum gas or liquid petroleum gas, is a flammable mixture of hydrocarbon gases used as fuel in heating appliances, cooking equipment, and vehicles. It is increasingly used as an aerosol propellant and a refrigerant, replacing chlorofluorocarbons to reduce damage to the ozone layer.

Natural gas and is almost entirely derived from fossil fuel sources, being manufactured during the refining of petroleum (crude oil), or extracted from petroleum or natural gas streams as they emerge from the ground. It was first produced in 1910 by Dr.

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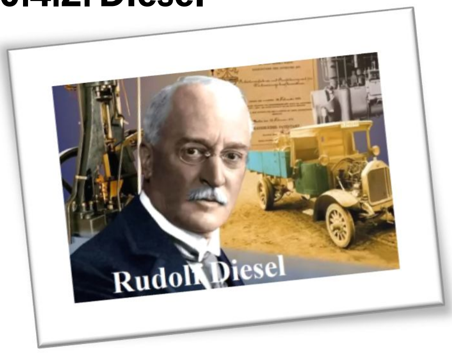
Walter Snelling. It currently provides about 3% of all energy consumed and burns relatively cleanly with no soot and very few sulfur emissions.

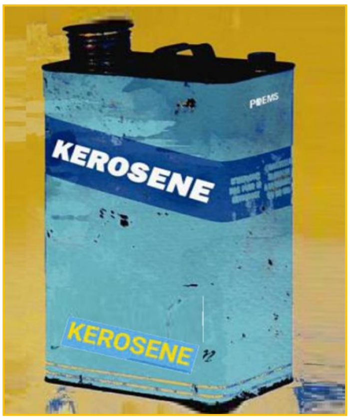
20.4.2. Diesel



Diesel fuel is the common term for the petroleum distillate fuel oil sold for use in motor vehicles that use the compression ignition engine named for its inventor, German Engineer Rudolf Diesel. Diesel fuel, in general, is any liquid fuel used in diesel engines, whose fuel ignition takes place, without any spark, as a result of compression of the inlet air mixture and then injection of fuel.

Diesel engines have found broad use as a result of higher thermodynamic efficiency and thus fuel efficiency diesel fuel, the combustible liquid used as a fuel for diesel engines, ordinarily obtained from fractions of crude oil that are less volatile than the fractions used Petroleum diesel. Petroleum diesel, or fossil diesel, is the most common type of fuel, used in freight trucks, trains, buses, and farm and construction vehicles.

20.4.3. Kerosene



Kerosene, also called paraffin or paraffin oil, flammable hydrocarbon liquid commonly used as a fuel. Flammable hydrocarbon oil is used as fuel in lamps and heaters. It is widely used to power jet engines of aircraft (jet fuel) and some rocket engines and is also commonly used as a cooking and lighting fuel, and for fire toys such as poi. In parts of Asia, kerosene is sometimes used as fuel for small outboard motors or even motorcycles. Kerosene is a low viscosity clear liquid formed from hydrocarbons obtained from the fractional distillation of petroleum.

20.4.4. Fuel oil

Fuel oil, also called furnace oil, fuel consisting mainly of residues from crude-oil distillation. It is used primarily for steam boilers in power plants, aboard ships, and industrial plants. The term fuel oil ordinarily does not include such fuels. Fuel oil is variously referred to as distillate fuel oils, diesel fuel oils, light fuel oils, gas oil, or just distillate. Fuel oil is produced from the burnable liquids derived from crude oil and is also called kerosene, home heating oil, diesel fuel, or coal oil.

Oil-it is formed from the sea, the sea contains many tiny animals and plants called plankton, they get their energy to live and multiply from sunlight. When they die they sink to the bottom of the sea. Those that died millions of years ago form oil and gases which are the main sources of Fuel oil is a distillate fuel that is used commonly for burning in furnaces, boilers, stoves, and lanterns to generate heat.

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20.4.5. Natural Gas

The natural gas extracted by drilling through the impermeable rocks. Petroleum oil is separated into useful substances through a process called the refining of petroleum. Natural gas is mainly made up of methane, which is given off by anaerobic bacteria breaking down some of the organic matter which formed oil and coal. Compressed natural gas (CNG) is used as fuel in automobiles as it is more environment-friendly than petrol and diesel. It also uses the production of hydrogen and ammonia.

20.4.5.1. Advantages of natural gas

1. Natural gas is a complete fuel in itself that can be used directly for heating purposes in homes and industries. There is no need to add anything else to it.
2. Natural gas is a good fuel because it has a high calorific value of up to 50 kJ/g. Moreover, natural gas burns with a smokeless flame and causes no air pollution. It also does not produce any poisonous gases on burning. Natural gas is, therefore, an environment-friendly fuel as compared to other fossil fuels.
3. A great advantage of natural gas is that it can be supplied directly from the gas wells to the homes and factories for burning through a network of underground pipelines, and this eliminates the need for additional storage and transport.

20.5. POLLUTION CAUSED BY FOSSIL FUELS

Fossil fuels are non-renewable resources, as they have taken millions of years to form. Once these resources are used, they will not be replenished. Moreover, fossil fuels are the largest source of carbon dioxide, a greenhouse gas that contributes to climate change, and their production causes both environmental and human health impacts. These concerns are triggering the world to look at alternate sources of energy that are both less harmful and renewable. Additionally, the gradual depletion of conventional fossil fuel reserves has led companies to develop more challenging reserves. These unconventional resources usually have higher production costs and a greater risk of environmental impact.



The main disadvantage of using fossil fuels is that the burning (or combustion) of fossil fuels causes a lot of pollution in the environment. This is explained below.

1. The burning of fossil fuels produces acidic gases such as sulfur dioxide and nitrogen oxides. These acidic gases cause acid rain. The acid rain damages trees and plants

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reduce the fertility of the soil by making it acidic and pose a danger to aquatic life like fish by making the water of lakes and rivers acidic. The burning of fossil fuels also puts a poisonous gas, carbon monoxide, into the air.

2. The burning of fossil fuels produces a large amount of carbon dioxide which goes into the air. Though carbon dioxide gas is not harmful immediately, it damages the environment in the long run. The presence of increasing amounts of carbon dioxide gas in the atmosphere is causing an increased greenhouse effect leading to excessive heating of the earth. This is harmful to all life on earth.
3. The burning of fossil fuels especially coal produces smoke which pollutes the air.
4. The burning of coal leaves behind a lot of ash. It also puts tiny particles of ash called fly-ash, into the air causing air pollution.

20.6. ADVANTAGES AND DISADVANTAGES OF FOSSIL FUELS

20.6.1. Advantages of fossil fuels

1. A major advantage of fossil fuels is their capacity to generate huge amounts of electricity in just a single location.
2. Fossil fuels are very easy to find.
3. When coal is used in power plants, they are very cost-effective. Coal is also in abundant supply.
4. Transporting oil and gas to the power stations can be made through the use of pipes making it an easy task.
5. Power plants that utilize gas are very efficient.
6. Power stations that make use of fossil fuel can be constructed in almost any location.

20.6.2. Disadvantages of fossil fuels

1. Pollution is a major disadvantage of fossil fuels. This is because they give off carbon dioxide when burned thereby causing a greenhouse effect. This is also the main contributory factor to the global warming experienced by the earth today
2. They are a non-renewable resource, i.e., once used they cannot be replaced.
3. Combustion of fossil fuels makes the environment more acidic. This has led to unpredictable and negative changes in the environment.
4. Harvesting of fossil fuels also causes fatal diseases among the people. The coal miners often suffer from Black Lung Disease. The natural gas drillers are constantly exposed to chemicals and silica which is dangerous for their health.
5. The use of natural gas can cause unpleasant odors and some problems, especially with transportation.

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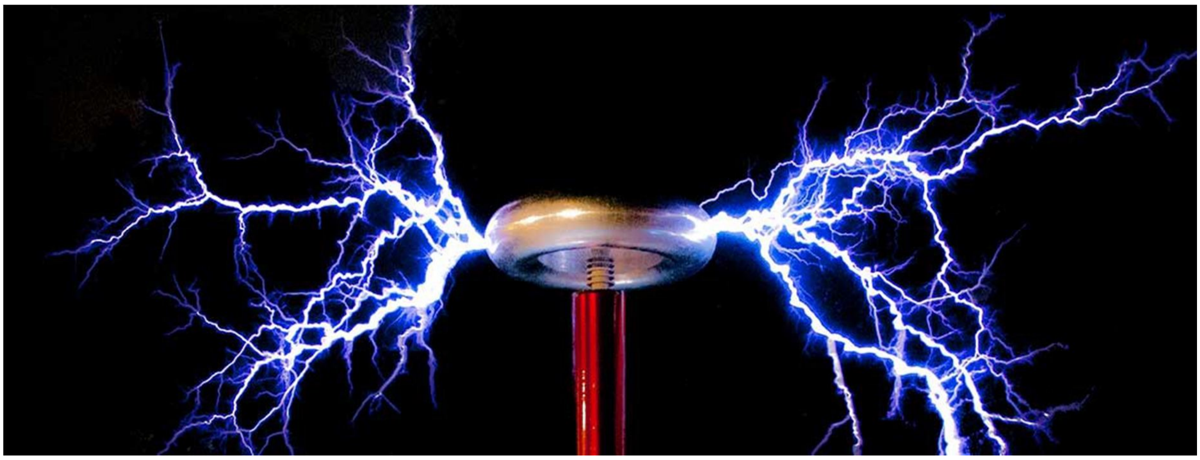
CHAPTER.21

ELECTROSTATIC ENERGY

21.1. INTRODUCTION

When you rubbed the balloon against the towel, due to friction, the electric charge transferred from the towel onto the balloon. Since the balloon is an insulator, the electric charge cannot move and stays there. This charged balloon, when brought near the wall, induced an equal and opposite charge on the wall. Also, when a glass rod is rubbed with silk, the rod acquires one kind of charge and the silk acquires the second kind of charge. This is true for any pair of objects that are rubbed to be electrified. Now if the electrified glass rod is brought in contact with silk, with which it was rubbed, they no longer attract each other. They also do not attract or repel other light objects as they did on being electrified.



This charge that stays there on the surface of an insulator is called static charge, and their study is called Electrostatics. The branch of physics which deals with the study of static electric charges (stationary electric charges) and interaction between them is known as electrostatic or static electricity.' the energy is formed called Elecrostaic energy.

There are two types of charges were named as positive and negative by the American scientist Benjamin Franklin. We know that when we add a positive number to a negative number of the same magnitude, the sum is zero. This might have been the philosophy in naming the charges as positive and negative. By convention, the charge on glass rod or cat's fur is called positive and that on the plastic rod or silk is termed negative. If an object possesses an electric charge, it is said to be electrified. When it has no charge it is neutral.

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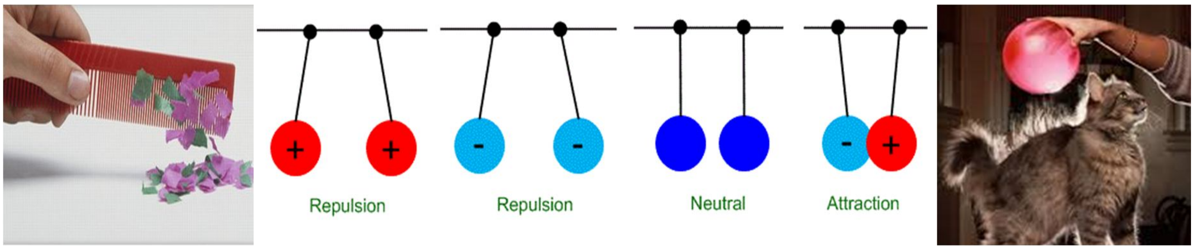

There are two types of charges, namely positive and negative and their effects tend to cancel each other. Unlike charges attract each other but like charges get repulsion between them. French scientist Augustin de Coulomb tried to understand the force of attraction or repulsion between the two charges. He found out that similar charges repel each other while opposite charges attract each other, by a force known as Coulomb's law**.** The law of the energy of interaction in electrostatics is very simple stated as,

'Force of attraction or repulsion between two point charges is inversely proportional to the square of the distance between them and directly proportional to the product of the magnitude of the two charges and acted along the line joining the two charges.'

If two-point charges q_1, q_2 are separated by a distance r in a vacuum, the magnitude of the force (F) between them is given by,

$$F \,\alpha\, \frac{q_1 q_2}{r^2} \qquad \therefore F = K\frac{q_1 q_2}{r^2}$$

Although Coulomb's Law is quite sufficient for finding electric fields and forces, the integral form in which we have expressed it is not always the most useful approach to a problem. Another integral form, called Gauss's Law, is often more useful.

21.2. GAUSS'S LAW

Gauss law is also called the law of electrostatics it is one of the most fundamental theorems in Electrostatic

'The total normal electric induction (TNEI) over any closed surface area of any shape is equal to the total charge enclosed by the closed area.' or

'The total normal electric induction (TNEI) over any closed surface area of any shape is equal to the algebraic sum of the charges enclosed by closed area.'

T.N.E.I. = Σ q

In general, the energy of a system of charges, just like that of any other mechanical system, may be divided into its potential and kinetic contributions. Under static conditions, however, the entire energy of the charging system exists as potential energy, and we are particularly concerned with that potential energy which arises from electrical interaction of the charges, the so-called electrostatic energy

21.3. ELECTROSTATIC POTENTIAL ENERGY

Potential energy can be defined as the capacity for doing work that arises from position or configuration. In the electrical case, a charge will exert a force on any other charge and potential energy arises from any collection of charges. For example, if a positive

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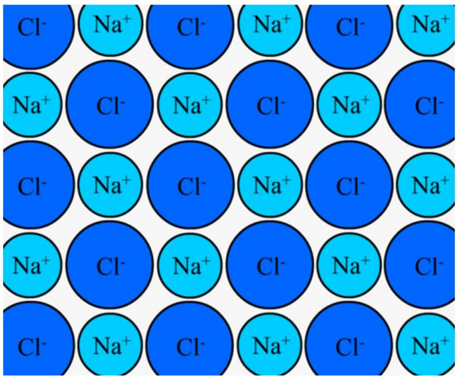
charge Q is fixed at some point in space, any other positive charge which is brought close to it will experience a repulsive force and will, therefore, have potential energy.

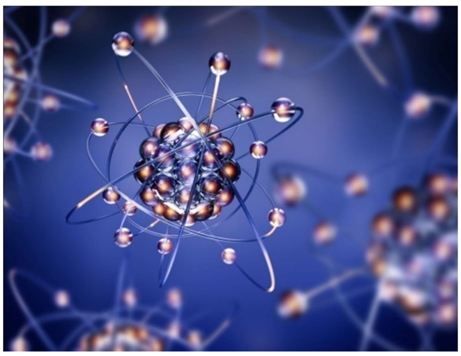
Electric potential is a measure of the potential energy per unit charge. If you know the potential at a point, and you then place a charge at that point, the potential energy associated with that charge in that potential is simply the charge multiplied by the potential. Electric potential, like potential energy, is a scalar, not a vector.

21.4. THE ELECTROSTATIC ENERGY OF AN IONIC CRYSTAL



Consider an application of the concept of electrostatic energy in atomic physics. We cannot easily measure the forces between atoms, but we are often interested in the energy differences between one atomic arrangement and another. Since atomic forces are electrical, chemical energies are in large part just electrostatic energies. Let's consider, for example, the electrostatic energy of an ionic lattice. Anionic crystal-like NaCl consists of positive and negative ions which can be thought of as rigid spheres. They attract electrically until they begin to touch; then there is a repulsive force that goes up very rapidly if we try to push them closer together.

21.5. ELECTROSTATIC ENERGY IN NUCLEI



Consider other examples of electrostatic energy in atomic physics, the electrical energy of atomic nuclei. The property of the nuclear forces is that hold the protons and neutrons together in a nucleus. Firstly, the force is not a simple function of the distance between the two protons. At large distances, there is an attraction, but at closer distances there is repulsion. The distance dependence is a complicated function, still imperfectly known.

Secondly, the force depends on the orientation of the spin of the proton. The protons have a spin, and any two interacting protons may be spinning with their angular momenta in the same or opposite directions. And the force is different when the spins are parallel from what it is when they are antiparallel. The difference is quite large; it is not a small effect.

21.6. CORONA DISCHARGE

The collection of huge electric charges is difficult. While lightning, the charges are collected by corona discharge and send to earth, which is a huge absorber. Here the electrostatics energy collects and passed towards the earth.

When an uncharged body is brought near a charged body having sharp corners there is a large number of charges at the corners. Due to induction, they induce a large number of opposite charges. This creates a very strong electric field between them. Finally, the dielectric strength breaks down and there is a fast flow of charges.

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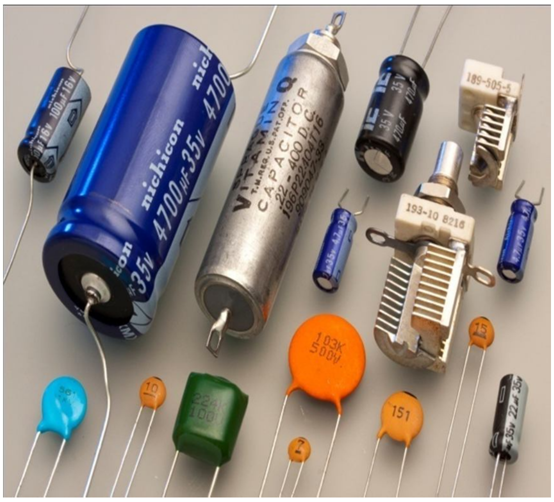
21.7. PHOTOCOPIER

For a photocopier to work, a field of positive charges must be generated on the surface of both the drum and the copy paper. These tasks are accomplished by the corona wires. These wires are subjected to a high voltage, which they subsequently transfer to the drum and paper in the form of static electricity. Toner is very important in the photocopier. Toner is dry ink, it is a pigmented liquid. Toner is a fine, negatively charged, plastic-based powder.

The black color in photocopier toner comes from pigments blended into the plastic particles while they are being made. Toner is stuck on larger, positively charged beads and stored inside a toner cartridge. When toner-coated beads are rolled over the drum, the toner particles find the positively charged ions on the unexposed areas on the drum's surface attractive. The same particles are subsequently even more drawn to the electrostatically charged paper. The plastic in the toner lets you keep it from jumping ship once you've finally got it on the paper; all you have to do is apply heat to the toner, and the plastic particles melt and fuse the pigment to the paper.

21.8. CAPACITOR



When a source is connected to a capacitor, it spends energy to charge up the capacitor. This charging energy is stored in the dielectric medium in the form of electrostatic potential energy. There are different types of capacitors that hold the charges and increase the electrostatic energy. Depending upon the size and shape there are three types of capacitor or condenser,

1. Parallel plate condenser.
2. Spherical condenser.
3. Cylindrical condenser

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A capacitor is a device used to store energy. The electric energy is stored in the capacitor by transferring an electron from one plate of the capacitor to the other. Hence work will have to be done by the battery to remove the electrons against the opposing forces. As the charges on the plate increases, the opposition also increases. This work done is stored in the form of electrostatic energy in the electric field between the plates, which can later be recovered by discharging the capacitor.

21.9. ELECTROSTATIC ENERGY STORED IN A CAPACITOR

We know that when charges are deposited on the capacitor then a certain amount of work is done. This much amount of work is stored as energy in the capacitor or conductor. Let q be the charge deposited on the capacitor of capacity 'C' then the potential is V. If, the additional charge does is be deposited on the capacitor against. It is increased potential V, then a small amount of work done 'dw' is given by,

$$\text{Workdone} = \text{Potential} \times \text{Charge}$$

$$dw = V \times dq$$

$$\therefore dw = \frac{q}{C} \times dq$$

Hence, Total amount of work done in order to change the condenser from O to Q

$$\int dw = \frac{1}{C} \int_0^Q q \cdot dq$$

$$W = \frac{1}{C}\left[q^2/2\right]_0^Q = \frac{1}{C}\left[\frac{Q^2}{2} - \frac{0}{2}\right]$$

$$W = \frac{Q^2}{2C} \quad \text{as } Q = CV$$

$$W = \frac{C^2V^2}{2C} = \frac{1}{2}CV^2$$ But workdone(W) is the energy stored (E) in the condenser

$$\therefore E = \frac{Q^2}{2C} = \frac{1}{2}CV^2 = \frac{1}{2}QV$$

This is expression for elcrostatics energy stored in the condenser

21.10. VAN-DE-GRAFF GENERATOR

A common laboratory device for producing high voltages and creating static electricity is the Van de Graaff generator. It stores electrostatic energy and works on the principle of electrostatic.

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In 1929, Robert J Van-de-Graff designed in an electrostatic machine that is used to accelerate the charged particles e.g. protons, electron α-particles, etc.

Van-de-Graff generator consists of a hollow metallic sphere (S) is called as done. This dome is supported by two insulated supports. Inside the dome, there are two metal combs C_1 and C_2. Comb C_1 is connected to high voltage supply P and comb C_2 is connected to dome. There is a rubber belt (BB) which passes over two pulleys P_1 and P_2 pulley P_1 is rotated using a motor, so that belt can rotate. Inside the dome, there is a gas discharge tube T. Whole arrangement is enclosed in a steel tank S to avoid the leakage of charges in the atmosphere, as shown in **Fig.21.1.**

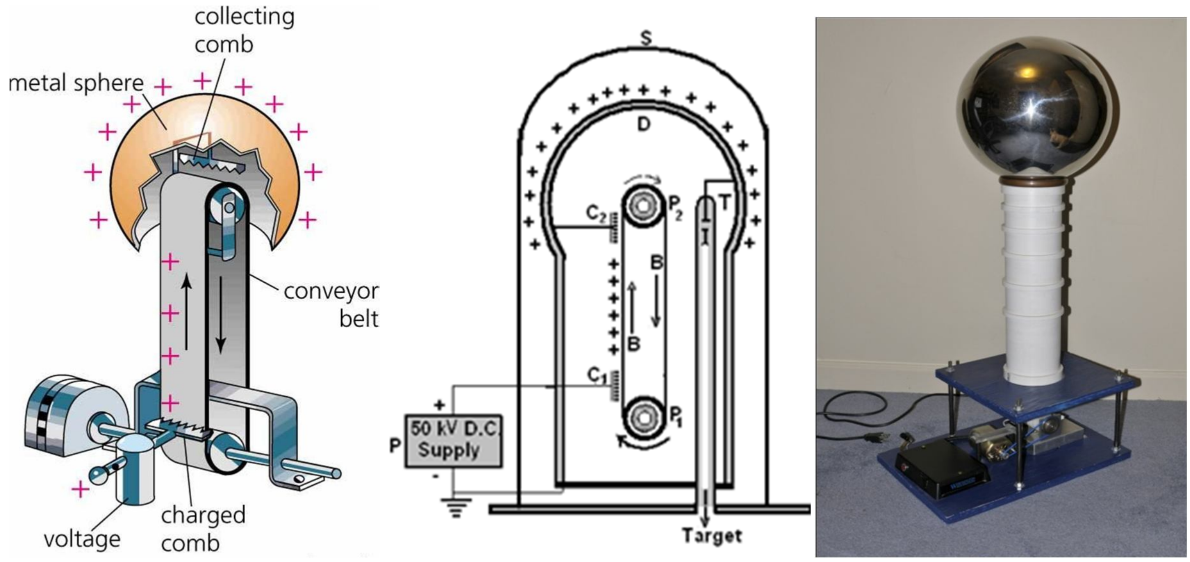

Fig.21.1: Van-de-Graff generator

When motor rotated, pulley P_1 rotates therefore the belt rotates, and the charges from metal comb C_1 transferred through the belt in upwards direction. The comb C_2 collects the chares and transferred these changes to the dome. These charges spread and stored over the dome. Which increases the potential of the dome to a very large extent about one million volt. Due to the high potential between the dome and target charged particles travel through a gas discharge tube (T) with very high speed and strikes on the target.

21.10.1. Uses of Van-De-Graff generator

1. It is used to produce a high potential difference.
2. It is used to accelerate charge particle-like proton, deuteron, etc
3. It is used to study nuclear structure
4. To study the different nuclear reactions.
5. Inkjet printing.
6. Xerox copying machine.

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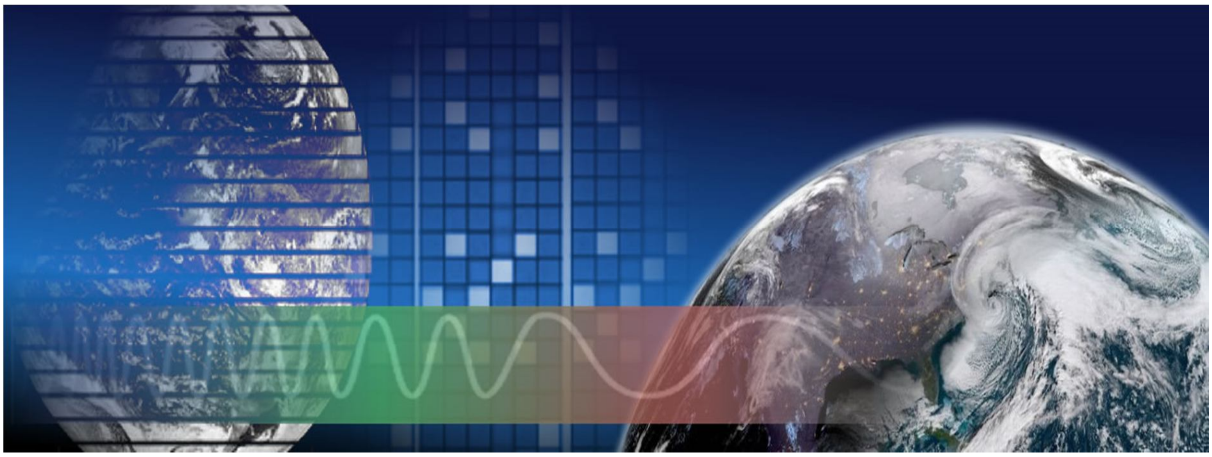
CHAPTER.22

ELECTROMAGNETIC ENERGY

21.1. INTRODUCTION

Electromagnetic energy is a form of energy that is reflected or emitted from objects in the form of electrical and magnetic waves that can travel through space. Electromagnetic energy is a term used to describe all the different kinds of energies released into space by stars such as the Sun. These kinds of energies include some that you will recognize and some that will sound strange.

Examples are radio waves, microwaves, TV waves, RADAR waves, Ultraviolet light (This is what causes Sunburns), infrared radiation, visible light- (all colors of the spectrum that we see), ultraviolet light, X-rays and gamma radiation.



All these waves do different things (for example, light waves make things visible to the human eye, while heat waves make molecules move and warm up, and X-rays can pass through a person and land on film, allowing us to take a picture inside someone's body) but they have some things in common.

Stationary electric charges produce electric fields, whereas moving electric charges produce both electric and magnetic fields. Regularly repeating changes in these fields produce what we call electromagnetic radiation. Electromagnetic radiation transports energy from point to point. This radiation propagates through space at 299,792 km per second (about 186,000 miles per second). That is, it travels at the speed of light. Indeed light is just one form of electromagnetic radiation. The properties of electromagnetic radiation depend

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strongly on its frequency. Frequency is the rate at which the radiating electromagnetic field is oscillating. Frequencies of electromagnetic radiation are given in Hertz (Hz). One Hertz is one cycle per second.

22.2. RELATION BETWEEN VELOCITY, FREQUENCY & WAVELENGTH

The properties of electromagnetic radiation depend strongly on two functions: frequency and wavelength. Frequency is the rate at which the radiating electromagnetic field is oscillating. Frequencies of electromagnetic radiation are given in Hertz (Hz). One Hertz is one cycle per second. Wavelength is the distance between any point on one wave and the analogous to point on the next wave. Wavelengths are generally given in meters (or some decimal fraction of a meter) or Angstroms (Å, i.e.10^{-10} meter). Another quantity is period (T) that can be used to describe an electromagnetic wave. Frequency (n) is the reciprocal of the period. The wave speed (v) is the distance traveled by a wave per unit time. The relation between velocity, frequency, and wavelength is given by the relation:

$$v = n\lambda$$

Therefore the wave speed is equal to the product of its frequency and wavelength.

22.3. DISTRIBUTION OF ENERGY

The solar energy that permeates the earth and objects absorb, transmit, and/or reflect varying amounts of solar energy (**Fig.22.1**). Aerial films are sensitive to visible light waves that reflect from these objects. Some specialty films react to near-infrared radiation.

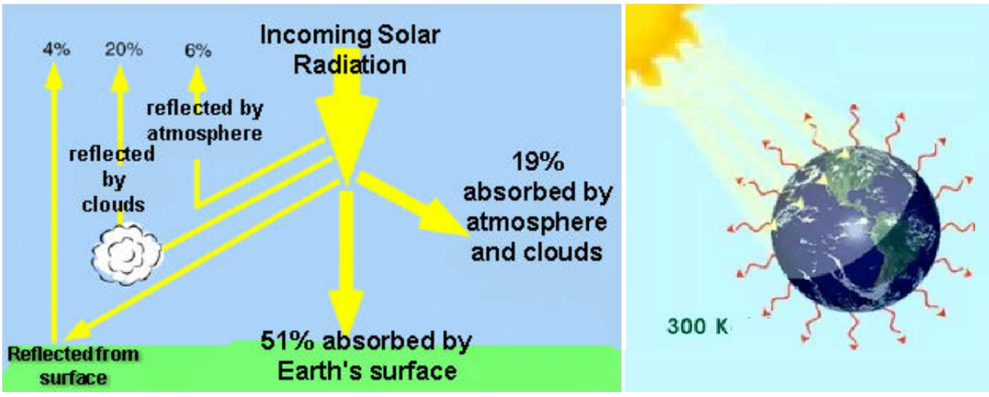
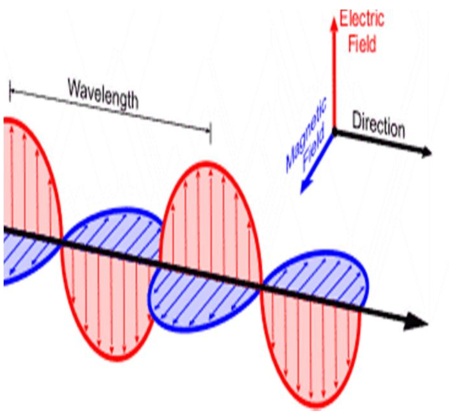


Fig.22.1: Distribution of Solar energy

22.4. ELECTROMAGNETIC ENERGY WAVE



Simply described, an electromagnetic energy wave is a complex form of energy composed of oscillating electric and magnetic fields joined together and capable of conveying energy to the matter it intercepts. Electromagnetic energy exists over a vast wavelength or frequency range which can be summarized in the following diagram. Please notice that infrared, visible light, ultraviolet light, X-rays, and gamma rays are all forms of electromagnetic energy at extraordinary frequencies. Our concern lies below the infrared.

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22.4.1. Electromagnetic spectrum

The electromagnetic (EM) spectrum is the range of all types of EM radiation. Radiation is the energy that travels and spreads out as it goes. The entire distributions of electromagnetic radiation are according to frequency or wavelength. Although all electromagnetic waves travel at speed of light in a vacuum, they do so at a wide range of frequency, wavelength, and photon energies. The EM spectrum comprises the span of all electromagnetic radiation and consists of many sub-range components such as radio waves, infrared, visible light, ultraviolet, X-ray, and gamma rays.

The entire electromagnetic spectrums, from the lowest to the highest frequency (longest to shortest wavelength) are shown in **Fig.22.2.** The various portions bear different names based on differences in behavior in the emission, transmission, and absorption of the corresponding waves and also based on their different practical applications.

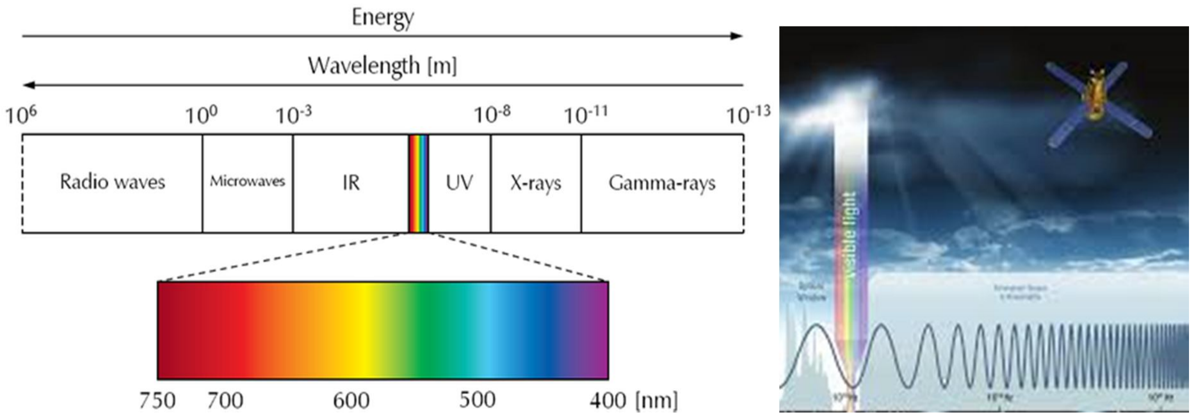

Fig.22.2: Components of the electromagnetic spectrum

22.4.1.1. Radio waves

Radio waves from the portion of the electromagnetic spectrum at lower frequencies than microwaves. The wavelengths of radio waves range from thousands of meters to 30 cm. These correspond to frequencies as low as 3 Hz and as high as 1 gigahertz (10^9 Hz). Radio-wave communications signals travel through the air in a straight line, reflect off of clouds or layers of the ionosphere, or are relayed by satellite in space.

22.4.1.2. Microwave

The microwave region extends from 1,000 to 300,000 MHz (or 30 cm to 1 mm wavelength). Although microwaves were first produced and studied in 1886 by Hertz, their practical application had to await the invention of suitable generators, such as the klystron and magnetron. Microwaves play an increasingly wide role in heating and cooking food. They are absorbed by water and fat in foodstuffs and produce heat from the inside.

22.4.1.3. Infrared

The infrared electromagnetic spectrum extends from the long-wavelength or end of the visible-light range to the microwave range. This radiation is invisible to the eye; it can be detected as a sensation of warmth on the skin. The infrared range is usually divided into three regions: near-infrared (nearest the visible spectrum), with wavelengths 0.78 to about 2.5 micrometers (a micrometer, or micron, is 10^{-6} meter); middle infrared, with wavelengths 2.5

to about 50 μm; and far infrared, with wavelengths 50 to 1,000 micrometers. Most of the radiation emitted by a moderately heated surface is infrared; it forms a continuous spectrum.

22.4.1.4. Visible light

The visible spectrum of light is the section of the electromagnetic spectrum that is visible to the human eye. It ranges wavelength between 700 and 400 nm, it is the part of the electromagnetic spectrum that we can see and which is expressed through rainbow colors. Humans see the visible portion of the electromagnetic spectrum as various colors that span a range encompassing 400 nm to 700 nm wavelengths. Various colors of the rainbow are blends of the additive primary physical colors of red, green, and blue. Visible light is sensed by a camera or a multispectral sensor. **Fig.22.2** visualizes the basic components of visible light and their relationship with shorter and longer wavelengths.

22.4.1.5. Ultraviolet

Ultraviolet that portion of the electromagnetic spectrum extending from the violet, or short-wavelength, end of the visible light range to the X-ray region. Ultraviolet (UV) radiation is undetectable by the human eye, although, when it falls on certain materials, it may cause them to fluoresce i.e., emit electromagnetic radiation of lower energy, such as visible light. Many insects, however, can see ultraviolet radiation. They are very important for medical applications because they are used for medical diagnostics.

22.4.1.6. Gamma rays

Gamma rays are the electromagnetic radiation of the shortest wavelength and highest energy. They have wavelengths less than 0.01 nm, are those with greater energy. Gamma rays are detected by their ability to ionize gas atoms or to create electron-hole pairs in semiconductors or insulators. By counting the rate of charge pulses or voltage pulses or by measuring the scintillation of the light emitted by the subsequently recombining electron-hole pairs, one can determine the number and energy of gamma rays striking an ionization detector or scintillation counter.

22.5. USE ELECTROMAGNETIC ENERGY

Up to the end of the microwave spectrum, most all modern conveniences that use electromagnetic energy in one way or another area in the lower frequency region, including millimeter waves, cell phones, Wi-Fi, microwave ovens, space and terrestrial communications, radar for airports and military uses AM and FM radio, television transmission, and cable services networks that send out electromagnetic energy inside coaxial cables of many frequencies simultaneously to individual homes, offices, and just about everywhere you can install the cable, for entertainment, telephone, computer internet access, also in electromagnetic crane, etc. Electromagnetic energy has become all-pervasive in the conduct of modern life.

22.6. BEHAVIOUR OF ELECTROMAGNETIC ENERGY

Electromagnetic energy waves travel at what we call by convenience the speed of light. It is universally accepted to be in a vacuum: 299,792,458 m/s. The frequency of the wave or the number of times per second a peak in the wave passes by, and the wavelength, the length between wave peaks measured in meters. Electromagnetic energy follows clearly defined rules in its behavior from the creation of the energy wave to the travel of the wave through space and the atmosphere of the earth, and what happens when it meets matter of all kinds. The behaviors are defined by sometimes complex and sometimes simple, but they all share the fact that whatever the electromagnetic energy wave is doing or what energy is imparted to the things around it is dependent on the wavelength or frequency of the energy wave. The physical and electrical properties of the substances, gases, and biological organisms, as well as size concerning the wavelength of the incident electromagnetic energy, are all important factors that influence strongly the transfer of energy from the electromagnetic energy wave to the materials and organisms the wave intercepts.

It is important to note that the electric and magnetic fields of electromagnetic energy enable us to measure, characterize, and thus visualize the otherwise invisible fields, visible light accepted. It is the measurement of these fields and thus the energy they can impart to inorganic and organic matter that scientific research uses to make determinations on electromagnetic energy safety for humans.

22.7. MECHANISMS OF ELECTROMAGNETIC ENERGY TRANSFER

Without the existence of established mechanisms for the transfer of electromagnetic energy to whatever it intercepts, nothing is going to happen. For example, light (short wavelengths) passing through a pane of glass does so essentially undisturbed and does not heat the glass because there is no mechanism of interaction of glass with electromagnetic energy with light. If there were, the light would be absorbed, and little could pass through. When glass contains certain chemical constituents that can absorb light at selected wavelengths, colored glass is made whereupon some of the energy is absorbed in selected wavelengths, passing other wavelengths undisturbed. At very long wavelengths, such as with power-frequency fields, radio, and microwave, up to the infrared, selective absorption of electromagnetic energy occurs, but the situation is extremely more complex than that of visible light.

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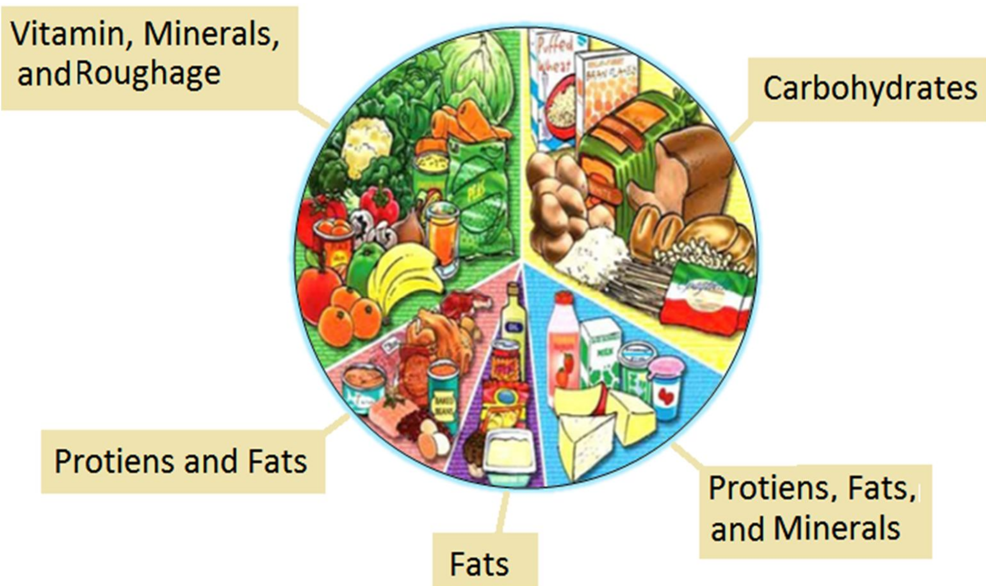
CHAPTER.23

ENERGY FROM FOOD

23.1. INTRODUCTION

We need energy for our daily activities such as walking, talking, playing, singing, writing, reading, etc for that we need energy. Plant, animals, and birds also required energy to survive. Recently a whole world passing through corona-virus disease COVID-19, corona warriors play a very important role for us. They guide us and they gave one important suggestion, 'Stay home...Stay Safe...Stay Healthy. It is a good message to reflect that health is wealth. We can say that good health is important than money and other things. All of us want to be healthy.

Food is one of the most basic requirements of life. Food supplies us with energy. The first law of thermodynamics explains human metabolism: the conversion of food into energy that is used by the body to perform activities. Metabolism in humans is the conversion of food into energy, which is then used by the body to perform activities. The human body converts energy stored in food into work, thermal energy, and/or chemical energy.



Food is also required for the growth and maintenance of the body. It also protects from diseases. We eat different kinds of food contains various chemical substances required for our body. These chemical substances are called nutrients.

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23.2. COMPONENTS OF FOOD

The nutrients can be broadly grouped into the following seven classes

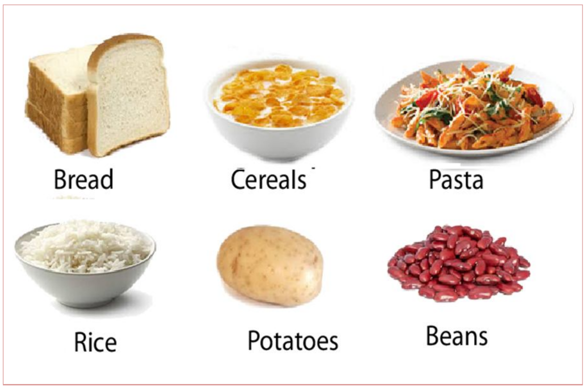
1. Carbohydrates
2. Fats
3. Proteins
4. Vitamins
5. Minerals
6. Water
7. Roughage

Our body needs all these nutrients, along with roughage and water, to remain healthy. A food containing all the above nutrients insufficient for maintaining good health is called healthy food. Roughage (or Fiber) and water are not nutrients, but it is important to include them in our diet to stay healthy. Lets us know about all the above compounds in detail.

23.2.1. Carbohydrates

Carbohydrates are organic compounds of carbon, hydrogen, and oxygen. The bulk of food consists of carbohydrates. It is one of the main sources of energy in the human body. One gram of carbohydrates yields about 4 Kcal of energy. Excess of carbohydrates in the body converted into fat which is store in the body. There are two main types of carbohydrates in the food: sugars and starch. Carbohydrates provide energy to the muscles, the brain, and the nervous system. No matter what kind of carbohydrate you eat (rice, apples, cereal), they all get converted to glucose and are used as energy.

Sugars like glucose are the simplest carbohydrates found in fruits, honey, milk, and milk products. Glucose can be easily utilized by the body to release energy. Simple carbohydrates are absorbed quickly for energy. That is why glucose is given to patients and sportspersons who require a quick supply of energy.



Starch is a complex carbohydrate that is found primarily in whole grains, pasta, potatoes. Complex carbohydrate contains many vitamins and minerals as well as fiber. However, complex carbohydrates may be refined, removing many important nutrients - along with their benefits.

With the popularity of diets like Atkins and Paleo, carbohydrates have been labeled 'bad' food that can cause obesity. In reality, eating too much of any food can lead to weight gain. Carbohydrates are critical for brain function as well as maintaining energy during strenuous and extended exercise.

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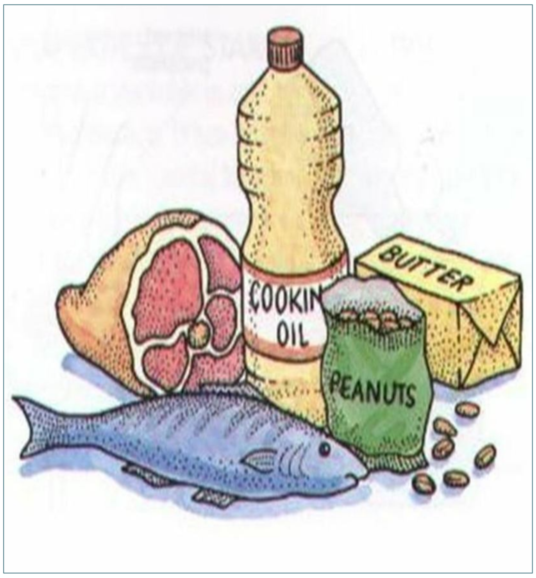
23.2.2. Fats



Fats are a natural component of various foods, and they come in different forms. The oils used in cooking are a form of fat. Fats are also found in foods of animal origin, such as meat, dairy, poultry, and fish, and such common foods like avocados, nuts, and olives. Fats are a major source of energy or calories and also help your body absorb some vitamins. Fat is composed of carbon, hydrogen, and oxygen. In fat oxygen content is much lower than that of carbohydrates. Fat is made fatty acids and glycerol. Like carbohydrates, fat is also an important source of energy. One gram of fat gives 9 kilocalories of energy.

Fat can be stored in the body for subsequent use. Thus, fat serves as a storehouse of energy in the body. Fat protects our body against cold. We take more fat during the winter. Animals living in a cold climate store a lot of fat under their skin. Whaleman seal, polar bear, and penguin store fat under their skin to fight cold.

Eating too much fat is also not good for us. Excess body fat leads to a condition called obesity which is harmful to our body.it may lead to heart problems.

Fats are of two types: **Animal fats and Vegetable fats**

1. Animal Fats

Butter, ghee, milk, meat, fish, etc. are examples of animal fats. These are more digestible than vegetable fat snd contain vitamins A and D in greater proportion.

2. Vegetable Fats

Oils from groundnut, coconut, mustard, soybean, sunflower, etc. are examples of vegetable fat.

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23.2.3. Proteins

Proteins are made up of small units called amino acids. Each unit of an amino acid contains carbon, hydrogen, oxygen, and nitrogen. Sulfur and phosphorus are also present in certain amino acids. Proteins are part of every cell in our body and are needed to build and repair muscle, tissue, skin, nails, and hair. Protein also helps build hormones and enzymes. Proteins build and repair body structures, produce body chemicals, carry nutrients to your cells, and help regulate body processes. Excess proteins provide calories and are composed of basic elements called amino acids. There are two types of amino acids: those our body can generate, known as nonessential, and those that can only be obtained from the food you eat, known as essential amino acids. Protein is an essential nutrient to keep your body functioning well. Animal proteins and plant proteins are some tips for healthy protein choices


Animal proteins are called first-class proteins because they contain all the essential amino acids. Mostly protein: Meat, poultry, fish, eggs, etc.

Plant proteins are called second class proteins because they do not have all the essential amino acids. Some plant proteins are legumes, nuts, nut butter, seeds, seed butter, milk, cheese, cottage cheese, soy beverages, yogurt, whole-grain bread, rice, pasta, barley.

Proteins are needed for the growth and repair of worn-out tissues of our body. Like carbohydrates and fats, proteins can also give energy. One gram of protein gives 5.6 kilocalories of energy. Protein foods are essential for growing children, pregnant women, and people recovering from injuries or sickness. Proteins, fats, and carbohydrates are the nutrients that our body needs in a larger amount. These nutrients are called macronutrients. Vitamins and minerals are micronutrients because we need them only in traces.

23.2.4. Vitamins

Vitamins are needed in very small quantities to our bodies. Vitamins are organic compounds that are essential for the normal working of the body. These substances are required in very small quantities. They keep us healthy and safe from diseases. Milk, egg, meat, fruits, vegetables, and dry fruits are rich sources of vitamins. Vitamins are also available in the form of tablets, capsules, and injections.

Functions of Vitamins

1. Vitamin A keeps our eyes and skin healthy.
2. Vitamin C gives strength to the body to fight against infection and diseases.
3. Vitamin D helps our body to use calcium for bones and teeth.

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Vitamins are classified into two groups based on their solubility in fats and water. They are:

1. Fat-soluble vitamins: They are vitamins A, D, E, and K

2. Water-soluble Vitamins: They are vitamins B and C.

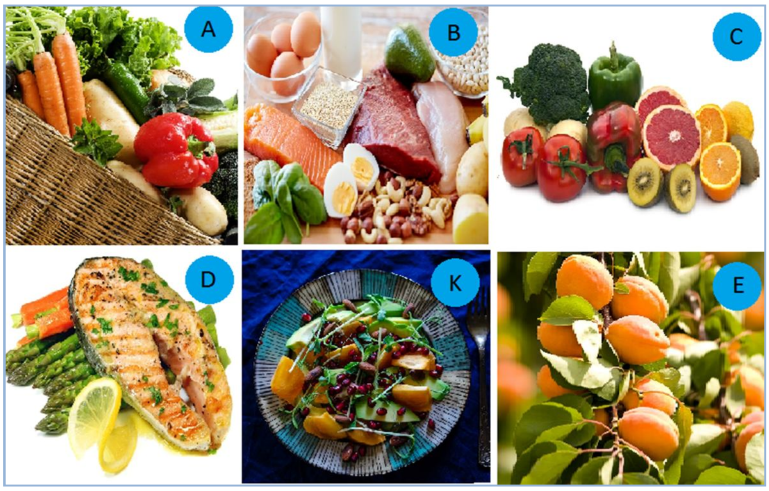
Sources of Vitamins

Vitamin A: Sources: Leafy vegetables, carrots, papaya, kidney beans, egg yolks, and butter.

Vitamin B: Available in several foods such as fish, meat, eggs, milk and green vegetables.etc

Vitamin C: Citrus fruits such as oranges, lemons, tomatoes, cauliflower, spinach, etc.

Vitamin D: Few foods such as fatty fish, livers, salmon. The major source of Vitamin D is the synthesis in our skins with the help of sunlight.



Vitamin K: Leafy green vegetables, tomatoes, peas, pomegranate, basil, fennel and more

Vitamin E: Sources: Eggs, olives, apricots, oil, and meat.

23.2.5. Minerals

Minerals such as calcium, zinc, iron, and potassium in your body are very important for body functions. Minerals are necessary for the normal working of our bodies.

About 4% weight of the human body is made up of minerals. Roughly 16 mineral elements are known to be essential for us. Calcium and phosphorus are essential for the proper formation of bones and teeth. Milk, cheese egg pulses, etc. are rich in calcium and phosphorus. Iron is necessary for the formation of haemoglobin - the red pigment present in the red blood corpuscles of the blood, the deficiency of which causes anemia. Green leafy vegetables nuts peas and liver are rich in iron. Vitamin contains Iodine, sodium potassium, zinc, and magnesium is necessary for a healthy body.

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Sources of minerals

Iodine: fish, spinach, curd, ginger

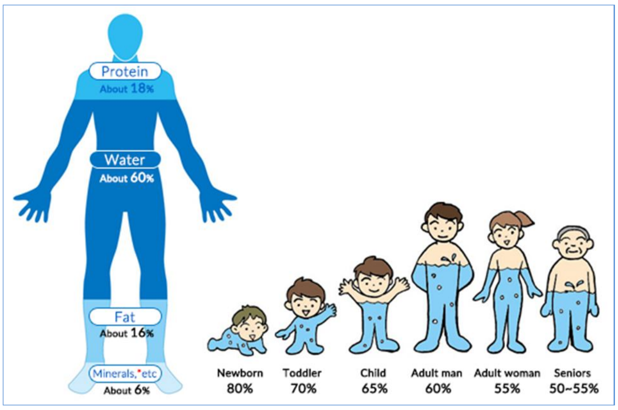
Phosphorous: milk, banana, soybean, green chilies

Iron: liver, apple, spinach,

Calcium: milk, egg

23.2.6. Water

On average, the body of an adult human being is 60% water, most of which is contained in the cells, which need water to live. The amount of water in the human body varies according to age. The body of a newborn, for example, is composed of more water (75%) than that of an elderly person (50%).



The maximum part of our body is covered with water. Water is very essential for living things. Many foods, especially fruits, contain a lot of water. Water plays a role in nearly every major body function. It regulates body temperature, carries nutrients and oxygen cells via the bloodstream, and helps carry away waste. Water also helps cushion joints and protects organs and tissues. It just likes energy liquid food for our body. Water performs the following functions in our body.

1. It transports food material within the body.
2. It helps in the formation of urine and feces.
3. It is an essential part of blood and digestive juices.
4. It regulates our body temperature.

23.2.7. Roughage (Fibre)

All the vegetable matter that we take in as part of our food cannot be digested. The fibrous parts of vegetables fruits and cereals contain cellulose. Cellulose forms the fiber content in food and is called roughage. Although it does not have any nutritive value yet it is needed in our diet. It performs the following functions in our body.

1. It is effective in regulating the process of digestion.
2. It prevents constipation.
3. It helps in the regular movement of bowels.
4. It helps the food to pass down the alimentary canal properly.

Roughage does not provide any nutrients to our body but it is an essential ingredient of our food as it helps our body to get rid of undigested food. It is mainly provided by plant products like whole grains, pulses, fresh fruits, and vegetables.

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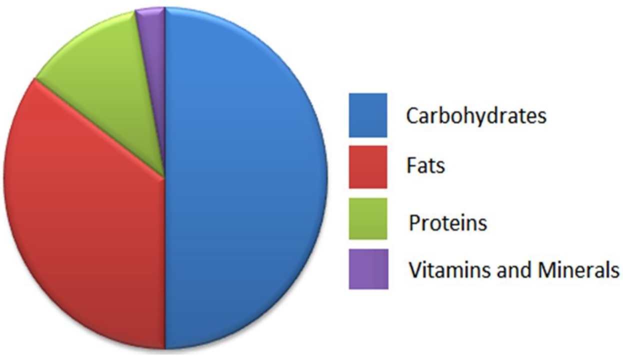
Fiber is the part of plant foods that your body doesn't absorb. The two main types of fiber are soluble and insoluble.

Foods high in soluble fiber include citrus fruits, apples, pears, plums and prunes, oatmeal and oat bran, and barley. Legumes, such as dried beans and peas, are also high in soluble fiber. This type of fiber helps lower blood cholesterol, slows the rise in blood sugar, and adds bulk to stools.

Insoluble fiber is found in many vegetables, wheat bran, and whole-grain bread, pasta, and cereals. Insoluble fiber also adds bulk to stool, stimulates the gastrointestinal tract, and helps prevent constipation.

23.3. BALANCED DIET



A diet is said to be balanced when it provides the right proportion of fats, carbohydrates proteins, vitamins, minerals, roughage, and water to maintain a healthy body. A balanced diet should contain 50% carbohydrates 35% fats, 12% proteins, 3% minerals, and vitamins and a sufficient amount of water and roughage.

A balanced diet should have the following three qualities:

1. It should be rich in various essential nutrients like minerals and vitamins.
2. It should provide just enough raw materials needed for the growth, development, repair, and replacement of tissues of the body.
3. It should provide the right quantum of energy required by the body.

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CHAPTER.24

COSMIC ENERGY

24.1. INTRODUCTION

As we know that there are so many forms of energy which we have studied in previous chapters. Beside these energies, there is also one form of energy i.e. cosmic energy. It is this energy that animates life and maintains balance in the entire universe. We all are surrounded by it, in & out, always, every time, and everywhere.

Cosmic energy is the energy of the Consciousness. It is present in the galaxies, in the space, in the atoms and everywhere. Macrocosm and microcosm, everything is filled with cosmic energy. Cosmic stands for 'Universe'. We know that every single particle that exists has some energy associated with it. The whole universe also has some energy associated with it. This energy- the one associated with cosmos- is called the cosmic energy. In Hinduism, cosmic energy is often known as 'Shakti' who is the "Divine Mother" and is responsible for all creation. 'Shakti' represents power, might, superior strength, and capability. Cosmic energy is the invisible energy that makes everything possible. Slowly and steadily, scientists are associating the energy that flows freely through our body, mind, and spirit with the cosmos. Humanity has found a way to prove that everything in the universe is constantly recharged by the cosmic energy.

All of us are constantly availing this energy but as our mind remains distracted with thoughts of past and future, so we are unable to get the most out of it. It is said that if we want

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to invite more of positive cosmic energy into our life, we need to focus our mind. One way of focusing the mind is to meditate. Meditation controls our thought, stabilized our mind and thus we can get lot of Cosmic energy into us. Cosmic energy is the basis of all our actions, reactions to situations and functions in totality. Our body receives some amount of cosmic energy when we are asleep in total silence and with peace of mind. Cosmic energy is essential for the following reasons:

1. To maintain an orderly life
2. To lead a happy and healthy life
3. To completely involve in all the situations in life
4. To expand our consciousness
5. To obtain knowledge

24.2. HOW DOES COSMIC ENERGY WORKS?


The universe is made up of energy was in existence long before the universe came to being. This energy can be found in all living and non-living things. It moves at such a fast speed, faster than we can even think. This same energy moves everything on earth making everything to be interconnected. Cosmic energy is a life force that flows through our bodies following predefined pathways referred to as chakras and through a field that is referred to as the aura. Our body is truly wonderful. It is like an interconnected web of many systems and organs working together. When one system is stressed or agitated, the brain sends signals across the body & the whole body feels stressed out & disturbed. When we are emotionally disturbed, stress hormones, adrenalin & cortisol are released in blood inducing illness in the body.

This energy nourishes the cells of the body which supports the organs in their functions. An interruption to the flow of cosmic energy gives negative thoughts and feelings. This negativity causes diminished functionality of the cells and organs and, therefore, leads to reduced productivity. Again, this is what is believed to cause illnesses. To reverse this, cosmic energy has to flow through the affected parts and charge them with positive energy. This causes the body to strengthen as the energy flows more healthily and naturally.

24.3. HOW DO WE GET COSMIC ENERGY?

Sometimes we feel sadness in life, and no power on this earth seems to be able to help us. Cosmic energy is really important for a person’s spiritual and physical well-being. It is also considered to be the fuel for life.

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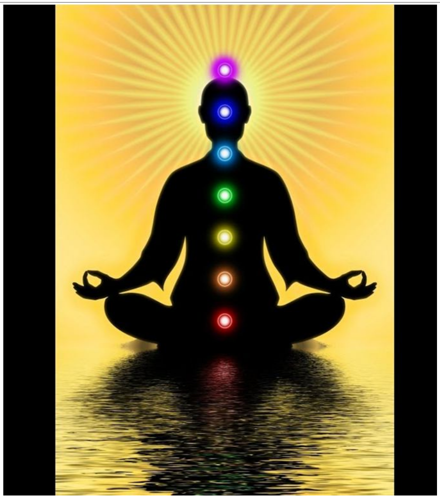

As we mentioned earlier, cosmic energy is available to us in abundant supply. It is up to us how much energy is to be taken for healing our body or spiritual development. There are different ways in which a person can get this cosmic energy. The easiest way to build a relationship with the cosmos is by limiting the level of negativity in one's life. You can do this by harmonizing your breathing through techniques such as meditation and yoga. When you should start practicing cosmic energy meditation! It has the magical ability to change your life for the better! There are two main ways to receive cosmic energy;

24.3.1. Meditation

As you meditate, cosmic energy flows through our entire body, mind, and soul. It helps us to be open to the insights of the cosmos and to gain the clarity that enriches our lives. All you need to do meditation at least daily. There are some basic tips to help you for meditation:

1. Find a quiet spot where there is no disturbance.
2. Sit in an upright position comfortably. You can also sit in a chair.
3. Close your eyes so that you can focus better.
4. Make no efforts to control the breath; simply breathe naturally.
5. Take a deep, slow breath
6. Release all thoughts that come to you.

If your mind wanders, return your focus to your breath.

Maintain this meditation practice for two to three minutes to start, and then you can try it for longer time.

24.3.2. Deep Sleep

A person may also receive cosmic energy through sleep. However, in today's world we do not get normal sleep due to stressful life so we do not get sufficient energy. Natural deep sleep recharges our cosmic energy today. This happens when, as we are deeply asleep. The easiest way to attain deep sleep is through hypnosis techniques. Another way is through deep sleep guided meditation which enables your body to get to an intense resting state.

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24.4. BENEFITS OF COSMIC ENERGY

Our body and mind are surrounded by an energy field, which is nourished by cosmic energy. This positive energy always helps in the healing of the physical, mental and spiritual level. Cosmic energy reduces negativity, aids in complete healing and creates harmony in life. There are number of benefits associated with cosmic energy. The benefits are both physical and spiritual. Some benefits are listed below:

1. **Cosmic energy regulates the blood flow and lowers the stress on the heart.**
2. Cosmic energy helps in lowering cortisol and lactate levels in the body. These are often associated with mental stress.
3. Cosmic energy helps in eliminating free radicals from the body.
4. Cosmic energy does wonders in treating all psychological issues such as anxiety, irritability and depression. We get more relaxation.
5. Cosmic energy aids in healing cardiovascular diseases and develops skin resistance and helps to improve the memory function.
6. Cosmic energy helps us lead a happy and prosperous life. When we are open to cosmic energy, we start living for others which gives us internal happiness.

24.5. CONCLUSION

It is believed that the earth has a positive and negative impact on humanity. The planet produces a frequency that aligns with our energy produced by our bodies. This enables us to have good health and wellbeing. It also helps us to receive insights into a higher level of consciousness. When we meditate, we attain complete alignment with the world around us.

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