MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION
(Autonomous)
(ISO/IEC - 27001 - 2005 Certified)
SUMMER – 16 EXAMINATION
Subject Code : **17611** **Model Answer**

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

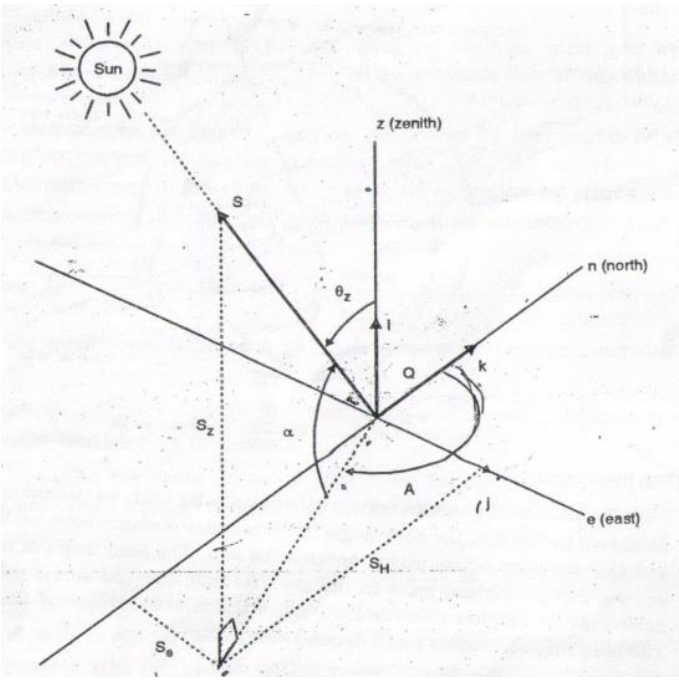
Q.1 (a) (02 mark for conventional and 02 for non conventional Any four each)

i. Non Conventional energy sources :
   1. Solar energy
   2. Wind energy
   3. Tidal energy
   4. Geothermal energy
   5. Bio mass

ii. Conventional energy sources :
   1. Thermal energy
   2. Nuclear energy
   3. Coal
   4. L.P.G
   5. Crude oil

Q.1 (b) (04 marks for a neat sketch)

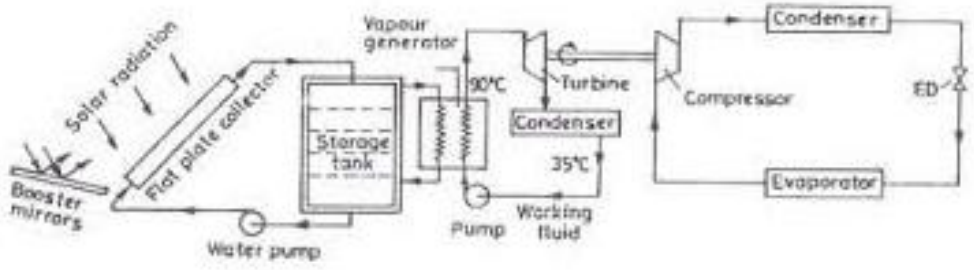
Solar angles



Q.1 (c)(02 marks for sketch and 02 for explanation)

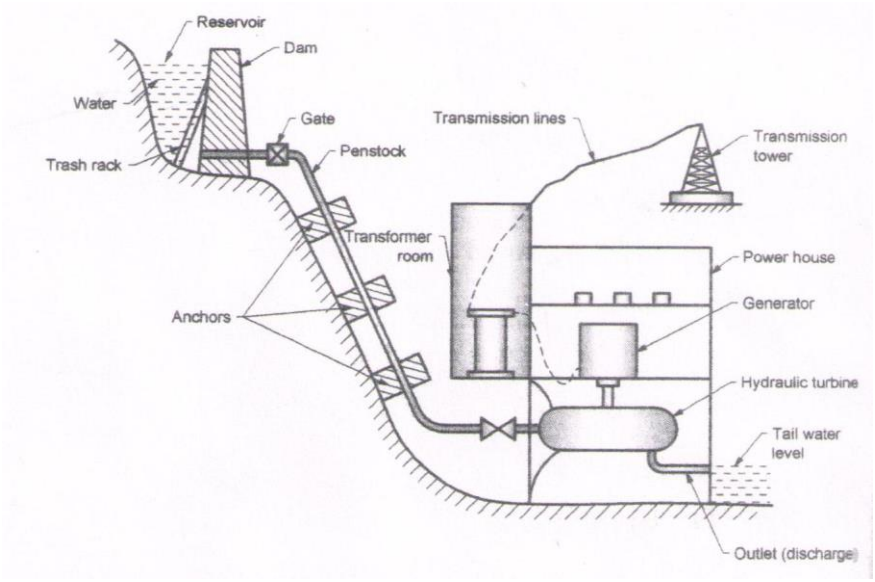
A Solar vapor compression refrigeration system is shown in figure. It consists of mainly solar collector and storage tank for heat exchange in the exchanger. The turbine power is used to run the compressor of usual VCR system.

It is to be noted that there is no requirement of external electrical power supply to the compressor as it is given by the turbine running on solar energy.



.1 (d) (02 marks for sketch and 02 for explanation)

Small hydro electric power plant:



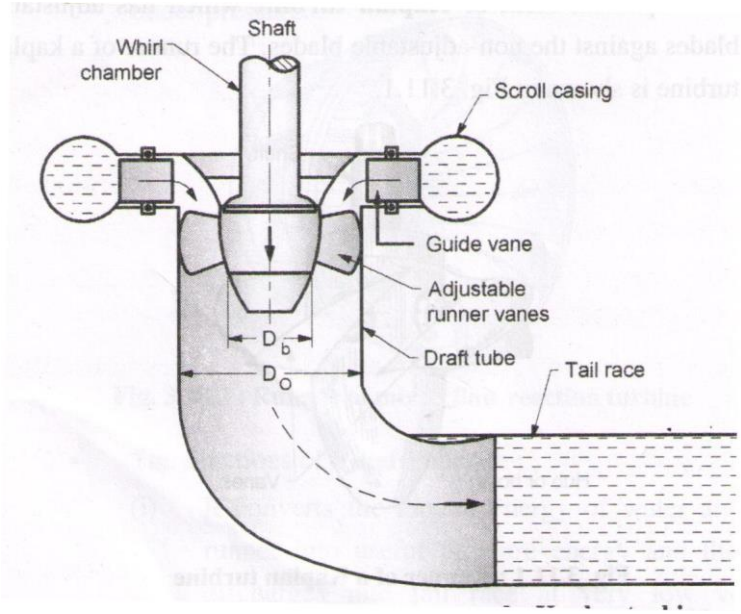
A small hydro electric power plant consists of the following :

1. Reservoir : used to store water during rainy season. This water is used to run the hydraulic turbine
2. Dam : It is a structure of considerable height built across the river. It provides working head of water for power plant
3. Gate : It is provided for controlling of flow of water from reservoir to turbine
4. Waterway and penstock: Waterway carries water from the dm to the power house. It includes canal and penstock or tunnel
5. Hydraulic turbine: These are used to convert the kinetic energy of water into mechanical energy

Q.1 (e) (02 marks for sketch and 02 for explanation)

Kaplan turbine:

IT is a axial flow reaction turbine in which water flows parallel to the axis of shaft. It has a vertical hollow shaft which is enlarged at the bottom in the shape of propeller called hub or boss. The vanes are fixed on the hub which acts as the runner of the Kaplan turbine. It has scroll casing guide mechanism and draft tube .



Kaplan turbine

Q.1 (f)(03 marks for explanation and 01 for storage value)

Photosynthesis : It is the process in which solar energy is converted into biomass energy. Photosynthesis process occurs only in green plants. It is the process of combining CO2 from the atmosphere with water in the presence of light energy to produce carbohydrates and oxygen.

The photosynthesis process is complex but overall photosynthesis process can be represented by the following process

$$6CO_2 + 6H_2O + \text{light energy} = C_6H_{12}O_6 + 6\ O_2$$

Total energy stored in the photosynthesis process is about 4500 kJ

Q.1 (g) (02 marks for objectives and 02 for needs)

Energy Audit: An energy Audit is the first step in energy management programme. It shows how efficiently energy is being used and highlights opportunities for energy cost savings. It also shows ways to improve productivity**.**

Objectives of energy Audit :

The objectives of energy management are as follows:

1. To reduce energy consumption
2. To minimize energy cost. It involves the following:
    a) Look for alternative sources of energy which is cheaper than existing source of energy
    b) Reduce waste of energy

c) Adopt new technology requiring low energy consumption

3. Reduce emissions so as minimize environmental effects.

Need of Energy Audit : Energy audit takes a thorough look at a particular facilities, process or technologies. A compressive audit provides a detailed energy project implementation plan for a facility. This type of audit offers the most accurate estimate of energy savings and cost.

Q.2 (a) (04 marks for explanation)

Effect of greenhouse gases on climate change : The effect of earths atmosphere due to trapping of long wavelength infrared radiations by the CO_2 layer in the atmosphere is called green effect.

CO_2 produced by power plants has no ill effect on human life biologically but increased concentration of it may cause the climate change due to its heat trapping quality leading to green house effect.

Global Warming: It is also called as climate change. It refers to the long term fluctuations in temperature, precipitation, wind and earth elements of the earth climate system.

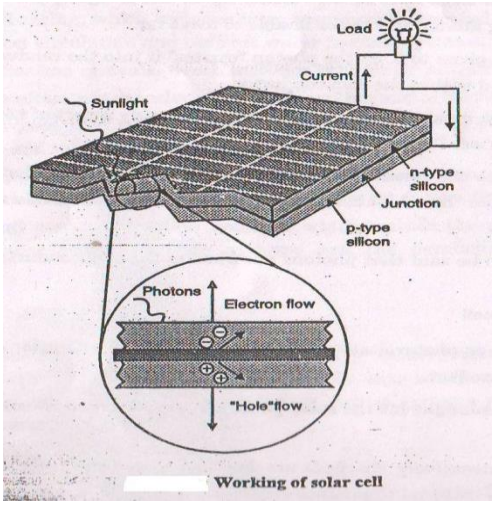
Q.2 (b) (02 marks for sketch and 02 for explanation)

Principles of photovoltaic power generation :

Photovoltaic electric conversion: When photon is absorbed, its energy is given to an electron in the crystal lattice. The energy given to this valence bond excites it into the conduction band.

Photovoltaic cell: A solar cell or photovoltaic cell is a device that converts solar energy into electricity by the photovoltaic effect. Photons in sunlight hit the solar panel and are absorbed by semiconducting materials such as silicon.

Electricity can be produced by solar cells whose principal component consists of a semiconductor that is typically made of silicon. Solar cells are often electrically connected and encapsulated as a module often has a sheet of glass. To make practical use of solar generated energy the electricity is most often fed into electricity grid using inverters.



Working of solar cell

Main elements of SPV :

1) Photovoltaic array
2) Inverter
3) Energy storage
4) System charge control
5) Balance of system (BOS) components

Q.2 (c) (02 marks for typesand 02 for explanation , any one)

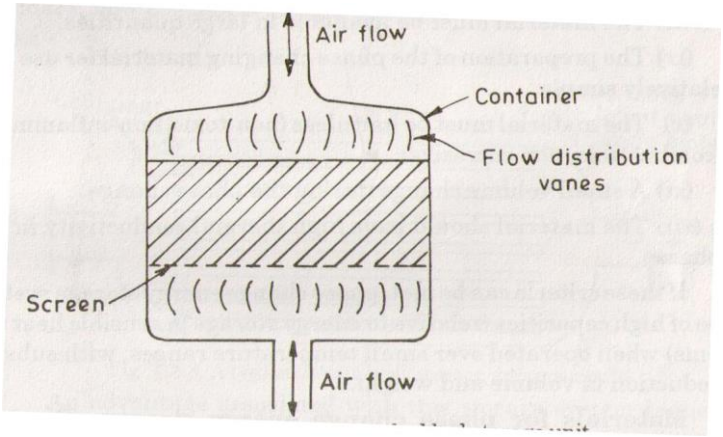
Types of geothermal resources: There are five general types of geothermal resources as :

a) Hydrothermal convective system
   i. Vapor dominated
   ii. Liquid dominated
   iii. Hot water fields
b) Geopressure resources
c) Petrothermal or hot dry rocks
d) Magma resources
e) Volcanos

Vapor dominated system : In this system the water is vaporized into steam that reaches the region with relatively druy condition at about 200 ^{o}C and the pressure about 8 bar . this steam is most suitable for running turbo electric power plants with less cost. However it also has the problem of corrosion and erosion of material.

Q.2 (d))(02 marks for sketch and 02 for explanation)

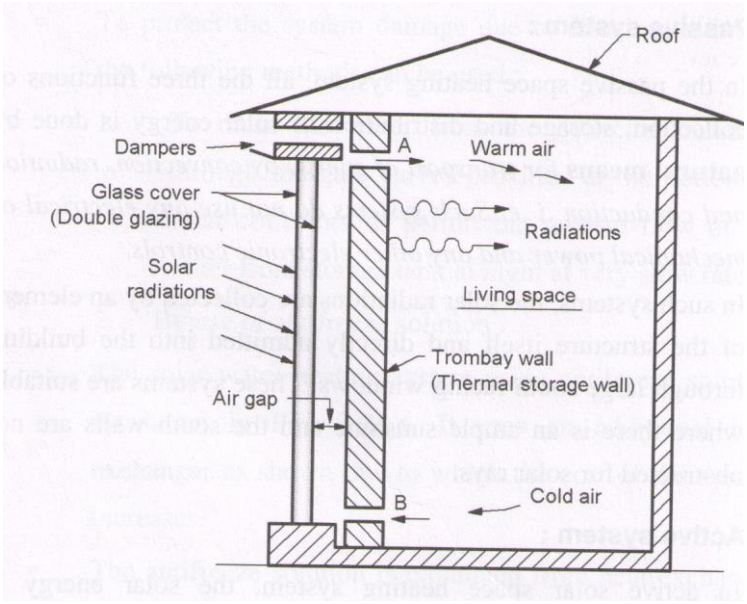
Packed Bed Solar exchanger Storage System: For sensible heat storage with air as transport mechanism, rock , gravel, or crushed stone in a bin has the advantage of efficient heat transfer process. It consists of a storage unit with a screen provided along with flow distribution vanes inside the container . Usually air is circulated to add or remove heat from the bed.



Q.2 (e))(02 marks for sketch and 02 for explanation)

Passive solar space heating system:

This system has south facing concrete or stone or brick wall 10 cms to 20 cm thick called trombay wall . It is designed for thermal storage and its outer surface painted black . The wall is covered by sheets of glass. It is provided with vents A and B at top and bottom for circulation of hot air and cold air . Radiations are absorbed by wall and air in the gap gets heated and flows from top and bottom. The living space gets energy transfer by radiation . Campers are provided at the top of glass covers to allow the excess heat to escape to the surroundings when the heating is not required

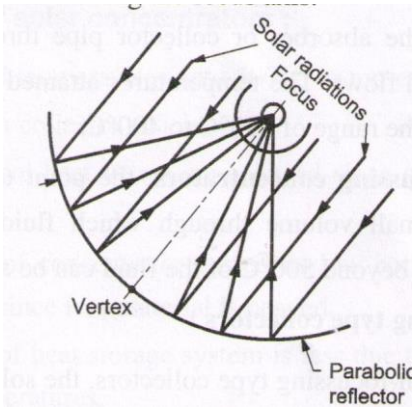


Passive solar space heating system:

Q.2 (f) (02 marks for sketch and 02 for explanation)

Solar concentrating collectors: They are broadly classified as

1. Focusing type or concentrating type collectors
    a) Line focusing type concentrators
    b) Point focusing type concentrators
2. Non focusing type collectors



Focusing type or concentrating type parabolic trough collectors

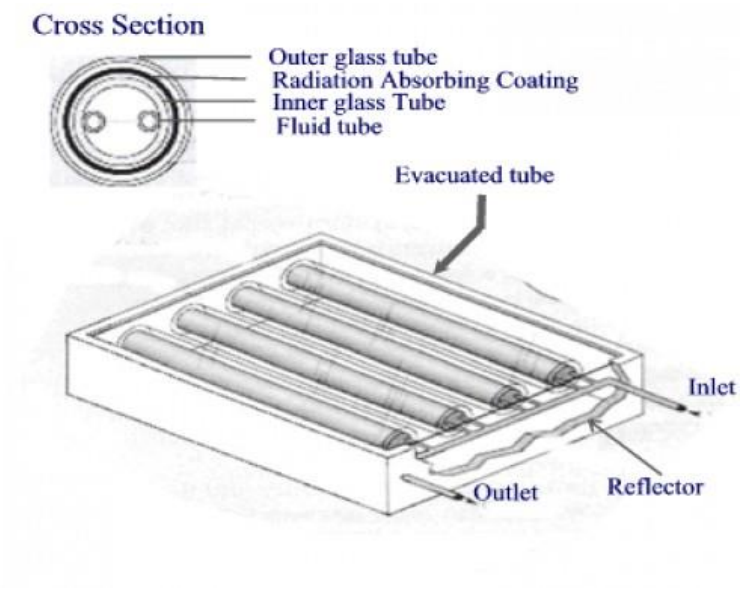
Q.3 (a) (02 marks for sketch and description and 02 for advantages)

Solar Evacuated Tube flat plate collector: (ETC):

ETC evacuated tube solar collectors convert energy from the sun into usable heat in a solar water heating system. This energy can be used for domestic and commercial hot water heating, pool heating, space heating or even air conditioning.

Construction:

The ETC solar collector is comprised of four main parts:



Evacuated Tube (ET)

Absorbs solar energy and converts it to usable heat. A vacuum between the two glass layers insulates against heat loss.

The Heat Transfer Fin helps to transfer heat to the Heat Pipe.

Heat Pipe (HP)

Copper vacuum pipe that transfers the heat from within the ET up to the manifold.

Manifold

Insulated box containing the copper header pipe. The header is a pair of contoured copper pipes with dry connect sockets that the heat pipes plug into.

Mounting Frame

Strong and easy to install with a range of attachment options.

Advantages of Solar Evacuated Tube collector: (ETC) over flat plate collector:

1. It absorbs direct, diffused and reflected components of solar radiations
2. It is fixed in the orientation thus there is no need for tracking
3. It has low cost and it is almost maintenance free

Q.3 (b) defination @ 1 mark each)

i) **Solar irradiance**
is the power per unit area produced by the Sun in the form of electromagnetic radiation. Irradiance may be measured in space or at the Earth's surface after atmospheric absorption and scattering.

Total Solar Irradiance (TSI), is a measure of the solar radiative power per unit area normal to the rays, incident on the Earth's upper atmosphere. Irradiance is a function of distance from the Sun, the solar cycle, and cross-cycle changes. Irradiance on Earth is most intense at points directly facing (normal to) the Sun.

ii) Solar constant
Amount of energy received in unit time on a unit area perpendicular to suns direction at the mean distance of earth from the sun.

iii) Extra terrestrial radiations

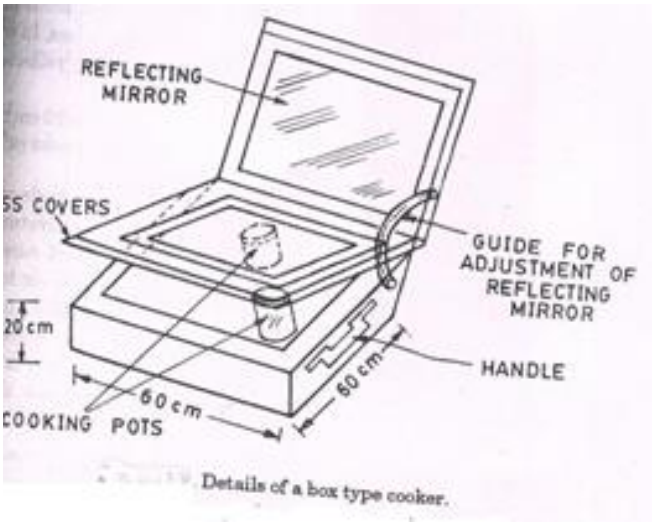
Solar radiation incident outside the earth's atmosphere is called extraterrestrial radiation. On average the extraterrestrial irradiance is 1367 Watts/meter2 (W/m2). This value varies by ±3% as the earth orbits the sun.

iv) T**errestrial radiation**.

Radiations received on the earth surface after the solar radiations have traversed through the layer of atmosphere.

Q.3 (c)

(02 marks for sketch and 02 for explanation)



Details of a box type cooker.

Solar cooker

Figure shows the box type solar cooker. The solar rays penetrate through the glass covers and absorbed by a blackened metal tray kept inside the solar box. Two glass covers are provided to again minimize the heat loss. The loss due to convection is minimized by making the box air tight by providing a rubber strip all rounds between the upper lid and the box. When the cooker is placed in the sun, the blackened surface starts absorbing sun rays and temperature inside the box starts rising. The blackened cooking pots get heat energy and food will be cooked in a period of time.

Q.3 (d) (01marks for each definition)

Definition of

i) Solar cell: Energy conversion device which are used to convert sunlight to electricity by use of the photo voltaic effect are called solar cells.

ii) Solar module: combination of such solar cells, designed to increase electrical power output is called solar power module.

iii) Solar panel: A solar panel is a collection of solar *cells*. Lots of small solar cells spread over a large area can work together to provide enough power to be useful. The more light that hits a cell, the more electricity it produces.

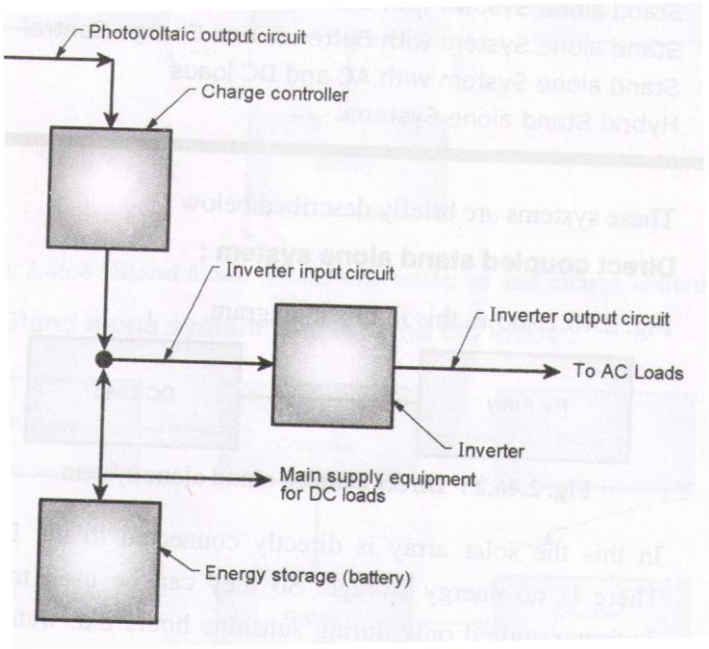
iv) Solar array: a solar array is a group of solar modules (panels) which are connected to the same system. If a roof has seven solar panels, then the roof has an **array** containing seven **solar modules.**

Q.3 (e) (02 marks for sketch and 02 for explanation)

Stand alone solar photovoltaic power plant/system

Salient features of system are

- Power supply to the system independently without common grid. Operate independently.
- Used for backup power when connecting to grid is very costly.
- Hybrid stand alone may include other power producing devices for backup.
- Various types are direct coupled, with battery storage, hybrid etc.

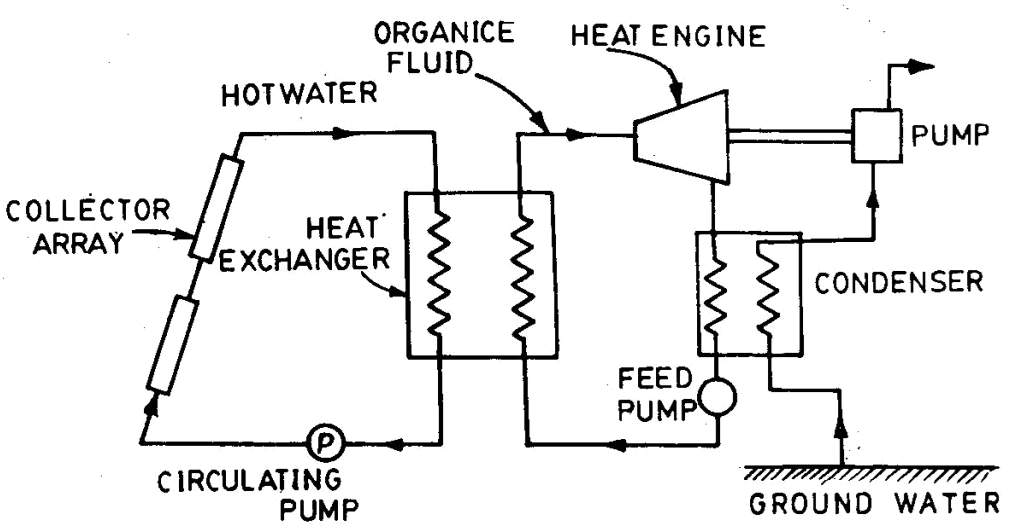


Q.3 (f) (02 marks for sketch and 02 for explanation)

The basic system consists of following components:

1. Solar collectors may be Flat plate or sun tracking concentrators
2. The heat transport system
3. Boiler or heat exchangers
4. Heat Engine : Rankine/ Stirling hot gas, rotary piston
5. Condenser

6. Pump may be Reciprocating, centrifugal, diaphragm



Schematic of a solar pump.

Q.4 (a)(04 marks for classification)

Classification of small hydro electric power plant :

1. Classification based on head availability – low , medium and high
2. Classification based on nature of load – base load, peak load
3. Classification based on water availability – run off river without pondage , with pondage, storage type, pumped storage peak load and mini and micro hydel plants

Q.4 (b) (1/2 marks for each any eight)

Following are the components of the hydro electric power plant.

1. Reservoir
2. Dam
3. Trash rack
4. Gate
5. Forebays
6. Surge tank

7. Waterway and penstock
8. Spillway
9. Power house
10. Hydraulic turbines
11. Draft tube
12. Tail race

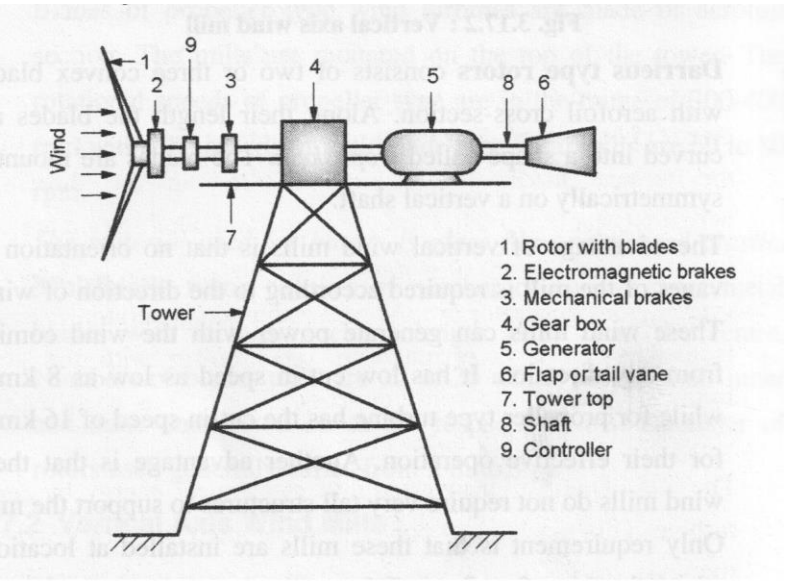
Q.4 (c) (1/2 mark for each, any eight)

Criteria for site selection of small hydro electric power plant

1. Water availability and method of storage
2. Availability of head
3. Distance of power station from power demand centre
4. Availability of construction materials
5. Access to site
6. Availability of transport facilities etc

Q.4 (d) (02 marks for sketch and 02 for explanation)

Horizontal axis wind turbine



Wind mill: Basic structure of windmill consists of the following components.

i) Rotor blades: The rotor blades extract the wind energy and converts it into rotational form

ii) Gearbox: It converts the rotational speed from low speed shaft and transforms it into faster rotation on the high speed shaft

iii) Hub: It is the connection point for the rotor blades and low speed shaft

iv) Mechanical brake: It is a disc brake used for repairs and maintenance of the wind mill.

v) Generator :It converts the rotational speed of high speed shaft to electrical energy

vi) Yaw mechanism. This mechanism keeps the rotor blades parallel to the flow of wind

vii) Anemometer and wind vane: They are the instruments for measuring wind speed

Q.4 (e) (02 marks for sketch and 02 for explanation)

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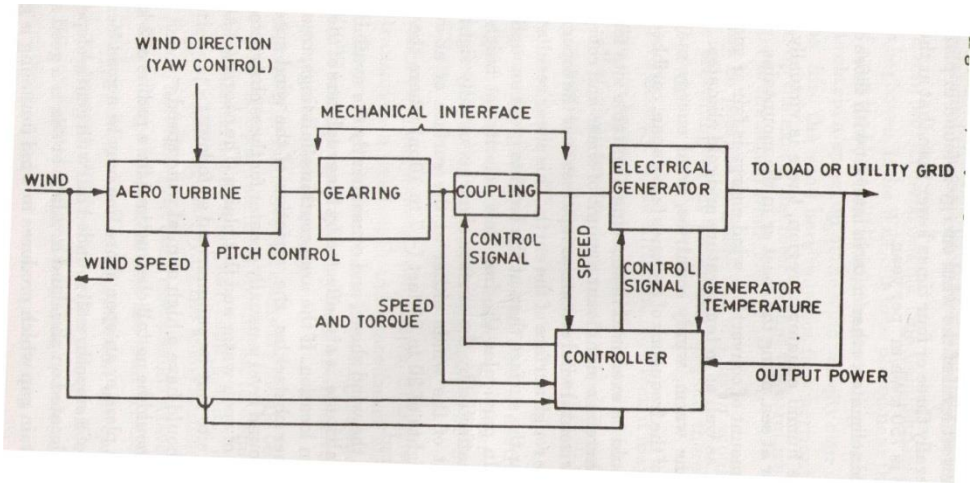

Block diagram showing main components of wind energy conversion system

Q.4 (f) (02 marks for explanation and 02 for factors)

The process of anaerobic digestion occurs in a sequence of stages involving distinct types of bacteria.

Hydrolytic and fermentative bacteria first break down the carbohydrates, proteins and fats present in biomass feedstock into fatty acids, carbon dioxide, hydrogen, ammonia and sulfides. This stage is called hydrolysis.

Next, acetogenic bacteria further digest the products of hydrolysis into acetic acid, hydrogen and carbon dioxide.

Methanogenic bacteria then convert these products into biogas. The combustion of digester gas can supply useful energy in the form of hot air, hot water or steam.

After filtering and drying, digester gas is suitable as a fuel for an I.C. engine, which combined with generator, can produce electricity.

Anaerobic digestion: Anaerobic digestion is a biochemical process in which the particular kinds of bacteria digest biomass in an oxygen free environment. The process of anaerobic

digestion occurs in a sequence of stages involving distinct types of bacteria.

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After filtering and drying, digester gas is suitable as a fuel for an I.C. engine, which combined with generator, can produce electricity.+

Factors affecting bio digestion: Following factors are affecting the biodigestion:

1) pH or the hydrogen-ion concentration
2) temperature
3) total solid content of the feed material
4) loading rate
5) seeding uniform feeding
6) Diameter to depth ratio
7) Carbon to nitrogen ratio
8) Nutrients
9) Retention time
10) Types of feed stock

Q5 a)(04 marks for explanation)

Bioethanol

Ethanol produced by microorganisms, e.g., Saccharomyces cerevisiae, from biomass is called bioethanol. Bioethanol is the most widely used biofuel for transport purposes.At present, bioethanol (2 carbon atoms) is not cost-competitive as compared to petrol (4-12 carbon atoms), but is being used for transport due to government subsidies.

A bio-ethanol to be used /suitable for transport purposes should have the following desirable features:

i) It should be portable in sufficient quantities in the vehicle,

ii) It should burn in the internal combustion engines, and

iii) It should be roughly equivalent to petrol in energy content.

iv) Ethanol has a much higher latent heat of vaporisation (855 MJ/kg) than petrol (293 kJ/kg). This energy is obtained from the air in the carburettor. As a result, the fuel mixture entering the cylinder is much cooler and hence denser in case of ethanol than in the case of petrol.

v) Ethanol has a higher octane number (99) than petrol (80-100). As a result, ‘preignition’ does not occur when ethanol is used in engines set for petrol.

vi) Higher octane rating of ethanol allows the compression ratio of the engines to be increased; this results in increased production of power. In view of the above points, ethanol burning engines have only 10% more fuel consumption than petrol ones although ethanol has only about 62% as much energy content as petrol.

vii) Ethanol is burnt more completely so that hydrocarbon emission is drastically lower as compared to that in case of petrol.

vii) Ethanol has a much higher flash point (45°C) than petrol (13°C). Flashpoint is the temperature at which a substance catches fire. Therefore, ethanol is much less likely to catch fire and explode in cases of fuel leakage, e.g., during accidents.

vii) In can be mixed with petrol; this increases the octane rating of petrol.

So bioethanol is a good option suitable as automobile fuel.

Q5 b)(1/2 mark each for each source any four, 02 marks for energy yield)

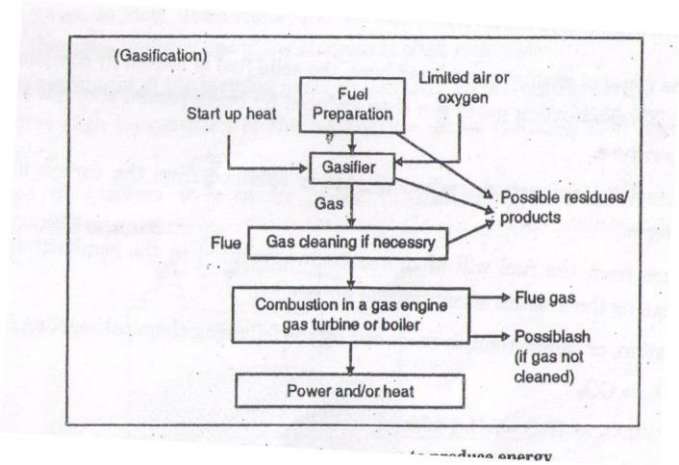
Biomass is organic matter derived from living, or recently living organisms. Biomass can be used as a source of energy and it most often refers to plants or plant-based materials which are not used for food or feed, and are specifically called lignocellulosic biomass . As an energy source, biomass can either be used directly via combustion to produce heat, or indirectly after converting it to various forms ofbiofuel. Conversion of biomass to biofuel can be achieved by different methods which are broadly classified into: thermal, chemical, andbiochemical methods.

1. Wood: The hard wood energy yield is around 17 MJ/kg
2. Energy crops : The energy crops energy yield is around 15 to 18 MJ/kg
3. Agricultural residues: The agricultural residues energy yield is around
    a) Grass : 7.21MJ/kg
    b) Tree leaves : 7.5 MJ/kg
    c) Wheat straw : 16 MJ/kg
    d) Rice husk : 14 MJ/kg
    e) Sugarcase bagasse : 7 to 9 MJ/kg
4. Food waste : The food waste energy yield is around 10 MJ/kg
5. Industrial waste and co-products: The industrial waste energy yield is around 4 to 7 MJ/kg

Q5 c) (03 marks for sketch and explanation and 01 for composition)

Gasification of solid biofuel

The gasification process in general involves the reaction of solid fuels with hot steam and air or oxygen and the subsequent production of gaseous fuel by partial oxidation. The figure explains the process of gasification of biofuel.



The gas resulting from this gasification process mainly consists of following ingredients :

a) Carbon monoxide CO
b) Hydrogen H
c) Methane CH_4
d) Carbon di oxide CO_2
e) Nitrogen N_2

Q5 d) (02 marks for each explanation)

The term fermentation is often used interchangeably with anaerobic digestion when describing the physical decomposition of organic material under the influence of micro organism such as yeast, enzymes bacteria etc. In reality, fermentation is a distinct biological reaction that makes up one step in the greater process of anaerobic digestion. It is responsible for acidogenesis, the forming of acids.

Dry Fermentation

Organic input remains stationary throughout process, eliminating moving parts and resulting in low system maintenance and repair costs. Batch process and stationary system allow precise control over input removal ensuring maximum energy yield. Closed loop liquid cycle — no additional liquid required following start-up, eliminating post-process waste water treatment needs. No pre-treatment or sorting of inputs required prior to system loading, saving time and money for system operators. This system has low energy consumption, using only 5% of the energy generated for plant operation.

Organic input volume reduced by minimum of 40%, a significant additional cost benefit, and waste water is eliminated, removing risk of groundwater contamination.

Wet Fermentation

System requires mechanical parts to circulate biomass in liquid holding tank, leading to increased maintenance and repair costs. Liquid mixture causes premature removal of input before all organic matter has been digested, resulting in a loss of energy. System requires additional liquid to allow fermentation, greatly increasing the amount of system waste water and costly post-process treatments.

Inputs require pre-treatment to prevent breakdown of mechanical parts as input is agitated and moved through system. Input is limited to "wet" waste streams. Typical systems consume 10-30% of the energy generated for plant operation, and treatment of waste water requires additional energy.

Q. No. 5 e) (02 marks for each explanation)

Types of energy audit: The types of Energy Audit are classified as

1) Preliminary Audit
2) Detailed Audit

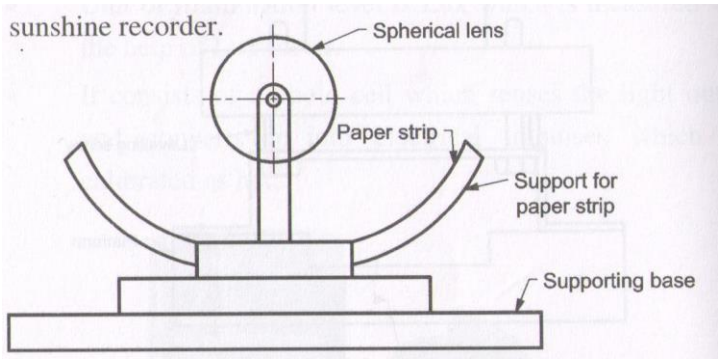
Preliminary Audit: It is quick exercise to establish energy consumption in the organization. It estimates the scope for saving. It identifies the most likely areas for attention and immediate saving in energy. It also sets a reference point and identifies areas for more detailed study of energy.

Detailed Energy Audit Methodology: It is a comprehensive analysis of an energy project and offers the accurate estimate of energy savings and cost. It covers the detailed study of present energy consumption, the use of energy for various processes with calculations of energy efficiency and to evaluate the improvements which can be carried out in its energy use. Detailed audit finally recommends the energy conservation proposals with cost of
investment needed. It also presents the detailed study of expected savings in energy cost. The detailed energy audit report consists of the following :

1. Details about plant
2. Description of production processes involved
3. Description of energy and utility system
4. Detailed process flow diagram and energy
5. Calculation of energy efficiency and process systems
6. Recommendations for energy conservation

Q5 f) (02 marks for sketch and 02 for explanation)

Sunshine recorder :



A sunshine recorder is a device that records the amount of sunshine at a given location. The results provide information about the weather and climate as well as the temperature of a geographical area. This information is useful in meteorology, science, agriculture, tourism, and other fields. It has also been called a heliograph.

There are two basic types of sunshine recorders. One type uses the sun itself as a time-scale for the sunshine readings. The other type uses some form of clock for the time scale.

Principle and Construction:

A Campbell-Stokes sunshine recorder concentrates sunlight through a glass sphere onto a recording card placed at its focal point. The length of the burn trace left on the card represents the sunshine duration. A homogeneous transparent glass sphere L is supported on an arc XY, and is focused so that an image of the sun is formed on recording paper placed in a metal bowl FF' attached to the arc. The glass sphere is concentric to this bowl, which has three partially overlapping grooves into which recording cards for use in the summer, winter or spring and autumn are set.

Three different recording cards are used depending on the season. The focus shifts as the sun moves, and a burn trace is left on the recording card at the focal point. A burn trace at a particular point indicates the presence of sunshine at that time, and the recording card is scaled with hour marks so that the exact time of sunshine occurrence can be ascertained. Measuring the overall length of burn traces reveals the sunshine duration for that day. For exact measurement, the sunshine recorder must be accurately adjusted for planar levelling, meridional direction and latitude.

Q6 a) (02 marks for sketch and 02 for explanation)

Infrared thermometer

An infrared thermometer is a thermometer which infers temperature from a portion of the thermal radiation sometimes called blackbody radiation emitted by the object being measured. They are sometimes called laser thermometers if a laser is used to help aim the thermometer, or non-contact thermometers or temperature guns, to describe the device's ability to measure temperature from a distance. By knowing the amount of infrared energy emitted by the object and its emissivity, the object's temperature can often be determined. Infrared thermometers are a subset of devices known as "thermal radiation thermometers".

The design essentially consists of a lens to focus the infrared thermal radiation on to a detector, which converts the radiant power to an electrical signal that can be displayed in units of temperature after being compensated for ambient temperature. This permits temperature measurement from a distance without contact with the object to be measured. A non-contact infrared thermometer is useful for measuring temperature under circumstances where thermocouples or other probe-type sensors cannot be used or do not produce accurate data for a variety of reasons.

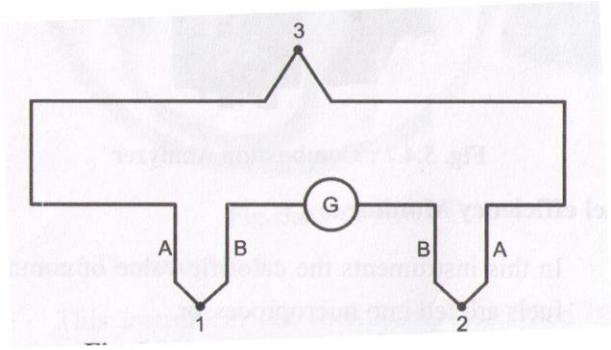
Q6 b) (02 marks for sketch and 02 for explanation)

Angstrom Pyrheloimeter

This pyrheliometer has a rectangular aperture, two manganin-strip sensors (20.0 mm × 2.0 mm × 0.02 mm) and several diaphragms to let only direct sunlight reach the sensor. The sensor surface is painted optical black and has uniform absorption characteristics for short-wave radiation. A copper-constantan thermocouple is attached to the rear of each sensor strip, and the thermocouple is connected to a galvanometer. The sensor strips also work as electric resistors and generate heat when a current flows across them. When solar irradiance is measured with this type of pyrheliometer, the small shutter on the front face of the cylinder shields one sensor strip from sunlight, allowing it to reach only the other sensor.

A temperature difference is therefore produced between the two sensor strips because one absorbs solar radiation and the other does not, and a thermoelectromotive force proportional to this difference induces current flow through the galvanometer. Then, a current is supplied to the cooler sensor strip (the one shaded from solar radiation) until the pointer in

the galvanometer indicates zero, at which point the temperature raised by solar radiation is compensated by Joule heat.



Q6 c) (02 marks for statement and 02 for explanation)

Boiler Efficiency & Furnace efficiency

The term boiler efficiency is often substituted for combustion or thermal efficiency. True boiler efficiency is the measure of fuel to steam efficiency. Basically Boiler efficiency can be tested by the following methods:

1) The Direct Method: Where the energy gain of the working fluid (water and steam) is compared with the energy content of the boiler fuel.

2) The Indirect Method: Where the efficiency is the difference between the losses and the energy input.

The direct method is also known as 'input-output method' due to the fact that it needs only the useful output (steam) and the heat input (i.e. fuel) for evaluating the efficiency. This efficiency can be evaluated using the formula:

$$Boiler\ Efficiency = \frac{Heat\ Output}{Heat\ Input} x\,100$$

$$Boiler\ Efficiency = \frac{\text{Steam flow rate x (steam enthalpy – feed water enthalpy)}}{\text{Fuel firing rate x Gross calorific value}}\ x\ 100$$

Let m_s = Rate of steam generated kg per hour

h_1 = Enthalpy of steam at the exit of boiler in kJ/kg

h_2 = Entahlpy of feed water in

m_f = rate of fuel consumed in kg / hr

G.C.V. = Gross calorific Value in kJ/ kg

$\eta = m_s(h_1 - h_2) / m_f$ x G.C.V

The purpose of the Furnace performance test is to determine efficiency of the furnace and specific energy consumption for comparing with design values or best practice norms. There are many factors affecting furnace performance such as capacity utilization of furnaces, excess air ratio, final heating temperature etc. It is the key for assessing current level of performances and finding the scope for improvements and productivity. Heat Balance of a Furnace Heat balance helps us to numerically understand the present heat loss and efficiency and improve the furnace operation using these data. Thus, preparation of heat balance is a pre-requirement for assessing energy conservation potential. Efficiency of furnace is calculated as below

$$Furnace\ efficiency\ = \frac{Heat\ Output}{Heat\ Input}\ x\ 100$$

$$Furnace\ efficiency\ = \frac{Heat\ in\ stock\ (kJ)}{Heat\ in\ Fuel\ (kJ)}\ x\ 100$$

Q 6 d) (02 marks for sketch and 02 for explanation)

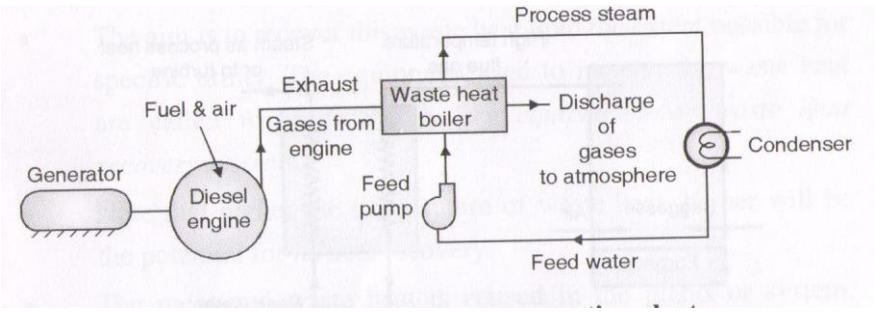
Waste heat recovery

A waste heat recovery unit (WHRU) is an energy recovery heat exchanger that recovers heat from hot streams with potential high energy content, such as hot flue gases from a diesel generator or steam from cooling towers or even waste water from different cooling processes such as in steel cooling.

Heat recovery units

There are following different types of waste heat recovery units which are practically possible - Recuperators, Regenerators, Heat pipe exchanger, Thermal Wheel or rotary heat exchanger, Economizer, Heat pumps, Run around coil, etc.

One such waste heat recovery system for diesel engine cogeneration plant is shown in the figure below.



Q 6 e) (04 marks for list any four)

Types of Solar Cells

Solar cells are typically named after the semiconducting material they are made of. These materials must have certain characteristics in order to absorb sunlight. The following are the different types of solar cells as per their active material in it.

Amorphous Silicon Solar Cell (A-Si)

Bio-hybrid Solar Cell

Buried Contact Solar Cell

Cadmium Telluride Solar Cell (CdTe)

Concentrated PV Cell

Copper Indium Gallium Selenide Solar Cell

Dye-Sensitized Solar Cell (DSSC)

Gallium Arsenide Germanium Solar Cell (GaAs)

Luminescent Solar Concentrator Cell (LSC)

Multi-junction Solar Cell

Q6 f) (4 marks)

Depletion of Solar Radiation

If the Sun's radiation was not filtered or depleted in some manner, our planet would soon be too hot for life to exist. We must now consider how the Sun's heatenergy is both dispersed and de pleted. This isaccomplishedthroughdispersion,scattering,reflection, and absorption.

If the Sun radiations are not filtered or depleted, earth surface would soon become too hot for life to exist. We must consider how suns energy is both dispersed and depleted. This is accomplished through following processes:

DISPERSION.—
Earlier it was learned thatEarth's axis is inclined at an angle of 23 1/2°. Thisinclinati on causes the Sun's rays to be received on thesurface of Earth at varying angles of incid ence,
depending on the position of Earth. When the Sun'srays are not perpendicular to the surfa ce of Earth, the energy becomes dispersed or spread out.

SCATTERING.—

About25percentoftheincoming solar radiation is scattered or diffused by theatmosphere. Scatt ering is a phenomenon that occurswhen solar radiation passes through the air and some ofth e wavelengths are deflected in all directions bymolecules of gases, suspended particle

s, and watervapor. These suspended particles then act like a prismand produce a variety of colors.

REFLECTION.—
Reflectionistheprocesswhereby a surface turns a portion of the incident backinto the medium through which the radiation came.A substance reflects some insolation. This meansthat the electromagnetic waves si mply bounce backinto space. Earth reflects an average of 36 percent of theinsolation.Theperce ntofreflectivityofallwavelengths on a surface is known as its albedo. Earth'saverage albedo is fro m 36 to 43 percent. That is, Earthreflects 36 to 43 percent of insolation back into space.In calcu lating the albedo of Earth, the assumption ismade that the average cloudiness over Eart h is 52percent.