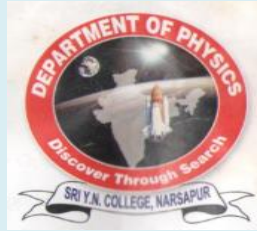




I BSC SEMESTER-II
PHYSICS STUDY MATERIAL
SKILL DEVELOPMENT COURSE (SDC)

SOLAR ENERGY



2022-2023

Department of Physics
Sri Y.N.College (A)
Narsapur

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LEARNING OUTCOMES

After successful completion of the course, students will be able to:

1. Acquire knowledge on solar radiation principles with respect to solar energy estimation.
2. Get familiarized with various collecting techniques of solar energy and its storage.
3. Learn the solar photovoltaic technology principles and different types of solar cells for energy conversion and different photovoltaic applications.
4. Understand the working principles of several solar appliances like Solar cookers, Solar hot water systems, Solar dryers, Solar Distillation, Solar greenhouses.

SYLLABUS

Unit - I : SOLAR RADIATION: (6 HRS)

Sun as a source of energy, Solar radiation, Solar radiation at the Earth's surface, Measurement of Solar radiation-Pyroheliometer, Pyranometer, Sunshine recorder, Prediction of available solar radiation, Solar energy-Importance, Storage of solar energy, Solar pond

Unit - II : SOLAR THERMAL SYSTEMS: (10 HRS)

Principle of conversion of solar radiation into heat, Collectors used for solar thermal conversion: Flat plate collectors and Concentrating collectors, Solar Thermal Power Plant, Solar cookers, Solar hot water systems, Solar dryers, Solar Distillation, Solar greenhouses.

Unit - III : SOLAR PHOTOVOLTAIC SYSTEMS: (10 HRS)

Conversion of Solar energy into Electricity - Photovoltaic Effect, Solar photovoltaic cell and its working principle, Different types of Solar cells, Series and parallel connections, Photovoltaic applications : Battery chargers, domestic lighting, street lighting and water pumping

Co-curricular Activities (Hands on Exercises): (04 hrs)

[Any four of the following may be taken up]

1. Plot sun chart and locate the sun at your location for a given time of the day.
 2. Analyse shadow effect on incident solar radiation and find out contributors.
 3. Connect solar panels in series & parallel and measure voltage and current.
 4. Measure intensity of solar radiation using pyranometer and radiometers.
 5. Construct a solar lantern using Solar PV panel (15W)
 6. Assemble solar cooker
 7. Designing and constructing photovoltaic system for a domestic house requiring 5kVA power
 8. Assignments/Model Exam.
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SOLAR RADIATION

LONG ANSWER QUESTIONS

1. *How can you prove that the 'Sun is ultimate source of Energy'?*

Ans : The sun is the last source of energy. Every morning the sun raises, and gives lights and heat to the earth and every evening when sun sets, plants convert light energy from the sun into the chemical energy (food) by the process of photosynthesis. Animals by eating life plants and use the same chemical energy for all their life activities.

One of the most sources of energy, is the Sun Energy. We get solar heat energy from the sun and the sunlight can also be used to produce electricity from Solar (Photo Voltaic) when the cells of the sun heats, the earth's surface and earth heats the all.

Yet without sun, we wouldn't exist. Deep the core of our local start (the Sun) hydrogen atoms react by nuclear fusion, they produce massive amount of that streams in all directions at the speed of light. In just eight minutes, that energy travels 93 million miles to earth.

We use many different forms of energy here on earth, but here is the thing almost all of them originates with sun. Sun not just light and heat (thousand) energy the law of conservation of energy says that energy can't be created or destroyed. But can change its forms. And that is what happens with energy from the sun. It changes into lots of different forms.

1. Heat energy from the sun causes changing weather patterns that produce wind, wind turbines, then convert wind power into electrical energy.
2. Hydroelectricity is electrical energy produced from moving water and water flows because heat energy from the sun cause evaporation that keeps water moving through water cycle.
3. Right now, much human activities was energy from fossil fuels. Such as coal, oil, natural gas, these energy sources on created over very long periods of time from decayed and fossilized living matter (animals & plants) and the energy in that living matter. Originally came from the sun through photo synthesis.
4. The Sun sends more energy to the earth in one hour than the whole planet needs in a year.

2. What do you mean by Solar Radiation, Heat Balance and Temperature ?

Ans : Solar Radiation : Solar radiation also called as the solar resource or sunlight is a general term of electromagnetic radiation

emitted by the sun. Solar radiation can be captured and turned in touseful forms of energy such as heat and electricity, using a variety of technologies.

Solar radiation means as visible light, ultraviolet light, infrared, radio waves, X-ray and Gamma rays. Radiation is one way to transfer heat, thus about 71% of the total incoming solar energy is absorbed by the earth system of the 340 watts per sq.m's of solar energy that falls on earth, 29% reflected back into space basically by clouds but also by other bright surfaces and the atmosphere itself.

Excessive exposure to the sun is known as to be associated with increased rise of various such cancers cataracts and other eye diseases as well as accelerated the skin scratches. It may also adversely affect people's ability to resist infectious diseases, and compromise the effectiveness of vaccination programmes.

Heat Balance (Surface Budget of the Earth) : The earth as a whole does not accumulate or lose heat. It only maintains its temperature. This can only happen if the amount of heat received in the form of insolation equals to amount of heat list by the earth. Considerably 100 units are received as insolation from sun, while passing through atmosphere some energy is absorbed and same is reflected and some is scattered out of 100 units 35 miles are reflected back (27 units by clouds, 2 snow ice covered, area of earth) and 6 units are scattered into spaces, remaining 65 units are absorbed by the earth surface (56 units by earth and 14 units by atmospheres therefore 65 units are received on earth as incoming insolation. It is balance between incoming and outgoing heat is known as earth's heat budget.

Temperature : The amount of insolation received as well as absorbed by earth (Land surface and at atmosphere) creates heat which is measure in terms of temperature. Temperature is degree of hotness or coldness of a place. It is measured in Degree, Celsius or Fahrenheit. But insolation it is the heat energy which make things hot. It is the cause, it is measured in calories. Temperature distribution is shown with the help of isotherms. Isotherms are line joining places with equal temperature. Close space between isotherms indicate rapid change where wide spacing means slow change.

**3. How is Solar Radiation will be received at Earth's Surface ?
Explain with neat diagram.**

Ans : The Solar radiation that reaches the Key earth's surface without being diffused is called direct beam of solar radiation the same of the diffuse and direct solar radiation is called global solar radiation. Atmospheric conditions can reduce direct beam radiation by 10% nuclear, day, days and 100% daily thick, peak days.

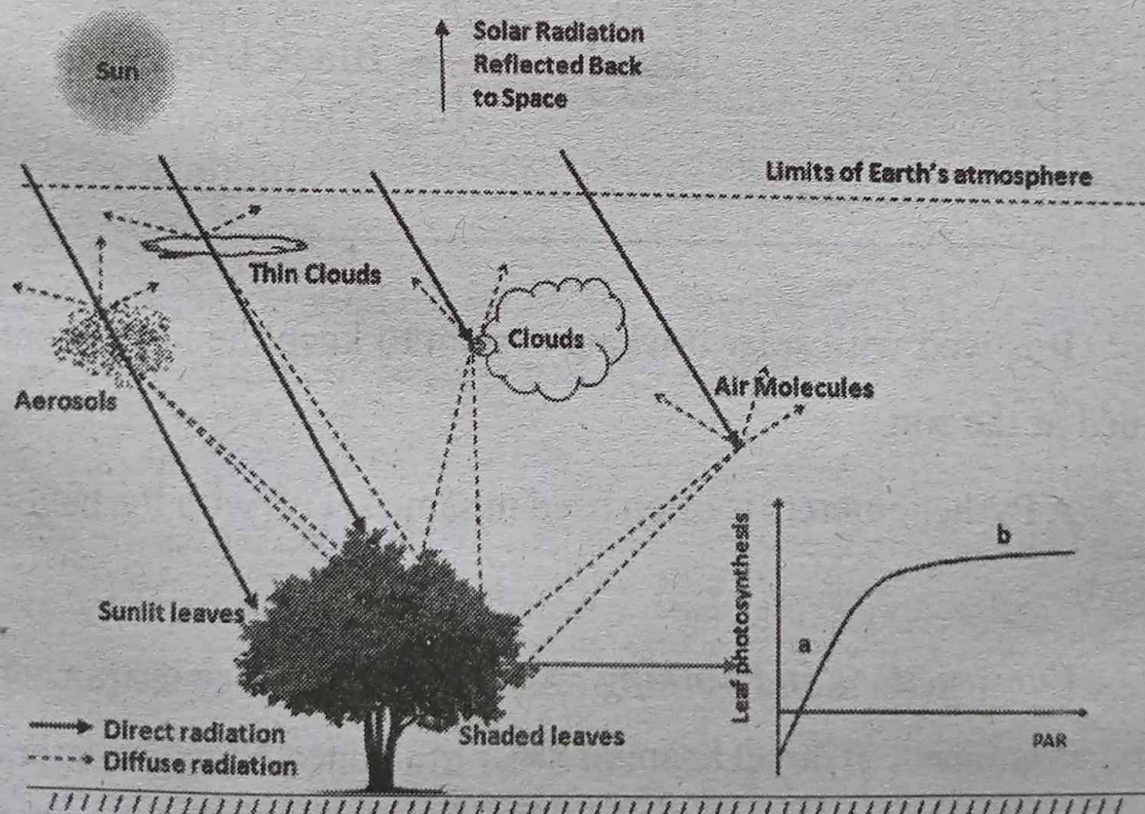
Solar radiation is radiant (electromagnetic) energy from the sun, of the light that reaches Earth's surface, infrared radiation makes up 49.4%, white visible light provides 42.3% and U.V. radiation makes up just 8% of told solar radiation. Each of these buds has a different impact on the environment.

Main effects of Solar Radiation at Earth's surface :

1. Atmospheric effects, including absorption and scattering.
2. Lose variations in the atmosphere, such as watervapor, cloud, and pollution.

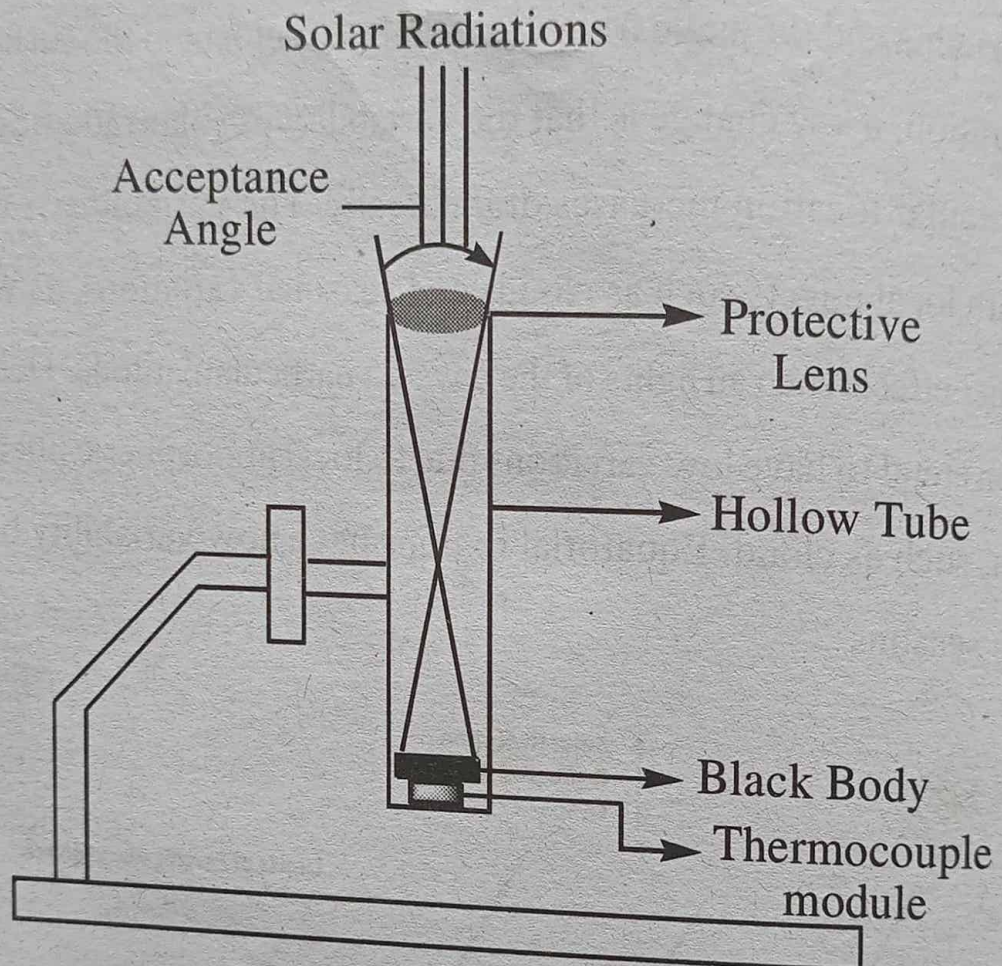
3. Latitude of the location.
4. The season of the year at the time of the day.

These are four main effects of solar on earth. These changes include variation in the overall power received the special content of the lights and the angle from which light is incident in the surface. In addition, a key change is that the variability of solar radiation at a particular location increases dramatically. The variability is due to both local effects such as clouds and seasonal variations, as well as other effects such as lights of the day as a particular latitude. Desert regions tend to have low variations due to local atmospheric phenomena, such as cloud. Equatorial regions have how variability between seasons.



4. Explain about Pyrheliometer. How can you measure the Solar Radiation with Pyrheliometer ?

Ans : A Pyrheliometer is an instrument for measurement and direct solar irradiance.



It is wed with solar tracking system to keep the instrument aimed at the sun.

A Pyrheliometers is often used in same set up with Pyrheliometer.

Constructions and working : A Pyrheliometer is an instrument for measurement of direct beam of Solar irradiance. Sunlight enters the instrument though a window and directed on to a thermopile

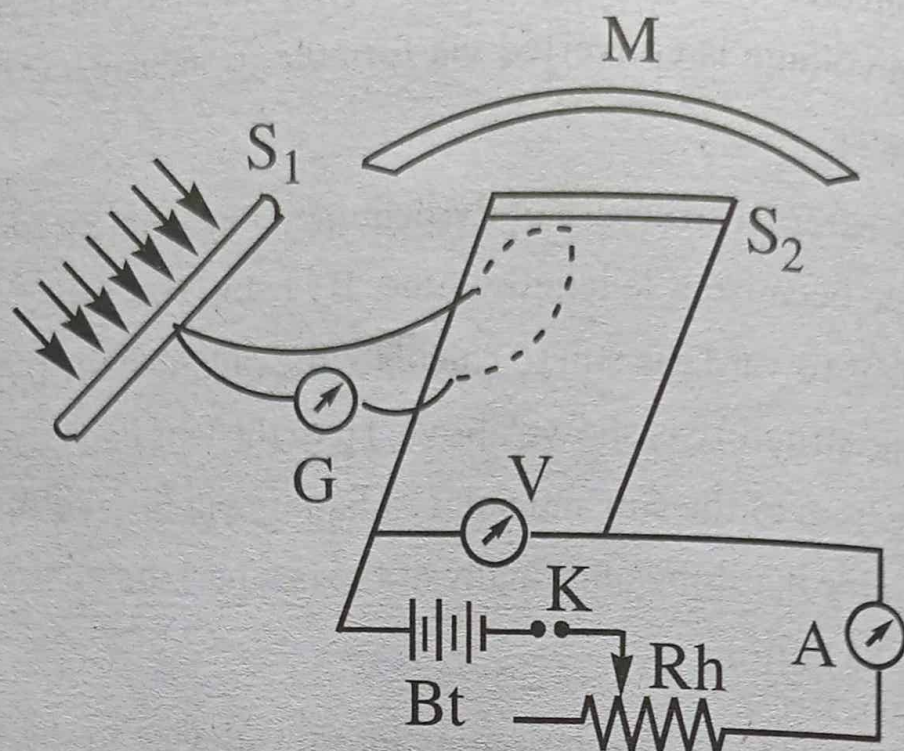
which converts heat to an electrical signal that can be recorded, the signal voltage is converted via formula to measure watts per square meter.

The external structure of Pyrheliometer instrument tools like a telescope because it is lengthy tube. By using this tube, we can spot the lens toward the sun to calculate the radiance the pyrheliometer basic structure is shown above. Here the lens can be pointed in the direction of the sun and solar radiation will flow throughout the lens, after that tube and finally at the last part includes a black object at the bottom.

The irradiance of solar enters into this device to the crystal quartz windows and directly reaches out a thermopile. So, this energy can be changed from heat to an electrical signal that can be recorded.

A calibration factor can be applied once changes the mv signal to a corresponding radial energy flame, and it is calculated 14 watts/mt ; this kind of information can be used increase insolation maps. It is a solar energy measurement that is received on a specified time to change around the globe, the isolation factor for a specific area is very useful once setting up solar panels.

Pyrheliometer Circuit Diagram : The circuit diagram of the Pyrheliometer is shown below. It includes two equal strips specified with two strips S_1 and S_2 with equal. Here a thermocouple is used its one junction can be connected to S_1 . Whereas the other is connected to S_2 . A re-positive galvanometer can be connected to see thermocouple. The strip is connected to an exterior electrical circuit.



Once both the strips are protected from the radiation of solar, then the galvanometer illustrates there is no deflection because both the junctions are at equal temperature. Now S_1 strip is exposed to the solar radiation.

- S_2 is protected with a cover like M . When S_1 strip gets heat radiation from the sun, then strip temperature will be increased, thus the galvanometer illustrates deflection, when current is supplied throughout the S_2 strip, then it is adjusted and the galvanometer illustrates there is no deflection. Now, both again both strips are at equal temperature.
- If the heat radiation amount occurred over the unit area within the unit time on S_1 strip is Q . With absorption coefficient, so the heat radiation amount which is absorbed through the S_1

strip S_1 within unit time is 'QAa'. In addition, the heat generated in unit time within S_2 strip can be given through V. Here V is potential difference, I is flow of current through it.

When heat absorbed is equivalent to the heat generated, so

$$QAa = VI ; Q = \frac{VI}{Aa}$$

By substituting the values of V, I, A and a the value of Q can be calculated.

Advantages of Pyrheliometer :

1. Very low power consumption
2. Operates from a wide range of voltage supplies
3. Ruggedness
4. Stability

Applications :

1. Scientific meteorological
2. Observations of climate
3. Testing research of material
4. Estimation of the solar collector's efficiency
5. PV devices

5. Explain about Construction and working principle of Pyranometer.

Ans : Pyranometer is a device that measures solar irradiance from a hemispherical field of view incident on a flat surface. The S.I units of irradiance are Watts per Square meter W/Sq.m.

A Pyranometer is a type of Actinometer used for measuring solar irradiance on a plane surface. This word comes from the Greek word Pyr means fire and anemometer means above in sky. As the above heat is measured through this instrument. Therefore, it is known as Pyranometer. The working principle of the Pyranometer is based on thermo electric detection.

Pyranometer which is Radiometer with a glass dome that has hemispherical view of the whole sky. Pyranometer does not require much maintenance and are designed for long life service. Pyranometer is used for measuring the diffused radiation and beam radiations which varies with the cosine of angle of incidence.

0° angle of incidence = Full response

60° angle of incidence = 50% response

90° angle of incidence = Zero response.

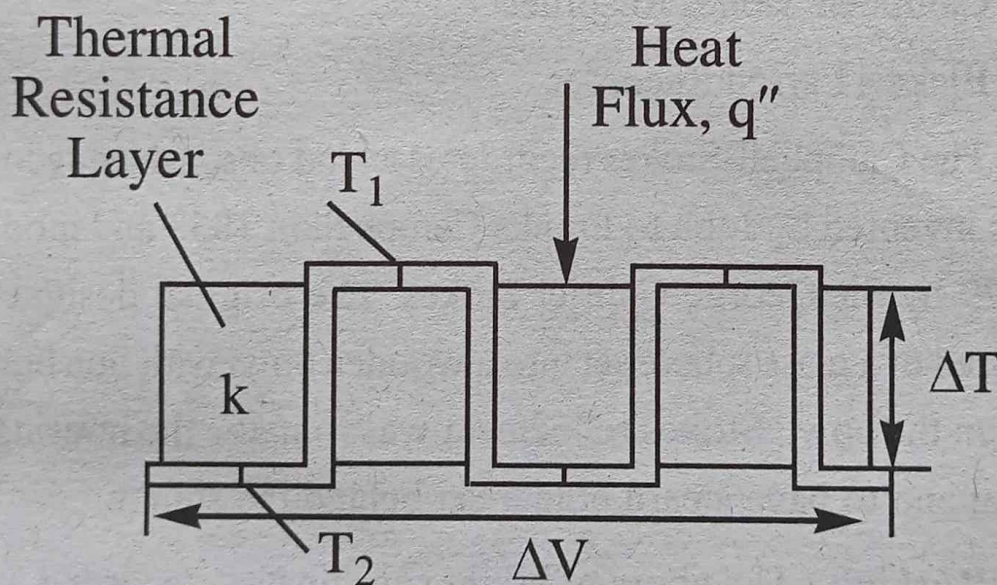
The incident angle ' θ ' is the angle between a normal to the PV module face and the incoming solar beam irradiance.

A Pyranometer measures solar radiation in Wb/m^2 . Solar radiation is the source of energy, the energy flux is expressed in Wb/m^2 . It includes visible as well as non-visible part of the spectrum. Solar radiation can reach us directly or in other ways filtered by clouds. Scattered by the atmosphere and reflected by ground surface. Spectrally flat Pyranometer is often preferred because they can be used in horizontal, inclined and tilted orientations using the same instrument with the same calibration. Pyranometers are also available with digital outputs. In the case of the calculation are

performed inside the instrument. It is designed to measure the solar radiation flux density (W/m^2) from the hemisphere. It measures the wavelength in the range of $0.3 \mu\text{m}$ to $3 \mu\text{m}$.

Classification of Pyranometer : There are two types of technologies of Pyranometer used with the help of which it can measure the temperature.

Thermopile Technology (Thermoelectric Pyranometer) : This type of Pyranometer used collection of thermo-couples which are connected in series where the top surface is exposed to heat flux that is the radiation from the sun and the bottom surface is insulated when there are thermal resistance layers due to which heat, which heat will not be transfer from the top layer to bottom layer.



The bottom surface will be cold surface and reference temperature will be there. The top surface will be heated by the solar radiation due to difference in temperature and voltage will be generated to the voltage can be measured Δv represents change in voltage and may be measured based on the temperature difference which is represented by or higher will be the voltage difference on Δv .

6. What is the Sunshine Recorder? Explain it.

Ans : Sunshine recorder is a tool that records the amount of sunshine at a given location or region at any time the results provide information about the weather and climate as well as the temperature of a geographical area. This instrument is useful in Meteorology, Science, Agriculture, Tourism and other fields. It has also been called heliograph.

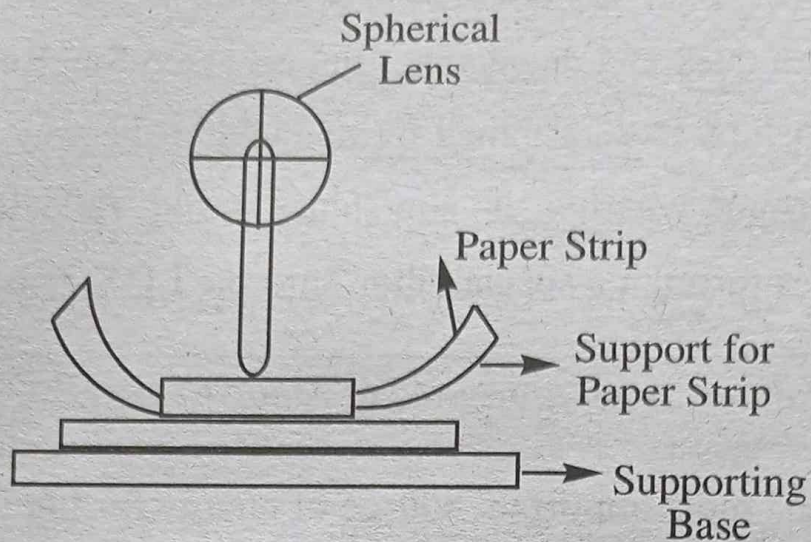
There are two basic types of sunshine recorders. One type uses the sun itself as time-scale for the sunshine readings, the other type uses some form of clock for the time scale.

The popular types of Sunshine Recorders are :

- i) Campbell Stokes Recorder
- ii) Blake - Larsen Recorder

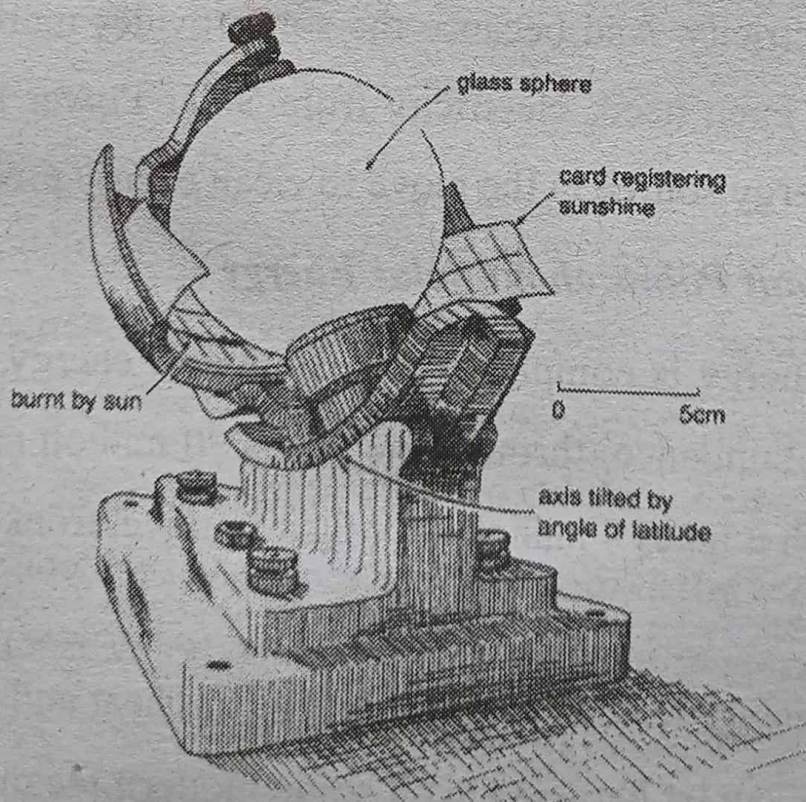
The Campbell-Stokes recorder is a kind of sunshine recorder. It was invented by John to Franks Campbell in 1853 and modified in 1879 by Sir George Gabriel Stokes. The original designed by consisted of a glass sphere set into a wooden bowl with Sun burning trace on the bowl. Stokes refinement was to make the housing out a metal and to have a card holder set behind the sphere.

Working : The hours of bright sunshine are recorded by the rays of the sun passing through the sphere, which undergoes focus and burn a hole through the card placed behind it the card itself is calibrated. So that the hours and minutes of the day are measured across it. At down to dusk, however the sun will usually leave a scorch mark rather than a burn and so the readings at these times of day are some-what difficult to read times.



The main advantage of sunshine recorder is that it is inexpensive. However, it is less accurate as well. Also it is not sophisticated as Parameter and Pyrheliometer.

ii) The Blake-Larsen Sun Recorder is a simple and unique sensor to determine sunshine duration as the human eye would do by its design and measuring principle.



In contrast with present methods, it even determines sunshine duration with dusk and dawn. The Blake-Larsen Sun Recorder is unique. Sunshine is determined by mimicking the way a human would determine whether the sun shines. Light, reflected by the dome, passes through a special filter onto the LUX-sensor.

7. Write about the importance of Solar Energy.

Ans : It is the most important source of energy for life form. It is renewable source of energy, unlike non-renewable sources such as fossil fuels. Solar energy technologies use the sun's energy to light homes, produce hot water heat homes as shown in solar tankless water heater reviews and electricity.

Solar energy - A Clean Source : No greenhouse gas emissions are released into the atmosphere, when you use solar panels to create electricity. And because the sun provides more energy than we will even need, electricity from Solar Power is a very important energy source in the move to clean energy production.

Important Points about Solar Energy :

1. Solar energy is completely free source of energy, and it is found abundance, through the sun is 90 million miles from the earth it takes 8 million a for light to travel from that much distance.
2. Solar energy which comprises of radiant heat and light from the sun can be harassed with some modern technology like

photowhite cells, solar heating. Artificial photosynthesis, solar architecture and solar thermal electricity.

3. Solar technology can be distinguished into active and passive. Photostatic panels and solar thermal collectors which harness solar energy are energyless of active solar technology. Passive technology includes construction rooms to improve air circulation, orienting space to use sunlight favorably.
4. The water cycle is an important result of solar insulation. The earth oceans and atmosphere absorb solar radiation and their temperatures rise, warm air rises from the oceans, causing convection. When this air rises to high altitudes, clouds are created by condensation of water vapor, these clouds cause rain that falls back to the earth surface, which completes the water cycle.
5. By means of photosynthesis, solar energy is converted into chemical energy by green plants, which creates the biomass that makes up fossil fuels.
6. Horticulture, and agriculture seek to make the minimum use of solar energy. These include techniques like the timing of planting cycles and mainly of plant varieties. Green houses are also used to convert light into cultivation of special crops.
7. Solar powered hot water systems utilize the solar energy to heat water. In certain areas go to 70% of the water domestically for temperatures as high as 60 degrees Celsius can be made available solar heating.

8. Solar energy can also be used for making portable, brackish or solar water without using electricity of chemicals, waste, water can be treated. Creating salt from sea water is also one of oldest uses of solar energy.
9. Food can be cooked dried or pasteurized using solar energy.
10. Solar energy in converter into electricity by using either photo voltaic (direct method) or concentrated solar power (indirect). Large beam of sunlight focused into a small beam of while mirror or lenses in the case of concentrated solar power. Photo-electric effect is used by photovoltaic to convert solar energy into electric energy.

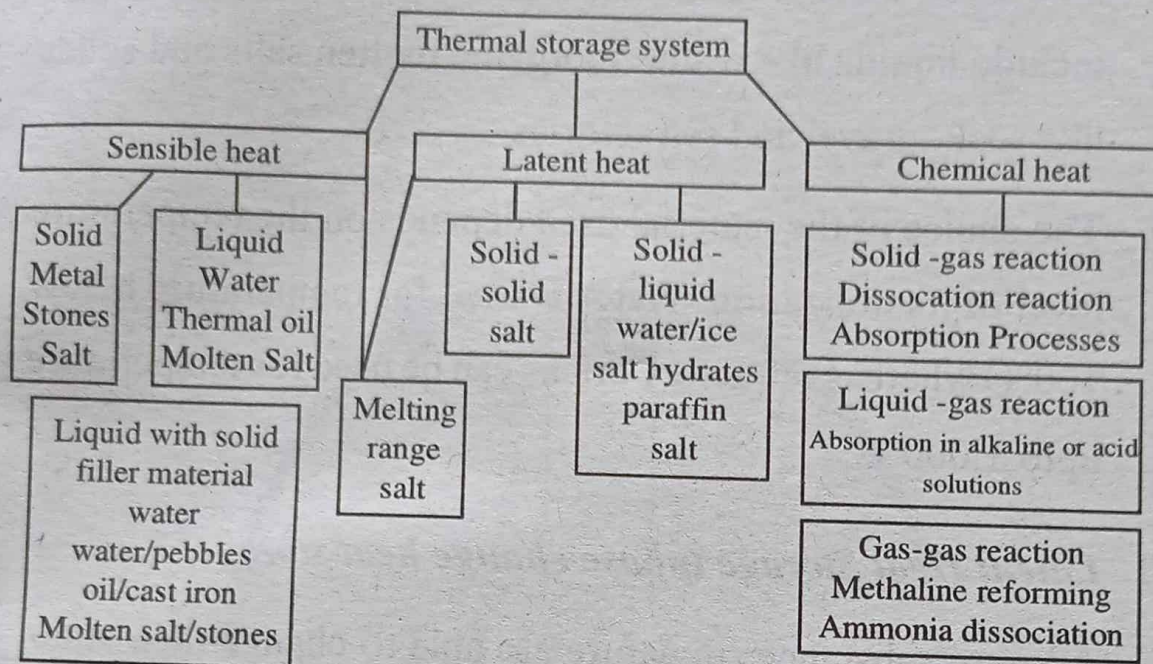
8. *What is the Classification of Solar Energy Storage System?*

(Or)

Explain the different types of Energy Storage.

Ans : Solar energy is available only during sunshine hours. Consumer Energy demands to follow their own time pattern and solar energy does not fully match the demand. As a results, Energy Storage is must to meet the Consumer requirement.

Three sensible heat storages, where the addition or removal of heat results in a change in temperature. Latent heat storage (Phase change energy storge). Energy absorbed or released during a change in phase, without a change in temperature (isothermal).

Methods for Storing Solar Thermal Energy :**A) Sensible Heat Storage :**

1. Heating a liquid or solid which does not change phase comes under this category.
2. Heat that causes a changes in temperature in an object is called sensible heat.
3. The quantity of heat stored is proportional to the temperature rise of the material.
4. If T_1 and T_2 represent the lower and higher temperature. V the volume and 'e' the density of the storage material, and C_p the specific heat then the energy stored Q is given by

$$Q = Ve \int_{T_2}^{T_1} C_p dT$$

5. For a sensible heat storage system, energy is stored by heating a liquid or a solid. Materials that are used in such a system include liquids like water. Inorganic molten salts and solids like rock, gravel and refractories.
6. The choice of the material used depends on the temperature level of its utilization. Water is used for temperature below 100°C whereas refractory bricks can be used for temperature upto $1,000^{\circ}\text{C}$.

B) Latent Heat Storage (phase change heat storage) :

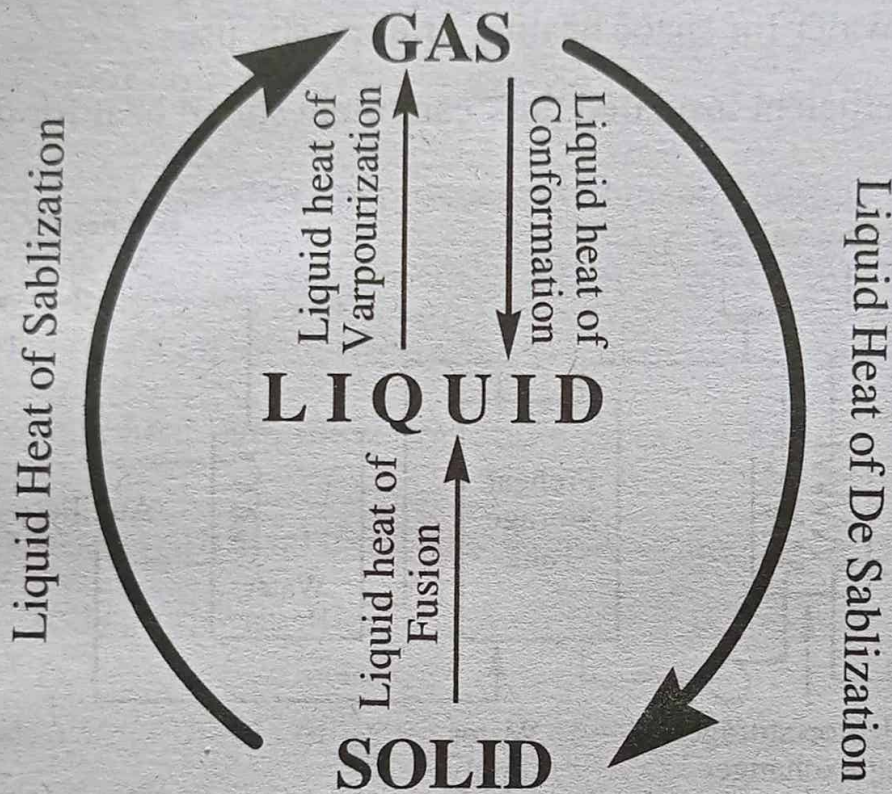
1. All pure substances in nature are able to change their state. Solids can become liquids (ice to water) and liquids can become gases (water to vapors) but changes such as these require the addition or removal of heat.
2. In this system, heat is stored in a material when it melts, and heat is extracted from the material when it freezes.
3. Heat can also be stored when a liquid changes to gaseous state, but as the volume change is large such a system is not economic.
4. Latent heat arises from the work required to overcome the forces that hold together atoms of molecules in a material, the regular structure of a crystalline solid is maintained by forces of attraction among its individual atoms; which oscillate slightly about their average positions in this crystal lattice.

5. Formula,

$$Q = ML$$

M = Mass,

L = Individual latent heat



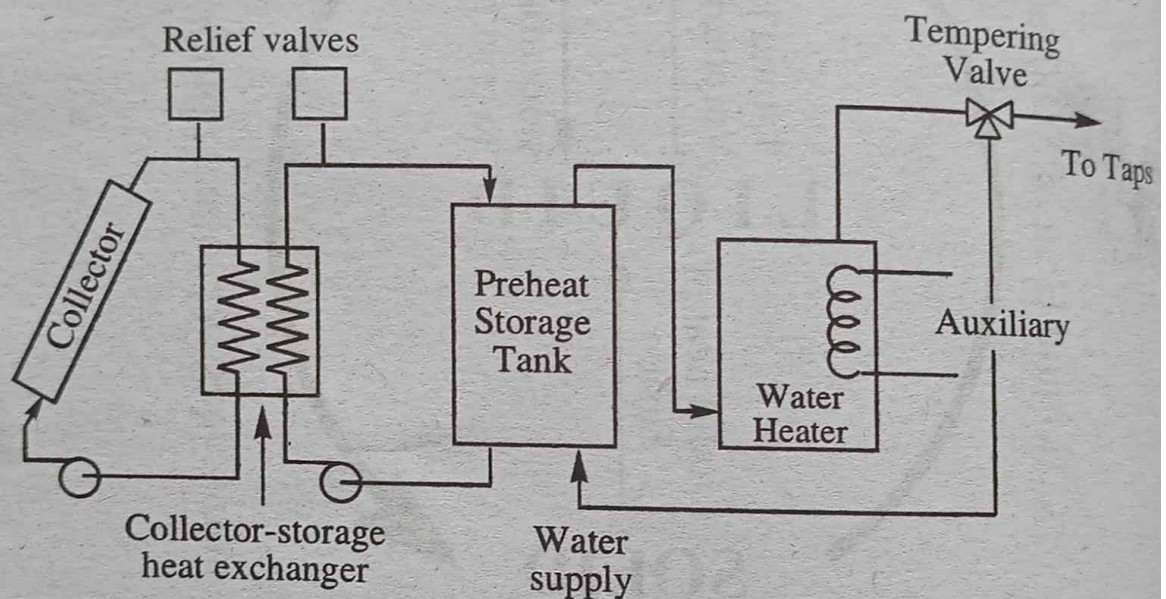
C) *Thermo Chemical Storage :*

1. With a thermo chemical storage system, solar heat energy can start an endo-thermic chemical reaction and new products of reactions remain intact.
2. To extract energy, a reverse exothermic reaction is allowed to take place.
3. Actually, thermo-chemical, thermo energy is the binding energy of reversible chemical reactions.

9. Discuss in detail about Hot Water Tank.

Ans. Stratified Storage :

1. A hot water storage tank (also called a hot water tank, thermal storage tanks hot water, thermal storage which, heat storage tanks and hot water cylinder) is a water tank used for storing hot water for space heating or domestic use.
2. An efficient insulated tank can retain stored heat for days.



Solar Power Plant (Hot Water Only)

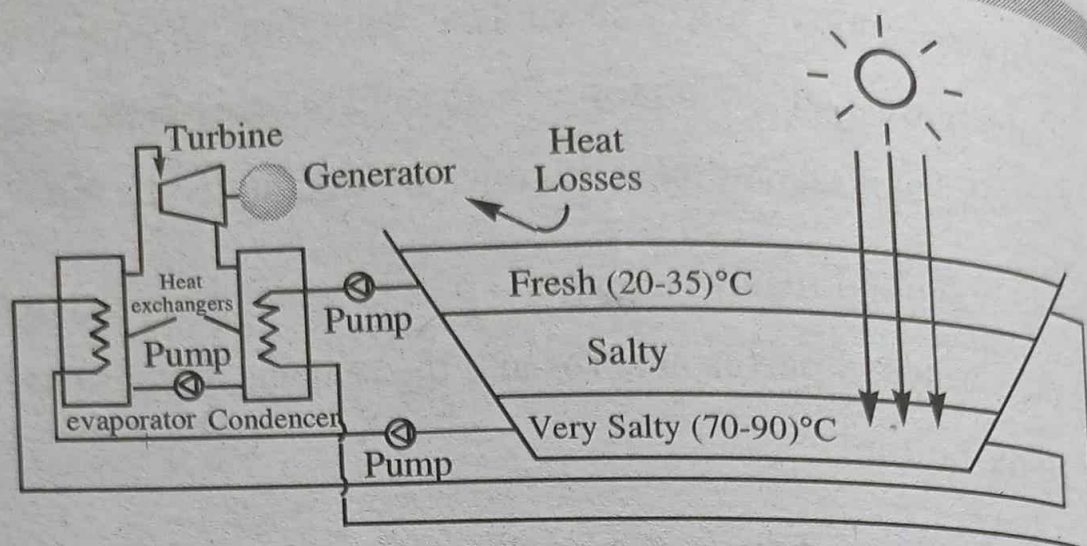
3. Hot water tanks may have a built-in gas or oil burner system, electric immersion heaters, an external heat exchanges, such as a central heating system, or heated water from another energy source such as a wood burning store.

10. What is the Solar Pond ? Write with diagram.

Ans. 1. A Solar pond is a pool of salt water which collects and stores Solar thermal energy, the salt water naturally forms a vertical

salinity gradient also known as a 'halocline', in which low salinity water floats on top of high salinity water in the layers of salt solutions increase in concentration in depth.

2. Normal pond receive sunlight a part of which is reflected at the surface, a part is absorbs and the remains is transmitted to the bottom.
3. Due to this, the lower part gets heated up and density decreases as a result of which is rides up and convection current are set up (As a result the healed water reaches top layer and looses its heat by connection and evaporation).
4. A natural or artificial body of water for collecting and absorbing solar radiation energy and storing it as heat.
5. Thus, a solar pond combines solar energy collection and sensible heat storage.
6. They are large shallow bodies of water that are arranged so that the temperature gradient an reversed from the normal.
7. This allow the use for collection and storage of solar energy which may under ideal conditions be delivered at temperature 40-50° above notes.
8. In can be use for various applications, such as process heating, water desalination, refrigeration, drying and power generation.



SHORT ANSWER QUESTIONS

11. What are the differences between Pyrheliometer and Pyranometer ?

Ans. Both instruments like pyrheliometer and pyranometer are used to calculate Solar irradiance. These are related in their intention, but there are some differences in their construction and working principle.

Pyranometer	Pyrheliometer
1. It is one kind of acetometer mainly used to measure the solar irradiance over a plane surface.	1. This instrument is used to measure direct ray solar irradiance.
2. It was thermoelectric detection principle.	2. In this, the thermoelectric detection principle is used.

<i>Pyranometer</i>	<i>Pyrheliometer</i>
3. In this, the measurement of increase temperature can be done through thermocouples that which are linked in series. Otherwise series-parallel to build thermopile.	3. In this, increasing temperature can be calculated through thermocouples that are allied in series / series, parallel to create thermopile.
4. This is frequently used in meteorological research stations.	4. This also used in meteorological research stations.
5. This instrument calculation global solar radiation.	5. This instrument calculation direct solar radiation.

12. *Explain about the Solar Radiation Instruments.*

Ans. Pyranometer, Pyrliometer are radiometers designed for measuring the irradiance on a plane surface, normally from solar radiation and lamps and some instruments are

1. Sun trackers
2. Albedometer
3. UV Radio meters
4. Net Radio meters
5. Horticultural sensors
6. Sunshine Recorder
7. Pyrgeometer etc.

13. How can you Estimate the available Solar Radiation ?

Ans. The irradiance can be predicted using statistical methods such as Artificial Neural Networks (ANN), Support Vector Machines (SVM) or Auto Regressive Moving Average (ARMA). However, they either lack accuracy because they cannot capture long-term dependency or cannot be used with big data because of scalability.

Solar irradiance forecasting system based on real time and Historical Meteorological Data Combination Method and different Metals are used to predict the solar radiation multilayered feed forward network is also using the prediction of Solar Radiation.

14. What is the importance of Solar Energy ?

Ans. It is the most important source of energy for life forms. It is a renewable source of energy, unlike non-renewable sources such as fossil fuels, solar energy technologies use the sun's energy to light homes, produce hot water, heat homes as shown in tankless water heaters and electricity.

1. Reduce Air pollution, fossil fuels create a lot of pollutants.
2. Reduce water usage. If your energy source does not use fossil fuels to power itself, it probably uses some sort of water as its resource.
3. Reduce dependence on Non-renewable energy sources.
4. Improves human health in the long run.
5. Helps fight climate change.

6. No greenhouse gas emissions are released into the atmosphere when we use solar panels to create electricity. And because the sun provides more energy than we will ever need, electricity from Solar Power is a very important energy source in the move to clean energy production.
7. Solar is the cheapest and most abundant energy source in the world.

15. *Disadvantages of Solar Energy.*

Ans.

1. The initial cost of purchasing a solar system is fairly high.
2. Weather dependent, although Solar Energy can still be collected during cloudy and rainy drops the efficiency of solar system drops.
3. Solar Energy Storage is expensive.
4. Uses of lot of space.
5. Associated with Pollution.
6. Location and Sunlight availability. Latitude is one of the main factors in determining efficiency of solar power.

16. *Explain the following :*

a) Solar Radiation, b) Heat Balance, c) Temperature.

Ans. a) Solar Radiation : The energy received by the earth is known as incoming solar radiation, which in short is termed as insolation. Solar radiation, often called the solar resource of just sunlight is a

general term for the electro-magnetic radiation emitted by the sun. Solar radiation can be captured and turned into useful forms of energy, such as heat and electricity, using a variety of technologies.

b) Heat Balance : The total radiation returning from the earth and the atmosphere respectively is $17 + 48 = 65$ units, which balances the total 65 units reached from the sun. This is the heat budget or heat balance of the earth i.e., the balance of incoming and outgoing radiation is termed as heat balance.

c) Temperature : Degree of hotness or coldness measured on a definite scale. It is a measure of average kinetic energy per molecule in a substance. It is different from heat, although the two quantities are intimately related, the units of temperature are degree Celsius and Kelvin.



UNIT II

SOLAR THERMAL SYSTEMS

LONG ANSWER QUESTIONS

1. *What is the Principle of Conversion of Solar Radiation Unit ?*

Ans. The basic principle of solar thermal utilization of shortwave solar radiation into heat Photo thermal conversion processing. If radiation incidences on material a certain part of the radiation is absorbed.

The first is by conduction through solid materials in the presence of a temperature difference. In a moving fluid, the fluid molecules gain heat or lose it by induction or radiation and carry it by their movement from one place to another they process the third mechanism is called correction.

Heat transfer occurs mainly three mechanisms. The first is by conduction through solid materials in the presence of a temperature difference. The second mechanism is radiation in which energy moves in space by electromagnetic waves. In a moving fluid the fluid molecules gain heat or lose at by conduction or radiation

and carry it by their movement from one place to another this process. The third mechanism is called convection, the heat transfer may be accompanied by other physical phenomena such as heat generation with medium. Vapor condensation, liquid evaporation etc.,

1. Conduction : The phenomenon of heat conduction is a process of propagation of energy between the particles of a body which are indirect contacts and have different temperatures.

The basic equation for steady State heat conduction is known as Fourier's equation. According to this quantity of heat (dQ), passing through an isothermal surface (dA), per time interval (dt) is proportional to the temperature gradient ($\delta t / \delta n$) and can mathematically be expressed as,

$$dQ = -K \left(\frac{\delta t}{\delta n} \right) \cdot dA \, dt$$

Where the proportionality factor 'K' is the physical property of the substance, which derives the ability of a substance to conduct heat and is called thermal conductivity, the heat flux q , derives as the rate of heat flow per unit area of the isothermal surface is given by

$$q = -K_n A \frac{\delta t}{\delta n}$$

q = The rate of heat transfer

K_n = Thermal conductivity of the material in the direction

A = The area normal to the direction of heat flow

$\delta t / \delta n$ = The temperature gradient in the direction of heat flow

The direction of heat flux a is normal to the surface and is positive in the direction of decreasing temperature, which explain the negative sign on the right hand side of equation.

The heat transfer rate for different surfaces or configurations,

S. No.	Configuration	Heat Transfer Rate
1.	Flat Plate	$q = \frac{K}{L}(T_2 - T_1)$
2.	Cylinder Wall	$q = T \frac{K(T_2 - T_1)}{r T_n (r_2 / n)}$
3.	Conduction in Extended surface (Heat flow M uniform Rectangular Form)	$q = \frac{\tanh mL}{mL} [q_r - h(T_0 - T_a)]$

2. Radiation : Radiation is process by which heat flows from a body at a higher temperature to a body at a lower temperature when the bodies are separated in a space or even vaccum emits between them. The heat energy transmitted by radiation is called radiant heat.

Radiation is the mode of heat transfer by which the sun transfer energy to the earth the quantity of energy leaving a surface as radiant heat depends on the absolute temperature and the nature of Surface.

A Perfect Radiator, so called black body emit radiant energy from its surface at a rate 'q' given by

$$q = A\sigma T^4$$

Where, A = Area of the body

T = Absolute temperature (Ok) and

σ = Stefan Boltzmann Constant

$$= 56.7 \times 10^{-9} \text{ w/m}^2 - \text{k}^4$$

Real bodies do not meet specifications of an ideal radiator and emit radiation at a lower rate than do black bodies, the ratio of radiation emission of a real body to the radiation emission of a black body at same temperature is called emittance, the real body emits radiation at a rate

$$q = \Sigma A\sigma T^4$$

Where, Σ is average emittance of surface

3. **Convection** : Convection is a process that transfer heat from one region to another by motion of a fluid the rate of heat transfer by convection q_c between a surface and a fluid can be calculated from the relation

$$q_c = h_c A (T_s - T_f)$$

Where,

q_v = Rate of heat transfer by convection (K.cal/hr)

A = Base area of heat transfer by convection (m^2)

T_s = Surface temperature

T_f = Fluid temperature

h_c = Convection heat transfer co-efficient

K.cal/hr.m² - c°

2. Discuss in detail about the Collectors used for Solar Thermal Conversion with neat diagrams.

Ans. Receivers collect that solar energy and convert into heat energy. A generator can be used to produce electricity from this heat energy. Thermal Energy Storage (TES) are high pressure liquid storage tanks used along with a solar thermal system to allow plants to bank several hours of potential electricity.

Evacuated tube collectors are the most common solar thermal technology in China and in the world. They make use of glass tube to surround the absorbers with high vacuum and effectively resist atmospheric pressure.

Introduction : Solar thermal power generating systems use mirrors to collect sunlight and produce steam by solar heat to drive turbine for generating power.

This system generates power by rotating turbines like thermal and Nuclear power plants and then force is suitable for power generation.

Solar Power Generations : There are two main ways of generating energy from the sun. They are :

- i) **Photo Voltaic(pv) :** Converts sunlight directly into electricity

ii) **Connecting Solar Thermal** : Generates electricity in directly.

Solar Thermal Systems : There are two types of Solar Thermal Systems. They are :

- a) **Passive** : A passive system require no equipment, like when heat build up the inside can when its left part in the sun. *Eg* : Thermal chimneys
- b) **Active** : An active system requires some way to absorb and collect solar radiation and then store it. *Eg*: Solar thermal power plants

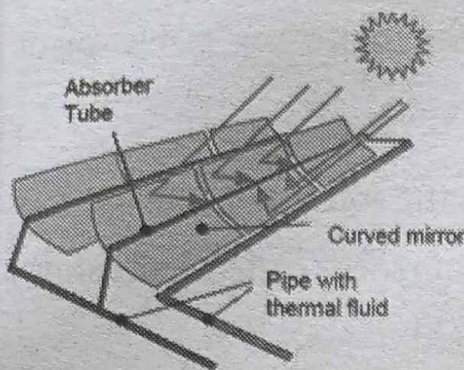
Basic working Principles :

1. Mirrors reflect and concentrate sunlight.
2. Receivers collect the solar energy and convert it into heat energy.
3. A generation can then be used to produce electricity from this heat energy.

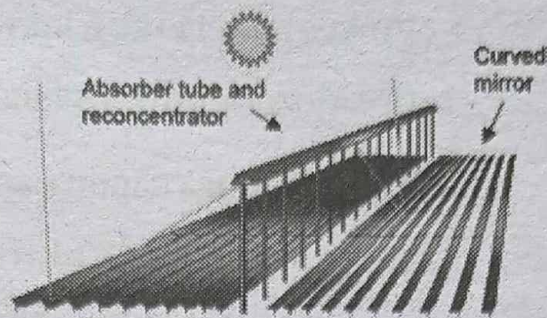
Thermal Energy Storages (TES) : TES are high pressure liquid storage tanks used along with thermal system to allow plants to bank several hours of potential electricity.

1. **Two-tank Direct System** : Solar thermal energy is stored right in the same heat transfer fluid that collected it.
2. **Two-tank Indirect System** : Functions basically the same as the direct system except it work with different types of heat transfer fluids.
3. **Single-tank Thermodyne System** : Store thermal energy as a solid usually silicas.

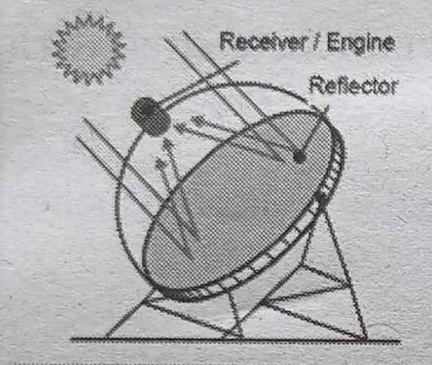
Types of Thermal Power Plants



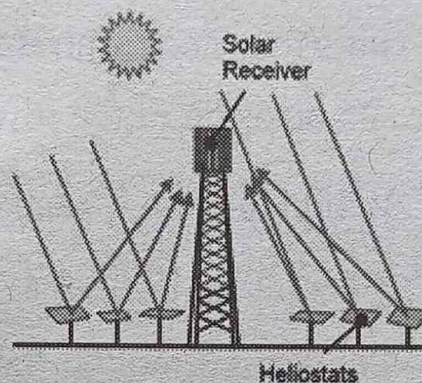
Parabolic Trough



Linear Fresnel



Dish/Engine



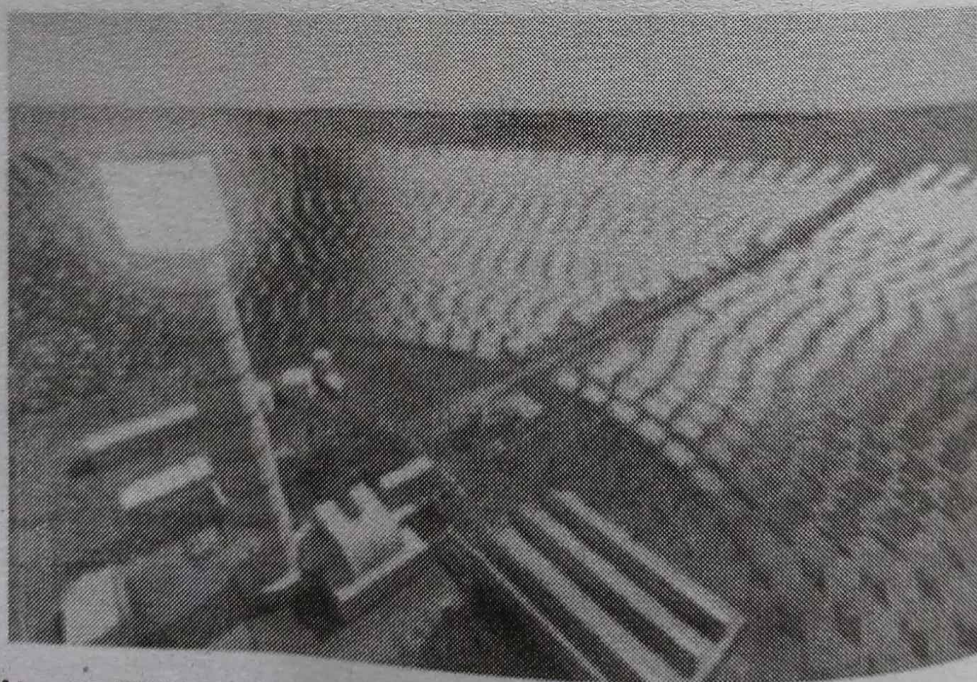
Central Receiver

I) Parabolic Trough Systems :

1. A Parabolic trough consists of a linear parabolic reflector that concentrates light onto a receiver positioned along the reflector's focal line.
2. The receiver is tube positioned directly above the middle of the parabolic mirror and filled with working fluid.
3. The reflector follows the sun during the daylight hours by tracking along a single axis.
4. A working fluid (e.g. molten salt) is heated to 150-350°C as it flows through the receiver and is then used as a heat source for a power generation system.

II) Solar Power Tower System :

1. Power towers (also known as 'Central tower' power plant or heliostat power plant)
2. These designs capture and focus the sun's thousand energy to with thousands of tracking mirrors (called heliostats) is roughly a two square mile field
3. A town resides in the center of heliostat field. The heliostats focus concentrated sun light on, on a receiver which sits on a top of the tower.
4. Within the receive and concentrated sunlight heats molten salt to over 1000° F (538°C)
5. The heated molten Salt then flour into thousand storage tank, when it is stored, maintaining 98% thermal efficiency and evenatically pumped to a steam generator.
6. The stream drives a standard turbine to generate electricity



III) SolarDish/ Engine system :

1. The system consists of a stand-alone parabolic reflectors that concentrates light onto a receiver positioned at the reflectors fired point.
2. The working fluid in the receive is heated to 250-700°C and then used by a sterling engine to generate power.
3. Parabolic dish system have the highest efficiency of all solar technologies provide solar to electric efficiency between 31-32%

**IV) Enclosed Parabolic Trough :**

1. The enclosed parabolic trough solar thermal system encapsulates to the components within a greenhouse like glass-house.
2. The glass house protects the components from the elements that can negatively impact system reliability and efficiency.

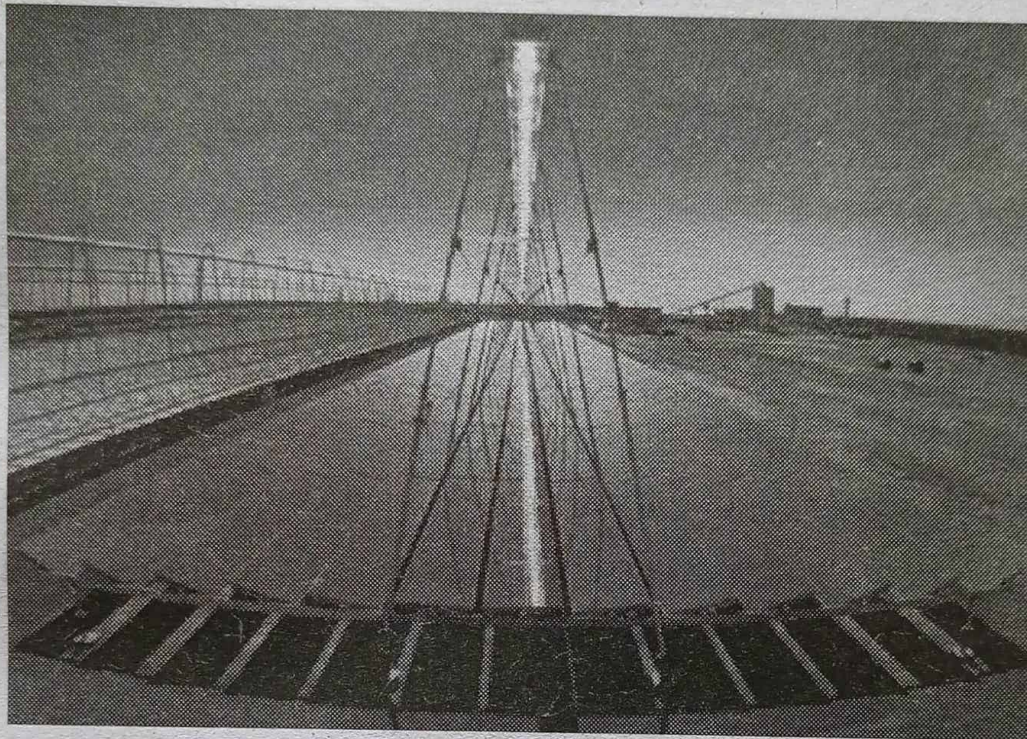
3. height, weight curved solar reflecting mirrors are suspended from the ceiling of the glass house by wires.
4. A single-axis tracking system positions the mirrors to retrieve the optimal amount of sunlight.
5. The mirrors concentrate the sunlight and focus it on a network of stationary steel pipes, also suspended from the glass house structure.
6. Water is pumped through the pipes and boiled to generate steam when intense sun radiation is applied. Y-Steel pipe also suspended from the glass house structure.



V) *Compact linear Fresnel Reflector :*

1. Linear Fresnel reflectors use long, thin segments of mirrors to focus sunlight onto a final absorber located at a common focal point of the reflectors.
2. These mirrors are capable of concentrating the sun's energy to approximately 30 times its normal intensity.

3. This concentrated energy is transferred through the absorber into some thermal fluid.
4. The fluid then goes to through a heat exchange to power a steam generator.



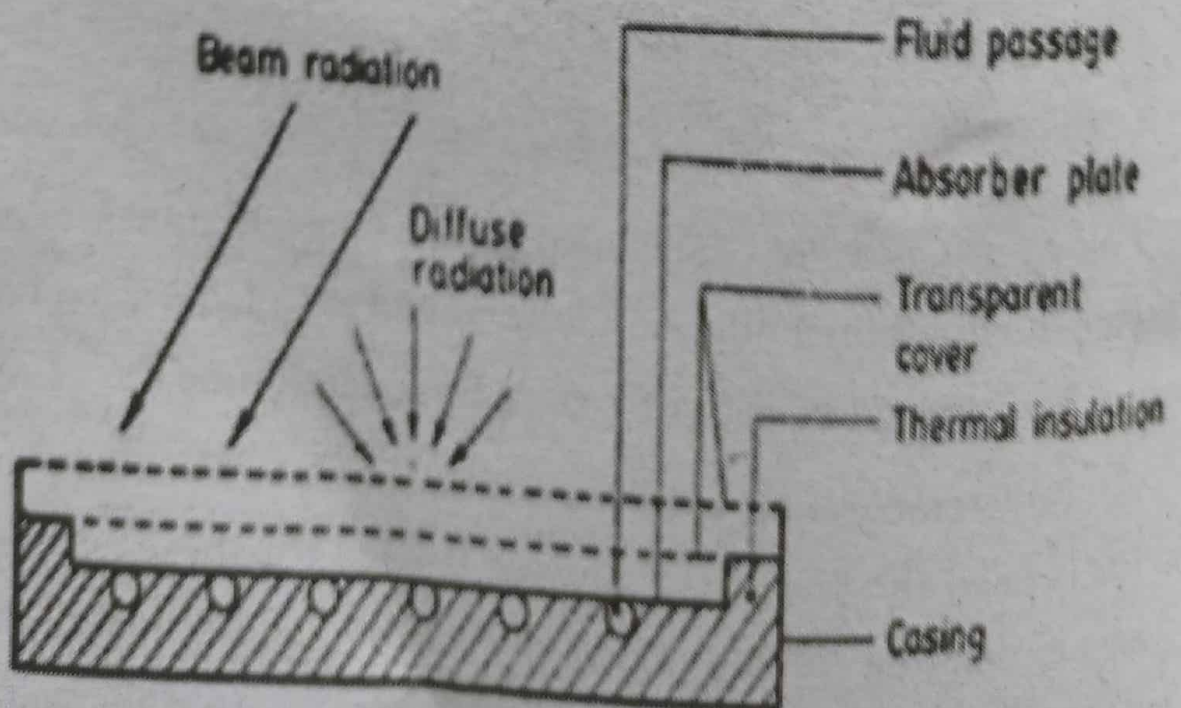
3. *Discuss about Flat-Plate Collectors and Concentrating Collectors.*

Ans. Flat-Plate Collectors : When no optical concentration is done, the device in which the collection is achieved is called a flat-plate collector. **Ex :** Liquid based, air based, Evacuated tube.

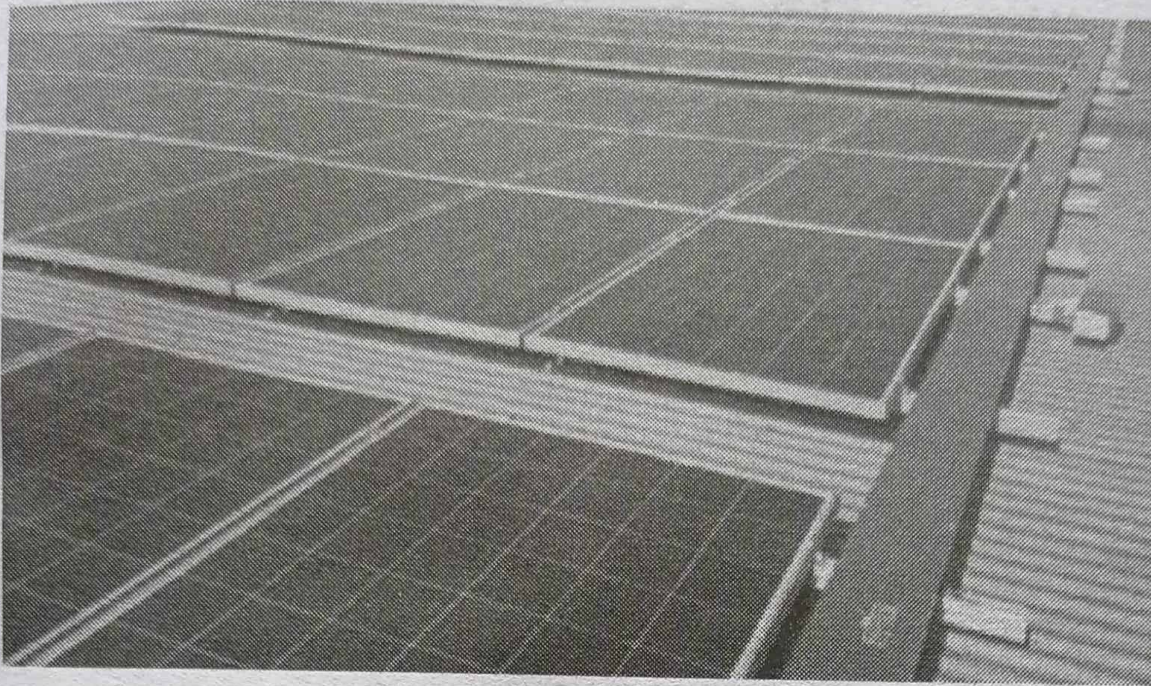
For low temperature applications below 100°C . Flat plate collector is used the basic solar device is used for these systems are the water heating collectors, namely the flat plate collector and the evacuated tube collector. These collectors are used for water heating and most space heating applications.

Working : The flat plate collector mainly consist of a causing absorber plate, transparent glass cover, insulating material and fluid passage tubes. The transparent cover of glass or plastic allows short-wave solar radiation (Beam, diffuse radiation) to enter the born and full on black plate, but its prevents the long wave (thermal) radiation emitted by black plate from being lost the radiation is absorbed by absorber plate, which is coated with black absorber paint the fluid tubes which are connect to connected to absorber plate, absorb the heat and transferred as the water passing through tubes and gets heated. The hot water collected from all tubes flow into a storage tank.

Insulation (Paddy husk, saw dust, glass wools) provided to the absorber plate to avoid was of heat by connection less of heat by low re-radiation is avoided by having good absorber coating the convective loss is reduced by minimizing the air gap between the glass covers.



Flat Plate collector



Solar Flat Panel

Another kind of collector that can be used for water heating is the evacuated tube collector, the collector contains an array of evacuated glass tubes. Each tube contains a long thick black absorber plate thermally attached to a pipe inside the glass tube, the vacuum inside the tube prevents heat loss and water temperatures up to 150°C can be reached the hot water can be used for industrial purposes.

Concentrating Collectors : Focusing collector is a device to collect solar energy with high intensity of solar radiation on the energy absorbing surface. Such collectors generally use optical systems in the form of reflectors or refractors.

Types : (1) Line focusing (2) Point focusing

In practice, line is a collector pipe and the point is a small volume through which no fluid flows.

Main types of Concentrating Collectors are :

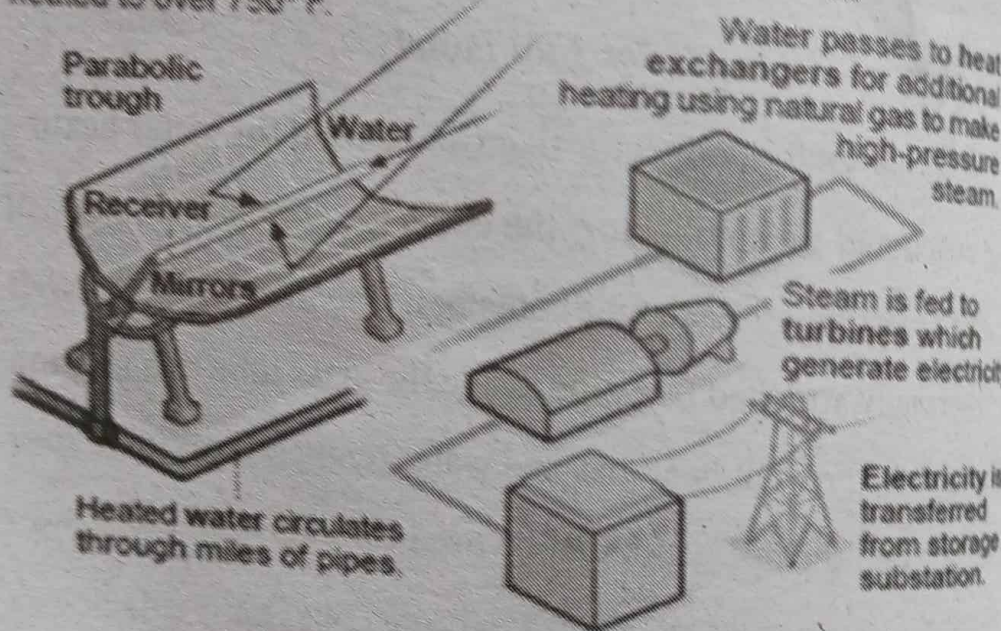
1. Parabolic trough collector
2. Mirror strip collector
3. Flat-Plate collectors with adjustable mirrors
4. Compound parabolic concentrator.

Making electricity from the sun's heat

Concentrated solar power

A field of tracking mirrors focuses sunlight onto a glass receiver containing water that can be heated to over 750° F.

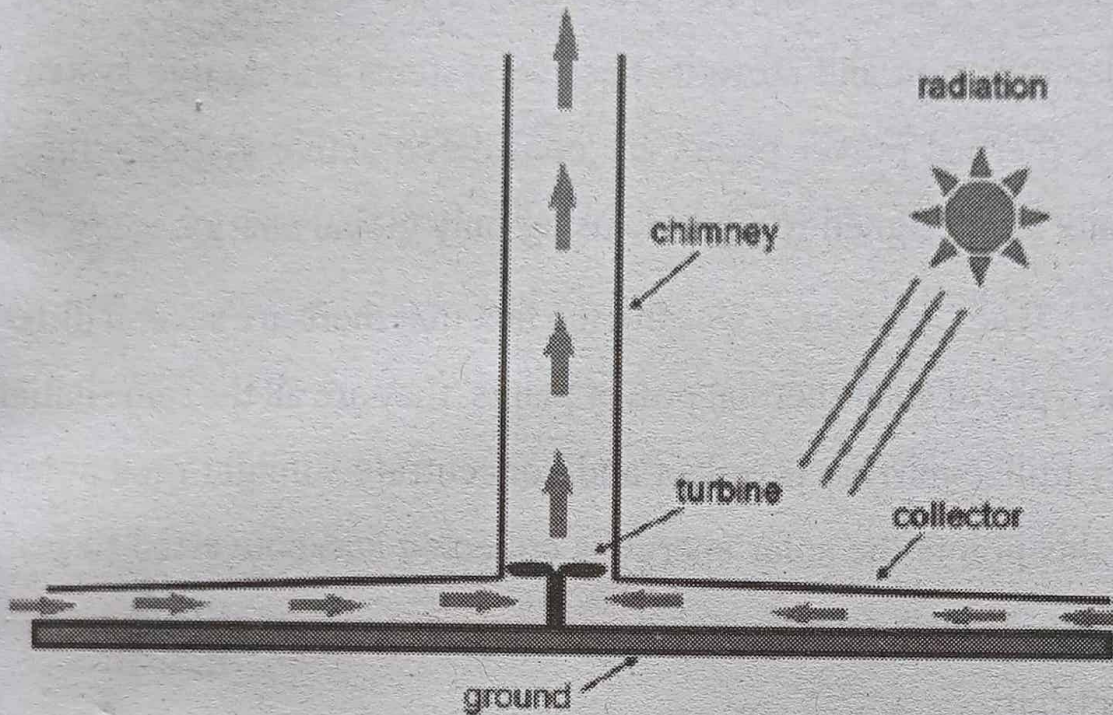
The sun's reflected radiation intensifies 30 to 100 times on receiver.



Converting solar energy into electricity

Power Tower : A power tower has a field of large mirrors that follow the sun's path across the sky, the mirrors concentrate sunlight onto a receiver on top of lighttower. A completely keeps mirror aligned. So, the reflected rays of the sun, are always aimed at the receiver, where the temperatures will above 1000°C can be

reached. High pressure steam is generated to produce electricity. The power lower system with heliostats, is shown in the figure given below.



Solar Chimney Tower plant

Concentrating collectors have large mirror systems to focus beam solar radiation onto a pipe containing water or onto a small receiver. The mirrors must be moved mechanically to follow the movement of the sun throughout the day. These collectors produce higher temperatures than flat plate collectors but they are more and more expensive and more difficult to use. Small concentrating collectors may be used in bright sunlight for cooking food.

4. Explain about Solar, Thermal Power Plant.

Ans. Solar Thermal Power Plants are electricity generation plants that utilize energy from the sun to heat a fluid to a high temperature.

This fluid then transfers its heat to water, which they become superheated steam. This steam energy subsequently transformed to mechanical energy by thermal engine and then converted into electrical energy by a generator. There are two types of systems to collect solar radiation and store it. Passive systems and Active systems. solar thermal power plants are considered active systems, these plants are designed to operate using only global energy.

Types of Plants : Despite the fact that there are several different types of solar thermal power plants, they are all the same initially they utilize mirrors to reflect and concentrate sunlight on a point. At this point the solar energy is collected and converted to heat energy. Which creates steam and runs a generator. This creates electricity.

1. Parabolic Troughs : These troughs also known as linear focus collectors are composed of a long parabolic shaped reflector that concentrates incident sunlight on a pipe that runs down the trough. The collectors sometimes utilize a single axis solar tracking system to track the sun across the sky as it moves from east to west to ensure that there is always maximum solar energy incident on the mirrors. The receiver pipe in the center can reach a temperature upward of 400°C as the trough focus. Sun gets 30-100 times its normal intensity.

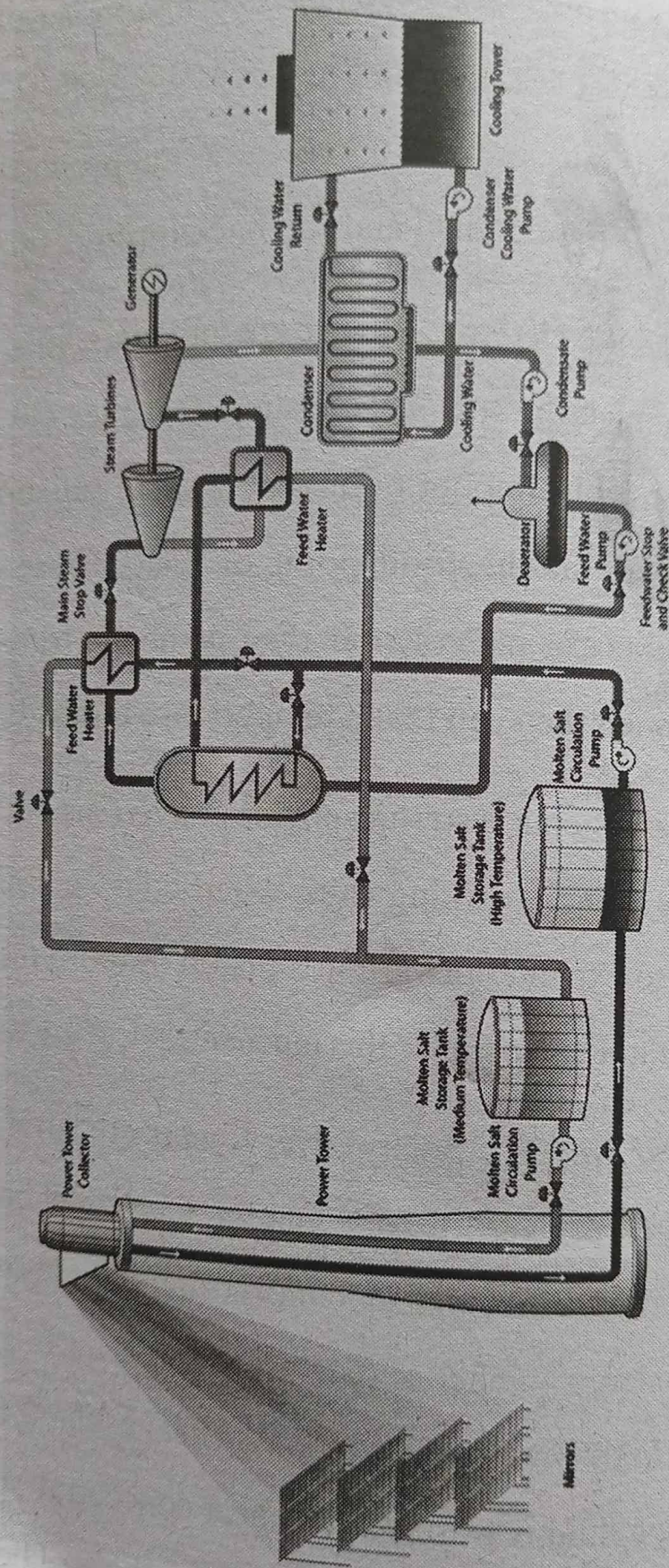
These troughs are lined up in rows on a solar field. A heat transfer fluid is heated as it runs through the pipes in the parabolic

trough. This fluid then returns to heat exchangers at a central location where the heat is transferred to water, generally high pressure moves a turbine into a power a generator and produce electricity. The heat fluid is then cooled and run back through the solar field.

2. Parabolic Dishes : If there are large parabolic dishes that use motor to track the sun. This ensures that they always receive the highest possible amount of incoming solar radiation that they then concentrate at the focus point of dish. These dishes can concentrate sunlight much better than parabolic troughs and the fluid run through then can reach temperature upwards 750°C.

In these systems, a sterling engine convert heat to mechanical energy by pressing, working fluid when cold, and allowing the heated fluid to expand outward in a piston or more through a turbine. A generator can convert this mechanical Energy to Electricity.

3. Solar Towers : Solar power towers are large towers that act as a central receiver for solar energy, they stand on the middle of a large array of mirror that all concentrate sunlight on a port in a tower. These large number of flat, sun tracking mirrors are known as heliostat. In the tower then is mounted heat exchangers where the heat exchange fluid is warmed. The heat concentrated to this port can be 1,500 times as intense as incident sunlight. The hot fluid is then used to create steam to run a turbine and generator.



Producing electricity, Power plant generator

5. What do you know about the Solar Cookers ?

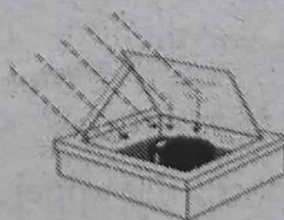
Ans.

1. Solar cookers are passive solar devices
2. Sun light is converted to heat energy which retained for cooking.
3. Solar cookers utilizes the simple principle of reflection, concentration, absorption and greenhouse effect to convert sunlight to heat energy.
4. The steps involved in the solar cookers are concentrating, capturing and connecting the solar energy.
5. It is clean cooking technology

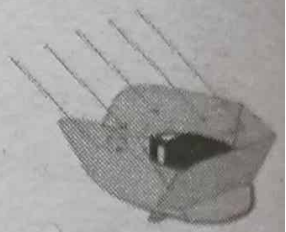
Classification :

- a) **Direct type** : Use some solar energy concentrator to focus sunlight on to area. **Ex** : Parabolic solar cooker.
- b) **Indirect type** : A box covered with transparent method like glass. Employs greenhouse effect for cooking. **Ex** : Solar box cooker.
- c) **Advanced type** : The cooker use either a flat piece or focusing collector which collect the solar heat and transfer, thus to the cooking vessel. **Ex** : Thermal storage solar cooker.

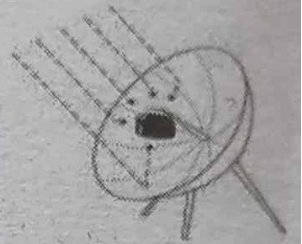
o Box Types Cooker



- Panel Types Cooker
(Multi reflector type)



- Parabolic Types Cooker



Common types of Solar Cookers

Solar Box Cooker : It is most common and in expensive type of solar cooker, and employs greenhouse effect of is most popular and easier to build. Typical model $60 \times 60 \times 20$. Reaches temperature up to $140-150^\circ$. Advantages of slow even cooking large quantities of food.

Working : It consists of an insulated box with a glass or plastic window. The window acts as a solar energy tray by exploiting the greenhouse effects the solar rays penetrate through a glass cover and absorbed by a blackened metal they kept inside the solar box. To minimize the heating effect, the walls and outer side of pot should be painted black, the solar rays entering the box are of short wavelength. It degrades into thermal radiation which are of higher wavelength.

The higher wavelength radiation is not able to pass through glass sheet the upper cover of the cooker has two glass sheets

parallel and they heat loss through re-radiation is minimizes from the blackened surface. The loss due to connection is minimized by making the box air tight by providing a rubber strip all round between the upper lid and the box.

Parabolic Cooker :Parabolic type solar cooker developed by National Physical Laboratory (NPL) of India at New Delhi as early as 1955. Focus a lot of sun energy onto a very small space using parabolic shape. From this we can get the temperature up to 450°C. It works on the principle of that when 3D parabola is aimed at sun, the rays are reflected onto the focus. It consists of a large parabolic and working pot holder. When the reflector surface is aimed at the sun, the rays falling on the parabolic surface converges to the focus of the Parabola. The cooking pot is placed at the focus of the reflector the pot surface are blackened to improve absorption.

6. *What is the Solar Hot Water System ?*

Ans. Solar water heating system is a device that uses solar energy to heat water for domestic, commercial and industrial needs. Heating of water is the most common application of solar energy in the world. A typical solar water heating system can save upto 1,500 units of electricity every year, for every 100 liters per day of solar water heating capacity.

Parts of Solar Water Heating System : A Solar water heating system consists of a flat plate solar collector a storage tank kept at height behind the collector and connecting the collector usually comprises copper tubes welded to copper sheets with toughened

glass sheet on top and insulating material at the back. The entire assembly is placed in a flat box. In certain models, evacuated glass tubes are used instead of Copper, a separate cover sheet and insulating box are not required in this case.

Working of a Solar Water Heater :

1. The system is generally installed on the roof or open ground with the collector facing the sun and connected to a continuous water supply.
2. Water flows through the tubes, absorbs solar heat and becomes hot.
3. The heated water is stored in the tank remains hot as a storage tank is insulated and heat losses are small. Circulation of water from the tank through the collectors and back to the tank continues automatically due to density difference between hot and cold water. (Thermo syphon effect)

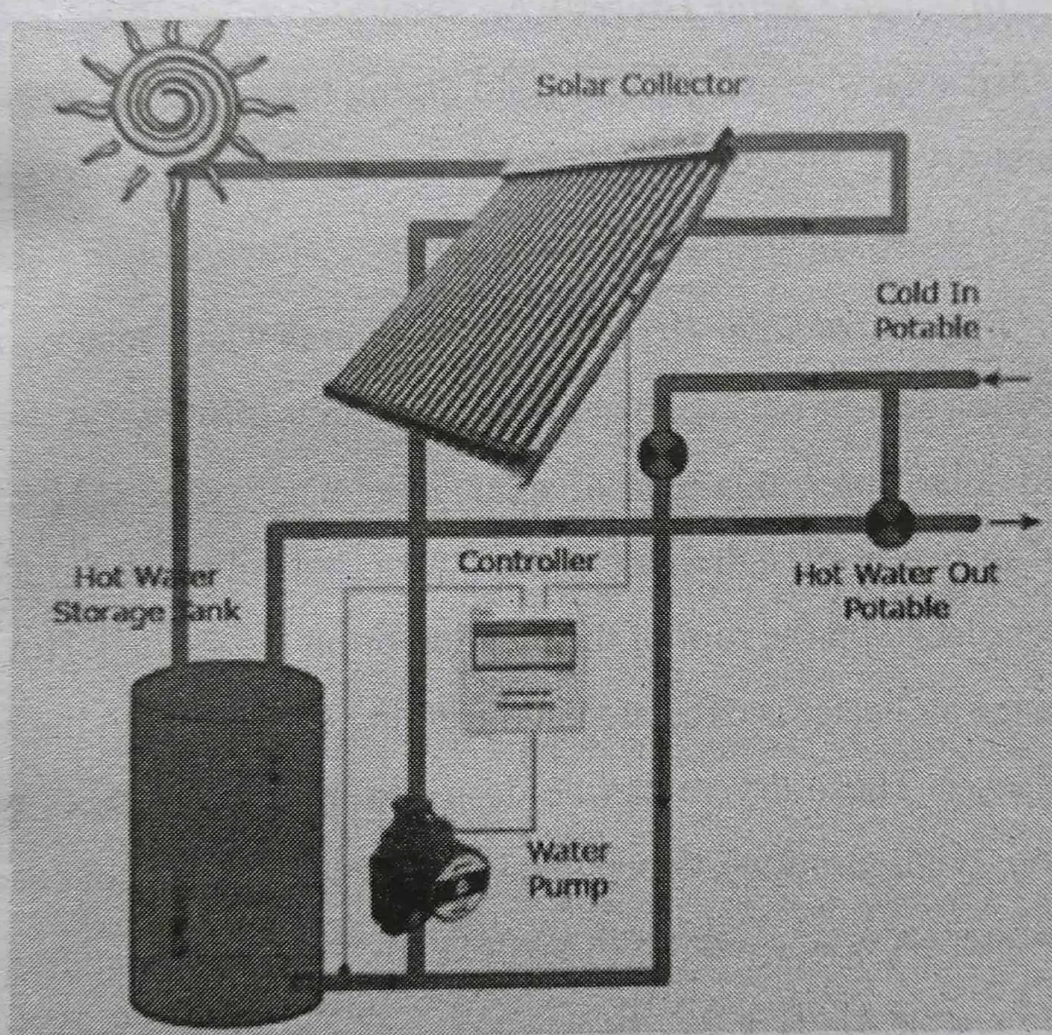
Uses of Solar Water Heater :

1. **SWH :** SWH's can be used in homes for producing hot water that can be used for bathing, cleaning and washing. Solar water heaters of 100-300 liters capacity are suited for domestic application, a larger system also can be used for a variety of industrial applications. Hot water at 60-80°C could be obtained through use of solar water heaters.

2. **Fuel Savings :** A 100 liters capacity SWH can replace an electric geyser for residential use and saves 1,500 units of electricity annually.

3. *Saves cost on Power Generation* : The use 100 SWH'S 100 liters capacity each can contribute to a peak load saving of 1 MW.

4. *Environmental Benefits* : A SWH of 100 liters capacity can power emission of 1.5 tones of Carbon dioxide per year.



7. What are the Solar Drying Systems ? Explain.

Ans. Solar dryers are devices that works on solar energy to dry substances, especially food, there are two general types of solar dryers. Direct and Indirect.

The basic function of Solar dryer is to heat ask to a constant temperature with solar energy. Which felicitates extraction of humidity from crops inside a drying chamber the food is not expose to direct sunlight in indirect sun dryers as the fresh air is heated separately from the food chamber.

Integrated Solar Dryers : An integrated solar dryers is one in which solar energy collection and drying take place in separate cabinet dryers, rack dryers, tunnel dryers, greenhouse dryers and multi-rack dryers are small in size and are standalone units.

Distributed Solar Dryers : A Solar dryer in which solar energy collection and drying take place in separate units is known as distributed solar dryer, this type of solar dryer has two parts, (i) flat plate air heater (ii) a drying chamber. Air is heated in the flat plate heater placed on the roof of the building or on the ground. Hot air from the air heater is circulated in the drying chamber with the help of blower. These dryers can be designed in different sizes with various configurations, depending upon the temperature of hot air, flow rate, types of products to be dried etc.

Mixed mode Solar Dryers : A solar dryer in which solar energy collection takes place in both air heater and drying unit and drying takes place only in the drying unit is known as a mixed mode solar dryer. In this dryer solar energy is collected through a flat-plate solar collectors and also by the roof of drying chamber. In large industrial drying systems, the solar heated air is combined

with air heated by conventional energy this adds to the reliabilities of the system and at the same time helps in significantly reducing conventional energy consumption.

Uses of Solar Dryers : Solar dryers can be utilized for various domestic purposes, they also find numerous applications in industries. Such as textiles, wood, fruit and food processing, paper, pharmaceuticals, and agro industries. Solar dryers have the following advantages.

1. Solar dryers are more economical compared to dryers that run on conventional fuel / electricity.
2. The drying process is completed in the most hygienic and eco-friendly way.
3. Solar drying systems have low operation and maintenance cost.
4. Solar dryers last longer. A typical dryer can last 15 - 20 years with minimum maintenance.

8. Explain about Solar Distillation System.

Ans. Solar water distillation is the process of using energy from sunlight to separate fresh water from salts or other contaminants. The untreated water absorbs heat. Slowly reaching high temperatures the heat causes the water to evaporate, cool and condense into vapour leaving the contaminants behind. Solar stills can be used for low capacity and self-reliant water supplying systems.

Working Procedure : Solar water distillery or solar stills are usually used in remote areas, where there is limited access to fresh water. The basic principles of solar water distillation are simple and effective as a distillation replicates the way nature makes rain. A solar still works on two scientific principles: evaporation and condensation. The salts and minerals do not evaporate with the water. For example, table salt does not turn into vapour until it gets to a temperature over 1400°C . However, it still does take a certain amount of energy for water to turn into vapour. While a certain amount of energy is needed to raise the temperature of a kilogram of water from 0°C to 100°C , it takes five and half times that much energy to change it from water at 100°C to water vapour at 100°C . Practically, all this energy, however, is given back, when the water reaches the condenser.

Most solar stills are simple black bottomed vessels filled with water and topped with clear glass or plastic. Sunlight, i.e., absorbed by the black material, speeds the rate of evaporation. The evaporation is then trapped by clean topping and funneled away. Non-volatile pollutants do not evaporate. So, they are left behind. Most solar stills need to be about 5 square meters in size to produce enough water for a single person for a day. Multiple solar distillation systems are required to produce a large quantity of distilled water.

9. What do you know about Solar Green House?

Ans. A greenhouse (also called glass house, or of with sufficient heating a hothouse) is a structure with walls and roof more or less transparent to solar radiation.

of transparent material, such as glass, in which plants requiring regulated climatic conditions are grown. These structure range in size for small sheds to industrial sized buildings. Amihali green house is known as a cold frame, the interior of the house exposed to sunlight becomes significantly warmer than the entered temperature, protecting its contents in cold weather.

Many commercial glass green houses or hothouses are hi-tech production facilities for vegetables, flowers or fruits, the glass green houses are filled with equipment including screening installations, heating, cooling, lighting and may be controlled by a computer to optimize conditions for plant growth. Different techniques are then used to exoculate optimality degrees and comfort ratios of green houses, such as air, temperature, relative humidity and vapour pressure deficit, in order to reduce production with prior to cultivation of a specific crop.



Solar Green House

Applications :

1. Green houses allow for greater control over the growing environment of plants. Depending upon the technical specification of a green house, key factors which may be controlled include temperature, levels of light and shade, irrigations, fertilization applications, and atmospheric humidity.
2. Green houses are often used for growing flowers, vegetables, fruits and transplants. Special greenhouse varieties of certain crops, such as tomatoes, are generally used for commercial production.
3. Many vegetables and flowers can be grown in greenhouses in late winter and early spring, and then transplanted outside as the weather warms. Seed tray racks can also be used to stack seed crops inside the greenhouse for later transplanting outside.

SHORT ANSWER QUESTIONS

10. *What are the Types of Solar Collectors ?*

Ans. The different types of solar thermal pond collectors

1. Evacuated tube Solar thermal systems
2. Flat plate solar thermal systems
3. Thermodynamic plate ponds
4. Solar thermal air collectors

5. Solar thermal bowl collectors
6. Domestic Solar hot water systems
7. Domestic solar water heating systems
8. Flat plate collectors

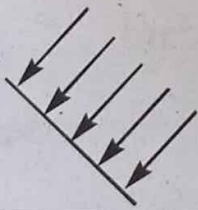
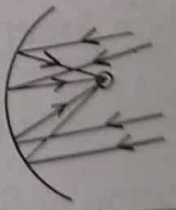
11. Write the History of Solar Thermal Systems.

Ans.

1. In 1866 Augustin Mouchout used a parabolic trough to produce steam for the solar system engine.
2. In 1886 The first patent for solar collector was obtained by Italian Alessandro Battaglia in Genoa, Italy
3. In 1913; Frank Shuman finished a 55 HP parabolic solar thermal energy station in Meadi, Egypt for irrigation
4. In 1929, the first solar power system using a mirror dish was built by American Scientist Dr. R.U. Goddard.
5. In 1968, the first concentrated solar plant, which entered into operation in Sant' ilario, near Genoa, Italy.
6. In 1981, the 10 MW solar one power tower was developed in Southern California
7. In 1984 the parabolic trough technology of the solar energy generating systems began its combined capacity is 354 MW.
8. In 2014, the world's largest solar thermal plant 392 MW achieves commercial operation in Ivanpah, California, USA

12. What are the difference between Flat Plate Collectors and Concentrating Collectors?

Ans.

Flat Plate Collectors	Concentrating Collectors
1. Absorber area is larger	1. Absorber area is small
2. Concentrating ratio is 1	2. Concentrating ratio is high
3. It uses both beam and diffuse radiation	3. It uses mainly beam radiation
4. Application limited to low temperature was suitable for all places its can work in clear and cloudy days	4. High temperature application such as power generation suitable where there are more clear days in a year
5. Simple in maintenance	5. Difficult in maintenance
6. Flat Plate Type 	6. Concentrating Type 
7. Domestic purposes	7. Wide range of use

13. Explain about Solar dryers and give a short note about One Solar Dryer.

Ans. Solar dryers are devices that use solar energy to dry substances especially food, there are two general types of solar dryers- Direct and Indirect.

The basic function of solar dryer is to heat air to a constant temperature with solar energy, which facilitates extraction of humidity from crops inside a drying chamber. The food is not exposed to direct sunlight in indirect sun driers as the fresh air is heated separately from the food chamber.

Integrated Solar dryers : An integrated solar dryer is one in which solar energy collection and drying take place in a single unit. Cabinet dryers, race dryers, tunnel dryers, green house dryers and multi-rack dryers are small in size and are stand alone units.

14. Explain in briefly about the Main Components of Thermal Power Plant and its Formation.

Ans. The main parts of Thermal Power Plant

1. River or Canal
2. Circulating water pump
3. Condenser
4. Heater
5. Economizer
6. Boiler
7. Super heater
8. Turbine

Function : Thermal Power Plant (TPP) is a power plant in which the prime mover is steam driven. Water is heated, turns into steam and spins a steam turbine which drives an electrical generator. After it passes through the turbine the steam is condensed in a condenser.

15. Write about Solar Distillation. Explain the Advantages of it.

Ans. Solar water distillation is the process of using energy from the sunlight to separate fresh water from salts or other contaminants. The untreated water absorbs heat slowly reaching high temperature. The heat causes the water to evaporate, cool and condense as vapour leaving the contaminants behind.

Advantages : According to Dev and Tiwari (2011), there are various advantages of solar stills over the desalination technology such as :

- a) An easy small scale, and cost effective technique for producing safe water in homes or in small communities
- b) Producing distilled water
- c) Simplicity in design
- d) No moving parts

16. Define the Solar Cooker, and write how does it work

Ans. A Solar Cooker or Solar Oven is a device which uses the energy of sunlight to heat food or drink to cook or sterilize it. High-tech devices for example electric ovens powered by Solar cells, are possible and have some advantages such as, being able to work in diffuse light.

Working : Instead of converting Solar energy to electricity, a glass oven drops light particles called photons to generate heat.

the help of metal reflectors, which are positioned around the oven to maximize light input, photon pass through the ovens transparent glass top and strike the interior of the insulated box.

17. *Explain shortly about the Dis-advantages of Solar collector.*

Ans. *Cost :*

1. The initial cost of purchasing a Gober system is fairly high
2. Weather dependent, although Solar energy can still be collected during cloudy and rainy day, the efficiency of the system drops
3. Solar Energy storage is expensive
4. Uses a lot of space
5. Associated with pollution



UNIT III

SOLAR PHOTO-VOLTAIC SYSTEMS

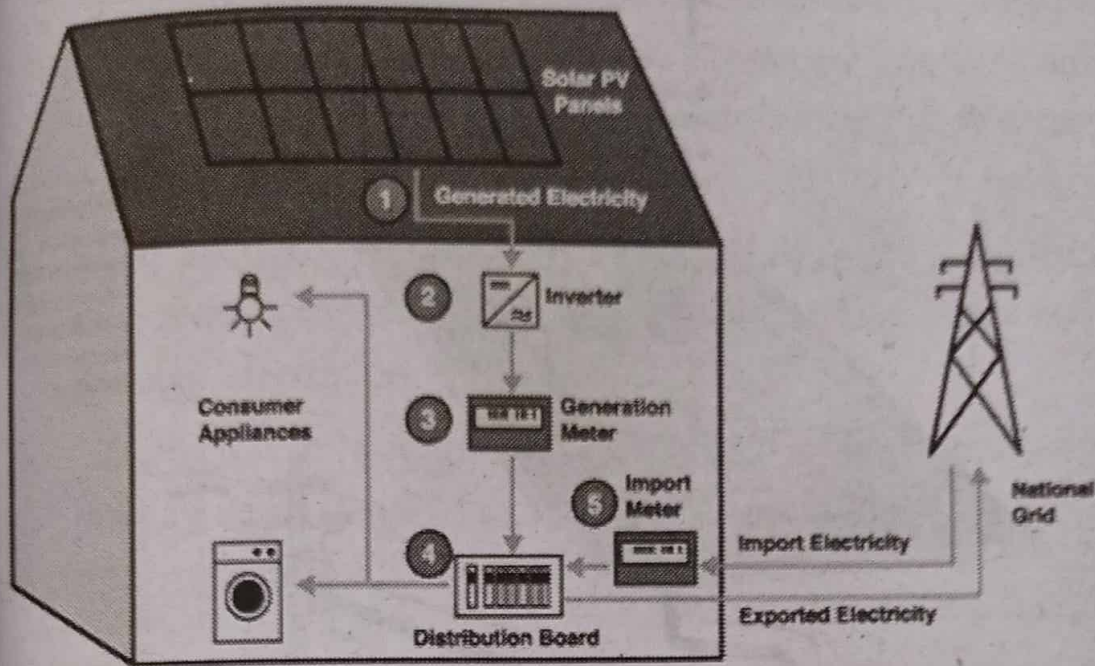
LONG ANSWER QUESTIONS

1. *Explain about the process of Converting Solar Energy into Electricity.*

Ans. Solar energy is free energy that we get from the sun. There is an increased demand for renewable sources of energy in the recent years solar energy is clean and environment friendly, So many countries are investing their money to produce useful electrical energy from solar energy.

Solar panels are made from Silicon and convert solar energy into electrical energy, there are simple steps in which solar panels convert solar power to electrical energy, these are discussed below.

We have to get our solar panels at the top of our house where maximum sunlight is available during the day, there are different types of solar panel array mountings. Adjustable, fixed and tracking solar panel mounts. We can choose the best solar panel mounting according to our requirements. Tracking solar panel mounts are more efficient as they can move in the direction of Sun.



The solar panel is connected to the solar charge controller the charge controller controls the charging of the battery and prevents it from over charging. It also prevents the reverse flow of current during the night when no charging takes place.

In the next step, connect the charge controller to the battery. The battery will start charging in the presence of sunlight if it is not fully charged. When a battery is fully charged, the charging process being stops automatically and to restarts again when the indicator detects that the battery to be charged.

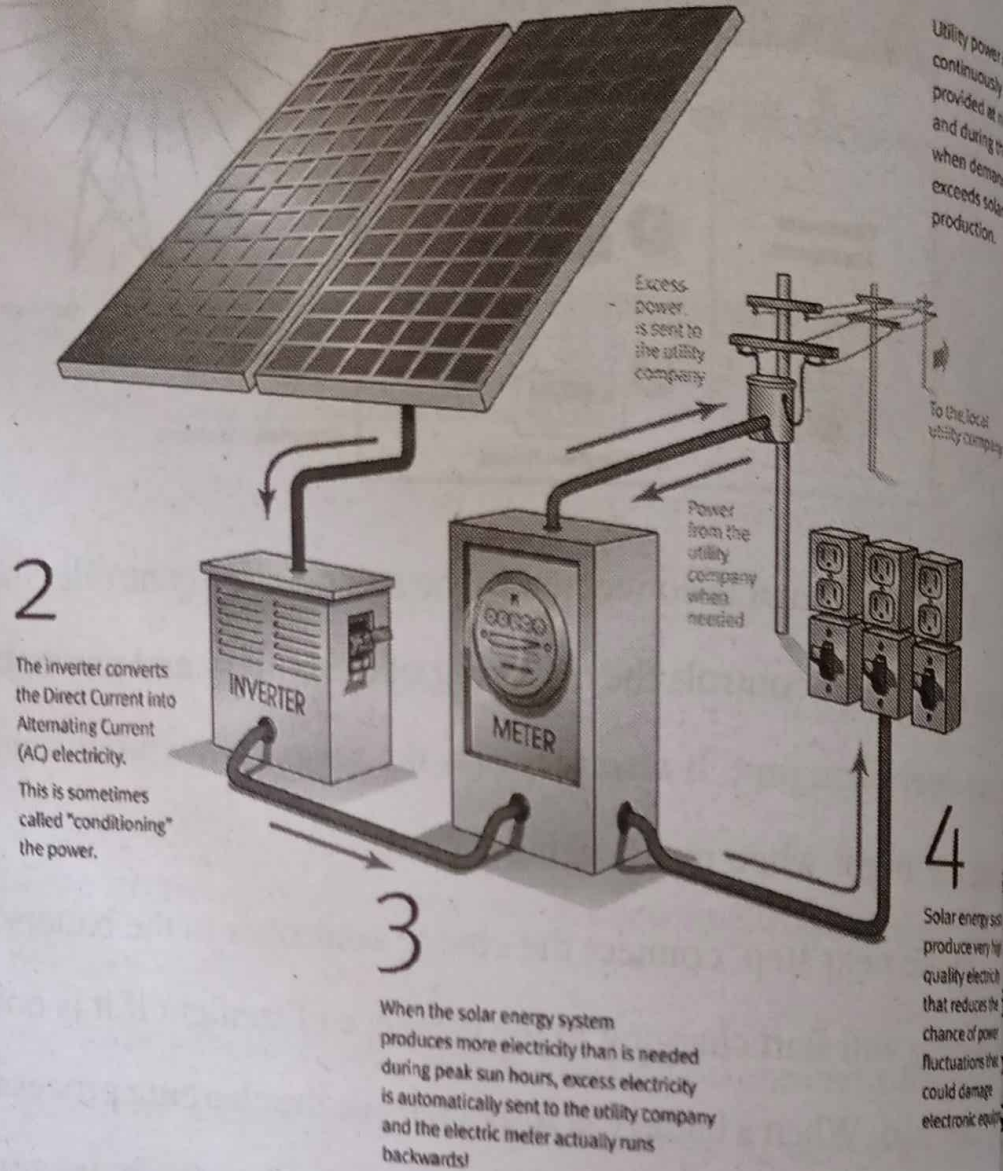
The power generated in the battery is 12 Volt DC voltage and we have converted it to AC current to run our home appliances that run on AC power. We have to install a power inverter to convert DC power to AC power for supporting our home device.

1

Sunlight falls on high capacity solar panels during daylight hours. The solar panels convert the sun's energy into Direct Current (DC) electricity which is sent to an inverter.

5

Utility power continuously provided at night and during times when demand exceeds solar production.



Stages :

1. Sunlight falls in high capacity solar panels during the daylight hours. The solar panels convert the sun's energy into Direct Current (DC) electricity which is sent to an inverter.
2. The inverter converts the direct current into alternating current. All this sometimes is called conditioning the power.

3. When the solar energy system produces more electricity than is needed during peak sun hours, excess electricity is automatically sent to the utility company and electric meter actually runs backwards.
4. Solar energy systems produce very high quality electricity that reduce the chance of power fluctuations that could damage electric equipment.
5. Utility current is continuously provided of night and during the day when demand exceeds, solar production.

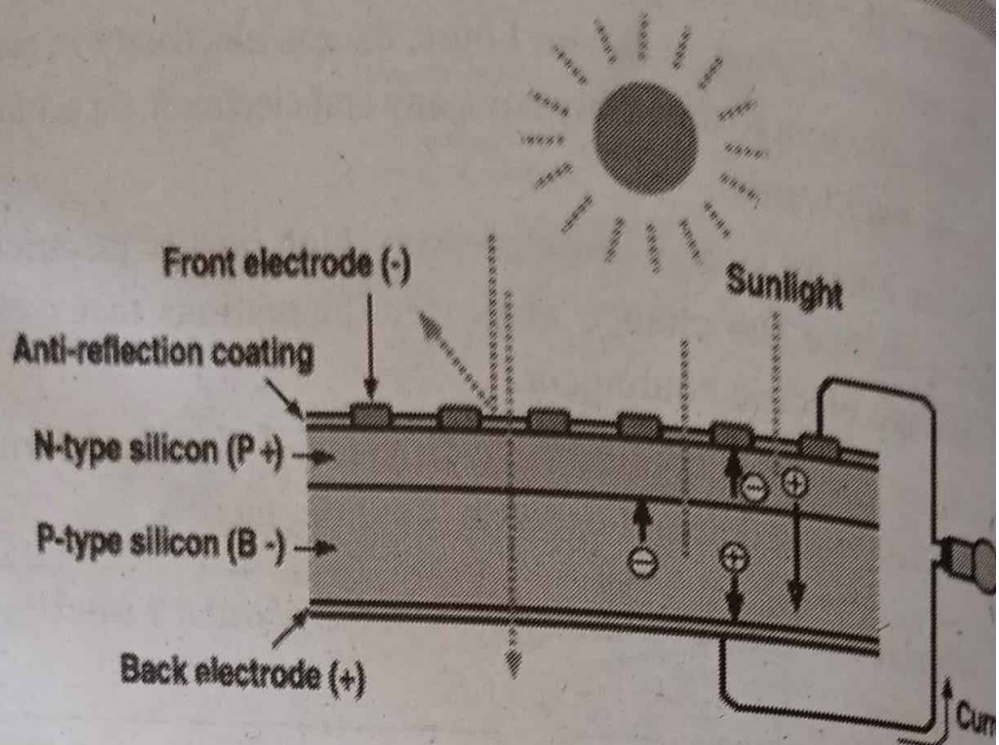
2. What is the Photovoltaic effect ? Write about it's working Principle.

Ans. The photovoltaic effect, can be defined as being the appearance of a potential difference (voltage) between the two layers of a semiconductor slice in which the conductivities are opposite or between a semiconductor and metal, under the effect of a light stream.

The effect is invented by Edmond Becquerel in 1839. When doing experiment involving weight cells he noted that the voltage of the all increased when its silver plates were exposed to the sunlight.

Description :

1. When photons are absorbed by photosensitizers, a voltage difference across a junction is produced.
2. The voltage difference is caused by the entered drift of electrons, which accepted the light energy and leaved the normal position.
3. Photovoltaic effect is the basic physics process through which a solar cell convert sunlight into electricity.



How do Photo Voltaic's work ?

1. Top layer is made of Silicon and on type (phosphorous) ing. First layer become negative type due to excess of n
tive electrons.
2. Middle layer has low margin P-type material.
3. The bottom layer is doped P-type (boron) along with Sili

How can we get electricity from the sun ?

When certain semi conducting materials, such as cer
kinds of Silicon, are exposed to sun light. They release the s
amounts of electricity. This process is known as photo ele
effect. The PV effect refers to the emission of electrons from
surface of metal in response to light. It is the basic physical pro
in which a solar electric or PV cell converts sunlight to electri

Sunlight is made up of photons or particles of solar en
photons contains various amounts of energy corresponding to
different wave lengths of the solar spectrum. When photon str

PV cell, they may be reflected or absorbed, or they may pass right through only the absorbed photons generate electricity when this happens, the energy of the photons is transferred to an electron in an atom of the PV cell (which is actually semiconductor)

3. What are the different types of different Solar Cells and their Efficiencies ?

Ans. The following are different types of solar cells. They are :

1. Amorphous Silicon Solar Cell (a-si)
2. Bio - hybrid solar cell
3. Cadmium Telluride Solar Cell (cdTe)
4. Concentrated PVCell (CVP anal HCVP)
5. Copper Indium Gallium Selenide Solar Cells (CI(G)S)
6. Crystalline Silicon Solar Cell (C-Si)
7. Float - Zona Silicon.

Efficiency : Efficiency is defined as the ratio of energy output from the Solar cell to input energy from the sun. In addition to reflecting the performance of the solar cell itself, the efficiency depends on the spectrum and intensity of the incidents Sunlight and the temperature of the Solar cell.

Based on types of crystal used, Solar cells can be classified as

- i) Mono crystalline Silicon cells
 - ii) Poly crystalline Silicon cells
 - iii) Amorphas Silicon cells
1. The mono crystalline Silicon cell is produced from pure silicon (single crystal). Since in mano crystalline Silicon is pure and defect free the efficiency of cell will be higher.

2. In polycrystalline Solar cell, liquid silicon is used as material and polycrystalline silicon was obtained following Solidification process. The material contains various crystalline sizes. Hence the efficiency of this type of cell is less than monocrystalline cell.

3. Amorphous Silicon :

- Amorphous Silicon is obtained by depositing silicon film on the substrate like glass plate.
- The larger thickness amounts to less than 1mm the thickness of human hair is 50-100nm.
- The efficiency of amorphous cells is much lower than of the other two cells.
- As a result they are used mainly in low power equipment such as watches and pocket calculators or as facade elements.

Comparison of types of Solar cell : Material efficiency

- Mono Crystalline Silicon- 14-17
- Poly Crystalline Silicon - 5 - 7
- Amorphous Crystalline Silicon - 13-15

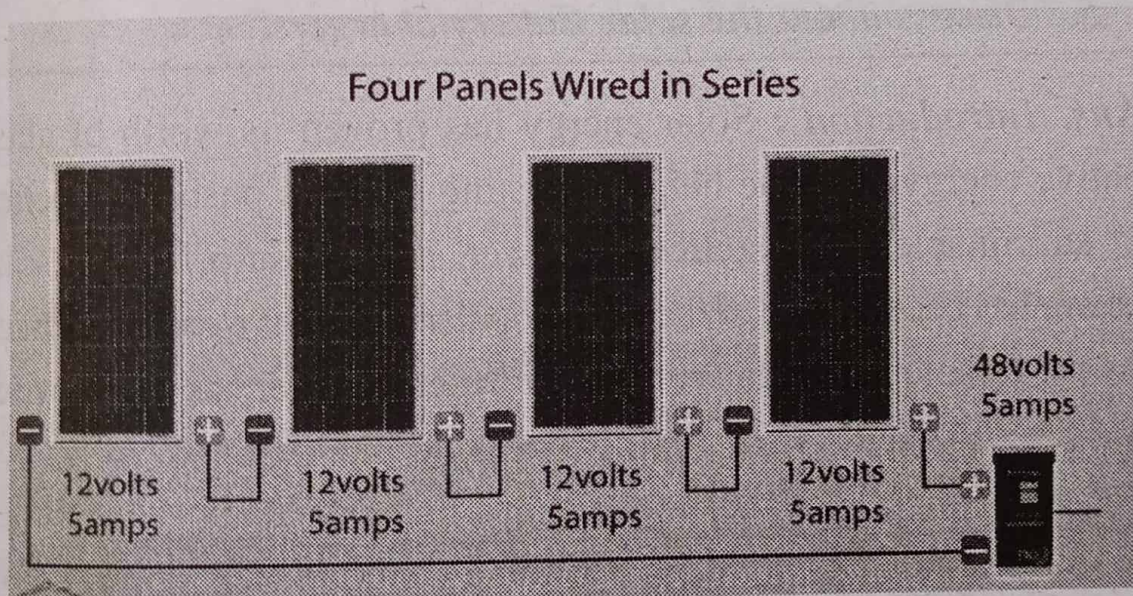
4. Explain about the Series and Parallel Connections of Solar Cells.

Ans. Wiring of Solar panels in a Series circuit :

- Connect the positive terminal of the first solar panel to the negative terminal of the next one.
- If we have 4 Solar panels in series and each was rated at 12 volts and 5 amps the entire array would be 48 volts at 5 amps.

1. Series Wiring : Series wiring is when the voltage of solar array is increased by wiring positive of one solar module to the negative of another solar module.

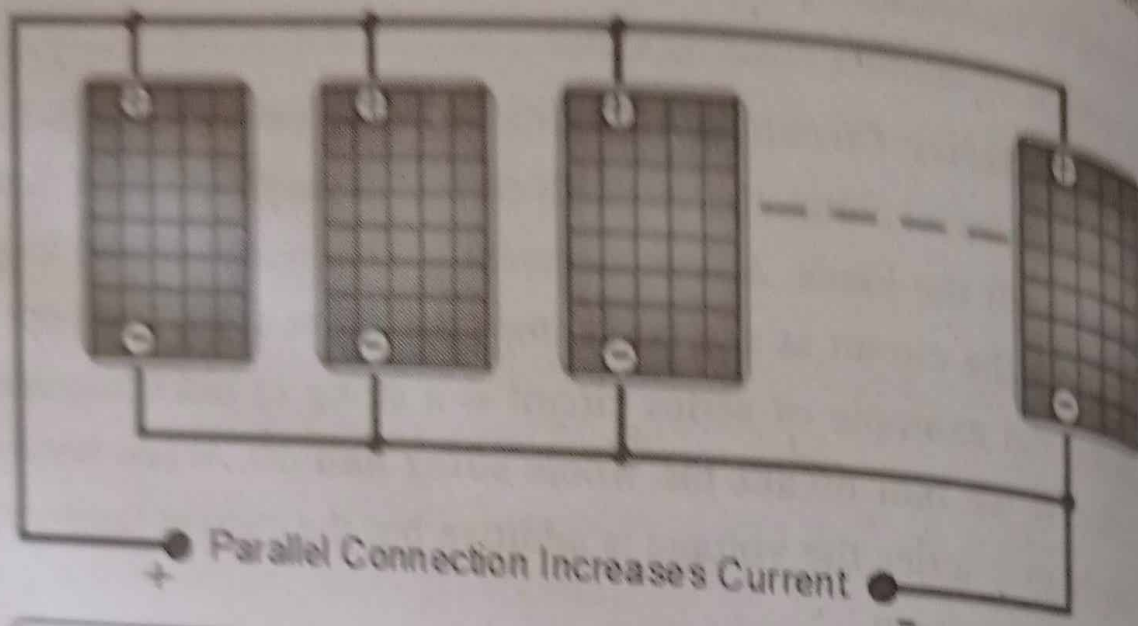
2. Series Circuits : These circuits have only one path for current to travel along, therefore all current in the circuit must flow through all the loads. A series circuit is a continuous closed loop. Breaking the circuit at any point stops the entire series from operating. An example of a series circuit is a string of old Christmas lights. If one bulb breaks the whole string turns off. When wiring panels in a series the voltage is additive but the current (ampere) remains the same.



3. Parallel Circuits : These circuits have multiple paths for the current to move along. If an item in the circuit is broken, current will continue to move along the other paths, while ignoring the broken one. This type of current is used for most household electric wiring. For example, when you turn off your TV, it does not also turn off your lights.

When wiring solar panels in parallel, the current is additive, but the voltage remains the same. Eg: If you had a solar panel, in

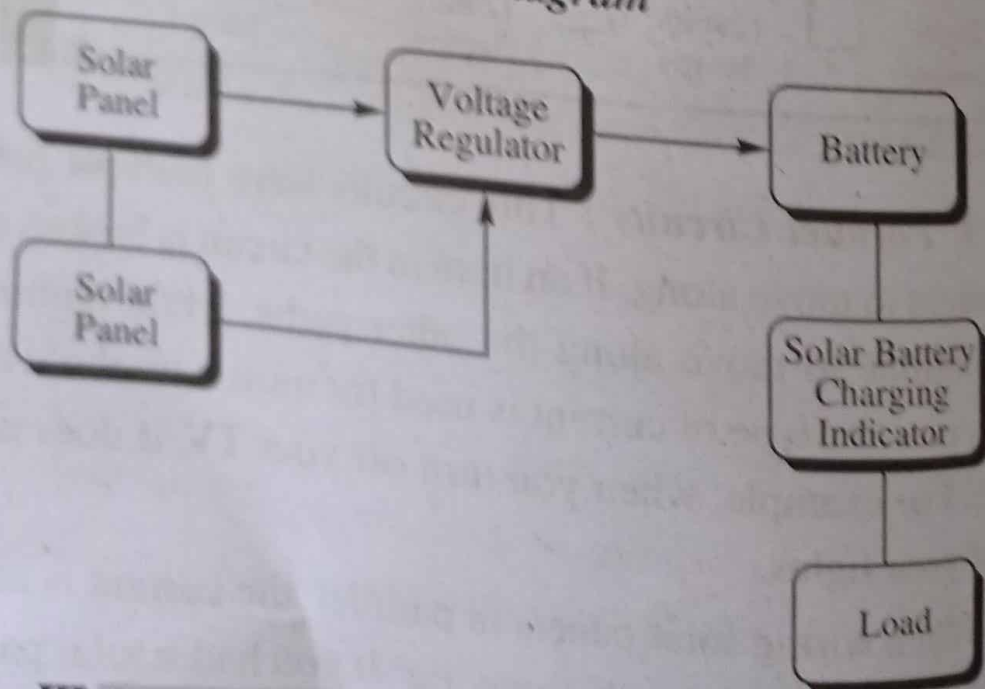
a parallel and each was rated at 12 volts and 5 amps the entire array would be 12 volts and 20 amps.



5. Discuss about the solar Battery chargers.

Ans. Introduction : Solar energy has proven its worth of alternative energy with the help of existing systems push in direction of sustainable clean source of power, it is no surprise that solar power has become one of the most popular alternative energy sources. As per techniques available, the solar battery charger has been devised.

Block Diagram



Objective: Our topic is around charging a 'V' Ah sealed battery with solar pond. This battery will supply power to led lights and a mobile phone charging point. For charging (V) battery, the battery will have the two inputs as solar (V) and AC(V). Automatic battery cut off after voltage goes down certain limits to ensure long battery life, the main object is to prevent the over charging battery.

As per the circuit diagram, the solar battery charger requires a Solar panel or adapter, IC LM317, IC LM324 are battery

Solar Process :

1. The sun is a star and make up of hydrogen and helium gas hence, it radiates an enormous amount of energy every second.
2. Solar cell works on the principle of "photo voltaic effect" as a sunlight is composed of photons, or packets of energy.
3. These photos contain various amount of energy corresponding to the different wavelength of light.
4. When a photon is absorbed, the energy of photon is transferred to the election in an atom of the cell.

Battery : Battery is power storage device. It is internally interfaced directly to panel with necessary they generally use lithium batteries for this purpose.

Battery Status : Charges have LED to determine their battery status.

LED Deplicts : (1) Battery status (2) Charging status (3) dis charging status

The Indicators for the same could be monitored via the connected colured LEDs.

The yellow LED associated with A_2 may be set for indicating the low voltage cut off threshold. When the LEDs shuts off the

transistor TIP 122 is inhibited from conducting and cuts off the supply to the load there by ensuring that the battery is never allowed to discharge to dangerous unrecoverable limits.

The A_4 LED indicates the upper full charge level of the battery, this output could be fed to the base of the LM 317 transistor in order to cutoff the charging voltage to the battery, preventing overcharge

Since the A_2 / A_4 do not have hysteresis included could produce oscillations at the cutoff thresholds the which won't necessarily be an issue or affect the battery performance or life.

Advantages :

1. As we use DC power supply directly to charge the mobile, the ripples will not be there in Solar mobile charger.
2. Prevents from overcharging the battery, which may affect the battery.
3. Emission free
4. Battery life will be high as we use solar mobile charger.

Applications

1. Emergency Power
2. Travelling in remote location
3. Domestic appliance
4. Everyday use

Conclusion :

1. The latest appliance being derived by the suatist are being made in solar mobile charger as environment friendly manner and so large amount of energy can be saved. When we use environment friendly products

2. Versatility of solar is high
3. The most recommended solar mobile charge
4. Adaptability is high are X term, voltaic, XD, solurja.

6. What is the about Domestic Lighting? Explain it.

Ans. Lighting or illumination is the deliberate use of light to achieve practical or aesthetic effects. Indoor lighting is usually accomplished using light filterers, and a is a key part of interior design.

Task light provides you with a specific amount of illumination to adequately carry out certain tasks. Indeed, light solution which are able to produce suitably bright illumination that is free of shadows are integral to wide range of domestic solution, such as cooking, reading, workshop time and grooming.

1. **Lighting** : Lighting is form of energy without which there can be no vision. When light strikes an object, it may be reflected, absorbed or allowed to pass through.
2. Types of light source based classification
3. **Natural light** :The bright radical energy of the sun, day light is a major determine factor in design of hotel guestrooms, and homes, especially where large wall areas have been decorated with glass.
4. **Artificial light** :Well planned artificial illumination help us to see contribution without strain and helps to prevent accidents. It makes a vital contribution to the attractiveness of homes and hotels
5. **Incandescent / Filament** : Here light is produced by heating are usually metal to a temperature at which it glows. Typical incandescent bulbs have tungsten filament in a sealed glass

container. Many gas filled and halogen lamps with halogen mined gas filling are also available.

6. Incandescent / filament gas filled (General lighting service) halogen lamps.
7. **Fluorescent / discharge** : Fluorescent tubes are cold (not produced by heat) source of light. A glass tube with inside coating of fluorescent powder is filled with vaporized mercury and argon. They ends are then sealed with cathodes. When electric current activate the gases in it, invisible UV rays cause the fluorescent coating to produce visible light.
8. **Direct lighting** : This kind of light comes from the sources such as calling fixtures or luminous calling the shed light downward or from lamps with translucent shades spreading light in all directions.
9. **Indirect lighting** : This is usually concealed sources in alcoves, cornices or valences. It may also come from a deep with an opaque shade open only of the top light is then thrown against the ceiling or washes against the wall and is reflected back into the room. It is softer than the direct lighting but often more costly in both installation and operation.
10. **Diffused lighting** : When light fitting are completely enclosed or conceded, as with some globes and ceiling panels, the light is diffused since it passes through the glass or plastic. Diffused lighting is also shared and produces that appearance.
11. **Semi-Indirect lighting** : It is possible to have some light passing through a diffusing board out some reflective off the ceiling, where the fixture is open on top.

7. Discuss in detail about Solar Street Lighting

Ans. Solar Street lights are raised night sources which are powered by solar panels. Generally a mounted on the lighting structure or integrated into pole itself. The Solar panels charge a rechargeable battery, which powers fluorescent or LED lamp during the night.

A typical Solar street light is weather proof and water resistant has low insect attraction rate and low glare cred has a longer life. The embedded Solar panel converts solar power into electrical energy. Which is stored in the inbuilt battery and used for dusk to down lighting operations.

Each street light can have its own photo voltaic panel independent of other street lights. Alternatively a number of panels can be installed as a central power source on a separate location and supply power to a number of street lights

Features : Most solar panels turn on and turn off automatically by sensly outdoor light using a light source. Solar street light and designed to work throughout the night. Many can stay list for more than one night, if the sun is not available for a couple of days.

Latest designs use wireless technology and fuzzy control theory for battery management the street light using the technology can operate as a network with each light having the capability of performing on or off the network.

Components :

Solar street light consists of 5 main parts. They are :

1. Solar panel
2. Lighting fixture

3. Rechargeable battery
4. Controller
5. Pole



Working Principle :

1. In the street lighting we have the charge controller circuit which is charged the battery in the day time by solar panel and by conventional power at night.
2. This switching between conventional and solar occurs through the relaying action.
3. The relaying action is done by two not logic operated transistor through LDR.
4. photo conductive device LDR(Light Dependent Resistor) whose resistance changes proportional to the extent of illumination. Which switches ON or OFF the LED during day and night and also dusk to down operation is done.

In this four circuits and used with proper functioning

1. Charge controller circuit

2. Dusk the dawn operation circuit
3. Switching circuit between conventional and solar
4. power circuit

Advantages :

1. Complete elimination of main power
2. Reduced energy costs
3. Reduced greenhouse gas emission
4. Reduced maintenance cost
5. Higher community satisfaction

Disadvantages :

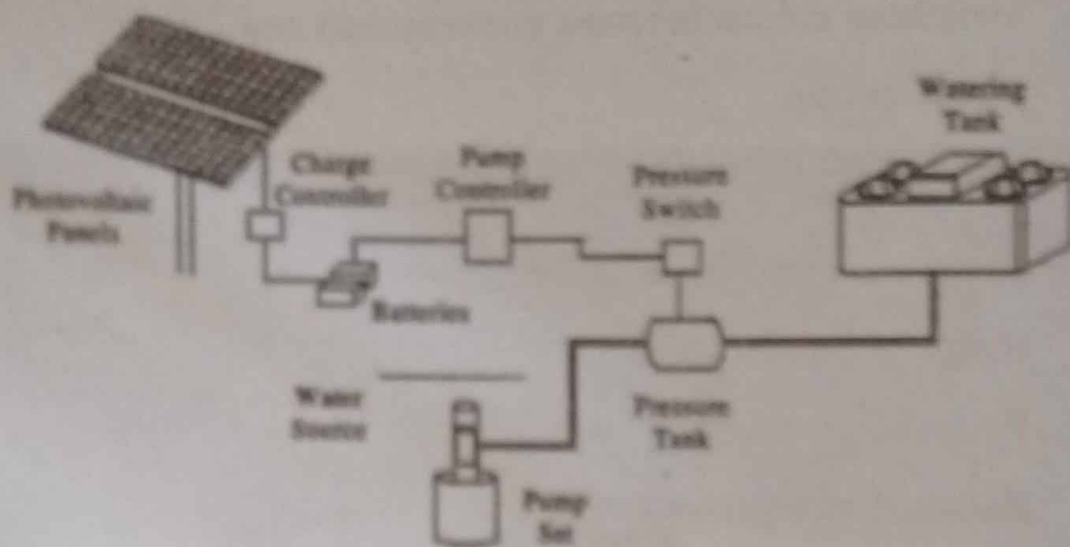
1. Chance of theft of solar panel in case of some security in rural Problems.
2. High initial cost

8. Define the Solar Water Pump and Narrate it with neat diagram.

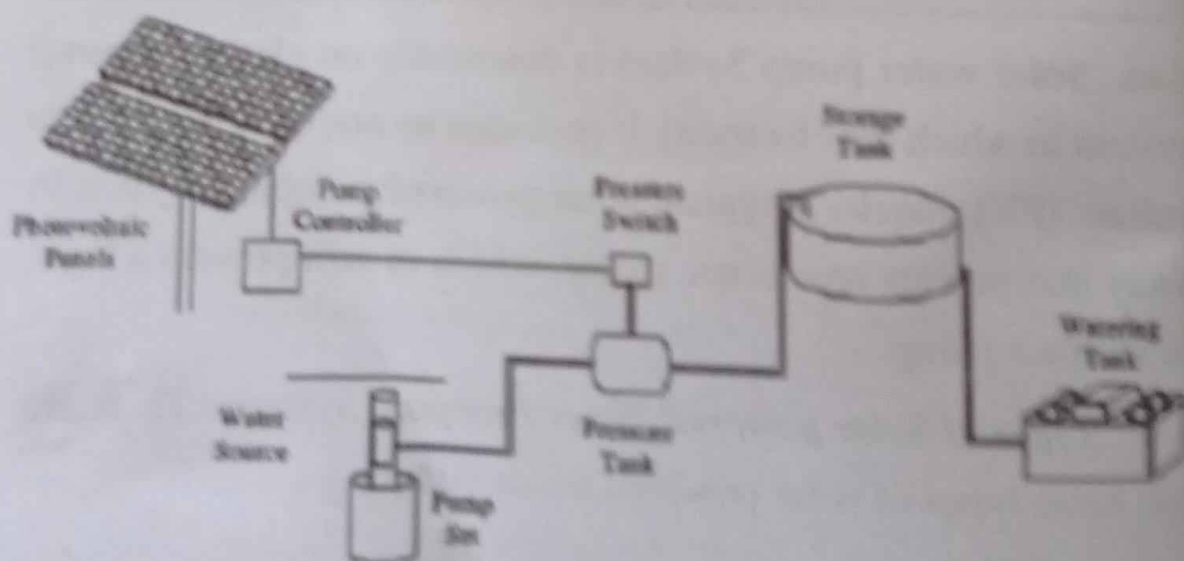
Ans. Solar water pump System is essentially on electrical pump system in which the electricity is provided by one or several photo voltaic (PV) panels. A typical solar powered pumping system to away that powers an electric motor, which in turn powers a bore, or sur-face pump.

Types of Solar powered Water Pumping System : There are two basic types of solar powered water pumping systems

1. Battery Based
2. Solar Direct

1. Battery Based :*Battery Based Solar water /Pumping System*

- i) It consists of photovoltaic (PV) panels, charge controller batteries, pump controller, and DC water pump.
- ii) Water supply for home or cabin
- iii) Pumping at night

2. Solar direct :*Solar Direct Water Pumping Systems (CSDPS)*

In Solar direct pumping system electricity from PV modules is sent directly to the pump which in-turn pumps water through a pipe to where its needed

Solar direct pumping systems are sized to store extra water on sunny days. So it is available on cloudy days and at night. Water can be stored in a larger than needed watering tank or in a separate storage tank and then gravity fed to smaller water tanks.

Working of Solar Water Pumping System : The system operates on power generated using Solar (PV) Photo Voltaic System. The photo voltaic array converts the solar energy into electricity, which is used for running the motor pumpset. The pumping system draws water from the open well, base well, stream, pond, canal etc.

Advantages :

1. Low operating cost
2. Free fuel
3. Environmental friendly
4. Easy transportation

Disadvantages :

1. Variable yield
2. Water quality
3. Theft

Applications :

1. Agriculture live-stock watering / crop irrigation, home gardens, and drip irrigation systems.

2. Domestic portable Water for remote homes, cap grounds
3. Pond water management and water transfer
4. Water supply for villages in developing world.

Conclusion : Photo-voltaic power for irrigation is cost competitive with traditional energy sources for small remote applications, if the toll system design and utilization timing is carefully considered and organized to use the solar energy as efficiently as possible. In the future, when to prices of fossil fuels rise and the economic advantages of mass production reduce the peak wall cost of the photo voltaic cell. photo voltaic while powerwill become more cost competitive and more common

SHORT ANSWER QUESTIONS

9. *What are the Advantages and Disadvantages of Solar cell?*

Ans. Advantages of Solar Cell :

1. It is clean and non polluting
2. It is renewable energy
3. Solar cell do not produce noise and they are totally silent.
4. They require very little maintenance.
5. They have long lifetime
6. There are no fuel costs or feel Supply Problems.

Disadvantages of Solar Cell :

1. Solar cell panels are very expensive

2. Energy has not to be stored in batteries
3. Air pollution and weather can effect the production of electricity
4. They need large one of land to produce more efficient power supply.
5. Sun does not shine consistently
6. Less efficient and costly equipment
7. Reliability, depends on location

10. Write down the Photovoltaic Applications.

Ans. In urban or remote areas', PV can power stand alone devices, tools and meters. PV can meet the need for electricity for parking meters, temporary traffic signs, emergency phones, radio transmitters, water irrigation pumps, stream flow gauges, remote and guard posts lighting for road ways and more.

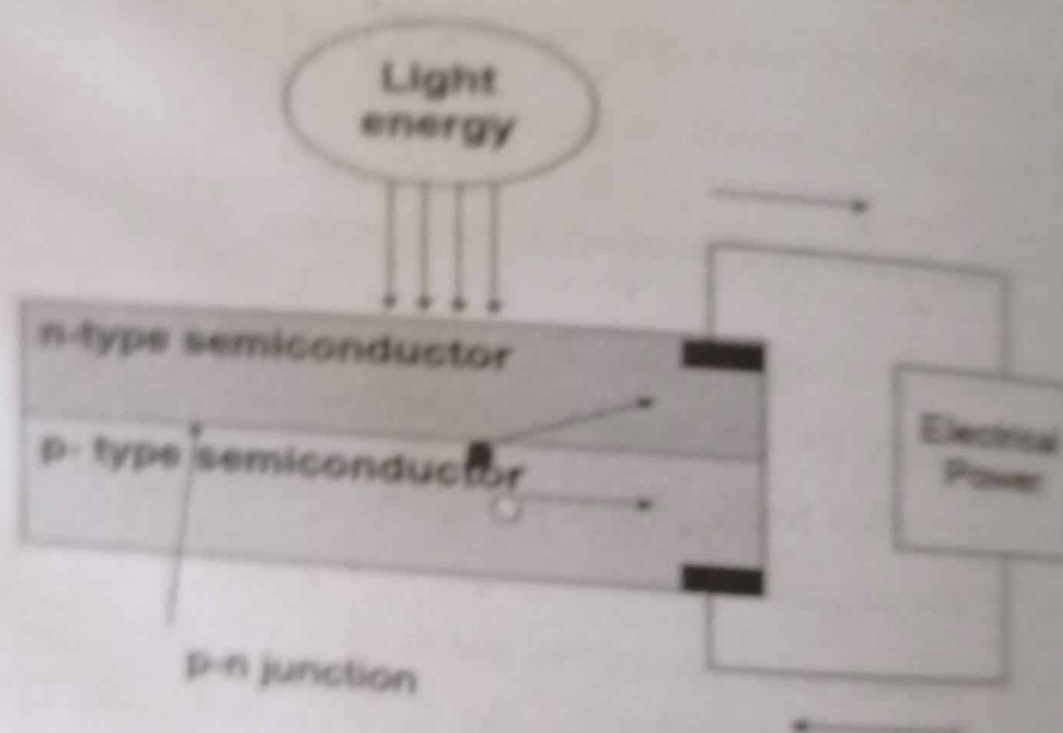
1. Solar cell for transportation, solar energy is used in cars. This solar to power is created by photovoltaic cells,
2. Solar cells in calculators, solar powered calculators use photovoltaic cells.
3. Solar cell panels on the roof top, solar panels are kept.

11. What do you mean by photovoltaic Effect ?

Ans. Photovoltaic comes from the words photo means light and the volt measurement of electricity photovoltaic. Electricity is obtained by using photovoltaic system. A basic photovoltaic system

consists of four components. They are: (i) Solar panel (ii) Battery (iii) Regulator and (iv) Load.

The generation of voltage across the PN junction in a semiconductor due to the absorption of light radiation is called photovoltaic effect the devices based on this effect is called photovoltaic devices.



12. Discuss about the Four main types of Solar Energy.

Ans. 1. Photovoltaic Systems : One of the most common ways to use solar power is to use photovoltaic systems or as they are also known solar cell systems, which produce electricity directly from sun light.

2. Solar water heating systems : A second type of solar energy is solar hot water system. In this the most common collector is called a flat plate collector. Which is mounted on the hot surface.

faces the sun. Small tubes run through the box and carry the fluid, either water or fluid, such as an equiti freeze solution to be heated. A heat build-up in the collects it heats the fluid passing through the fuses, the storage tank then holds the hot liquid.

3. Solar Power Plants : In this there are tree Systems

- i) Parabolic trough
- ii) A dish / engine system
- iii) A power tower Supply.

4. Passive Solar Heating : Solar power can be harnessed is through the method of pressive solar heating and day lighting. South facing windows will receive more such light while building can also in corporate native. Such as sunlight flows and walls that absorb and store the suns hat is most needed.



MODEL PAPER - 1

SOLAR ENERGY

Time : 1 ½ Hrs]

(W.E.F. 2020 - 21)

[Max. Marks : 50]

SECTION - A : (4 × 5 = 20 Marks)

(Answer any four questions. Each answer carries 5 marks.)

(At least 1 question should be given from each unit.)

1. What is the importance of Solar Energy ?
2. Explain about the solar radiation instruments.
3. What are the Solar Collectors types ?
4. Write about the solar distillation and explain the advantages of it.
5. Define the Solar Cooker and write how does it work.
6. Write down the photovoltaic applications.
7. Discuss the four main types of Solar Energy.
8. What is the Photovoltaic Effects ?

SECTION - B : (3 × 10 = 30 Marks)

(Answer any three questions. Each answer carries 10 marks)

(At least 1 question should be given from each unit)

1. How can you prove that the "Sun is ultimate source of Energy"?
2. Explain about Pyrheliometre and how can you measure the solar radiation with pyrheliometer ?

3. Discuss about the Flat-plate collectors and Concentrating collectors.
4. Write about the Solar, thermal power plant.
5. Explain about the Series and Parallel connection of Solar cells.
6. What is the Domestic Light? Explain it.

MODEL PAPER – 1 : Answers

SECTION – A

1. *What is the importance of Solar Energy ?*

Ans. Question No. 14, Unit – I.

2. *Explain about the solar radiation instruments.*

Ans. Question No. 12, Unit – I.

3. *What are the Solar Collectors types?*

Ans. Question No. 10, Unit – II.

4. *Write about the solar distillation and explain the advantages of it.*

Ans. Question No. 15, Unit – II.

5. *Define the Solar Cooker and write how does it work.*

Ans. Question No. 16, Unit – II.

6. *Write down the photovoltaic applications.*

Ans. Question No. 10, Unit – III.

7. *Discuss the four main types of Solar Energy.*

Ans. Question No. 12, Unit – III.

8. *What is the Photovoltaic Effects?*

Ans. Question No. 11, Unit – III.

SECTION – B

1. *How can you prove that the “Sun is ultimate source of Energy” ?*

Ans. Question No. 1, Unit – I.

2. *Explain about Pyrheliometre and how can you measure the solar radiation with pyrheliometer ?*

Ans. Question No. 4, Unit – I.

3. *Discuss about the Flat-plate collectors and Concentrating collectors.*

Ans. Question No. 3, Unit – II.

4. *Write about the Solar, thermal power plant.*

Ans. Question No. 4, Unit – II.

5. *Explain about the Series and Parallel connection of Solar cells.*

Ans. Question No. 4, Unit – III.

6. *What is the Domestic Light? Explain it.*

Ans. Question No. 6, Unit – III.



MODEL PAPER - 2

SOLAR ENERGY

Time : 1 ½ Hrs]

(W.E.F. 2020 - 21)

[Max. Marks : 50

SECTION - A : (4 × 5 = 20 Marks)

(Answer any four questions. Each answer carries 5 marks.)

(At least 1 question should be given from each unit.)

1. Difference between Pyrheliometer and Pyranometer.
2. Write about disadvantages of Solar Energy.
3. Write the history of Solar thermal systems.
4. Explain briefly about main components of thermal power plant and their formation.
5. What are the types of Solar Collectors ?
6. What are the advantages & disadvantages of Solar cell ?
7. What do you mean by Photovoltaic effect ?
8. What are the applications photovoltaic ?

SECTION - B : (3 × 10 = 30 Marks)

(Answer any three questions. Each answer carries 10 marks)

(At least 1 question should be given from each unit)

1. Explain about Construction, working principle of pyranometer with diagram.
2. What is the Solar Pond ? Write with diagram.
3. What is the Solar Hot water system? Explain with neat diagram.

4. What do you know about "Solar Green House"? Write with neat diagram.
5. What are the different types of Solar cells and their efficiencies ?
6. Discuss about the Solar battery charges with a diagram.

MODEL PAPER – 2 : Answers

SECTION – A

1. Difference between Pyrheliometer and Pyranometer

Ans. Question No. 11, Unit – I.

2. Write about disadvantages of Solar Energy.

Ans. Question No. 15, Unit – I.

3. Write the history of Solar thermal systems.

Ans. Question No. 11, Unit – II.

4. Explain briefly about main components of thermal power plant and their formation.

Ans. Question No. 14, Unit – II.

5. What are the types of Solar Collectors ?

Ans. Question No. 10, Unit – II.

6. What are the advantages & disadvantages of Solar cell?

Ans. Question No. 9, Unit – III.

7. What do you mean by Photovoltaic effect ?

Ans. Question No. 11, Unit – III.

8. *What are the applications photovoltaic ?*

Ans. Question No. 10, Unit – III.

SECTION – B

1. *Explain about Construction, working principle of pyranometer with diagram.*

Ans. Question No. 5, Unit – I.

2. *What is the Solar Pond ? Write with diagram.*

Ans. Question No. 10, Unit – I.

3. *What is the Solar Hot water system? Explain with neat diagram.*

Ans. Question No. 6, Unit – II.

4. *What do you know about “Solar Green House”? Write with neat diagram.*

Ans. Question No. 9, Unit – II.

5. *What are the different types of Solar cells and their efficiencies ?*

Ans. Question No. 3, Unit – III.

6. *Discuss about the Solar battery charges with a diagram.*

Ans. Question No. 5, Unit – III.



MODEL PAPER - 3

SOLAR ENERGY

Time : 1 ½ Hrs] (W.E.F. 2020 – 21) [Max. Marks : 50

SECTION – A : (4 × 5 = 20 Marks)

(Answer any four questions. Each answer carries 5 marks.)

(At least 1 question should be given from each unit.)

1. Define the terms heat balance and temperature.
2. What are the Solar radiation instruments ?
3. Write about Solar distillation and its advantages.
4. Write the differences between Flat plate collectors and concentrating collectors.
5. Explain briefly the disadvantages of Solar Collectors.
6. Write down the Photovoltaic applications.
7. What are the advantages & disadvantages of Solar cell ?
8. What do you mean by the Photovoltaic Effect ?

SECTION – B : (3 × 10 = 30 Marks)

(Answer any three questions. Each answer carries 10 marks)

(At least 1 question should be given from each unit)

1. How is Solar radiation will be received earth's Surface ?
Explain with neat diagram.
2. What are the Sunshine recorders? Explain with diagram.
3. What is the principle of Conversion of Solar Radiation Unit?

4. Discuss in detail about the Collectors used for Solar thermal conversion with neat diagrams.
5. What are the solar drying systems? Explain.
6. Explain about the solar distillation system.

MODEL PAPER – 3 : Answers

SECTION – A

1. *Define the terms heat balance and temperature.*

Ans. Question No. 16 (b), (c), Unit – I.

2. *What are the Solar radiation instruments ?*

Ans. Question No. 12, Unit – I.

3. *Write about Solar distillation and its advantages.*

Ans. Question No. 15, Unit – II.

4. *Write the differences between Flat plate collectors and concentrating collectors.*

Ans. Question No. 12, Unit – II.

5. *Explain briefly the disadvantages of Solar Collectors.*

Ans. Question No. 17, Unit – II.

6. *Write down the Photovoltaic applications.*

Ans. Question No. 10, Unit – III.

7. *What are the advantages & disadvantages of Solar cell ?*

Ans. Question No. 9, Unit – III.

8. *What do you mean by the Photovoltaic Effect ?*

Ans. Question No. 11, Unit – III.

SECTION – B

1. *How is Solar radiation will be received earth's Surface ?
Explain with neat diagram.*

Ans. Question No. 3, Unit – I.

2. *What are the Sunshine recorders? Explain with diagram.*

Ans. Question No. 6, Unit – I.

3. *What is the principle of Conversion of Solar Radiation
Unit?*

Ans. Question No. 1, Unit – II.

4. *Discuss in detail about the Collectors used for Solar thermal
conversion with neat diagrams.*

Ans. Question No. 2, Unit – II.

5. *What are the solar drying systems? Explain.*

Ans. Question No. 7, Unit – II.

6. *Explain about the solar distillation system.*

Ans. Question No. 8, Unit – II.

