Energy

Topic 1 :- Solar Radiation

. Solar radiation refers to the energy emitted by the Sun in form of electromagnetic waves. These energy includes visible light, ultraviolet light, and infrared radiation.

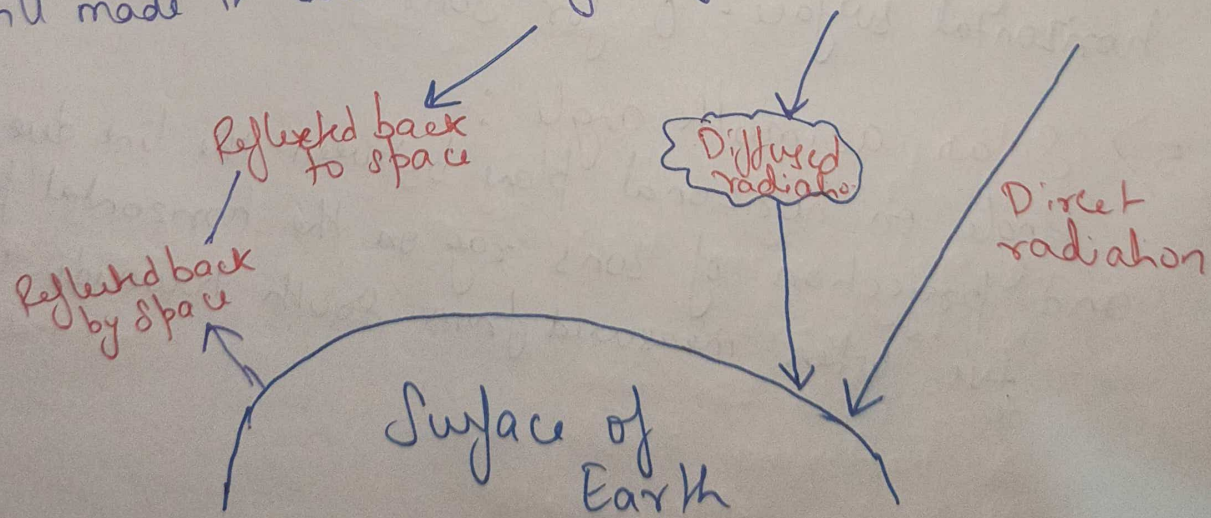
It plays crucial role in earth's climate, weather pattern and support life through photosynthesis.

Typy :-

It is classified into 2 types :-

(a) Direct radiation :- Also known as beam radiation or direct beam radiation. It is solar radiation travelling on a straight line from the sun down to surface of earth.

(b) Diffused Radiation :- describes radiation that has been scattered by molecules and particles in atmosphere but still made it down to surface of earth.



Reflected Radiation → These ~~ref~~ radiation which has been reflected off the ground. 4% of total.

Topic 2:- Solar Angles :-

1) Angle of incidence :-
Angle at which sunlight strikes a surface. It is angle between the direction of incoming sunlight and surface normal.

2) Angle of ~~reflection~~ Elevation :-
Angle between Sun & horizon. It indicate how high the sun is in the sky. It is responsible for changing length of shadow.

3) Zenith Angle :-
Angle between sun's ray and perpendicular to the normal plane. It is complement of inclination angle.

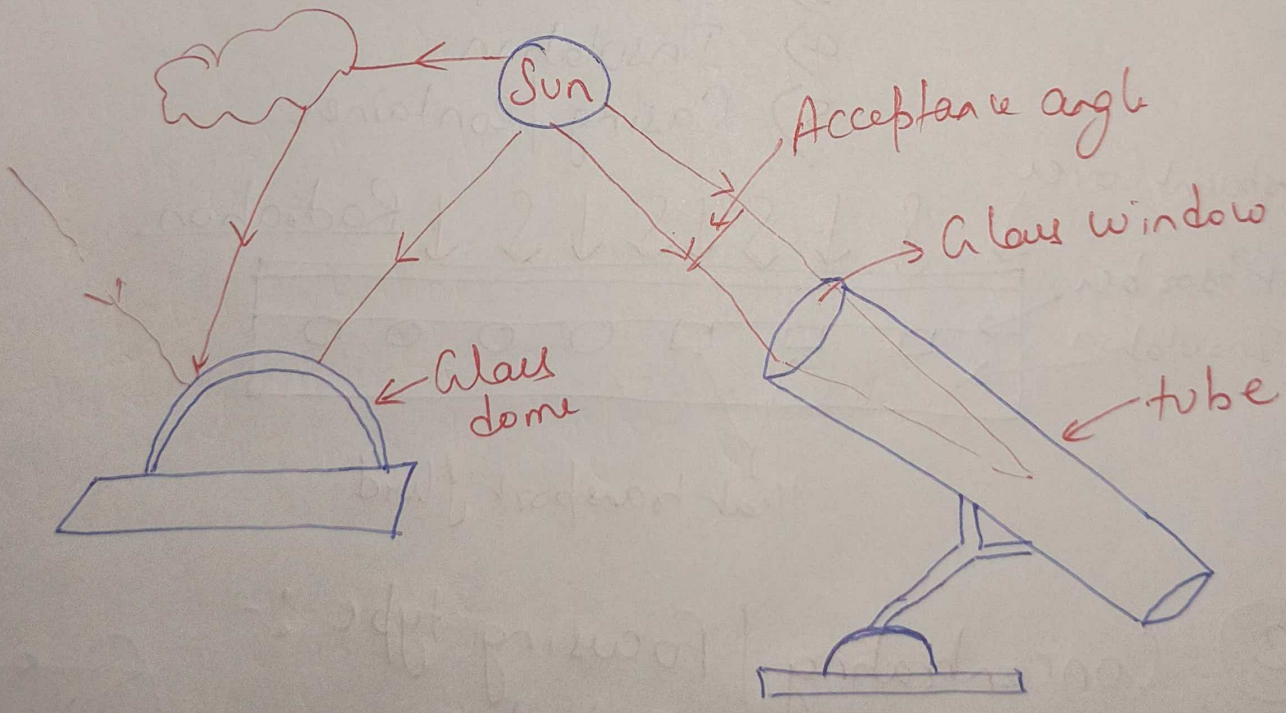
4) Inclination angle :-
Angle between sun's ray and the projection on horizontal surface. 0° for Sunrize & Sunset.

5) Solar azimuth angle :-
Angle on horizonal plane between the line due south and projection of sun's ray on the horizontal plane.
+ve when measured from South towards west.

Topic 3: Solar Radiation Measurements :-

1) Pyrheliometer → It is used to measure direct solar irradiance, which is amount of solar energy received per unit area from sun when the instrument is directly pointed at sun.

2) Pyranometer → It is used to measure total solar irradiance, which includes both direct solar radiation from sun and diffuse solar radiation that reaches the earth's surface after being scattered by atmosphere.



Pyrheliometer vs Pyranometer

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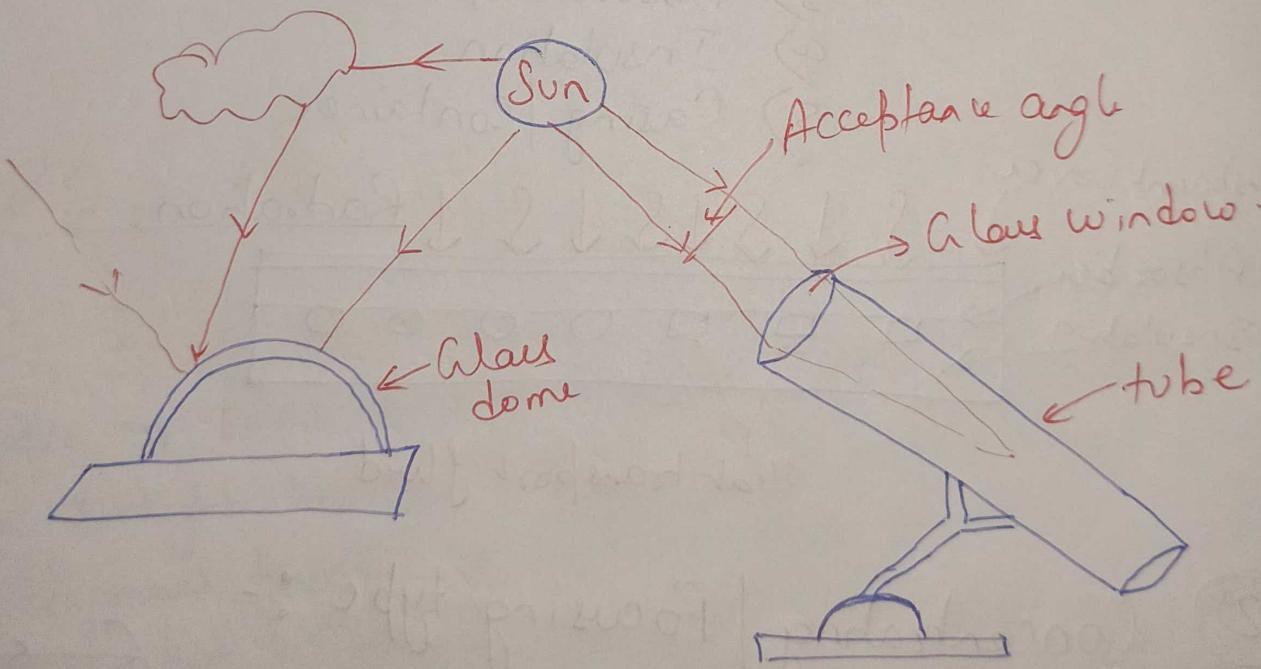


Pyrheliometer vs Pyranometer

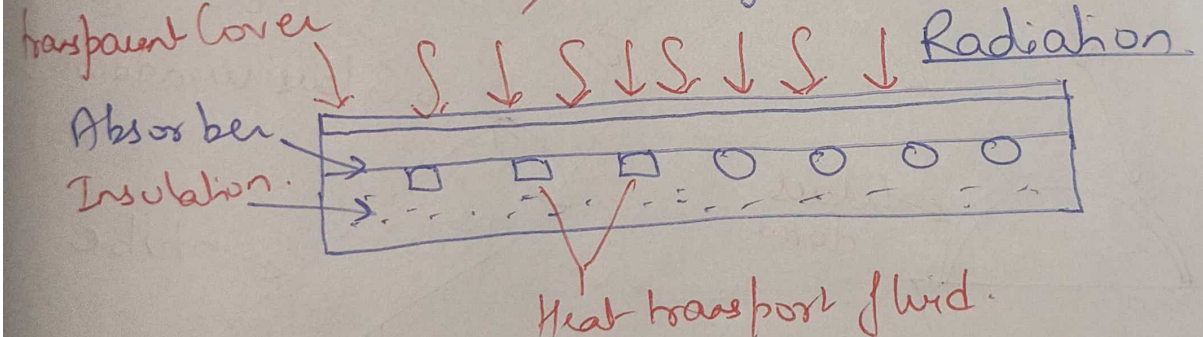
Topic 4 :- Solar Collectors :-

(1) Non-Concentrating / flat plate :-

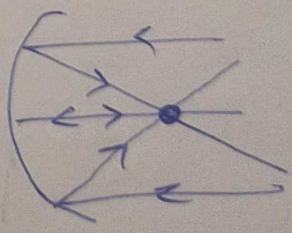
* Used for both beam & diffused radiation
* No orientation towards sun
* Little maintainence
* Mechanically simpler
* Temperature $< 90^{\circ}$

5 Components :-

1) transparent Cover
2) tubes / fins / passage
3) Absorber plate
4) Insulation
5) Casing / Container

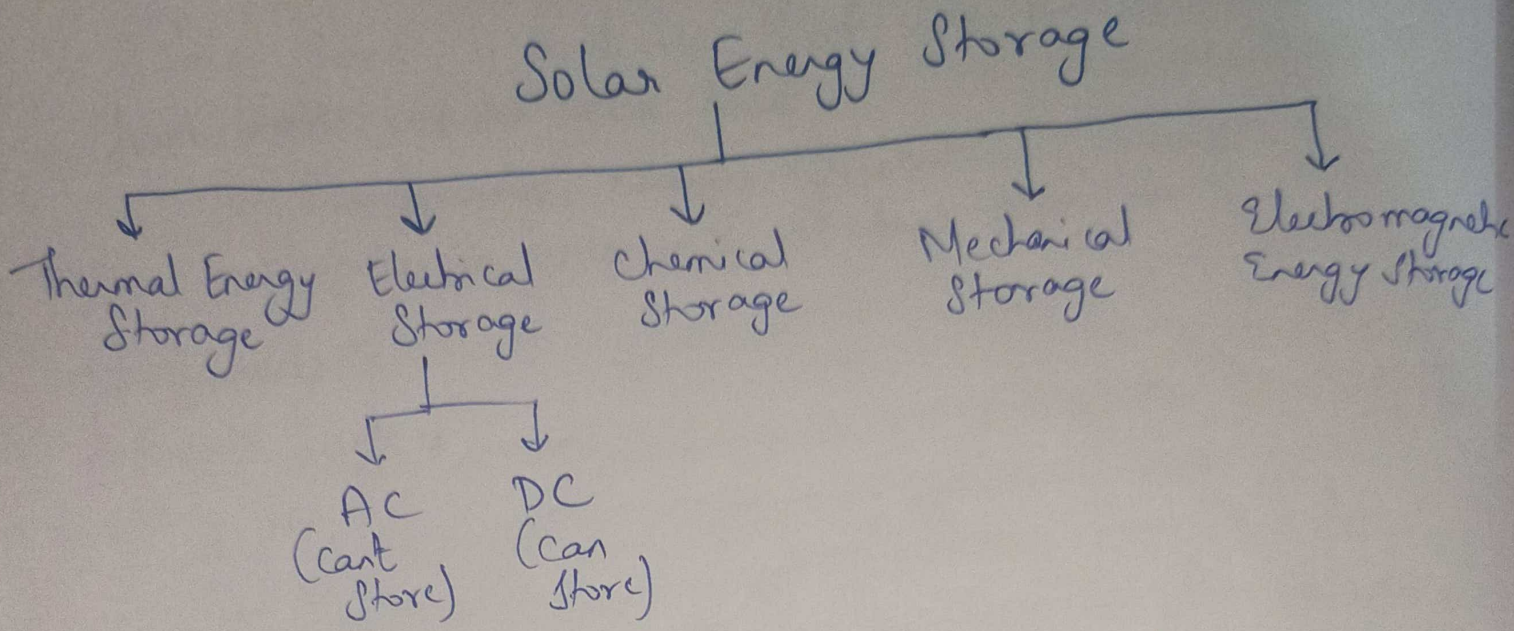


(2) Concentrating / Focusing type :-



* Only beam Radiation
* Parabolic
* Simple structure
* Reduced Heat lost
* Higher efficiencies
* High initial cost → Disadv.
* High Intensity.

Topic 5 :- Solar Energy Storage :-



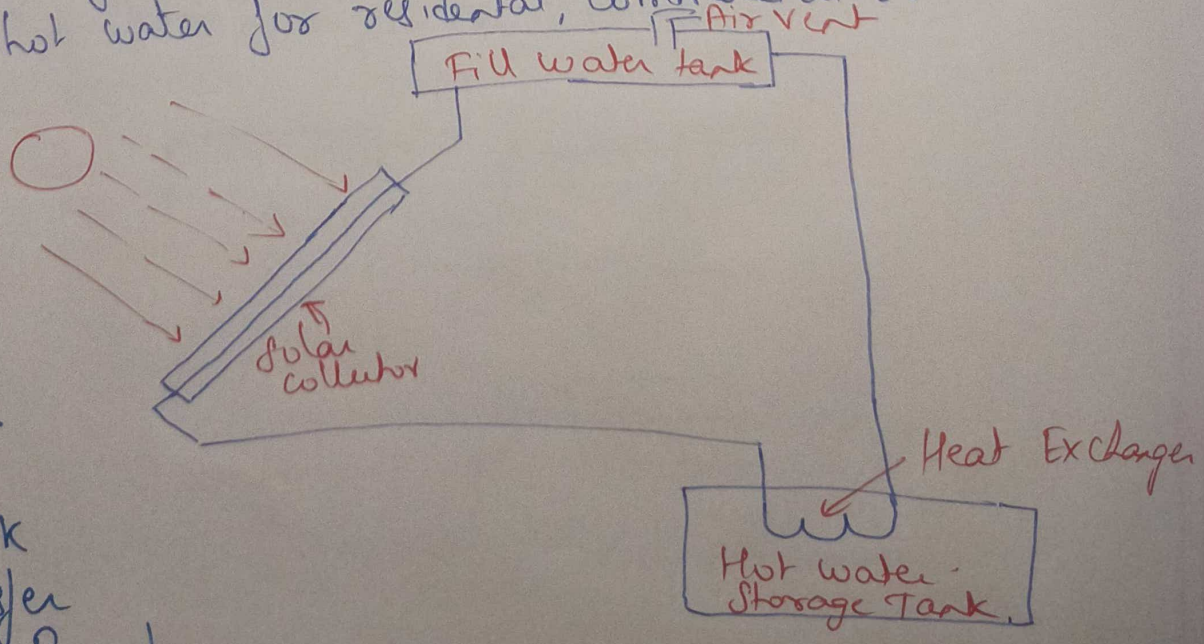
→ We can explain these in our own.

Topic 6 :- Application of Solar Energy :-

① Solar Heater :- Also known as solar water heater or solar thermal system, is a technology that uses sunlight to heat water or a heat-transfer fluid.

→ Environment friendly, energy efficient

→ Provide hot water for residental, commercial or industrial.



Component :-

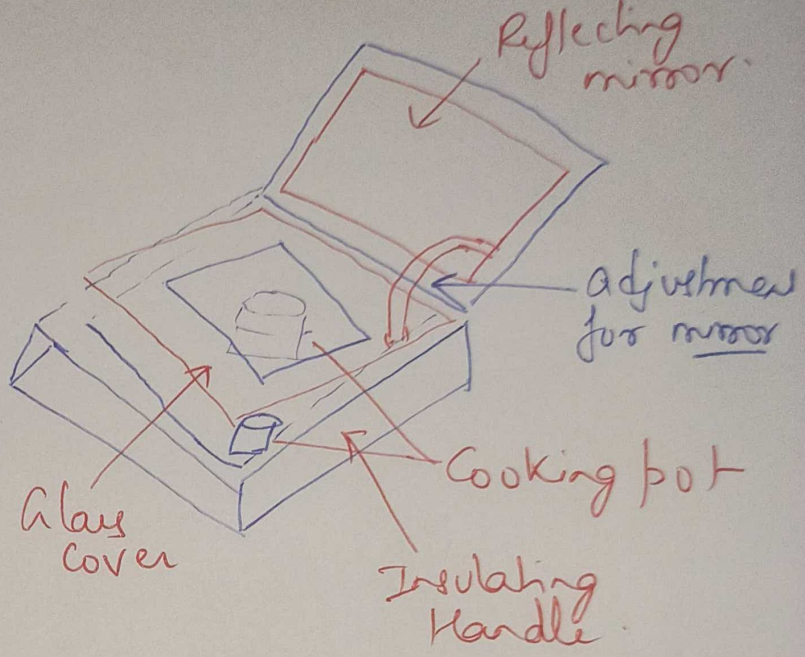
1) Collector
2) Storage tank
3) Heat Transfer
4) Controller & Pump

(2) Solar Cooker :- Also known as Solar Oven or Solar Stove, is a device that uses sunlight to heat food, water, or to cook food.

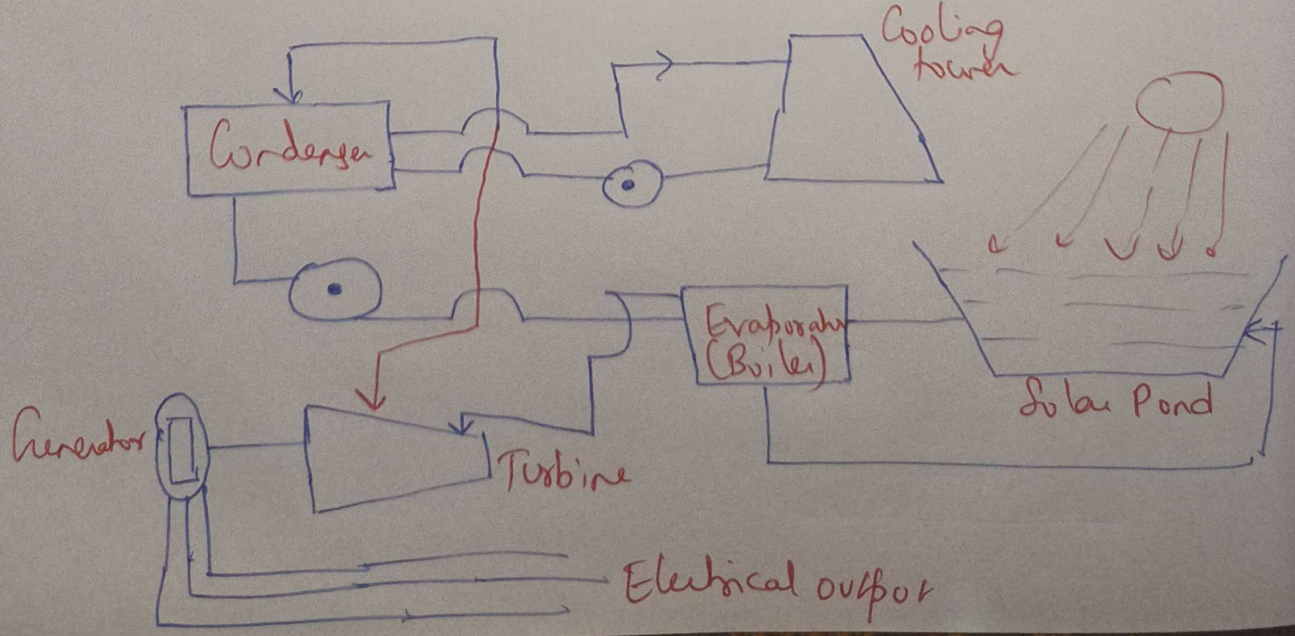
→ Eco-friendly, energy-efficient
→ popular in area with abudant sunlight.

Components :-

1) Reflective Surface
2) Cooking pot
3) Insulation
4) Glass or Plastic Cover

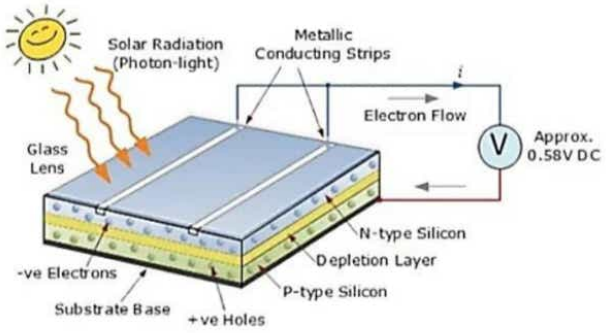


(3) Solar Pond :- It is a unique type of solar energy collector that utilizes the sun's energy to creat a stable temperature within a pond of water. This temp. gradient can be harnessed for various application like electricity generation, space heating & desalination.

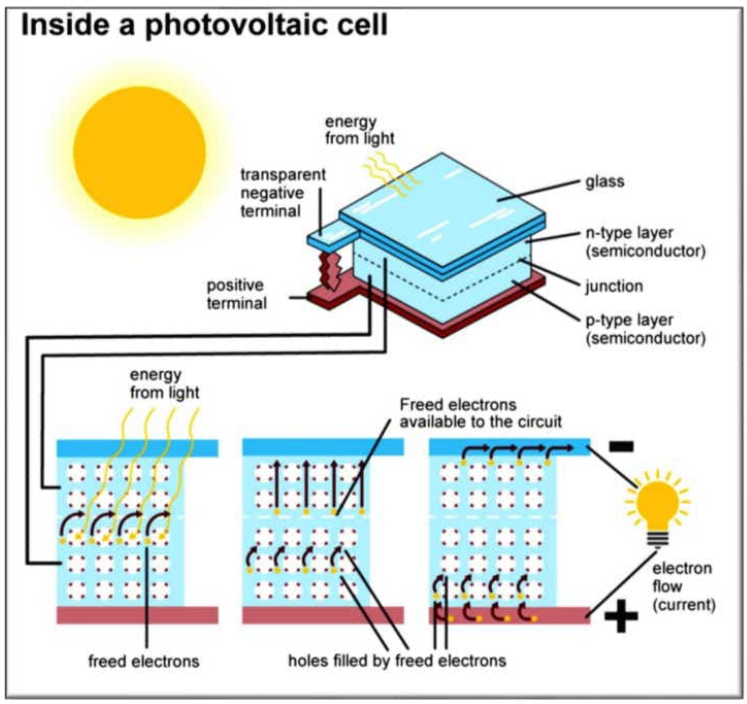


❑ PHOTOVOLTAIC CELL

The -voltaic part of photovoltaic comes from the name of Alessandro Volta, inventor of the electric battery. Thus, unlike photoelectric cells, which use electricity for certain small tasks, photovoltaic (or PV) cells actually produce electricity. Solar cells, the standard type of photovoltaic cells (often called simply photocells), operate without chemicals and with no moving parts to create energy directly from sunlight.



- A photovoltaic (PV) cell, commonly called a solar cell, is a nonmechanical device that converts sunlight directly into electricity. Some PV cells can convert artificial light into electricity.
- Sunlight is composed of photons, or particles of solar energy. These photons contain varying amounts of energy that correspond to the different wavelengths of the solar spectrum.
- A PV cell is made of semiconductor material. When photons strike a PV cell, they may reflect off the cell, pass through the cell, or be absorbed by the semiconductor material. Only the absorbed photons provide energy to generate electricity. When the semiconductor material absorbs enough sunlight (solar energy), electrons are dislodged from the material's atoms. ***Special treatment of the material surface during manufacturing makes the front surface of the cell more receptive to the dislodged, or free, electrons so that the electrons naturally migrate to the surface of the cell.***
- The movement of electrons, each carrying a negative charge, toward the front surface of the solar photovoltaic cell creates an imbalance of electrical charge between the cell's front and back surfaces. This imbalance, in turn, creates a voltage potential like the negative and positive terminals of a battery. Electrical conductors on the cell absorb the electrons. When the conductors are connected in an electrical circuit to an external load, such as a battery, ***electricity flows through the circuit.***

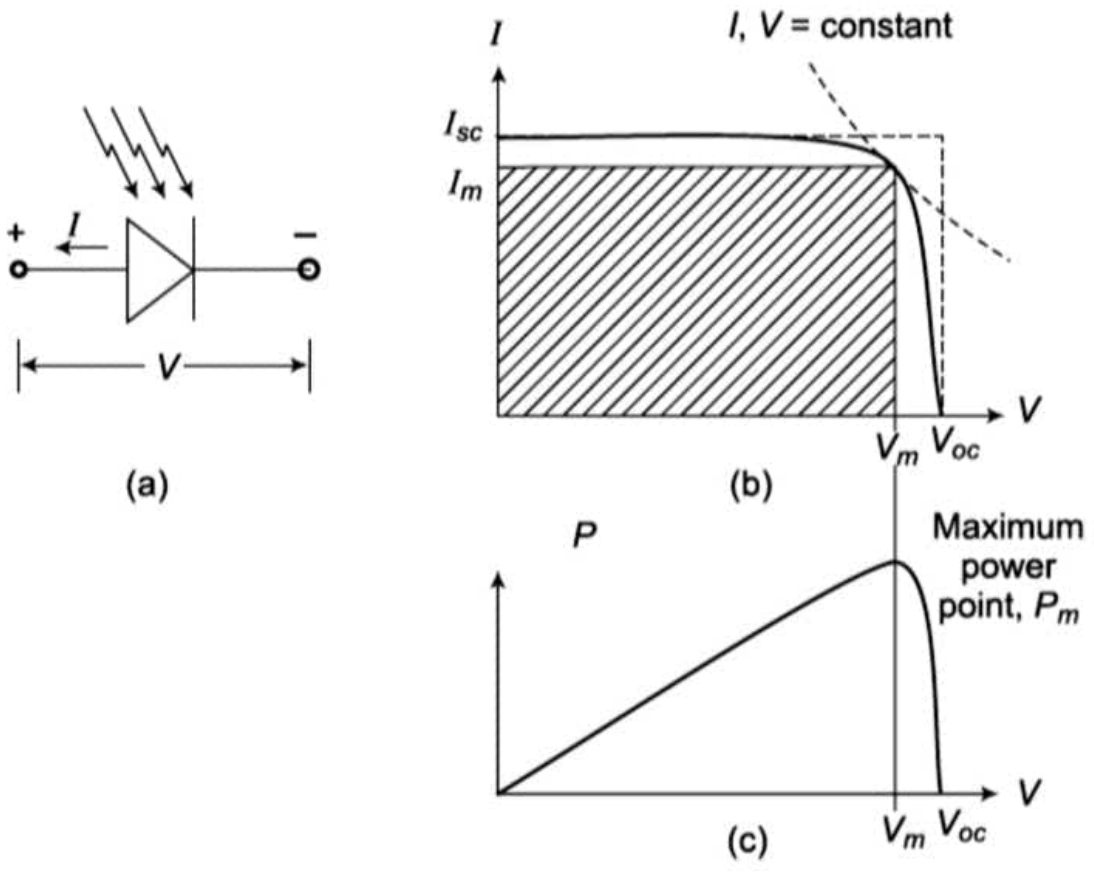


❑ I-V Characteristics of PHOTOVOLTAIC CELL

Mathematically, the *I-V* characteristic of a solar cell may be written (as per standard sign convention of an energy source) as:

$$I = I_L - I_o\left\{\exp\left(\frac{V}{V_T}\right) - 1\right\}$$

In order to obtain as much energy as possible from the rather costly *PV* cell, it is desirable to operate the cell to produce maximum power. The maximum power (P_m) point can be obtained by plotting hyperbola defined by $V \times I$ = constant, such that it is tangential to *I-V* characteristic. The voltage and current corresponding to this point are peak point voltage, V_m and peak point current, I_m respectively. Thus there is only one point on the characteristic at which it will produce maximum electrical power under the incident illumination level. Operating at other than maximum power point will mean that the cell will produce lesser electrical power and more thermal power. The maximum power point is also readily found by simply plotting cell power versus cell voltage as shown in Fig. (c). Alternatively, if a rectangle of maximum possible area is inscribed in the area defined by the *I-V* characteristics and *I-V* axes, it meets the characteristics at peak point as shown in Fig. (b).



(a) Schematic symbol of photovoltaic cell (b) *I-V* characteristic, maximum power point (c) *P-V* characteristics