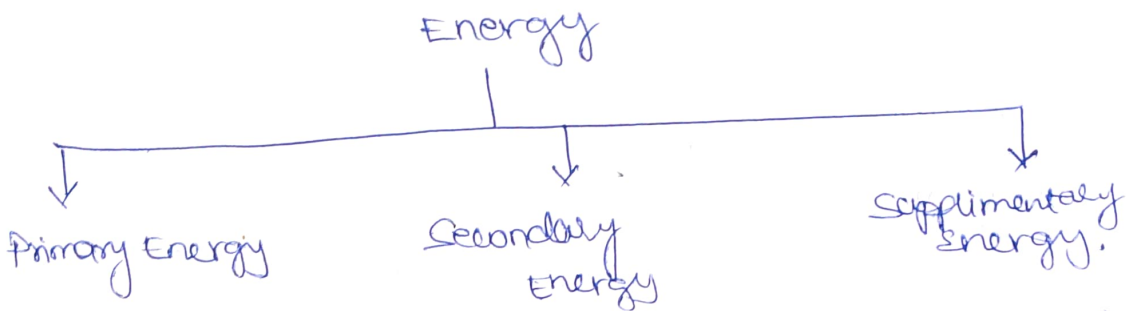
MODULE-1

Energy is the primary and most universal measure of all kinds of work by human beings and the nature.



primary energy sources can be defined as sources which provide a net supply of energy. coal, oil, uranium are the major primary energy sources. primary fuels only accelerate the growth but their supply is limited.

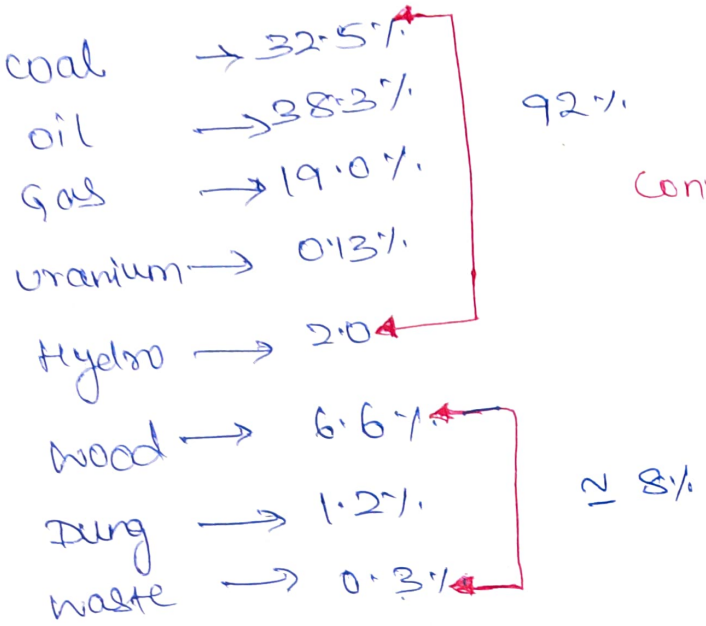
secondary fuels:- In secondary fuels the yield is less than the I/p. { agricultural, solar, wind water energy etc.

supplementary sources:- supplementary sources requires highest investment in terms of energy insulation.

conventional Energy sources:

(1) Fossil fuel — solid fuel { mainly coal including anthracite, bituminous and brown coal lignites } liquid fuel → petroleum derivatives, gaseous fuel → derivatives of natural gas.

World's total Energy consumption



Non-conventional energy sources

The major sources of non-conventional energy are solar, wind, sea, geothermal and biomass. Technologies are available to tap the earth's natural energy flows. The technology has used the term "Renewable" which has gained the widespread acceptance.

In Non-conventional energy solar energy is a major source of power. Its potential is 178 billion M.W. which is 20,000 times the world's demand.

WIND energy: It completely depends on geographic location. California is generating 500 MW by 900 windmills

wind energy can be utilized if and only if the wind speed is 3 m/sec

Favourable geographic location in India

Costal areas of Gujrat, Maharastra, and tamil nadu. are most favourable location

Generating capacity → 25,000 MW {max}.

Geothermal energy → Heat derived from the centre of the earth.

Geothermal Energy → Energy which lies embedded within the earth. According to various theories earth has molten core. The fact that Volcanic action takes place in many places of earth.

→ Energy available depth upto 1000m.
→ temp range 200°C to 300°C.
→ pressure 30 kgf/cm². (3000 kN/m²).
→ 1/3 of available thermal energy is from Geothermal Energy.

Hydrogen Energy:

Hydrogen has the highest energy content per unit of mass any chemical fuel and can be substituted for hydrocarbons in a broad range of applications.

Fuel cells:- Electrochemical device for continuous conversion of portion of free energy change in a chemical reaction to electrical energy.

	RENEWABLE Energy sources	NON-RENEWABLE Energy sources
(1)	Energy sources which cannot be exhausted	Energy sources get exhausted (in course of time)
(2)	Low carbon emission	High carbon emission and not environmental friendly
(3)	It is present in un-limited quantity	It is present in limited quantity and vanishes one day
(4)	Pollution free energy resources	Pollution free energy sources
(5)	Life of source is infinite	Limited life of source
(6)	Large land area required for installation of its power plant	less land area is required for its power plant installation
(7)	solar energy, wind energy, tidal energy etc are the examples of renewable energy	coal, petroleum, natural gas are the examples of Non-Renewable resources.

Point out the causes for energy crisis

An energy crisis is any great bottleneck (or price rise) in the supply of energy resources to an economy.

Causes for Energy crisis

(1) over consumption → fossil fuels such as oil, gas and coal due to over consumption - which in turn can put a strain on water and oxygen resources by causing pollution

(2) unexplored renewable energy options:- Renewable energy still remains unused in most of the countries

→ usage of non-renewable sources like coal still remains top choice to produce energy.

(3) Delay in commissioning of power plants

(4) waste of Energy

(5) poor distribution system

(6) Major accidents and Natural calamities like eruption of volcanoes, floods, earthquakes can also cause interruptions to energy supply.

(7) Miscellaneous factors → like sudden increase in demand of energy and tax hikes, political events and other reasons for crisis of Energy.

possible solutions of the Energy crisis

(1) Move towards Renewable Resources.

→ Reduce the world's dependence on Non-Renewable resources and to improve over all - conservation efforts.

(2) Buy energy efficient products

→ Replace bulbs with CFL's and LED's they use less watts of electricity and last longer

→ Lighting controls → these controls Preset lighting controls that can help to conserve electricity and reduce overall lighting costs.

(3) Energy Audits

→ Energy audits to be performed to identify the areas where home/office is losing energy and steps to be followed to improve the energy efficiency

(4) switch to Renewable energy.

Latitude ϕ :- It is location angle made by the radial line joining the location to the centre of the earth with the projection of the line on the equatorial plane. It is angular distance north/or south of the equator measured from the centre of the earth.

It is the angle between the line $\bar{OP}$ and projection of $\bar{op}$ on the equatorial plane.

Point 'p' represents the location on the earth's surface and 'o' represents the centre of the earth.

Define declination angle δ

'δ' → declination angle: is the angular distance of the sun's rays north (or) south of the equator.

It is the angle between a line extending from the centre of the sun to the centre of the earth and the projection of this line upon the earth's equatorial plane.

This is the direct consequence of the tilt and it would vary between 23.5° on June 22 to 23.5° on Dec 22.

Solstice :- (Solstice means sun standing still.)

At the time of winter solstice the $\delta = -23.5°$ {because sun rays would be 23.5° south of the earth's equator}.

At summer solstice the sun rays would be 23.5° north of equator. ($\delta = 23.5°$)

In general

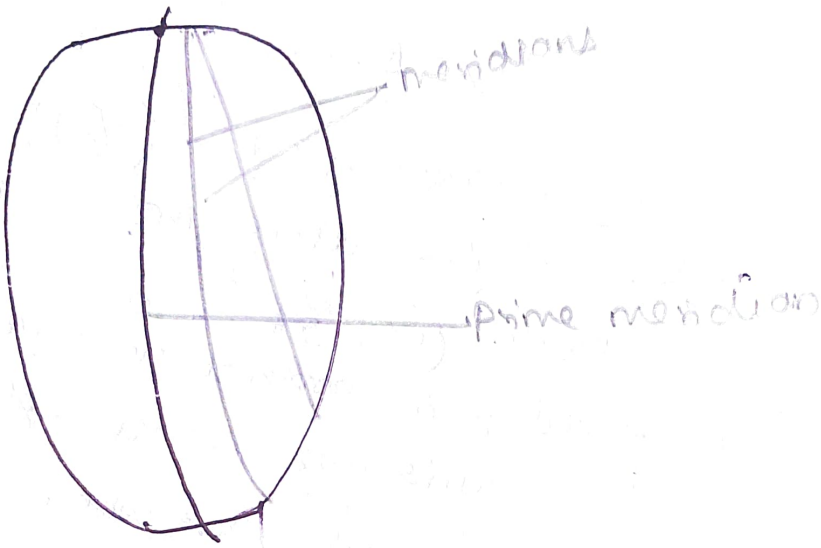
$$\delta \text{ (in degrees)} = 23.45 \sin\left[\frac{360}{365}(284 + n)\right].$$

where n = day of the year.

{Solstice occurs twice each year
June 21 (or June 22)
and Dec 22.

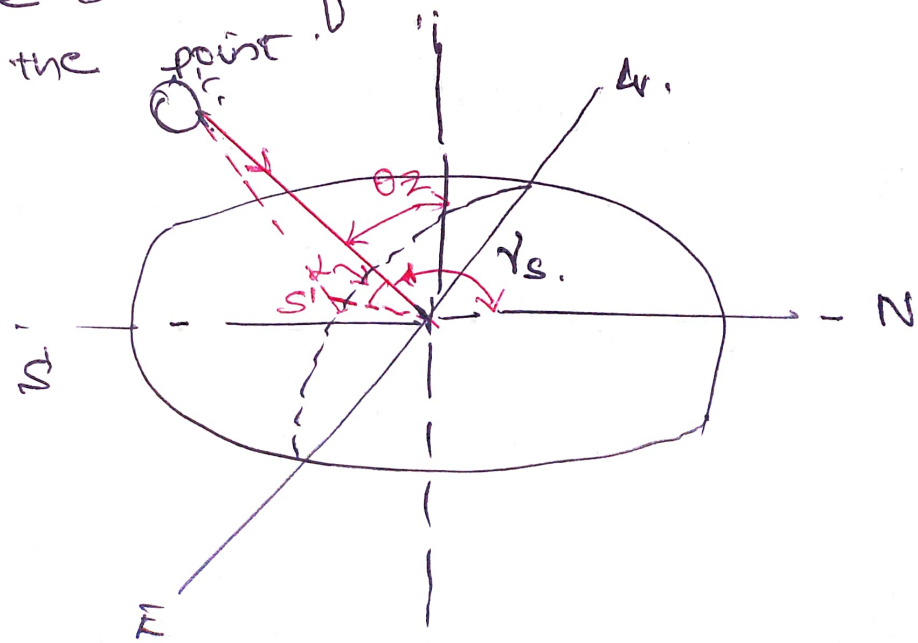
as the sun reaches its most northerly (or) southerly excursion relative to the celestial equator on the celestial sphere

Hour angle (ω):- It is the angle through which the earth must turn to bring meridian of a point directly in line with suns rays. The hour angle ω is equivalent to 15° per hour.



Altitude angle (α) (Solar altitude).

It is a vertical angle between the projection of the suns rays on the horizontal plane and the direction of suns rays passing through the point.



Zenith angle:- It is a vertical angle between the sun's rays and a line perpendicular to the horizontal plane through the point i.e the angle between the beam from the sun and the vertical

$$\theta_z = \frac{\pi}{2} - \alpha.$$

SOLAR AZIMUTH ANGLE:- (γ_s): It is the solar angle in degrees along the horizon east (or) west of North (or) It is a horizontal angle measured from north to the horizontal projection of the sun's rays. This angle is positive when measured west wise.

Cooper's equation:-

$$\delta = 23.45 \sin\left[\frac{360}{365}(284+n)\right]$$

Find the declination angle for June 19.

$$\delta = 23.45 \sin\left(\frac{360}{365}(284+n)\right).$$

$$= 23.45 \sin\left(\frac{360}{365}(284+170)\right).$$

$$= 23.43' \sin 86.$$

$$= 23.43^\circ \text{ ANS} //.$$

$$= 23^\circ 25' 56'' //$$

SOLAR AZIMUTH angle (γ_s) :-

PAGE:
DATE / /

Surface azimuth angle (γ) : It is the angle made between the horizontal projection of the normal to the tilted surface and the due south use measured in a clock wise direction

By convention the azimuth angle are taken to be positive when measured south to east and negative when measured south to west.

Angle of declination 'δ' :- It is the angle made between the suns rays and the earth's equator.

This angle is made as the earth rotates about a tilted axis, which is about 23.5° with a vertical passing through the earth. This angle is made as the earth rotates about a tilted axis which is about 23.5° with a vertical passing through the earth. The declination angle varies between 23.45° on June 21 and -23.45° on DEC 21

The angle becomes Zero on the two equinox days March 21 and September 22.

The declination angle for any day is calculated by

cooper equation

$$\delta \text{ (in degrees)} = 23.45 \sin\left\{\frac{360}{365}(284+n)\right\}$$

where n = day of the year.

β (slope) :- It is the angle made by the plane surface (receiving the solar radiation) with the horizontal. It is taken as positive for surface sloping towards the south and negative for sloping towards the north.

Latitude angle (ϕ) :-

Equinox days: The time (or) date (twice each year) @ which sun crosses celestial equator when day & night are of equal length.

Note!

The Zenith angle is the distance between the subsolar point and the latitude you are at.

subsolar point is the latitude where the suns rays form a 90° angle at noon.

LOCAL - SOLAR - TIME (L.S.T) :- (LOCAL APPARENT TIME).

L.S.T is used for calculating the hour angle

LST = standard time ± 4 (standard time longitude - longitude of location) ± (Equation of time correction)

The negative sign is applicable for eastern hemisphere

Equation of time correction. This describes the discripency between two kinds of solar time. The word equation is used in the medieval sense of "reconcile a difference". The two times that differ are apparent solar time, which directly tracks the diurnal motion of the sun, and the mean solar time, which tracks a theoritical mean sun with noons 24 hours apart.

Note(i):- Diurnal motion is caused by the earth's rotation around its axis, so stars appears to move along a circular arc path called the diurnal circle.

Note(2):- EQUATION OF TIME CORRECTION is given from standard table (or) chart and the value to be given if table not provided.

(1) Determine the local solar time and declination angle (angle of declination) at a location Latitude 23° 15' N, Longitude 77° 30° E at 12.30 IST on June 19. The equation of time correction = -(1'01").

Solution:

The L.S.T.

= I.S.T - 4(standard time longitude - longitude of location) + Equation of time correction.

= $12^h 30' - 4(82° 30' - 77° 30') - 1'01'$

= $12^h 8' 59''$

I.S.T is the time (local civil time) corresponding to 82.5° E longitude.

Declination angle δ

can be obtained by Cooper's equation

$$\delta = 23.45 \sin\left\{\frac{360}{365}(284+n)\right\}$$

$$\delta = 23.45 \sin 86^\circ.$$

$$= 23.43^\circ \text{ Ans.} \quad \{\text{taking } n = 170 \text{ on June 19}\}$$

Note: 82.5° Longitude East of Greenwich use.

Problem: Determine L.S.T and declination angle at a location Latitude 77°30 E at 12.00 I.S.T on Feb 20 given the equation of time correction = −(1'01").

Note: I.S.T based on longitude 82.5°, Which passes through Mirzapur, near Allahabad in Uttar Pradesh

It is shows 30 minutes ahead of Green which meridian.

3
5
3
4 = Count if(F9:F117, "M")

MEAN DISTANCE from SUN TO EARTH

= 150 million km

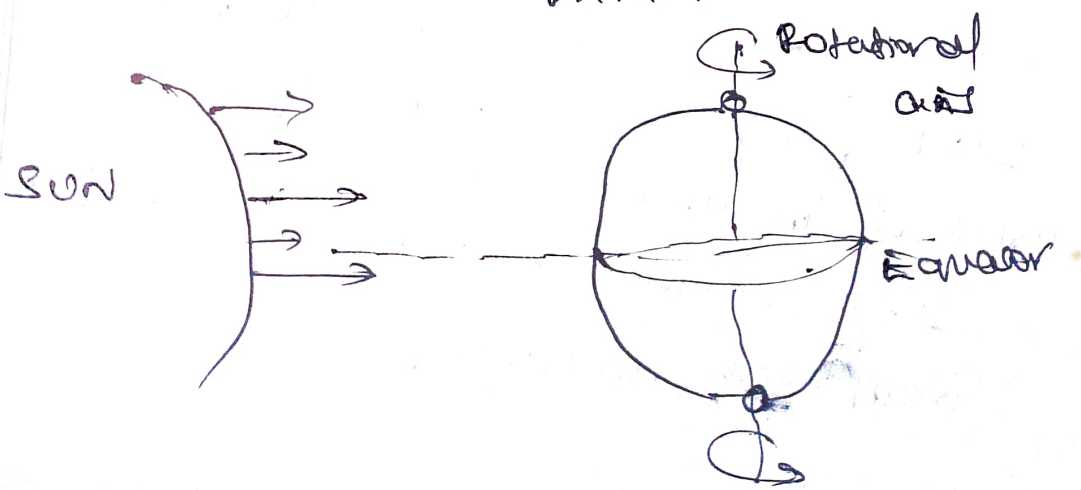
1 million = 10 lakhs.

1 Billion = 10,000 lakhs.

On march 22 → Delination is zero (+ve)

on sept 22 → Delination is zero (-ve)

during northern hemisphere winter



VTU

Renewable Energy in India.

Renewable energy comes under the purview of ministry of New and Renewable Energy (M.N.R.E).

India targetted to improve RES massively by 2022. → { Doubling existing capacity

→ almost second world's Renewable energy market will be available by 2022

→ India likely to surpass 175 GW of Renewable energy by 2022

→ India to auction of 100 GW of green energy by march 2020.

→ India generated 10.2 Billion units (BU:) of electricity from green energy sources including solar, wind and biomass

Renewable energy scenario by 2022

60 G.W → wind
100 G.W → solar
10 G.W → Biomass
5 G.W → small hydro.

KARNATAKA Government aims to generate 2700 MW by 2018 end - pavagada solar park (Tumkur dist, karnataka).

500 MW - to be commissioned by Dec

World wide RES Availability

Renewable energy → Biomass account

$\frac{1}{7}^{th}$ of all fuel consumed.

Biomass supplies 90% of consumed fuel for generation of world's electricity.

Wind → available world wide $= 7.5 \times 10^{20}$

Solar Energy available 3.8×10^{24} J/yr.

Biomass → 1.3×10^{21} J/yr.

World's standing biomass has energy content about 1.5×10^{22} J.

Hydro - World wide capacity by Hydro schemes → 2215 GW/yr

Tidal → 10^{26} J/yr (worldwide)

Wave → K.E in the order of 10^{18} J.

Coal of 8540 million tons available 20 years (Coal reserve).

SOLAR ENERGY

solar energy has the greatest potential of all the sources of renewable energy and if only a small amount of this form of energy could be used, it will be one of the most important supplies of energy specially when other sources in the country have depleted.

The solar power where sun hits atmosphere is 10^{17} watts.

whereas the solar power on earth's surface is 10^{16} watts.

Total world wide power demand $= 10^{13}$ watts.

∴ sun gives us (1000) times power what we need.

The energy radiated by the sun on a bright sunny day is $\boxed{1\ kW/m^2}$.

solar constant:

sun is a large sphere of hot gases, the heat being generated by various kinds of fusion reaction. Its diameter is 1.39×10^6 km. While that of earth is 1.27×10^4 km. The mean dist between the two is 1.50×10^8 km.

The rate at which solar energy arrives at the top of the atmosphere is called solar constant I_{sc}. This is the amount of energy received in unit time on a unit area perpendicular to the sun's direction at

the mean distance of the earth from the sun.

Solar constant is denoted as I_{sc}

If I = Intensity of solar radiation that reaches the earth, then the relation between I and I_{sc} is given by

$$\frac{I}{I_{sc}} = 1 + 0.033 \cos \frac{360(n-2)}{365}$$

Where

n = day of the year.

Beam and Diffuse radiation.

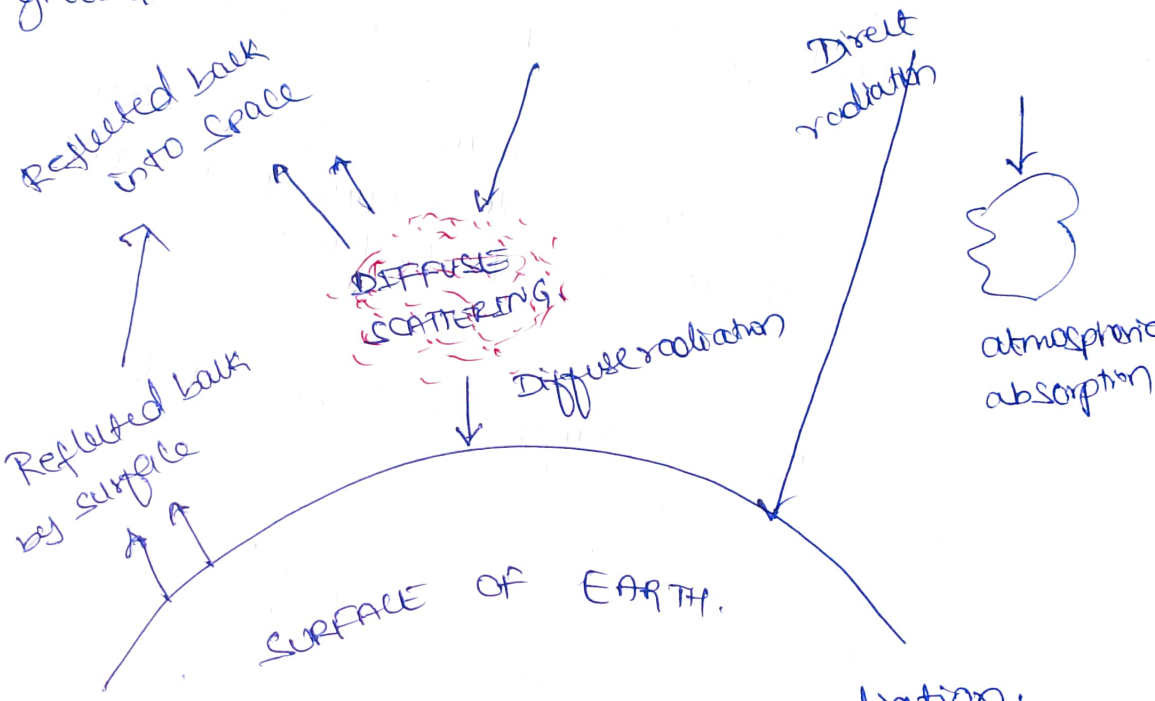
Solar radiation that penerates the earth's atmosphere and reaches the surface differs in both amount and charater from the radiation at the top of the atmosphere.

Solar radiation that has not been absorbed or scattered and reaches the ground directly from the sun is called "Direct radiation". (or) Beam radiation.

Diffuse radiation is that solar radiation recieved from the sun after its direction has been changed by the reflection and scattering by the atmosphere. Because of the solar radiation is scattered in all direction in the atmosphere diffuse radiation comes from all parts of the sky.

The total solar radiation received at any point on the earth's surface is the sum of the direct and diffuse radiation. This is referred to in a general sense as the insolation at that point.

Insolation: Insolation is defined as the total solar radiation energy received on a horizontal surface of unit area (eg 1 sq.m) on the ground in unit time.



Direct, diffuse and total radiation.

Insolation at a given location on the earth's surface depends on the altitude of the sun in the sky.

On clear {cloudless days} 10-20% of the insolation is from diffuse radiation.

Note!

Solar constant I_{sc} in SI units

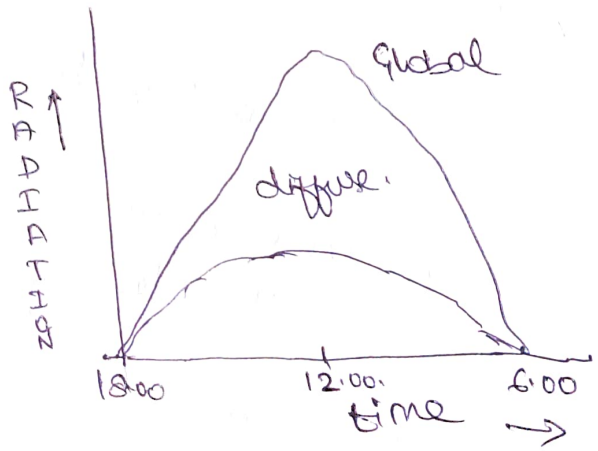
1353 w/m^2 (or) 4871 kJ/m^2.

India receives an annual average intensity of solar radiation between 16700 - 29260 kJ/m^2/day.

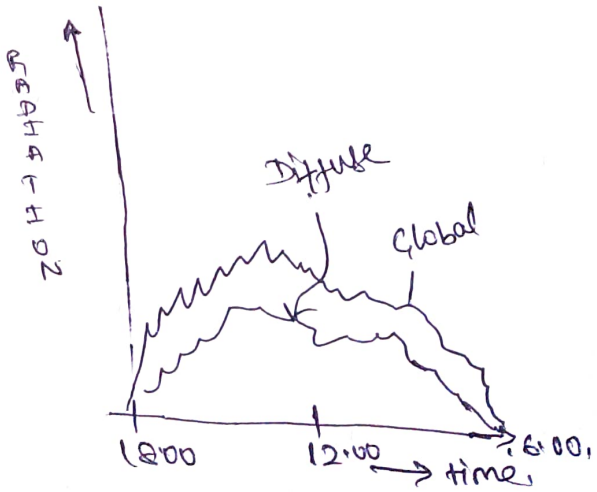
During the monsoon and winter months the daily solar radiation decreases to about 16700 kJ/m^2/day (4000 cal/cm^2/day).

The annual daily diffuse radiation received over the whole country is observed to be about 7300 kJ/m^2/day.

A typical daily record of global and diffuse radiation



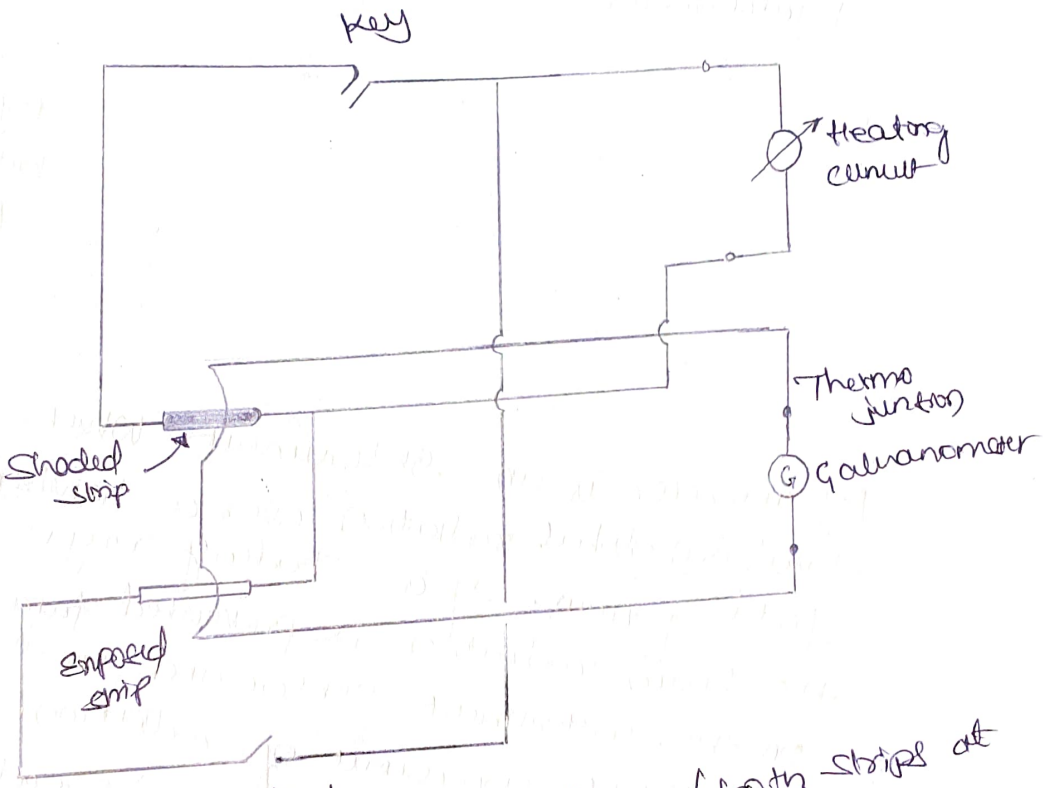
Regular (Normal day)



cloudy day

ANGSTROM PYRHELIOMETER.

Angstrom compensation pyrheliometer. In this a thin blackened shaded manganin strip, is heated until it is at the same temperature as a similar strip which is exposed to solar radiation It is shown schematically as under.



under steady state conditions (both strips at identical temperature) the energy used for heating is equal to the absorbed solar energy. Thermocouples on the back of each strip connected in opposition through a sensitive galvanometer (or null detector) are used to test for the equality of temperature.

Radiation energy H is

$H_{DN} = K i^2$.

H_{DN} = Direct radiation incident on an area normal to Sun's rays.

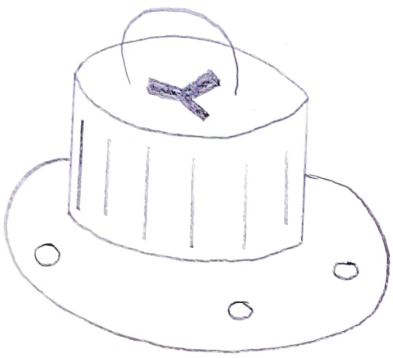
i = heating current in amperes

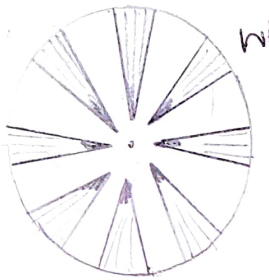
k is a dimension cond instrument constant

$$= \frac{R}{Wk'}$$

R = resistance per unit length of the absorbing strip (Ω/cm) W = width of absorbing strip and k' = absorbing coefficient.

Pyranometer





Pyranometer with alternate black/white sensor segment.

Pyranometer is an instrument which measures total (or) global radiation over a hemispherical field of view. If a shading ring is attached the beam radiation is prevented from falling on the instrument sensor and it measures only diffuse component of radiation.

In most of pyranometer sun's radiation is allowed to fall on black surface to which hot junctions of a thermopile attached. The cold junctions of thermopile are located in such a way that they do not receive the radiation.

∴ emf proportional to solar radiation is generated. emf range = 0 to 10 mV.

to a flat collector on Dec 1 at 9.00 AM. Solar time for a location at 28°35' N. The collector is tilted at an angle of latitude +10° with the horizontal and is pointing due south.

Soln $\gamma = 0$ {since collector is pointing due south.

$$\cos\theta_T = \cos(\phi - s)\cos\delta\cos\omega + \sin(\phi - s)\sin\delta$$

By cooper's equation

$$\delta = 23.45 \sin\left\{\frac{360}{365}(284 + n)\right\}$$

$$= 23.45 \sin\left\{\frac{360\,(284 + 325)}{365}\right\}$$

$$= -22.11^\circ.$$

Hour angle ω corresponding to 9.00 hr = 45°.

$$\cos\theta_T = \cos(28.58^\circ - 38.58^\circ)\cos(-22.11)\cos 45 + \sin(-22.11^\circ)\sin(28.58 - 38.58^\circ)$$

$$= 0.6451 + 0.0653$$

$$= 0.7104$$

$$\theta_T = 44.72^\circ \text{ Ans.}$$