CMR
INSTITUTE OF
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Internal Assesment Test – 1

Sub:Non-Conventional Energy Sources				Code: 18ME651
Date:26/04/2023	Duration: 90 mins	Max Marks: 50	Sem: VI	Branch(s): CSE/CIV/ECE/EEE/ISE

Note:Answer any 5 questions.

		Marks	OBE	
			CO	RBT
1	Elaborate on India's production and reserves of commercial energy sources.	10	CO1	L2
2	What is the need of alternate energy sources? Explain by considering solar energy.	10	CO2	L2
3	With neat sketch explain the working principle of Pyrheliometer. How does it differ from Pyranometer?	10	CO3	L2
4	With schematic representation, explain the mechanism of absorption, scattering, beam and diffuse radiation received at earth's surface.	10	CO3	L2
5	a) Determine the local solar time and declination at a location latitude 23˚15'N, longitude 77˚30'E at 12.30 IST on June 19. Equation of Time correction is = -(1'01"). b) Calculate the number of daylight hours in Srinagar on January 01 and July 01 the latitude of Srinagar is 34˚05' N.	5+5	CO3	L3
6	Define: solar constant, latitude angle, declination angle, solar azimuth angle and angle of incidence.	10	CO3	L1

SOLUTION TO IAT – I

1.

India's production & reserves of commercial sources

• Fossil fuels – i.e., solid fuel coal including anthracite, bituminous, peat and lignite, liquid fuels including petroleum and its derivatives and natural gas.
• Hydro-power
• Energy of nuclear fission
• Minor sources of energy include sun, wind, tides, geo-thermal etc.,
• Coal and Lignite

Coal is highly carbonaceous material formed when dead plant submerged in swamp environments is subjected to the geological forces of heat and pressure over hundreds of millions of years.
• Coal - has been considered as the major source of energy in India. It can be easily converted into other forms of energy such as electricity, gas and oil.
• The total estimate resources of coal are now placed at 1, 48, 79 million tonnes, but the mineable reserves are estimated to be 80,000 million tonnes i.e., on 55% of the total coal reserves.
• Lignite is brown coal with lesser amount of energy. In 1950-51, production of coal and lignite in India was 32.3 million tonnes which increased to 413 million tonnes in 2004-05.

Oil and Natural Gas

Demand for fossil fuels grew rapidly with the growth of the industrial sector and transport services. After Independence, the Government of India felt the need for oil exploration on an extensive scale, and therefore, (ONGC) was set up in 1956, and (OIL) was established in the year 1959.
• Total recoverable reserves of oil are estimated at 550 million tonnes and those of gas are estimated at 500 billion cubic tonnes.
• Production of crude oil is estimated in 2004- 05 at about 54 million tonnes and only 10 % of the total potential has been utilized.

Hydroelectric power

It plays an important role in the field of power development in India, our country has made considerable progress in the field of hydroelectricity power generation.
• It is the most economical source of power
• There no environmental pollution problem
• There is no waste disposal problem
• The annual hydroelectric potential is estimated to be around 90,000 MW (Mega-watt). Out of this, so far about 18,000 MW has been developed. This mean that only 20% of the total potential has been utilized.

Atomic or Nuclear Power

India has also developed nuclear power. Uranium and thorium are both sources of nuclear power generation. India's uranium reserves have been estimated to be of the order of about 70,000 tonnes, which is equal to 120 billion tonnes of coal.
Similarly, our thorium reserves of 3, 60,000 tonnes would be equivalent to 600 billion tonnes of coal.
• Considering the availability of uranium and thorium, the government of India took steps in setting up nuclear power plants at Tarapur (Maharashtra) , Kalpakkam (Tamil Nadu) during 1984- 86, Narora (Uttar Pradesh) during 1989-91 and only 3% of the total potential has been utilized.

2.

SALIENT FEATURES OF NON-CONVENTIONAL ENERGY RESOURCES

Advantages

• NCES are available in nature, free of cost.
• They cause no or very little pollution. Thus, by and large, they are environmental friendly.
• They are inexhaustible.
• They have low gestation period.

SOLAR ENERGY:

➢ Solar energy is a very large, inexhaustible source of energy. The power from the Sun intercepted by the earth is approximately **1.8×1011** MW which is many thousands of time larger than the present consumption rate on the earth of all commercial energy sources. Thus, in principle solar energy could supply all the present & future energy needs of the world on a continuing basis. This makes it one of the most promising of the unconventional energy sources.

➢ Solar energy is received in the form of radiation, can be converted directly or indirectly into other forms of energy, such as heat & electricity. This energy is radiated by the Sun as electromagnetic waves of which 99% have wave lengths in the range of 0.2 to 4 micro meters.

➢ Solar energy reaching the top of the Earth's atmosphere consists about 8% U.V radiation, 46% of visible light, 46% Infrared radiation.

Merits of solar energy:

• It is an environmental clean source of energy
• It is free & available in adequate quantities in all most all parts of world where people live.

Demerits of solar energy:

• It is a dilute source of energy because even in hottest region the radiation flux is available only 1 KW/m2 & total radiation over a day is 7 KW/m2.
• These are low values from the point of view of technological utilization.
• It is required large collecting areas are required in many applications & these results increase of cost.
• Solar energy availability varies widely with time, it occurs because of the day-night cycle & also seasonally because of the Earth's orbit around the Sun [even local weather condition.

Solar applications

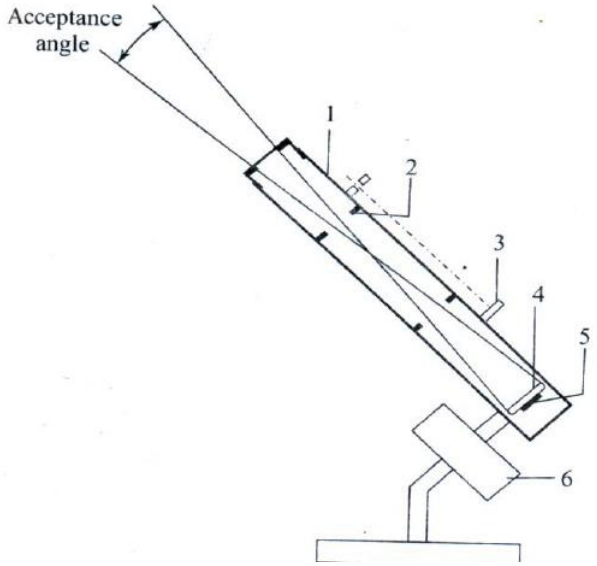
✓ Solar heating
✓ Solar cooling
✓ Solar pumping
✓ Solar furnace
✓ Solar production of hydrogen
✓ Solar green houses
✓ Solar distillation
✓ Solar energy
✓ Solar cooking

3.

Pyrheliometer:

This is an instrument which measures beam radiation falling on a surface normal to the sun's rays. In contrast to a pyranometer, the black absorber plate (with hot junctions of a thermopile attached to it)

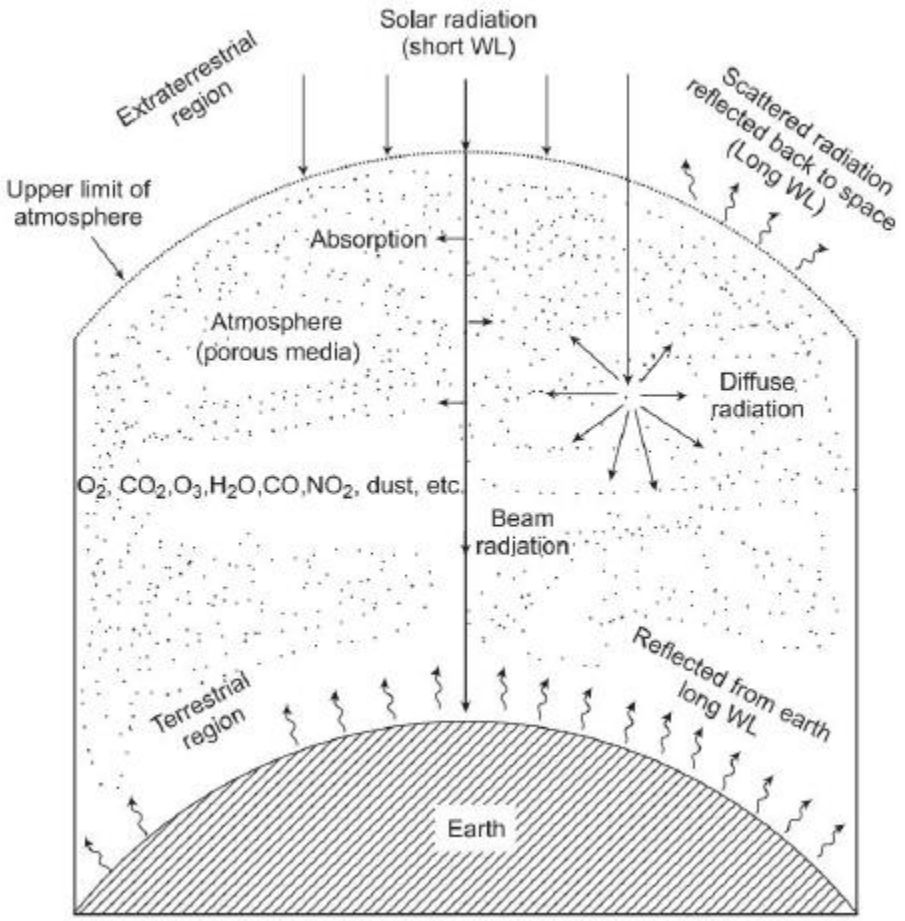
is located at the base of a collimating tube. The tube is aligned with the direction of the sun's rays with the help of a two-axis tracking mechanism and alignment indicator. Thus the black plate receives only beam radiation and a small amount of diffuse radiation falling within the acceptance angle of the instrument.
The Following figure shows a pyrheliometer.



1. Tube blackened on insidesurface,
2. Baffle
3. Alignment indicator,
4. Black absorber plate
5. thermopile junctions
6. two-axis tracking mechanism

Feature	Pyranometer	Pyrheliometer
Definition	Measures global solar radiation (direct + diffuse)	Measures direct solar radiation (beam)
Type of radiation	Both direct and diffuse solar radiation	Only direct beam solar radiation
Field of view	Hemispherical (180°)	Narrow, typically 5° or less
Sensitivity to orientation	Less sensitive to orientation, as it measures diffuse light	Highly sensitive to orientation, must be aligned with the sun
Tracking mechanism	Usually stationary, doesn't require tracking	Requires a solar tracking system to stay aligned with the sun
Construction	Typically a flat, horizontal surface with a sensor	Typically a tube-shaped instrument with a sensor at one end
Applications	Meteorology, climate research, solar energy assessments	Solar resource assessment, concentrator solar power systems
Measurement units	Watts per square meter (W/m^2)	Watts per square meter (W/m^2)
Price	Generally less expensive	More expensive due to the need for a tracking system
Installation complexity	Relatively simple, minimal calibration required	More complex, requires precise alignment and regular calibration

4.



The earth's atmosphere contains various gaseous constituents, suspended dust and other minute solid and liquid particulate matter. These are air molecules, ozone, oxygen, nitrogen, carbon dioxide, carbon monoxide, water vapour, dust, and water droplets. Therefore, solar radiation is depleted during its passage through the atmosphere. Different molecules do different things as explained below:

Absorption

Selective absorption of various wavelengths occurs by different molecules. The absorbed radiation increases the energy of the absorbing molecules, thus raising their temperatures:

(a) Nitrogen, molecular oxygen and other atmospheric gases absorb the X-rays and extreme ultraviolet radiations.

(b) Ozone absorbs a significant amount of ultraviolet radiation in the range ($l < 0.38\ \mu$ m).

(c) Water vapour (H2O) and carbon dioxide absorb almost completely the infrared radiation in the range ($l > 2.3\ \mu$ m) and deplete to some extent the near infrared radiation below this range.

(d) Dust particles and air molecules also absorb a part of solar radiant energy irrespective of wavelength.

Scattering

Scattering by dust particles, and air molecules (or gaseous particles of different sizes) involves redistribution of incident energy. A part of scattered radiation is lost (reflected back) to space while remaining is directed downwards to the earth's surface from different directions as diffuse radiation. It is the scattered sunlight that makes the sky blue. Without atmosphere and its ability to scatter sunlight, the sky would appear black, as it does on the moon. In cloudy atmosphere, (i) a major part of the incoming solar radiation is reflected back into the atmosphere by the clouds, (ii) another part is absorbed by the clouds and (iii) the rest is transmitted downwards to the earth surface as diffuse radiation. The energy is reflected back to the space by (i) reflection from clouds, plus (ii) scattering by the atmospheric gases and dust particles, plus (iii) the reflection from the earth's surface is called the albedo of earth-atmosphere system and has a value of about 30 per cent of the incoming solar radiation for the earth as a whole. Thus on the surface of earth we have two components of solar radiation: (i) direct or beam radiation, unchanged in direction and (ii) diffuse radiation, the direction of which is changed by scattering and reflection. Total radiation at any location on the surface of earth is the sum of beam radiation and diffuse radiation, what is known as global radiation. These terms may be properly defined as follows:

Beam radiation: Solar radiation propagating in a straight line and received at the earth surface without change of direction, i.e., in line with sun is called beam or direct radiation.

Diffuse radiation: Solar radiation scattered by aerosols, dust and molecules is known as diffuse radiation. It does not have a unique direction.

Global radiation: The sum of beam and diffuse radiation is referred to as total or global radiation.

5. (a)

The Local solar time=IST- (standard time longitude-longitude of location) + Equation of time correction.

$=12^h30'-4(82^030'-77^030')-1'01$

$=12^h8'59''$

Declination δ can be calculated Cooper 's Equation i.e.,

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

$$= 23.45 \sin\{\frac{360}{365}(284+170)\} = 23.45\ \sin 86^0 = 23.43^0$$

(b)

From given data:

$n = 1$ and 182 respectively for January 1 and July 1.

from Eq. (4.5), $\delta = -23.01°$ and $23.12°$ respectively for January 1 and July 1.

from Eq. (4.12):

on January 1, $t_d = (2/15)\cos^{-1}[-\tan(34.083°)\tan(-23.01°)] = 9.77$ hours

on July 1, $t_d = (2/15)\cos^{-1}[-\tan(34.083°)\tan(23.12°)] = 14.24$ hours

6.

Solar Constant, Isc is defined as the energy received from the sun per unit time, on a unit area of surface perpendicular to the direction of propagation of the radiation, at the earth's mean distance from the sun. The World Radiation Center (WRC) has adopted a value of solar constant as 1367 W/m2 (1.940 cal/cm2 min, 432Btu/ft2 hr or 4.921 MJ/m2 hr). This has been accepted universally as a standard value of solar constant.

Latitude (Angle of Latitude), (f) The latitude of a location on earth's surface is the angle made by radial line, joining the given location to the center of the earth, with its projection on the equator plane. The latitude is positive for northern hemisphere and negative for southern hemisphere.

Declination, (d) It is defined as the angular displacement of the sun from the plane of earth's equator. It is positive when measured above equatorial plane in the northern hemisphere. The declination d can be approximately determined from the equation:

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

where n is day of the year counted from 1st January.

Solar Azimuth Angle (gs) It is the angle on a horizontal plane, between the line due south and the projection of sun's ray on the horizontal plane. It is taken as +ve when measured from south towards west.

Angle of Incidence, (qi) It is the angle between sun's ray incident on the plane surface (collector) and the normal to that surface.

In general, the angle of incidence can be expressed as,

$$\cos\theta_i = \cos\delta\cos\omega(\cos\phi\cos\beta + \sin\phi\sin\beta\cos\gamma) + \cos\delta\sin\omega\sin\beta\sin\gamma + \sin\delta(\sin\phi\cos\beta - \cos\phi\sin\beta\cos\gamma)$$