USN

Internal Assessment Test 1 – Sept. 2017

Sub:	Non Convectional Energy Sources					Sub Code:	10ME754	Branch:	Mech	
Date:	21/09/2017	Duration:	90 min's	Max Marks:	50	Sem / Sec:	VII		OBE	

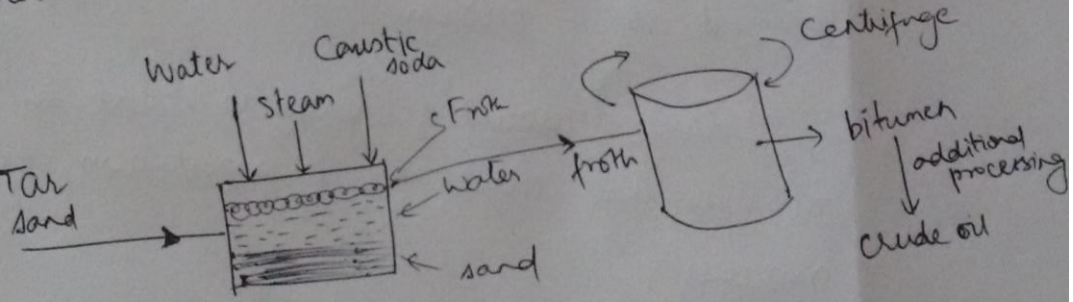
Answer any FIVE FULL Questions

		MARKS	CO	RBT
1	Explain Tar sands and oil shale as energy sources and also mention their limitations.	[10]	CO1	L2
2	Write short notes on spectral distribution of extra terrestrial radiation.	[10]	CO2	L2
3	Write notes on Beam and Diffuse radiation.	[10]	CO2	L2
4	Name the different types of solar thermal cycles and explain any one with neat sketch.	[10]	CO3	L2
5	List the different types of concentrating collectors. Explain any one with neat sketch.	[10]	CO3	L2
6	Describe the principle of working of a solar pond with neat sketch.	[10]	CO4	L2

Q1) Tar sands and Oil shale

Tar sands and oil shale is an expression used to describe porous sand ~~stone~~ stone deposits impregnated with heavy viscous oil called bitumen.

The sands obtained from surface mining are first passed through a conditioning drum where, water, steam and caustic soda are added and a slurry is formed. The slurry passes into a separation tank where the coarse sand settles at the bottom and a froth of bitumen, water and fine mineral matter forms on the top. The froth is diluted with naptha and subjected to centrifugal action. After this, the naptha is recovered and recycled and the bitumen obtained is subjected to hydroprocessing and desulphurisation to produce synthetic crude oil.



Conditioning drum to remove sand. froth consists of bitumen and air bubbles

[4 marks]

Oil shale refers to the finely textured rock mixed with a solid organic material called Kerogen. When crushed, it can be burned directly (like coal) and has a heating value of 2000 to 17000 KJ/kg. Alternatly, oil shale can be converted to oil. This is done by heating crushed oil shale to about 500°C in absence of air. Under these conditions pyrolysis occurs and the kerogen is converted to oil.

[2 marks]

Limitations

→ Surface mining of tar sands and oil shale results in environmental degradation.

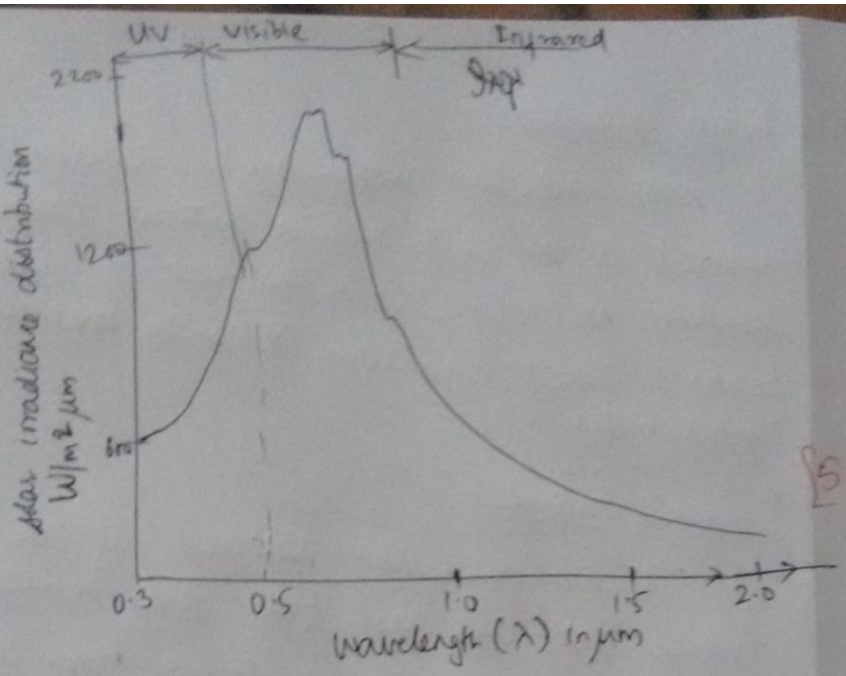
→ Disposal of spent shale and large amounts of sand is a problem.

→ Large amount of energy is spent in producing oil from these sources for transportation, mining and processing.

→ It is a non-renewable source of energy.

[3 marks]

Q2



[5 marks]

Solar radiation covers a continous spectrum of electromagnetic radiation in a wide frequency range. About 99% of the extra-terrestrial radiation has wavelength (λ) in the range from 0.2 μm to 4 μm. with a maximum spectral intensity at 0.48 μm (green portion of visible light). About 6.4% of the extra-terrestrial radiation is in the ultraviolet region ($\lambda < 0.38$ μm); another 48% is contained in the visible region (0.38 μm $< \lambda < 0.78$ μm) and the remaining 45.6% contained in the infra-red region ($\lambda > 0.78$ μm). The spectral solar-irradiation distribution for extra-terrestrial radiation is shown in figure. The area under this curve indicates the total radiation intensities in W/m².

[5 marks]

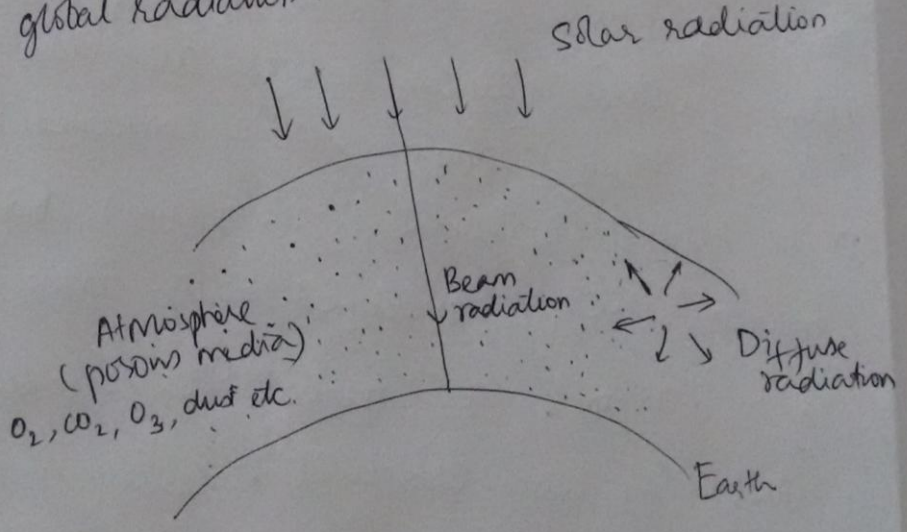
3) Beam radiation:

Solar radiation propagating in a straight line and received at the earth surface without change in direction ie inline with the sun is called beam or direct radiation. It can be measured using pyrheliometer.

Diffused radiation:

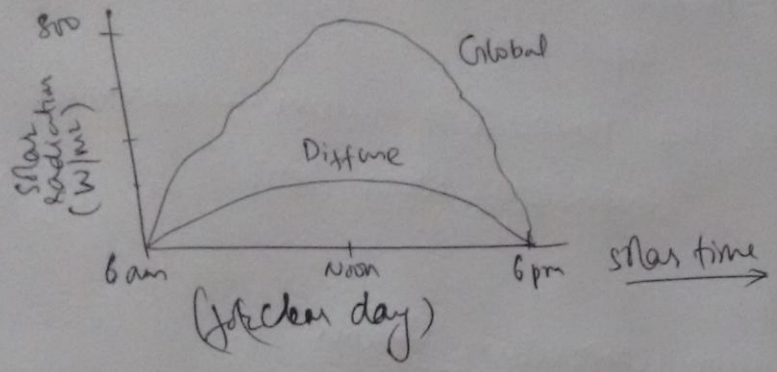
The solar radiation received at the earth's surface from all parts of the sky's hemisphere (after being subjected to scattering from the atmosphere) is known as diffused radiation. It does not have a unique direction. It may be measured using shading ring pyranometer.

Global radiation: The sum of beam and diffused radiation is referred to as total or global radiation. [5 marks]

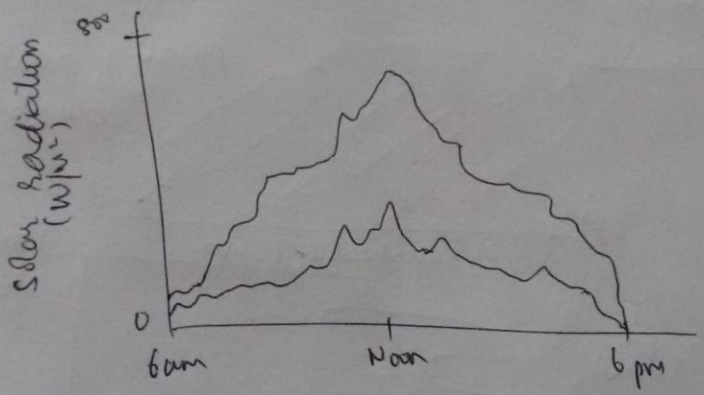


[3 marks]

Typical records of global and diffused radiation on a horizontal surface for a clear day and partially cloudy day are shown in figure below.



(for clear day)



(b) for cloudy day

[2 marks]

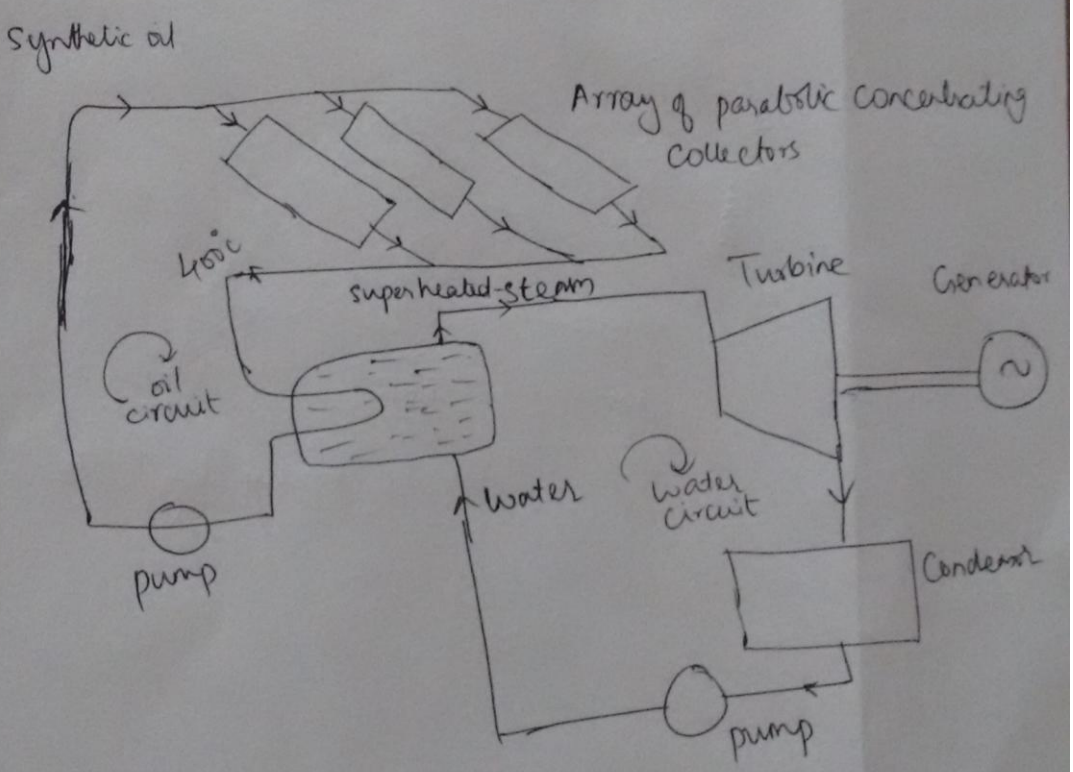
(Q4) Solar Thermal cycles can be classified as

(a) Low temperature systems → Works at max temperature of about 100°C.

(b) Medium temperature systems → Max temperatures upto 400°C

(c) High temperature systems → Works at temperatures above 400°C. [3 marks]

Medium temperature Systems



[5 marks]

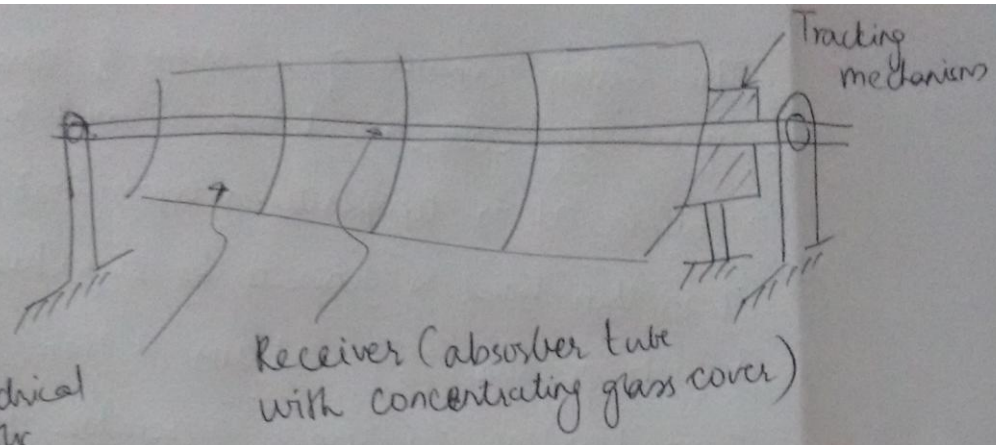
The system consists of an array of parabolic concentrating collectors which is used to heat synthetic oil to temperatures upto 400°C. This is oil is then used to generate ~~by~~ superheated steam at high pressure. The steam is then expanded in a steam turbine to run a generator. The spent steam is condensed in a condenser and pumped back into the heat exchanger. [2 marks]

(Q5) Solar power has a low density per unit area (1 kW/m² to 0.1 kW/m²). Hence, it is collected by covering a large ground area by solar thermal collectors. When temperatures higher than 100°C are required, it is required to concentrate the radiation. This is done by focussing or concentrating collectors. Eg

→ cylindrical parabolic concentrating collector

→ ~~Parab~~ Paraboloid concentrating collector.

[2 marks]



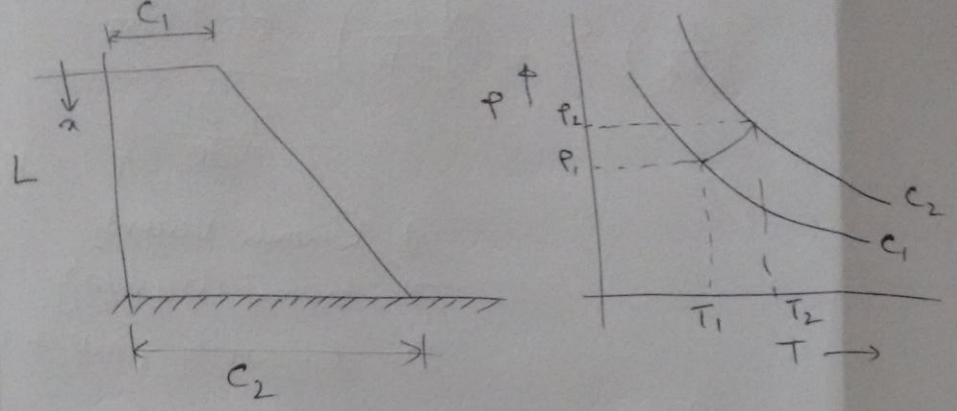
[4 marks]

A schematic of the cylindrical parabolic concentrating collector is shown in figure above. It consists of a concentrator and receiver. The concentrator shown is a mirror reflector having the shape of a cylindrical parabola. It focusses the sunlight onto its axis, where it is absorbed on the surface of the absorber tube and transmitted to the fluid flowing through it. A concentric glass cover around the absorber tube helps in reducing the convective losses to the surroundings.

To ensure that the sun's rays are always focussed onto the absorber tube, the concentrator has to be rotated. This movement is called "tracking" and a suitable mechanism is provided for the same.

[4 marks]

6 Principle of working of solar Pond



At top surface → density = ρ_1,
temperature = T_1
concentration = C_1

At bottom surface → density = ρ_2,
temperature = T_2
concentration = C_2

[3 marks]

Consider a pond of depth L, having salts dissolved in water, such that concentration C_1 at top is less than than at bottom C_2.

Let ρ_1 and T_1 be density and temperature at top, while ρ_2 and T_2 are those at the bottom. For no convection to occur,

$$\frac{d\rho}{dx} > 0$$

$\because \rho(C, T)$ it follows

$$\left(\frac{\partial \rho}{\partial C}\right)_T \left(\frac{dC}{dx}\right) + \left(\frac{\partial \rho}{\partial T}\right)_C \left(\frac{dT}{dx}\right) > 0$$

ie $$\left(\frac{dC}{dx}\right) > \frac{-\left(\frac{\partial \rho}{\partial T}\right)_C \left(\frac{dT}{dx}\right)}{\left(\frac{d\rho}{dC}\right)_T}$$

For a slightly more sophisticated analysis,

$$\left(\frac{dC}{dx}\right) > -\left(\frac{\nu+\alpha}{\nu+D}\right)\left[\frac{\left(\frac{\partial \rho}{\partial T}\right)_c \left(\frac{dT}{dx}\right)}{\left(\frac{\partial \rho}{\partial C}\right)_T}\right]$$

ν = kinematic viscosity
α = thermal diffusivity
D = diffusivity of salt in water

$\left(\frac{\nu+\alpha}{\nu+D}\right) = 1{\cdot}15$ for conditions in Solar pond [5 marks]

Water in a pool or tank usually heats up only a few degrees because of natural convection currents present. An artificially constructed pond in which significant temperature rises are caused to occur in the lower regions by preventing convection is called Solar pond. The usual method adopted to prevent convection is to dissolve a salt in water and to maintain a concentration gradient. An expression for the required concentration gradient was derived earlier.

[2 marks]