Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more importance. (Not applicable for subject English and Communication Skills)
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q.1 Attempt any FIVE: **20 M**

a) Define primary and secondary energy sources and give two examples for each.
(Primary energy & Secondary energy sources 2 Marks each)
Ans:

i) Primary energy sources:
The sources which provide net supply of energy.
Example: Coal, oil, uranium, natural gas etc.

ii) Secondary energy sources:
The sources which produce no net energy.
Example: Solar energy, wind energy, water energy etc.

b) List out the two advantages & disadvantages of renewable energy sources.
(Any two advantages & disadvantages 2Marks each)
Ans:

Advantages:
i) These energy sources recur in nature and are inexhaustible.

ii) The power plants using renewable sources of energy do not have any fuel cost and hence their running cost is negligible.

iii) As renewable have low energy density there is more or less no pollution or ecological balance problem.

iv) Save foreign exchange and generate local employment.

v) More site specific and are employed for local processing and application, their economic and technological losses of transmission and distribution being nil.

vi) Conversion technology tends to be flexible and modular. Renewable energy can usually be rapidly deployed.

Disadvantages:
i) Large size plants are required due to this delivered energy cost is increased.
ii) Energy sources are intermittent and also lack dependability.
iii) The user of these sources of energy has to make huge additional investment before deriving any benefit from it.
iv) These energy sources due to their low energy density have low operating temperatures leading to low efficiencies.
v) Since the renewable energy plants have low operational efficiency, the heat rejections are large which cause thermal pollution.
vi) These energy sources are energy intensive.

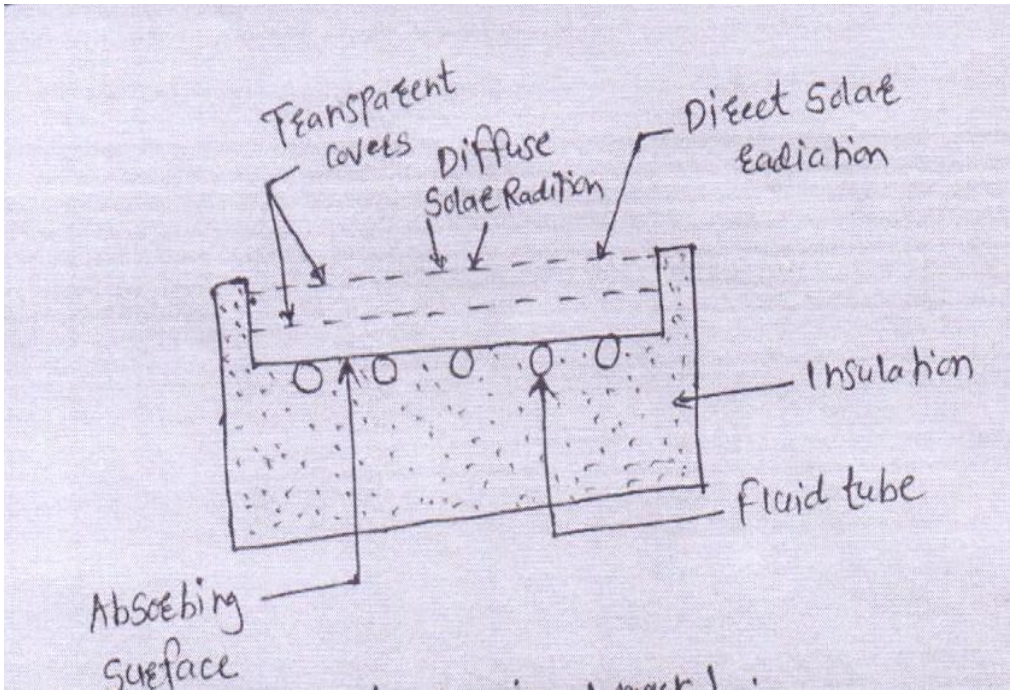
c) Distinguish between 'beam-radiation' and 'diffused radiation' (Any four points)
(Any four points 1Mark each)
Ans:

Sr. No	Beam Radiation	Diffused Radiation
1	Solar radiation received on the surface of earth without change in direction	Solar radiation received from the sun after its direction has been changed by reflection and scattering.
2	It produces shadow when interrupted	It does not produce shadow.
3	It comes from sun.	It comes from sky.
4	It is measured by pyrheliometer.	It is measured by pyranometer.

d) Explain the term 'Solar constant' and state its value.
(Definition 1Mark, Explanation 2Marks, Value 1Mark)
Ans:

- The 'Solar Constant is the energy from the sun received on a unit area perpendicular to solar rays at the mean distance from the sun outside the atmosphere.
- It is not affected by daily, seasonal, atmospheric condition, clarity of atmosphere etc.
- It is on a unit area on imaginary spherical surface around earths atmosphere for mean distance between the surface and the earth.
- It is on the surface normal to sun's rays. Sun rays are practically parallel.
- Its value is 1353 W/m^2

e) Draw and label the parts of Flate plate collector.
(Diagram 3Marks, Labelling 1Mark)
Ans:



f) State the advantages and limitations of geothermal energy.
(Any four advantages ½ Mark each, any four disadvantages ½ Mark each)

Ans:

Advantages:
i) Geothermal energy is cheaper.
ii) It is versatile in its use.
iii) It is the least polluting as compared to other conventional energy sources.
iv) It is available for multiple uses from a single resources.
v) Geothermal power plants have the highest annual load factors of 85% to 90% compared to 45% to 50% for fossil fuel.
vi) It delivers greater amount of net energy from its system as compared to other alternative.

Disadvantages:
i) Low overall power producing efficiency.
ii) Drilling operation is noisy.
iii) Large areas are needed for exploitation of geothermal energy.
iv) The withdrawal of large amount of steam or water from a hydro thermal reservoir may result in surface subsidence.

g) State the principle of hydrogen energy conversion and state its applications.
(Principle 2Marks, Application any four points ½ mark each)
Ans:

Hydrogen energy is a non conventional energy source. Hydrogen is considered as an alternative future source of energy. It is produced from water which is available in abundance in nature. Hydrogen atoms in the core of sun combine to form helium atoms which is called as fusion reaction.

Applications:
1. Used for generating electricity for domestic appliances.
2. It is utilized in automobiles.
3. It is employed for industrial uses.
4. Use in processing of heavy oil.
5. Used for manufacturing synthetic liquid or gaseous fuels.
6. Aircraft fuel in air transport.

Q.2 Attempt any FOUR: **16M**

a) State the need of alternate energy sources.

(Relevant description 4Marks)

Ans:

These are the sources which are nontraditional. They are alternatives to the conventional energy sources.

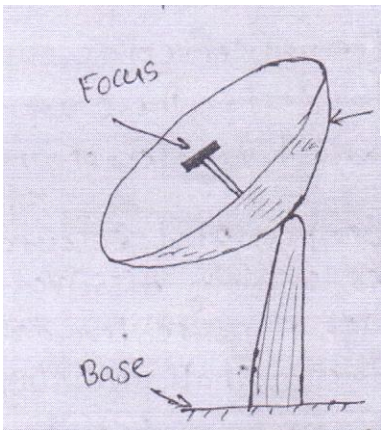
The demarcation between conventional and non conventional is not rigid. Today non conventional becomes conventional after a few decades.

Concern for the environment due to ever increasing use of fuels and rapid depletion of natural resources has led to development of alternative sources of energy which are renewable.

b) State the working of parabolic dish collector with labeled diagram.

(Diagram 2 Marks, Working 2 Marks)

Ans:



paraboloid

Working: A Paraboloida / dish collector brings solar radiation to a focus at a point actually a small central vol.

The absorber, located at the focus is a cavity made of a zirconium-copper alloy with a black chrome selective coating.

The heat transport fluid flows into with a black chrome selective coating. The heat transport fluid flows into and out of the absorber cavity through pipes bonded to the interior.

The dish can be turned automatically about two axes so that the sun can be fully tracked at essentially all times.

c) State any four advantages of solar heating system.
(Any four advantages 1Mark each)
Ans:

1. In heating a common heat transfer and storage medium, water issued, this avoids temperature drop during transfer of energy into and out of the storage.
2. Requires smaller storage volume.
3. Easily adopted to supply of energy to absorption air conditioners.
4. Low energy requirements for pumping of the heat transfer fluid.

d) State the factors to be considered for the selection of site for wind power plant.
(Any four points, 1Mark each)
Ans:

i) High annual average wind speed:
The fundamental requirements to the successful use of WECS, obviously, is an adequate supply of wind. The wind velocity is critical parameter. It is obviously desirable to select a site for WECS with high wind velocity.

ii) Availability of anemometry data:
The anemometer high above ground, accuracy, linearity, location on the support tower, shadowing and other readings, icing inertia of roter whether it measures the horizontal velocity component or vertical, and temperature effects are a few of the many difficulties encountered. This anemometry data should be available over some time period.

iii) Availability of wind curve at the proposed site:
this is important curve determines the maximum energy in the wind and hence is the principle initially controlling factor in predicting the electrical output. The curve also determines the reliability of delivered WECS generator power. Its curve goes to zero, there will be no generated power during that time.

iv) Wind structure at the proposed site:
For ideal site wind structure should be such that a smooth steady wind that blows all the time. But this ideal site is not possible.

v) Altitude of the proposed site:
it affects the air density and thus the power in the wind and hence the useful WECS electric power output. Wind must have higher velocities at higher altitude.

vi)Terrain and its aerodynamic:
One should know about terrain of the site to be chosen. If the WECS is to be placed near the top but not on the top of a not too blank hill facing the prevailing wind, then it may be possible to obtain high speed up of the wind velocity over what it would otherwise be. Also use hills or mountains which channel the prevailing winds.

vii) Local ecology:
If the surface is bare rock it may lower have lower hub heights hence lower structure cost. It trees or grass or vegetation are present, all of which tend to destructure the wind, then higher hub heights will be needed.

viii) Distance to Roads or railways:
This is another factor the system engineer must consider for heavy machinery, structures, materials, blades and other apparatus will have to be moved into any chosen WECS site.

ix) Nearness of site to local centre / users:
This obvious criterion minimizes transmission lines length and heavy losses and costs. After applying all the previous siting criteria, hope fully as one narrows the proposed WECS sites.

x) Nature of ground:
Ground condition should be such that the functions for a WECS are secured. Ground surface should be stable. Erosion problem should not be there.

xi) Favourable and cost:
Total cost should be favorable as this along with siting cost enters into the total WECS system cost.

xii) Other conditions such as icing problem, salt spray or blowing dust should not be present at the site.

e) Differentiate 'power-in-wind' and 'maximum power'. (Any four points)
(Any four points 1Mark each, Any other relevant point shall be considered)
Ans:

Sr. No	Power in wind	Maximum Power
1	It relates kinetic energy of wind, harnessed & directed to perform a task mechanically.	Theoretical power generated by wind turbine.
2	Depends on wind speed, location etc.	It depends on power coefficient.
3	Limitations to increase because of meteorological conditions.	It can be increased with design of inverter and other related accessories.
4	This decides actual design of wind turbine.	This gives maximum possible output which can be obtained after design.

f) Define Hydrothermal, geopressured, petrothermal, magma volcano.
(Definition 1Mark each)
Ans:

i. Hydrothermal: Hydrothermal convective system water is heated by contact with hot rocks. These are wet reservoirs containing steam and hot water or only hot water.

ii. Geopressured: The geopressured resources contain moderate temperature brings containing dissolved methane. These are trapped under high pressure in a deep sedimentary formation. Sealed between shale and clay.

iii. Petrothermal: These are composed of hot dry rock but no underground water.

iv. Magma volcano: The molten or partially molten rock (magma) occur at a moderate depth. The very high temperature above 650^{o}C.

Q.3 Attempt any FOUR **16M**

a) Define along with diagram incident angle, Zenith angle, Solar azimuth angle, and hour angle.

(Figure 1mark, definition of incident angle- ½ mark, definition of zenith angle ½ mark, other definitions 1 mark each.)

Ans:

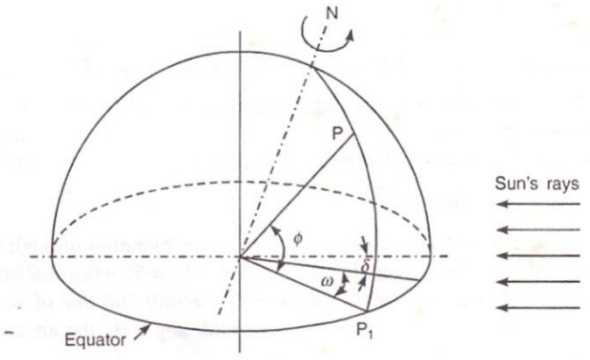


Figure 3.5 Latitude ϕ, hour angle ω and sun's declination δ.

Incident Angle: It is the angle being measured between the beam of rays and normal to the plane.

Zenith angle: It is the vertical angle between the sun's ray and the line perpendicular the horizontal plane through the point. It is the complimentary angle of the sun's altitude angle.

Solar azimuth angle : It is the angle subtended in the horizontal plane of the normal to the surface of the horizontal plane. The angle is taken positive if the normal is west of earth and negative when east of earth in Northern hemisphere.

Hour angle : It is the angle through which earth must rotate to bring the meridian of point directly under sun, it is angular measure of time at the rate of 15 degree per hour. Hour angle is measured from noon based on local apparent time in the forenoon.

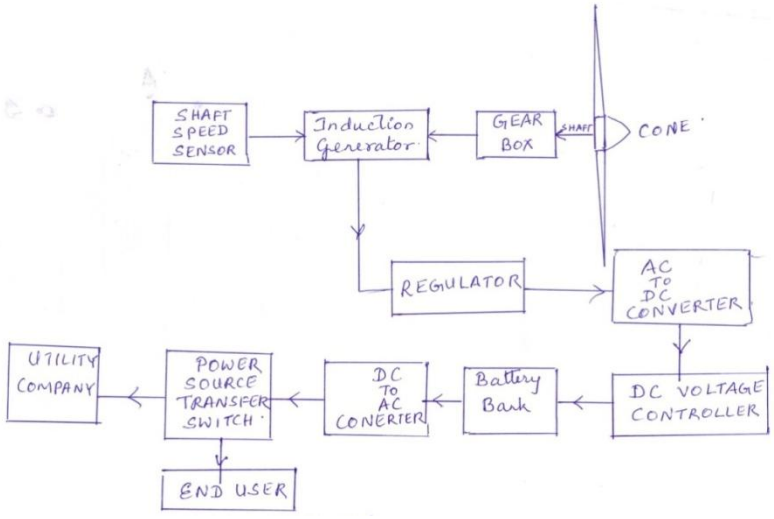
b) How total radiation of solar is measured by pyranometer?
(Relevant explanation 4Marks)
Ans:
A shading ring is attached, the beam radiation is prevented from falling on instrument sensor and then measures only the diffuse component of radiation is allowed to fall on a black surface to which hot junction of thermocouple are attached.

The cold junction of thermocouple is located in such a way that they do not receive any radiation. As a result an emf proportional to the solar radiation is generated. This emf which is usually in the range of 0-10mV , can be read or integrated over a period of time is obtained.

c) Explain the meaning of
- **i) Power coefficient**
- **ii) Thrust on turbines**

(Meaning of each term 2 marks).
Ans:
Power coefficient is a measure of wind turbine efficiency. It is the ratio of actual electric power produced by a wind turbine divided by total wind power flowing into the turbine blades at specific wind speed.
Thrust on turbine is the axial force applied by steam or wind on the rotor of steam or wind turbine.

d) With the help of block diagram label the basic components of wind electric system.
(Correct diagram 4Marks)
Ans:



e) Define the following methods of energy generation from biomass.

- **Combustion**
- **Anaerobic digestion**
- **Pyrolysis**
- **Gasification**

(Definition 1 Mark each)

Ans:

COMBUSTION: This is a method of extraction of energy from biomass by direct combustion.

ANAEROBIC DIGESTION: In this method biogas is produced when wet sewage, sludge, animal dung or green plants are allowed to decompose in a sealed tank under anaerobic (oxygen free) conditions.

PYROLYSIS: In this method high energy rich fuels (produced by roasting dry woody matter) is pulverized and fed to reactor and heated in absence or little presence of air.

GASSIFICATION: This is a process in which would produce a flammable gaseous mixture of hydrogen, carbon monoxide , methane , and other non flammable by-products. This is done by partially burning and partially heating the biomass in the presence of charcoal.

f) State the differences between 'Fixed bed gasifier " and 'fluidised bed gasifier'

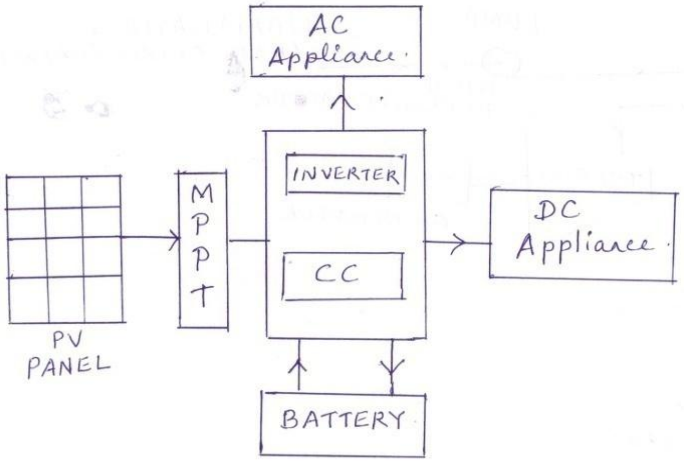
(For each difference 1 mark, any four differences shall be considered).

Ans:

	Fixed bed gasifier	**Fluidised bed gasifier**
Technology	There is necessity of a safety valve to prevent development of excessive pressure.	There is no need to provide any safety valve as the holder is free to rise .
Use of material	High carbon conversion .	lower carbon conversion
	High cold gas efficiency	Lesser cold gas efficiency
Use of energy	Low oxygen is required.	Moderate oxygen is required
Economy	Gas is produced at relatively low temperature. No need for expensive heat recovery equipment.	Gas is produced at moderately high temperature, heat recovery equipment is required.
Environment	Environmentally most gentle, produces syngas H2, CO, CO2	Environmentally more harsh.

Q.4 Attempt any TWO: **16M**

a) Draw block diagram of photovoltaic power generating system and explain its working.
(Block diagram 4 marks, Working 4 marks)
Ans:



Working : Solar PV panel converts solar energy to electrical energy in dc form. The electrical energy is generated when sunlight falls on the PV panel. There is no sunlight during the cloudy days and night hours, so battery is used here. Electricity is applied to the appliance and battery charging when sunlight is there. Some of the appliances are dc type and can use dc output of PV panel directly, but many appliances are ac type , hence dc supply of PV panel is converted into ac with the help of inverter. Overcharging and over discharging of battery shortens its life, so this needs battery protection by a device called charge controller.(cc) . MPPT (maximum power point tracker) is an impedance matching device which is used along with PV panel to extract maximum power.

b) State the principle and specification of :
- Solar heating system
- Solar cooking system
(Principle of solar heating system 2 marks, Specification of solar heating system any two expected 2 marks, Principle of solar cooking system 2 marks, Specification of solar cooking system any two expected 2 marks)
Ans:
Principle of solar heater:

Solar water heater is basically a flat plate collector and an insulated storage tank. The collector is a blackened metal plate with attached metal tube and usually provided with a glass cover and a layer of insulation beneath the plate. When mounted on a roof the collector absorbs solar radiations, by transfer of absorbed heat to the water circulating through the tube, hot water is supplied to the storage tank.

Specifications: (any two is expected)

1. Flat plate collector : Area 2 sq. M with selectively coated Cu- Cu absorber
2. Flat plate collector box: Aluminium box with dimensions
   Length: = 186cm +/- 1 cm
   Breadth= 124 cm +/- 1 cm
   Height = 10 cm +/- 1 cm

3 . Collector support frame: Structure should withstand wind velocity of 100 km/ sec

Principle of solar cooker:

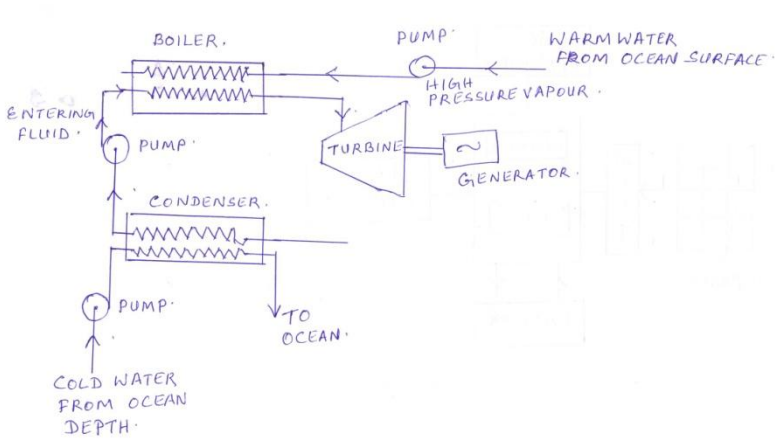
A reflecting mirror fitted inside the box or dish collector , reflects the solar radiation and helps in increasing the solar energy incidence. The cooking pots are made of aluminium or steel and painted black on the outer side. The food to be cooked is placed in the cooking pots , which is then placed in aluminium tray and covered by double glass lid. The cooker is kept facing the sun.

Specification for Solar cooker: (any two is expected)

1. Collector type: Dish or Box type
2. Reflecting mirror : material, reflectivity, mirror fixing
3. Bowl supporting frame
4. Bowl Stand
5. Tracking mechanism (manual or automatic)
6. Cooking vessel : (ISI marked pressure cooker of suitable capacity resistant black powder coated from bottom.)

c) Draw schematic diagram of ocean thermal electric power generation (closed cycle). Explain its operation.
(Diagram 4 marks, Operation 4 marks.)

Ans:



Operation: Warm water from ocean surface is circulated through a pump to a heat exchanger which acts as a boiler to generate working fluid ammonia vapour at high pressure.

This vapour expands in the turbine to develop mechanical power which is in turn runs an electric generator to produce electric power.

The working vapour from turbine at low pressure is condensed into condenser with the help of cold water drawn from the depth ocean through a pump.

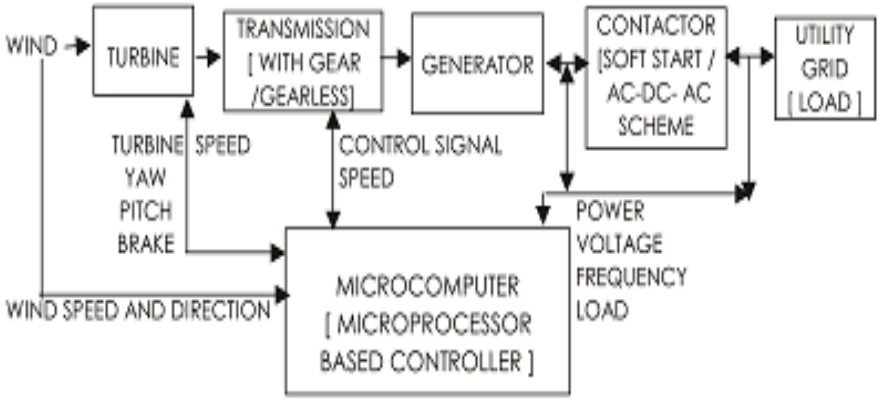
Q.5 Attempt any FOUR. **16M**

a) State the four advantages of Horizontal axis wind mill over Vertical axis wind mill.
(Any four points, 1Mark each)
Ans:

1. Blades are to the side of the turbine's center of gravity, helping stability.
2. The turbine collects the maximum amount of wind energy by allowing the angle of attack to be remotely adjusted
3. The ability to pitch the rotor blades in a storm so that damage is minimized
4. The tall tower allows the access to stronger wind in sites with wind shear and placement on uneven land or in offshore locations

5. Most Horizontal axis wind mills are self-starting
6. Can be cheaper because of higher production volume

b) Draw block diagram of variable speed constant frequency system of WEGS.
(Correct diagram 4Marks)
Ans:



c) Calculate the monthly average hourly Radiation falling with flate-plate collector facing south ($r=0^0$) with a slope of 15^0 has the following data:
Location - Chennai (13^0 00' N)
Month – October
Time – 11.00 to 12.00 (LAT)
I_g = 2408 kJ/m^2 –n
I_ϕ = 1073 kJ/m^2 –n
Given that ⟶ W = 7.5^0
Grounds reflectivity = 0.2
(Correct solution 4 Marks)
Ans:

Solution. (Not for leap year)
Given $\gamma = 0°$ and $n = 288$ for 15th October

$$\delta = 23.45 \sin\left[\frac{360}{365}(284+288)\right]$$

$$= 23.45 \sin[564.16]$$

$$= -9.599 \simeq -9.6°$$

$$R_b = \frac{\sin(-9.6°)\sin(13°-15°) + \cos(-9.6°)\cos 7.5°\cos(13°-15°)}{\sin 13°\sin(-9.6°) + \cos 13°\cos(-9.6°)\cos 7.5°}$$

$$= \frac{5.845 \times 10^{-3} + 0.976}{-0.0376 + 0.9594} = \frac{0.9818}{0.9218} = 1.065$$

$$R_d = \left(\frac{1+\cos 15°}{2}\right) = 0.983$$

$$R_r = 0.2\left(\frac{1-\cos 15°}{2}\right) = 0.017$$

Now for monthly average hourly Radiation

$$\frac{H_T}{H_g} = \left(1 - \frac{I_\phi}{I_g}\right) R_b + \frac{I_\phi}{I_g} R_d + R_r$$

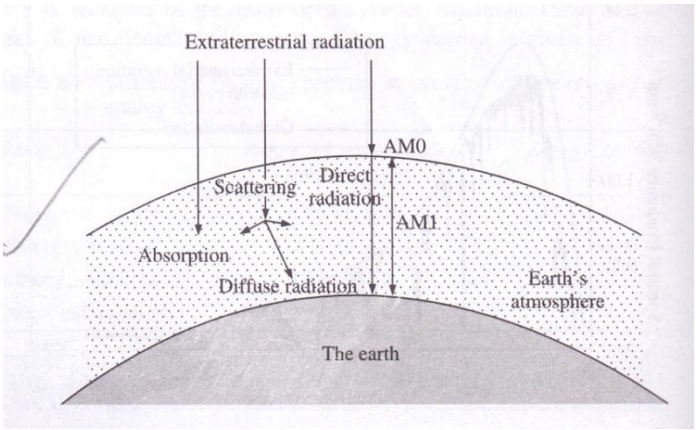
$$\therefore = \left[1 - \frac{1073}{2408}\right] \times 1.065 + \left(\frac{1073}{2408}\right) \times 0.983 + 0.017$$

$$= 0.59 + 0.455 = 1.045$$

$$\therefore H_T = 1.045 \times 2408 = 2516.36 \text{ kJ/m}^2/\text{h}.$$

d) Draw a neat diagram to show spectral distribution of extra terrestrial solar radiation.
(Correct diagram 4 Marks)

Ans:



e) State the advantages and disadvantages of floating drum type biomass plant.
(Any two Advantages 2Marks Any two Disadvantages 2Marks)
Ans:

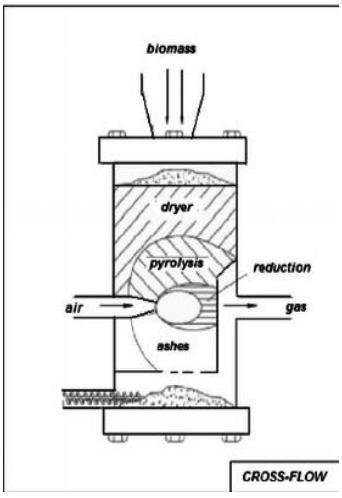
Advantages

- Floating-drum plants are easy to understand and operate.
- They provide gas at a constant pressure, and the stored gas-volume is immediately recognizable by the position of the drum.
- Gas-tightness is no problem, provided the gasholder is de-rusted and painted regularly.

Disadvantages

- The steel drum is relatively expensive and maintenance-intensive.
- Removing rust and painting has to be carried out regularly.
- The life-time of the drum is short (up to 15 years; in tropical coastal regions about five years).
- If fibrous substrates are used, the gas-holder shows a tendency to get "stuck" in the resultant floating scum.

f) Draw schematic diagram of fixed bed gasifier and explain its working.
(Diagram 2 Marks Working 2 Marks)
Ans:



In fixed-bed reactors there is a fuel bulk filling in the reaction chamber. Fresh biomass is fed from the top of the reactor, introduced through an opening or sluice on the reactor head and sinks slowly downwards by gravity as conversion of fuel conversion proceeds. A characterization of the various manners of operation of fixed-bed reactors results through the relative direction of gas stream and fuel bed movement (up- and downdraft).

Q.6 Attempt any FOUR. 16M

a) State the principles of Tidal power generation. Also state its limitations.
(Principle 2 Marks Limitations 2Marks)
Ans:

Tide or wave is periodic rise and fall of water level of the sea. Tides occur due to the attraction of sea water by the moon. Tides contain large amount of potential energy which is used for power generation. When the water is above the mean sea level, it is called flood tide. When water level is below the mean level it is called ebb tide. Tidal power is the only technology that draws on energy inherent in the orbital characteristics of the earth moon system, and to a lesser extent in the EarthSun system. A tidal generator converts the energy of tidal flows into electricity. Greater tidal variation and higher tidal current velocities can dramatically increase the potential of a site for tidal electricity generation.

Limitations: (any four)

- Tidal power plants can be developed only if natural sites are available on the bay.
- As the sites are available on the bays which are always far away from load centers, the power generated has to be transmitted to long distances. This increases the transmission cost and transmission losses.
- The supply of power is not continuous as it depends upon the timing of tides.
- The navigation is obstructed.
- Utilization of tidal energy on small scale is not economical.

b) List out the factors to be considered for site selection of 'Ocean thermal electric power plant'.

(Any four relevant points 1Mark each)

Ans:

- They can be installed in sheltered areas so that they are relatively safe from storms and heavy seas.
- Favored locations include those with narrow shelves (volcanic islands), steep (15-20 degrees) offshore slopes, and relatively smooth sea floors.
- These sites minimize the length of the intake pipe.
- Land-based or near-shore sites can also support mar culture or chilled water agriculture.
- A shelf-mounted plant could be towed to the site and affixed to the sea bottom.
- Floating OTEC facilities operate off-shore.
- Floating plants need a stable base for continuous operation.

c) How the energy can be obtained from biomass using fermentation method.

(Any relevant explanation shall be considered 4Marks)

Ans:

The biomass resource can be considered as organic matter, in which the energy of sunlight is stored in chemical bonds. When the bonds between adjacent carbon, hydrogen and oxygen molecules are broken by digestion, combustion, or decomposition, these substances release their stored, chemical energy. This method is a biochemical process. The fermentation that follows produces alcohol which is a very high energy fuel that makes it very practical for use in cars. Fermentation is an anaerobic process (occurs in the absence of oxygen) that breaks down the glucose within organic materials. It is a series of chemical reactions that convert sugars to ethanol.

The basic fermentation process involves the conversion of a plant's glucose (or carbohydrate) into an alcohol or acid. Yeast or bacteria are added to the biomass material, which feed on the sugars to produce ethanol (an alcohol) and carbon dioxide. The ethanol is distilled and dehydrated to obtain a higher concentration of alcohol to achieve the required purity for the use as automotive fuel. The solid residue from the fermentation process can be used as cattle-feed

and in the case of sugar cane; the biogases can be used as a fuel for boilers or for subsequent gasification.

The most common forms of biomass that are used in the production of bio-ethanol are high in sugar and include sugarcane, corn and sweet potatoes. Other forms of biomass that are used in fermentation processes are starchy materials such as wheat, barley, oat and rice along with lignocelluloses materials such as agricultural wastes and woody materials.

d) State the thermal classification of biomass.

(Any relevant classification shall be considered 4Marks)

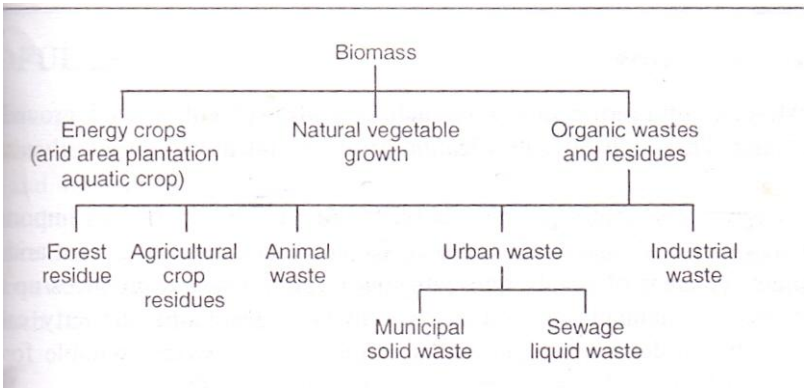
Ans:

Thermal conversion processes use heat as the dominant mechanism to convert biomass into another chemical form. The basic alternatives of combustion (torrefaction, pyrolysis, and gasification) are separated principally by the extent to which the chemical reactions involved are allowed to proceed mainly controlled by the availability of oxygen and conversion temperature. Further gasification can be classified into three types depending on the gas and feed stock flow path.

1. Down Draft
   - Closed Top
   - Open Top

2. Up Draft
3. Cross Draft

OR



e) State the different components of solar cell and explain the construction of solar PV module.
(Components 2 Marks, Construction 2Marks)
Ans:

Different components of solar cell

A solar cell is an electronic device which directly converts sunlight into electricity. PV (photovoltaic) panels are the most common type of panel, especially for residential installations. They are made from three layers:

N-Layer – silicon that is mixed with phosphorus; P/N Junction –pure silicon & P-Layer – silicon that are mixed with boron. Inverter- which converts DC current into AC current. Battery- which stores the electrical energy and used when solar panels are not providing the energy. Distributer- The distributor is the device that distributes the AC power created by the inverter to the grid, and sometimes to both the home in which the solar power system has been installed and the grid.

Construction of solar PV module

A solar photovoltaic module is composed of individual PV cells. This crystalline-silicon module comprises 4 solar cells and has an aluminum frame and glass on the front. The most common type of solar panel is constructed from thin wafers of crystalline silicon, 150mm by 150mm by 180 – 360 microns thick. The silicon cells are fragile and brittle, so they are built into a sandwich construction behind a glass cover sheet to provide protection from mechanical damage. The cells are encapsulated between films of polymer protecting the cells from the effect of moisture which would corrode the electrical connections. Cells are connected in series by flat strips of copper soldered onto the front face of one cell and the rear face of the next. To complete the PV panel or module, a frame of extruded aluminium is fitted around the edges of the glass sheet to protect and stiffen the panel and provide a means to fix down.

f) With reference to 'Box type solar cooker' explain its components, material used, specifications.
(Any 2 specification 2 Marks each)
Ans:

System Components	Specifications: Material	Specifications: Properties	Comments
Reflector Flat mirror or metal foil	Glass, Aluminium	Reflectivity should be high to ensure the increase in temperature of cooking utensil	Mirrors are more reflective but costlier and fragile.
Box (a) Outer box (b) Inner box	GI, Aluminium sheet, FRP	Enough to maintain stability and insulation	Low cost materials like cardboard can be used.
	Aluminium or copper (high heat conductivity)	Coated with non-toxic black paint to absorb the heat	Paint must be non-toxic when dry.
Transperent Cover	Glass or plastics	Glass traps the infrared radiation, prevents heat loss from top	Glass cover should be well sealed to prevent heat loss from the gap
Insulation	Wool, cotton, feathers, or even crumpled newspapers	Space between the outer and inner box including bottom of the tray must be insulated to reduce heat losses from the cooker	Must be free from volatile materials.
Cooking utensils	Aluminium, copper or stainless steel	Must be coated with black material to absorb	Lightweight, shallow pot must be used

Specifications (minimum four) - Should be as per BIS (IS 13429:2000), with size 550mmx550mmx170 mm ± 20 mm, four matt black coated cooking pots, thermal performance (F1) not less than 0.12 (ie, Grade A), The cover plate should be double glazed made of toughened glass with over all transmittance of not less than 65%, The body of the solar cooker should be 1.00 mm thick UV resistant FRP, The gaskets must be made of neoprene/EPDM on minimum 2 mm thickness, Mirror reflectivity should not be less than 75%, Each solar cooker must be provided with four castor wheels as per BIS 13429, All parts of the cooker must be made of rust/ corrosion free materials.

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