

JK LAKSHMIPAT UNIVERSITY, JAIPUR

INSTITUTE OF ENGINEERING AND TECHNOLOGY

End Term Examination (Backlog), November 2016

B. Tech in Mechanical Engineering, Semester VI

Roll No.....

ME 606: Solar Energy Technology

Time: 3 hours

Max. Marks: 100

Instructions to students:

1. Do not write anything other than your roll number on question paper.
2. Assume suitable data wherever required and mention it clearly.
3. Writing appropriate units, nomenclature, and drawing neat sketches/schematics/ flow chart wherever, required are an integral part of the answer.

- Q.1A Objective type multiple choice questions (10 questions @ 1 mark) 10
- i. Which of the following is not a bio-mass source?
(a) Gobar gas; (b) Coal; (c) Wood; (d) Nuclear energy
 - ii. A solar cell is made up of _____.
(a) silicon; (b) titanium; (c) magnesium; (d) teflon
 - iii. A solar cell converts _____.
(a) heat energy into electrical energy; (b) solar energy into electrical energy;
(c) heat energy into light energy; (d) solar energy into light energy
 - iv. Nuclear fusion reaction happens spontaneously in _____.
(a) the core of the earth; (b) the commercial nuclear reactor; (c) the atmosphere of the sun; (d) the eruption of a volcano
 - v. Which of these is not used for solar thermal applications: (a) liquid flat plate collector (b) evacuated flat plate collector (c) parabolic dish collector (d) photovoltaic cell
 - vi. Which is a measuring instrument for global radiation? (a) pyr heliometer (b) pyranometer (c) pyranometer with shaded ring (d) all of these
 - vii. Trombe wall consists of: (a) glazing (b) storage wall with vents (c) storage wall without vents (d) glazing and storage wall with vents
 - viii. Shading of the absorber plate by the side walls of the collector casing increases due to? (a) smaller spacing; (b) larger spacing; (c) high absorptivity coating; (d) all of these
 - ix. The effect of dust on a flat plate collector's cover is? (a) higher collector efficiency; (b) unchanged collector efficiency; (c) lower collector efficiency; (d) higher transmissivity of the cover
 - x. The efficiency of a flat plate collector on increasing fluid inlet temperature will? (a) Remain unchanged; (b) decrease; (c) increase; (d) first increase then decrease
- Q.2 Short answer type questions (4 questions @ 2.5 marks) 10
- i. Which is the most efficient type of solar collector and why?
 - ii. Mention the collection efficiency of three different types of solar collectors.
 - iii. Give few examples of the materials used for selective coatings for absorber plate.

- iv. What is the effect of number of covers on flat plate collector performance? 05
- Q.3A Explain the working principle of a solar cell with the help of suitable diagrams. 05
- Q.3B Make current voltage and power voltage graphs for solar cells and explain the terminology. 05
- Q.4A Which instrument is needed to measure global radiation? Explain its working with the help of a schematic diagram. 05
- Q.4B Explain the working of a solar chimney based power plant with the help of a schematic diagram. 05
- Q.5A Make suitable assumptions and estimate the collector area required for a 80MWe line focusing solar thermal power plant producing electricity for 8 hours every day. 05
- Q.5B It is proposed to set up a solar chimney power plant with a 300 m height. Calculate the maximum possible conversion efficiency obtainable with the chimney. Also estimate the efficiency of the plant as a whole and the daily electrical output in a typical summer month (in kWh), if the solar collection area of the greenhouse is 50,000 m². 05
- Q.6A Make schematic diagram of a sunspace for active space heating and explain its working. 05
- Q.6B Explain the working of a solar cooker with the help of its schematic diagram. 05
- OR
- Q.6B Explain the working of a solar dryer with the help of a schematic. 05
- Q.7A A low temperature solar thermal power generation system using flat-plate collectors is proposed to be set up. The system is required to generate 50 kWe round the clock. Estimate the collector area required and the cost of the solar system of such plant. 05
- Q.7B Calculate the bottom loss coefficient for the following flat plate collector system: L₁: 1.9 m; L₂: 0.9 m; L₃: 0.16 m; δ_b : 8 cm; δ_s : 4 cm; thermal conductivity of insulation: 0.05 W/m-K. 05
- OR
- Q.7B Calculate the side loss coefficient for the following flat plate collector system: L₁: 1.9 m; L₂: 0.9 m; L₃: 0.16 m; δ_b : 8 cm; δ_s : 4 cm; thermal conductivity of insulation: 0.05 W/m-K. 05
- Q.8A A photovoltaic system for supplying drinking water is installed in a village. The water is pumped from a bore well, from a depth of 48 m. The solar cells are made from single crystal silicon and the array consists 24 modules having dimension of each module as 1.1 m x 0.5 m. it is given that the inverter efficiency is 85 percent and the pump motor set efficiency is 45 percent. Calculate the water discharge rate at noon when the global radiation incident normally on the cells is 945 W/m². Assume cell's conversion efficiency as 12.5%. 10

Q.9A A residential house has a power requirement of 400 W for 4 hours every night. It is proposed to meet the requirement by using a PV array, a battery storage system and an inverter. The whole system is designed in such a way that it can meet an extra night's requirement even if there has been no sunshine during the day. Calculate the number of PV modules and batteries required. Given: (i) Solar radiation is available for an average of 6 hours daily and the average hourly global radiation flux incident on the array is 650 W/m^2 . (ii) Battery rating = 12 V; 120 Ah. Depth of discharge = 0.7. Charging and discharging efficiency = 0.9. (iii) inverter efficiency at full load = 0.85. 10

Q.9B Calculate the heat transfer coefficient between absorber plate and first cover glass for the following system: 10

Spacing between plate and first cover glass: 4 cm ; absorber plate size: $1.9\text{m} \times 0.9\text{m}$; spacing between first and second cover glass: 4 cm; plate emissivity: 0.92; glass cover emissivity: 0.88; collector tilt: 20° ; mean plate temperature: 70°C ; ambient temperature: 24°C ; wind speed: 2.5 m/s

In addition, following data for air may be used:

Properties of air at 60°C : $k = 0.029 \text{ W/m-K}$; $Pr = 0.696$; kinematic viscosity (ν) $= 18.97 \times 10^{-6} \text{ m}^2/\text{s}$

Properties of air at 40°C : $k = 0.0276 \text{ W/m-K}$; $Pr = 0.699$; kinematic viscosity (ν) $= 16.96 \times 10^{-6} \text{ m}^2/\text{s}$

Following equations may be helpful:

$Nu_L = 0.229 (Ra_L \cos\beta)^{0.252}$ for $Ra_L \cos\beta$ values from 5900 to 9.23×10^4

$Nu_L = 0.157 (Ra_L \cos\beta)^{0.285}$ for $Ra_L \cos\beta$ values from 9.23×10^4 to 10^6

OR

Q.9B Calculate transmissivity due to reflection -refraction for the following cover system: 10

Material: glass; angle of incidence: 15° ; Number of covers: 2; thickness of each cover: 4 mm; refractive index of glass relative to air: 1.52; extinction coefficient of glass: 15 m^{-1}