

**INTRODUCTION TO SOLAR AND WIND TECHNOLOGY
(CHEN 4222)**

Time Allotted : 3 hrs

Full Marks : 70

Figures out of the right margin indicate full marks.

*Candidates are required to answer Group A and
any 5 (five) from Group B to E, taking at least one from each group.*

Candidates are required to give answer in their own words as far as practicable.

**Group - A
(Multiple Choice Type Questions)**

1. Choose the correct alternative for the following: **10 × 1 = 10**
- (i) A solar thermal collector converts solar energy to
 - (a) electrical energy
 - (b) mechanical energy
 - (c) heat energy
 - (d) all of (a), (b) & (c).
 - (ii) Hour angle at solar time 10 A.M is
 - (a) -30°
 - (b) 30°
 - (c) -60°
 - (d) 60°.
 - (iii) Efficiency of practically used solar cell is approximately
 - (a) 10%
 - (b) 15%
 - (c) 25 %
 - (d) 40%.
 - (iv) The statement that the emissivity and the absorptivity of a surface at a given temperature and wavelength are equal is
 - (a) Stefan-Boltzmann law
 - (b) Plank's distribution law
 - (c) Wien's displacement law
 - (d) Kirchhoff's law of thermal radiation.
 - (v) Which collector efficiency is maximum?
 - (a) Flat plate
 - (b) Paraboloid dish
 - (c) Cylindrical parabolic collector
 - (d) Truncated cone concentrator.
 - (vi) Theoretical power available in a wind stream is proportional to
 - (a) velocity of wind
 - (b) viscosity of air
 - (c) the cubic power of velocity of the wind
 - (d) momentum of wind.
 - (vii) If the speed of wind stream remain unchanged while passing through blade of wind turbine
 - (a) a large power is generated
 - (b) zero power will be generated
 - (c) speed of the rotor will be extremely high
 - (d) the flow is known as stalled flow.

- (viii) Wind mill called Darriens mill is
(a) flexible boom mill (b) vertical axis mill
(c) horizontal axis single blade mill (d) horizontal axis multi blade mill.
- (ix) The rotor of a wind turbine has 3 blades. Which application is suitable for this turbine?
(a) Propel sailboats in river
(b) Run water pumps
(c) Drive heat pumps through friction of materials
(d) Run flourmills to grind grain.
- (x) Tip speed can be represented by
(a) Ratio of the rotor blade to the wind velocity
(b) ratio of the power coefficient to torque coefficient
(c) ratio of rotor tip speed to the mean speed of rotor
(d) ratio of available power to available torque.

Group - B

2. (a) Derive an expression to determine radiation heat transfer between two parallel plates. [(CO1)(Analyze/IOCQ)]
(b) An artificial satellite orbiting the earth is shifted towards mars. What shall be its temperature as it settles on mars orbit if its temperature on earth orbit was 315 K? Data given: distance between sun and earth = 1.5×10^{11} m, distance between sun and mars = 2.15×10^{11} m. [(CO1)(Evaluate/HOCQ)]
6 + 6 = 12
3. (a) What is declination angle? Determine declination angle of earth on 15th May, 2022. [(CO1)(Apply/IOCQ)]
(b) Why standard time is different from solar time of a place on earth. Determine the solar time of Kolkata (longitude 88.4° E) while the Indian standard time is 12 noon on the day of your exam. Given that the Indian Standard time is based on longitude 82.5°E. Take the time correction factor $E = 9.87 \sin 2B - 7.53 \cos B - 1.5 \sin B$; where $B = 0.989 \times (n-81)$ and n is the day of the year. [(CO1)(Evaluate/HOCQ)]
(2 + 2) + (3 + 5) = 12

Group - C

4. (a) Discuss different types of solar concentrating collector with diagram. Derive the thermodynamic limit of concentration ratio that is achievable for a circular solar collector. [(CO2)(Understand/LOCQ)]
(b) A south facing solar collector in northern hemisphere is tracking the sun rotating continuously about a horizontal east-west axis in order to minimize the angle of incidence. Derive an expression of angle of incidence of such collector at any day time. [(CO2)(Evaluate/HOCQ)]
7 + 5 = 12

5. (a) Develop thermal network diagram of a double glazed flat plate collectors considering all possible modes of heat loss from the collector. Discuss how do you calculate the overall loss coefficient of a solar collector.
[[CO2](Analyze/IOCQ)]
- (b) Discuss the I-V diagram of solar modules when connected in series and parallel? What is the utility of blocking diode and bypass diode in solar module?
[[CO2](Remember/LOCQ)]
(3 + 3) + (3 + 3) = 12

Group - D

6. (a) Draw the cross section of the wind turbine blade with appropriate labels for the lift and drag force. Explain in detail why lift is caused on the rotor blade.
[[CO3]Understand/LOCQ]
- (b) Calculate the rotor radius for an aero generator to develop 100 W at a wind speed of 7 m/s. The design power coefficient can be assumed to be 0.4 and the combined drive train and generator efficiency 0.9. Taking the air density as 1.224 kg/m³. Consider a 3 bladed rotor with an angle of attack (α) fixed at 4° and C_D/C_L to be 0.01, what blade angle is required at the tip of the rotor blade?
[[CO3]Analyze/LOCQ]
6 + 6 = 12
7. (a) Explain the process of pitch control and yaw control. [[CO3](Explain/LOCQ)]
- (b) A wind pump has to develop 1.75 kWh per day for lifting water for irrigation. Daily mean wind speed at the site is 4 m/s. Design the rotor radius for the wind pump. 1750 Wh energy is to be developed in a day. Take air density as 1.224 kg/m³ and overall system efficiency as 0.15.
[[CO4](Apply/IOCQ)]
6 + 6 = 12

Group - E

8. (a) What are the types of generators used in the wind turbine? Discuss the operating principle of different types of generators used in wind turbine.
[[CO4](Remember/LOCQ)]
- (b) Draw a schematic diagram of horizontal axis wind electric generator and show major components of a commercial wind turbine. [[CO4](Understand/LOCQ)]
- (c) How the optimum tower height of wind turbine is determined considering the cost of power generation.
[[CO3](Analyze/IOCQ)]
5 + 4 + 3 = 12
9. (a) Discuss the steps involved in successful planning and development of a wind farm.
[[CO4](Analyze/IOCQ)]
- (b) A 400 kW, 3 blade wind turbine is designed to deliver full power at a wind speed 15 m/s. The blades have a depth of 14 m and the rated speed the turbine is 48 rpm. Calculate the available wind power to drive the turbine, capacity factor and TSR. Given, Air density = 1.23 kg/m³.
[[CO4](Analyze/IOCQ)]
6 + (2 + 2 + 2) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	41.7	38.6	19.7

Course Outcomes (CO):

After completing this course students will be able to:

1. Understand different technologies used for solar collectors.
2. Students will be able to evaluate the performance and efficiency of different devices that extract power from solar energy.
3. Students will be able to understand the main components of wind energy system and its functions.
4. Understand the different types of wind turbines.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.