Roll No: ----------

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination – December 2017

Program/course: M.Tech REE **Semester – III**
Subject: Wind Energy Technology **Max. Marks : 100**
Code : MNEG 745 **Duration : 3 Hrs**
No. of page/s: 3

Section A

All questions are mandatory: (Each question: 4 marks)

Q.no.	COs	Question
1.	CO1	Compare horizontal axis and vertical axis wind turbine.
2.	CO2	Explain the aerodynamic forces on wind turbine blade using vector diagram.
3.	CO3	Draw and explain C_p versus TSR characteristics for various wind turbines.
4.	CO4	Explain the principle of operation of Induction machine.
5.	CO5	Discuss the environmental impacts of wind farms.

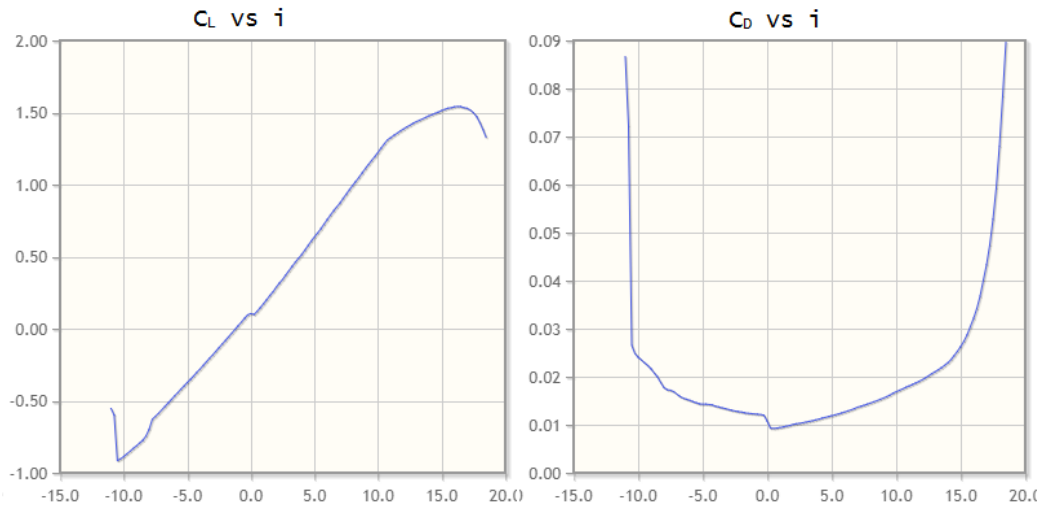
Section B

All questions are mandatory: (Each question: 10 marks)

Q.no.	COs	Question
6.	CO1	a. A one MW direct drive variable speed Wind Power Plant rated at 12.8 m/s wind speed has a rotor diameter of 60 m with a blade length of 28m and a speed range of 30 RPM to 50 RPM. Find the range of its tip speed ratio. b. Find the size of wind turbine rotor (diameter in m) that will generate 1MW of electrical power in a steady wind of 9.5 m/s. Assume $\rho = 1.226$ kg/m^3 $C_p = 0.45$. Assume $\eta_m = \eta_e = 0.90$.
7.	CO2	Derive the expression for aerodynamic efficiency of a wind turbine. Also comment on how maximum aerodynamic efficiency can be achieved in HAWT, with the help of phasor diagram.
8.	CO3	a. Explain the main factors, which govern the selection of site for a proposed wind farm. b. Explain different methods used to measure wind speed with a neat diagram.
9.	CO4	A four-pole induction generator is rated at 300kVA and 480V. It has the following parameters $R_s = 0.014\Omega$ $R_r = 0.0136\Omega$ $X_s = X_r = 0.15\Omega$ $X_m = 5\Omega$. Calculate the input shaft power at a slip of -0.025.

Section C

All questions are mandatory: (Each question: 20 marks)

Q.no.	COs	Question
10.	CO2	Calculate the total thrust and aerodynamic power developed in a three-blade wind turbine at a wind velocity of 9m/s. The machine specifications are as follows: Diameter = 9m Rotational speed = 100 rpm TSR = 5 Chord length = 0.45m, uniform throughout the blade Pitch angle = 5°, no twist Distance from axis to inner edge of the blade = 0.5m Aerofoil section = NACA 43012A (shown in figure) Note: 1. Divide the blade into four number of sections. 2. Assume relevant values of C_L and C_D if attack angle exceeds the given range  Figure NACA 43012A
11.	CO1	Derive the expression for maximum power generated in a Wind Turbine Also, calculate the maximum power of the same for the below given data: Rotor Diameter = 60 m Wind Speed, V = 7 m/s Air Density, ρ = 1.126 kg/m^3 Power Coefficient, C_P = 0.59

		OR
	CO4	Consider a wound rotor induction machine with the following parameters: $R_1 = 0.005\Omega\ R_2' = 0.004\Omega\ X_1 = 0.01\Omega\ X_2' = 0.008\Omega\ X_m = 0.46\Omega$ The line to line voltage is 480 V. The machine is rated as generator with a nominal power of 2.0 MW at a slip of -0.036. Find the following c. The rated stator current. d. The rated rotor current. e. The actual power supplied. f. The input shaft power. When the rotor circuit is short-circuited. In addition, if the same machine is utilized in standalone system, find the value of capacitor bank to supply adequate reactive power to the system.

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Section A

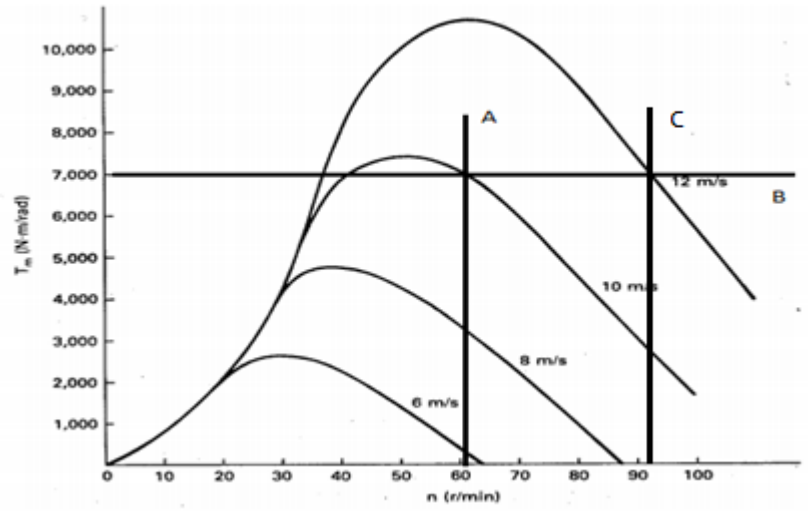
All questions are mandatory: (Each question: 4 marks)

Q.no.	COs	Question
1.	CO1	Elucidate the working principle of Savonius wind turbine with neat diagram.
2.	CO2	Explain tower shadow and its effect on power output of a wind turbine.
3.	CO3	Explain the physical significance of solidity and explain its variation with TSR.
4.	CO4	Describe the working principle of wind pump with a neat diagram.
5.	CO5	Explain wind energy distribution across India with neat diagram.

Section B

All questions are mandatory: (Each question: 10 marks)

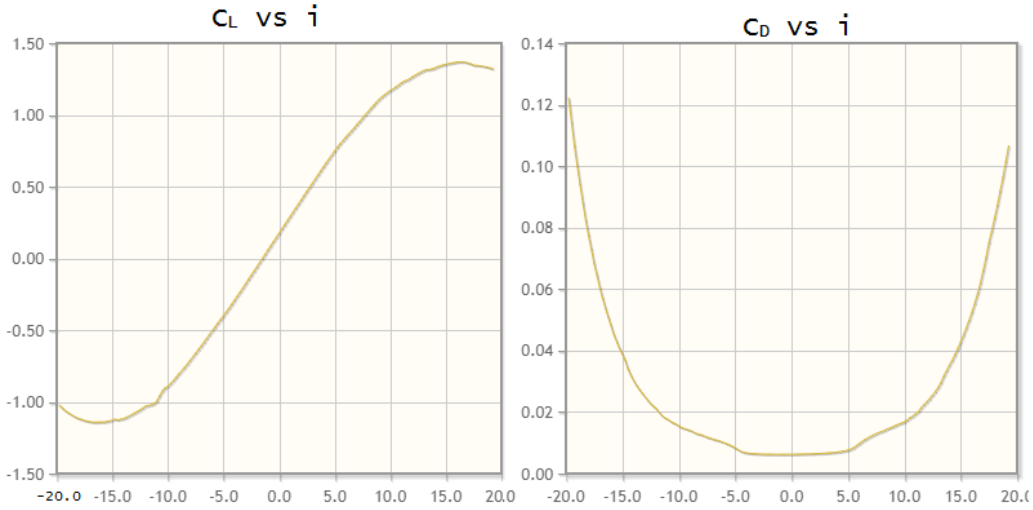
Q.no.	COs	Question
6.	CO1	a. Explain the working principle of wind energy conversion system with a neat diagram. b. Draw the aerodynamic forces acting on a blade of Darrieus rotor at four successive positions.
7.	CO2	Empirically, maximum power coefficient $C_{p_{max}}$ for rotor may be given as function of the following $$C_{p_{max}} = 0.053[R - Q](C_D/C_L)$$ Where $$R = \mu * B^{0.57}[1.58 + (B^{0.57} - 0.04)\mu]$$ $$Q = \frac{[1.92 * \mu^2 * B]}{[1 + 2\mu + B]}$$

		B is the number of blades a. Calculate the values of $C_{p_{max}}$ for $\mu = 4\ and\ 6$ for B = 3 and $(C_D/C_L) = 0.1$ b. Calculate the power developed by the wind turbine with a rotor diameter of 58.76 m, rotational speed of 15 rpm for a wind speed 10 m/s if it is operating at maximum $C_{p_{max}}$ obtained in the previous section.
8.	CO3	The Sandia HAWT has the Torque – speed characteristics as shown below.  Calculate the power from the figure at the intersection of AB and BC. Also, calculate the blade length of the wind turbine, if the ratio of blade length to hub radius is 6.2.
9.	CO4	Explain various types of electrical machines used in wind energy conversion system.

Section C

All questions are mandatory: (Each question: 20 marks)

Q.no.	COs	Question
10.	CO2	Calculate the total thrust and aerodynamic power developed in a three-blade wind turbine at a wind velocity of 9m/s. The machine specifications are as follows Diameter = 9m Rotational speed = 100 rpm TSR = 5

		Chord length = 0.45m, uniform throughout the blade Pitch angle = 5°, no twist Distance from axis to inner edge of the blade = 0.5m Aerofoil section = NACA 63-215 (shown in figure) Note: 1. Divide the blade into four number of sections. 2. Assume relevant values of C_L and C_D if attack angle exceeds the given range  Figure NACA 63-215
11.	CO3	a. Explain principle of operation of standalone and grid connected wind energy conversion system with a neat diagram. b. Derive and explain the equivalent circuit of Induction generator and comment on the torque – speed characteristics. **OR**
	CO4	Consider a wound rotor induction machine with the following parameters: $R_1 = 0.004\Omega\ R_2' = 0.003\Omega\ X_1 = 0.01\Omega\ X_2' = 0.006\Omega\ X_m = 0.68\Omega$ The line to line voltage is 400 V. The machine is rated as generator with a nominal power of 2.0 MW at a slip of -0.035. Find the following a. The rated stator current. b. The rated rotor current. c. The actual power supplied. d. The input shaft power. When the rotor circuit is short-circuited with a resistance R=0.1 ohms. Also, calculate the reactive power requirement of induction generator.