Name: Enrolment No:	UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2018

Programme Name: M. Tech REE **Semester : III**
Course Name : Wind Energy Technology **Time : 03 hrs**
Course Code : EPEC 8008 **Max. Marks : 100**
Nos. of page(s) : 3
Instructions: All questions are mandatory.

SECTION A

S. No.		Marks	CO
Q 1	Compare horizontal axis and vertical axis wind turbine.	4	CO1
Q 2	Draw the phasor diagram representing F_L, F_D, v, u, w if the angle between the chord and wind speed is 45 degrees.	4	CO2
Q 3	A 1.5 MW direct drive variable speed Wind Power Plant rated at 10.8 m/s wind speed has a rotor diameter of 52 m with a blade length of 25m and a speed range of 20 RPM to 30 RPM. Find the range of its tip speed ratio.	4	CO3
Q 4	Explain the blade design procedure applicable for standalone system.	4	CO4
Q 5	Explain the term Levelized cost of electricity (LCOE).	4	CO5

SECTION B

Q 6	A horizontal-axis wind turbine rotates at 80 rpm and the wind speed through the blade is 6 m/s. For a pitch angle of 5 degree (uniform throughout the blade), plot a graph showing the variation of the angle of incidence i with the radial distance along a blade.	10	CO2
Q 7	A wind turbine rated at 100kW has a rated wind speed of 11 m/s, a cut-in speed of 4.5 m/s, and a furling speed of 22 m/s. The wind speed frequency distribution over a year is given by a Weibull distribution having the shape parameter as 5 and scale parameter as 7 m/s. Determine the capacity factor and the yearly energy production. Hint: $f(v)=(\frac{k}{c})v/c^{k-1}e^{-(\frac{v}{c})^k}$	10	CO3
Q 8	a. Discuss the necessary conditions/constraints to be considered while designing a wind-solar hybrid system for any given site. b. Explain the off-shore wind energy scenario of India.	5+5	CO4

<table>
<tr><td>Q 9</td><td>The basic information about the Danish wind farm:

<table><tr><td>Wind farm capacity (MW)</td><td>50</td></tr><tr><td>Capital Investment (€)</td><td>70000000</td></tr><tr><td>Period of operation (years)</td><td>25</td></tr><tr><td>Decommissioning cost (€)</td><td>3000000</td></tr><tr><td>O & M costs (€/kWh)</td><td>0.0091</td></tr><tr><td>Capacity factor</td><td>0.25</td></tr><tr><td>Electricity selling price, tariff (€/kWh)</td><td>0.08</td></tr><tr><td>Annual discount rate (%)</td><td>8</td></tr><tr><td>Inflation rate (%)</td><td>3</td></tr></table>
Use the above information given and find the following
i. AEP
ii. O & M cost in euro for each year (€/year)
iii. Annual revenue from selling the electricity (€/year)
iv. Annual net income (€/year)
v. NPV of the wind farm</td><td>10</td><td>CO5</td></tr>
<tr><td colspan="4">SECTION-C</td></tr>
<tr><td>Q 10</td><td>Design an aerodynamic wind turbine using BEM theory for the Aerofoil NACA 63-215 (shown below in figure 1) to extract 1 MW of electrical power from a particular site having the wind profile given by Rayleigh distribution (shown below in figure 2)

Note: Assume required parameters and mention the same.

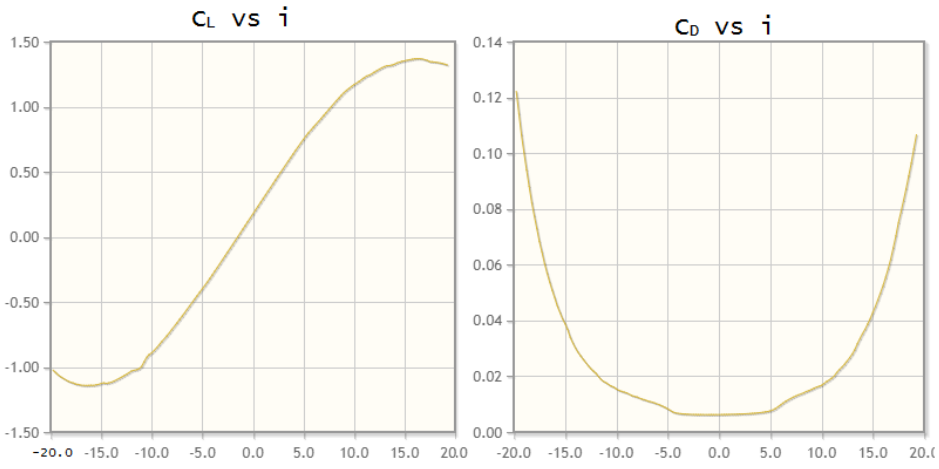
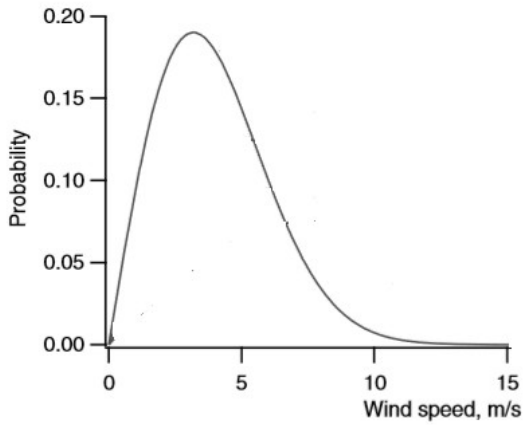
 

Figure 1. NACA 63-215</td><td>20</td><td>CO2</td></tr>
</table>

	 Figure 2. Rayleigh Distribution function		
Q 11	Consider a wound rotor induction machine with the following parameters: $R_s = 0.006\,\Omega\; R'_R = 0.004\,\Omega\; X_S = 0.015\,\Omega\; X'_R = 0.008\,\Omega\; X_M = 0.5\,\Omega$ The line-line voltage is 440 V. The machine is rated as a generator with a nominal power of 2.0 MW at a slip of -0.03. Find the following a. Rated stator and rotor currents, the actual delivered power, and the input shaft power when the rotor is short circuited. b. The value of external resistance added so that the slip of the machine becomes -0.4	**20**	**CO4**

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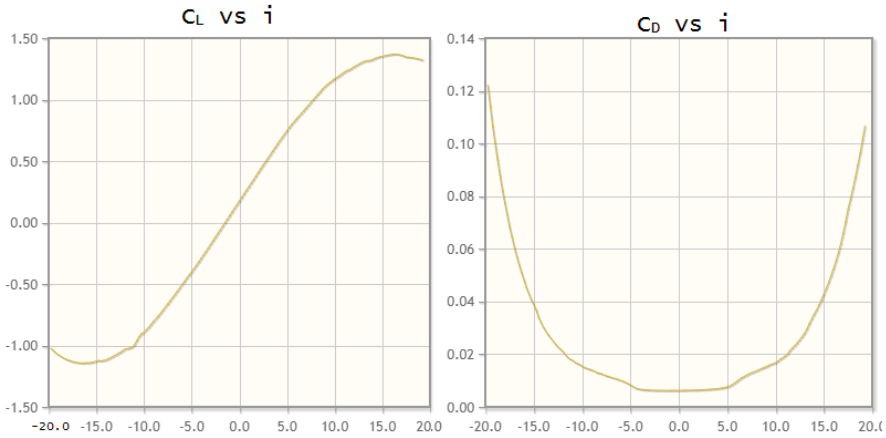
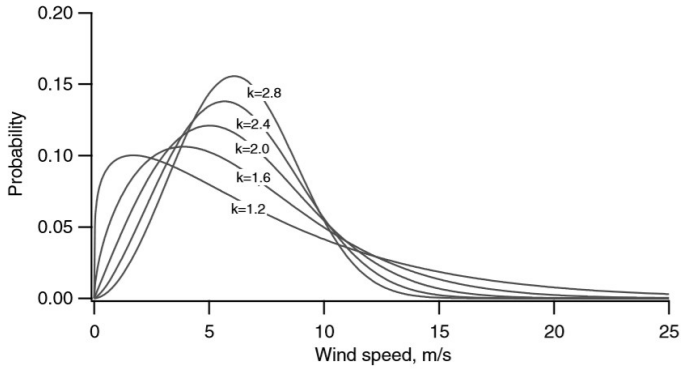
Instructions: All questions are mandatory.

SECTION A

S. No.		Marks	CO
Q 1	Explain why the blade tip of a modern wind turbine can move at a speed about ten times faster than the wind speed.	**4**	**CO1**
Q 2	Find the size of wind turbine rotor (diameter in m) that will generate 1.2 MW of electrical power in a steady wind of 8 m/s. Assume $\rho = 1.226$ kg/m^3 $C_p = 0.45$. Assume $\eta_m = \eta_e = 0.9$.	**4**	**CO2**
Q 3	Explain the physical significance of the following terms: a. Pitch angle b. Tower Shadow	**4**	**CO3**
Q 4	Explain the blade design procedure applicable for grid connected system	**4**	**CO4**
Q 5	Explain in detail about the environmental impacts created by wind farms in the coastal region of India.	**4**	**CO5**

SECTION B

Q 6	Derive an expression for maximum power extracted from a wind turbine with the following assumptions: a. $\eta_{Generator} = 90\%$ b. $\eta_{Wind\ Turbine} = (1/2) ¿ \eta_{Generator}$	**10**	**CO2**
Q 7	The wind data for a site in terms of percentage of time over a year for different speed groups is given below: **Speed group (m/s)** | $0<v\leq3$ | $3<v\leq6$ | $6<v\leq9$ | $9<v\leq12$ | $12<v\leq16$ | $16<v\leq20$ **Percentage of time** | 12.36 | 28.25 | 29.37 | 18.96 | 9.31 | 1.67 Calculate the annual average power in the wind passing normally through the swept area of a turbine of diameter 30 m.	**10**	**CO3**
Q 8	A four-pole induction generator is rated at 300kVA and 480V. It has the following parameters $Rs=0.015\Omega$ $R'_R=0.0132\Omega$ $X_S=X'_R=0.12\Omega$ $X_M=8\Omega$. How much power does it produce at a slip of -0.02? Also, find the torque, power factor and efficiency. (Ignore mechanical losses)	**10**	**CO4**

Q 9	a. Explain the impact of wind resource assessment on the economics of wind farms b. Explain in detail about the various components of cost involved in Wind farm project timeline.	**10**	**CO5**
	SECTION-C		
Q 10	Design an aerodynamic wind turbine using Momentum theory and Blade Element theory for the Aerofoil NACA 63-215 (shown below in figure 1) to extract 1 MW of electrical power from a particular site having the wind profile given by Weibull distribution (shown below in figure 2). *Note: Assume required parameters and mention the same.*  Figure 1. NACA 63-215  Figure 2. Weibull Distribution function	**20**	**CO2**
Q 11	**a.** Explain why DC generator and Synchronous generator are not preferred compared to Induction generator for wind turbine applications. **b.** Derive the expression for shaft power output of an induction machine. If this induction machine is connected to a three bladed wind turbine to satisfy the demand of an isolated system, comment on real and reactive power flow in the induction generator. Assume slip s = -0.036	**20**	**CO4**