Enrolment No:	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, July 2020

Course: Wind Energy Technology **Semester: II**
Program: M. Tech REE **Time 03 hrs.**
Course Code: EPEC 8008 **Max. Marks: 100**

Instructions:

1. **Attempt all the questions (Theory, Numerical, Case study etc.) on A4 size blank sheets.**
2. **Attempt all questions serially as per question paper.**
3. **Answer should be neat and clean. Draw a free hand sketch for circuits/tables/schematics wherever required.**
4. **Scan the whole answer script and check the resolution carefully before you upload on the blackboard. Note that answer scripts will be considered for evaluation only through Blackboard. No other mode of submission is acceptable.**
5. **You are expected to be honest about each attempt which you make to progress in life**

SECTION A - 40 Marks

S. No.		Marks	CO
Q 1	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: Radius = 10m Rotational speed = 100 rpm TSR = 5.5 Chord length = 0.45m, uniform throughout the blade Pitch angle = 5°, no twist Distance from axis to inner edge of the blade = 1m Aerofoil section = NACA 43012A (shown in figure) Note: 1. Divide the blade into three number of sections. 2. Assume relevant values of C_L and C_D if attack angle exceeds the given range	**20**	**CO2**

NOTE : The submission time of the Question Paper Answer Sheet is 24 Hhrs from the scheduled time (*exceptional provision due to extraordinary circumstance due to COVID-19 and due to internet connectivity issues in the far-flung areas*).
No Submission will be entertained after 24 Hrs

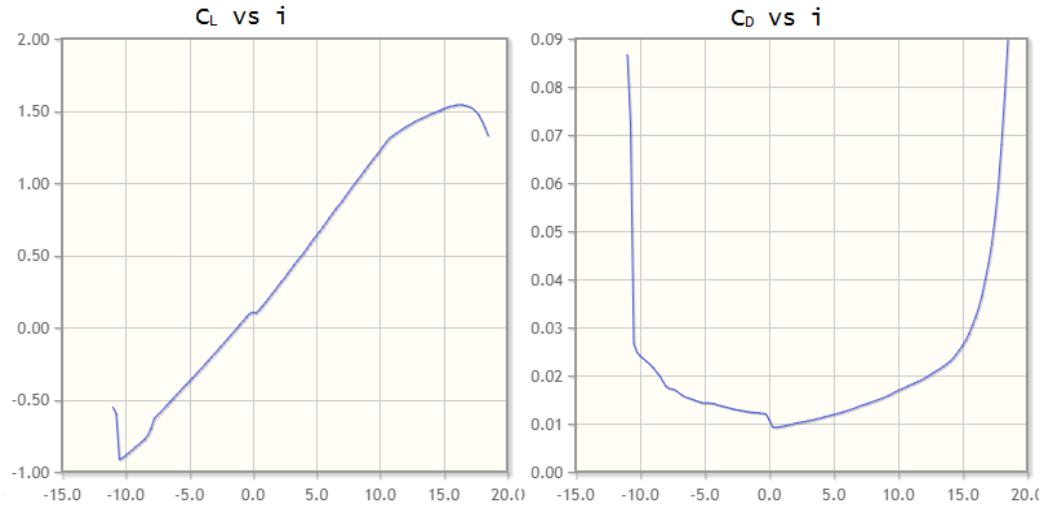
<table>
<tr><td></td><td> 

Figure NACA 43012A</td><td></td><td></td></tr>
<tr><td>Q 2</td><td>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</td><td>10+10</td><td>CO4</td></tr>
<tr><td colspan="4">SECTION B - 60 Marks</td></tr>
<tr><td>Q 3</td><td>Derive an expression for maximum power extracted from a wind turbine with the following assumptions:
a. $\eta_{Generator} = 90\%$
b. $\eta_{Wind\ Turbine} = (1/2) * \eta_{Generator}$</td><td>5+5</td><td>CO2,CO1</td></tr>
<tr><td>Q 4</td><td>The wind data for a site in terms of percentage of time over a year for different speed groups is given below:
<table>
<tr><td>Speed group (m/s)</td><td>$0 < v \leq 3$</td><td>$3 < v \leq 6$</td><td>$6 < v \leq 9$</td><td>$9 < v \leq 12$</td><td>$12 < v \leq 16$</td><td>$16 < v \leq 20$</td></tr>
<tr><td>Percentage of time</td><td>12.36</td><td>28.25</td><td>29.37</td><td>18.96</td><td>9.31</td><td>1.67</td></tr>
</table>
Calculate the annual average power in the wind passing normally through the swept area of a turbine of diameter 30 m.</td><td>10</td><td>CO3</td></tr>
<tr><td>Q 5</td><td>A four-pole induction generator is rated at 300kVA and 480V. It has the following parameters Rs=0.012Ω R'_R=0.015Ω X_S=X'_R=0.10Ω X_M=10Ω. How much power does it produce at a slip of -0.01? Also, find the torque, power factor and efficiency. (Ignore mechanical losses)</td><td>10</td><td>CO4</td></tr>
<tr><td>Q 6</td><td>i. Explain the impact of wind resource assessment on the economics of wind farms</td><td>5+5</td><td>CO5</td></tr>
</table>

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	ii. Explain in detail about the various components of cost involved in Wind farm project timeline.		
Q 7	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 $\eta_m = \eta_e = 0.9$.	**5**	**CO1**
Q 8	Explain the physical significance of the following terms: a. Pitch angle b. Tower Shadow	**5**	**CO3**
Q 9	Draw the equivalent circuit of Induction machine coupled to a wind turbine.	**5**	**CO4**
Q 10	Explain in detail about the environmental impacts created by wind farms in the coastal region of India.	**5**	**CO5**

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