

QUESTION ONE

The BEM Theory comprises the momentum and the blade element theories. The momentum theory examines the axial forces and the annular forces around the wind turbine blades;

- a) Briefly explain the terms Thrust and Torque, the link between them with respect to a wind turbine. (5.5 Marks)
- b) Neatly sketch an airfoil of a wind turbine blade; name and explain all the parts. (5 Marks)
- c) Neatly draw a well labelled side view sketch of a fluid flow, velocity and pressure diagram around a wind turbine. (5 Marks)
- d) Derive the elemental axial force (dF_x) and torque (dT) using the labelled sketches (14.5 Marks)

QUESTION TWO

Various forms of classifications of WTs (Wind Turbines); do exist;

- I. Explain and give two examples of each of the classification of the Wind Turbines according to the amount of the power generated and on rotational direction. For the rotational direction give two other ways of classification. (5.5 Marks)
- II. State and explain the benefits and four disadvantages of using wind energy for a wind turbine (6.5 Marks)
- III. State the major distinguishing aspects between HAWTs and VAWTs that are not in 2 (I) above. (8 Marks)

QUESTION THREE

- a) In approximately 10 steps, explain how an induction motor starts and maintains its motion
- b) Given that an induction motor has 4 poles and is connected to a grid of 50 Hz current;

Determine the;

- i) Synchronous speed of 1500 r/min.
 - ii) The 1% speed slip speed of the rotor
 - iii) The synchronous speed if it is a six-pole motor.
- c) Explain in clear 7 steps how the induction machine can be operated as a Generator; would a four-pole machine with synchronous speed 1500 r/min and 50 Hz frequency operate as a generator. Show how this happens.

QUESTION FOUR

Knowing that economic evaluation analysis methods attempt to manipulate costs and savings in time to some common basis and assess the costs against some comparative objective;

- a) State and explain the six common evaluation methods excluding the Simple Pay Back Period.
- b) Derive one of the commonly used formula in the economic analysis, the Uniform Series Formula (Equal Payment Annuity Formula) given the below terminologies;

QUESTION FIVE

Given a wind turbine with 5 m diameter rotor. Speed of the rotor at 20 m/s wind velocity is 260 r/min and its power coefficient at this point is 0.35. Calculate the tip speed ratio and torque coefficient of the turbine. What will be the torque available at the rotor shaft? Assume the density of air to be 1.24 kg/m^3 .

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