KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2024/2025 ACADEMIC YEAR

FOURTH YEAR FIRST SEMESTER
MAIN EXAMINATIONS

FOR THE DEGREE OF BACHELOR OF SCIENCE IN RENEWABLE ENERGY AND BIO FUELS TECHNOLOGY

COURSE CODE: REN 413

COURSE TITLE: Wind Energy II

DURATION: **2 HOURS**

DATE: 10/01/2025 **8-10AM**

INSTRUCTIONS TO CANDIDATES

- Answer **QUESTION ONE** (Compulsory) and any other **TWO** (2) Question.
- Indicate **answered questions** on the front cover.
- Start every question on a new page and make sure question's number is written on each page.
- Where sketches are used, they MUST be neat and CLEAR to get full marks

This paper consists of **4** printed pages. Please Turn Over

KIBU observes ZERO tolerance to examination cheating

Question One

(a) The aerofoil (airfoil) is important in extraction of energy from wind

i. State what is meant by airfoil and compare it with a hydrofoil **[2 Marks]**

Explain the main advantage of airfoil when used in wind turbines and aircrafts **[2 Marks]**

(b) ii. With the aid of a neat, clearly labeled sketch, explain the meaning of the following terms as related to airfoils.

i. Lift force **[2 Marks]**

ii. Drag force **[2 Marks]**

iii. Angle of attack

iv. Explain the Betz limit and provide its value. **[4 Marks]**

(c) There are two main types of wind turbines; vertical axis, and horizontal axis

i. Explain one advantages and one disadvantages of VAWT **[2 Marks]**

ii. Explain one advantages and one disadvantages of HAWT **[2 Marks]**

iii. Electrical energy is normally measured in kWh, but the SI unit is Joules. Calculate number of Joules in 1 kWh **[2 Marks]**

(d) With the aid of a neat diagram, explain how wind energy can be converted into electrical energy. **[4 Marks]**

(e)

On large wind turbines, blades are slightly twisted from root to tip. Explain in detail why this is necessary. **[4 Marks]**

(f) What is the Capacity Factor (CF) of wind Turbine? What is considered to be a reasonable value for a commercial wind turbine? **[4 Marks]**

Question Two

(a) A *30 m* diameter HAWT is mounted with its hub at *50 m* above a ground surface that is covered by shrubs and hedges. **[12 Marks]**

Estimate the ratio of power in the wind per 1 m^2 of rotor area at the highest point that a rotor blade tip reaches, to the lowest point that it falls to.

(b) The wind gradient (or wind exponent) shows the variation of air velocity in the boundary layer profile above the solid ground. It depends on the roughness of the ground surface, usually denoted by the roughness length factor. **[4 Marks]**

For an unknown roughness length factor, find the wind speed at 120 meters above ground, if the wind speed at 40 m and 80 m has been measured as 4 m/s and 4.5 m/s, respectively.

$$V_2 = V_1 \frac{\ln\left(\frac{h_2}{z_0}\right)}{\ln\left(\frac{h_1}{z_0}\right)} \qquad P = \frac{1}{2}\rho A v^2 \qquad \lambda = \frac{\omega R}{V_1}$$

(c) Define wind park efficiency or wind farm efficiency. What major loss factors are present in wind parks or wind farms? **[4 Marks]**

Question Three

(a) Distinguish clearly between

(a) Constant speed constant frequency WTG unit. **[1 Marks]**

(b) Variable speed constant frequency WTG system. **[1 Marks]**

(c) Nearly constant speed constant frequency system. (16) **[1 Marks]**

(b) Why is a tall tower essential for mounting a horizontal axis wind turbine? **[7 Marks]**

(c) Describe the electrical layout of a typical wind form by means of single line diagram. State the essential equipment. **[10 Marks]**

Question Four

(a) In the process of controlling a wind turbine generator, very many control measures are implemented. Describe the *purpose* and *mechanism* for carrying out the following.

i. Yaw control **[3 Marks]**

ii. Pitch control **[3 Marks]**

iii. Teetering control **[3 Marks]**

(b) With the aid of another vector diagram, illustrate the principle of pitching to feather. **[6 Marks]**