



# UNIVERSITY OF MINES AND TECHNOLOGY, TARKWA

SECOND SEMESTER EXAMINATIONS, APRIL/MAY 2019

**COURSE NO:** RN 276

**COURSE NAME:** WIND ENERGY AND MEASUREMENT TECHNIQUES

**CLASS:** RN II

**TIME:** 3 HOURS

Name: \_\_\_\_\_ Index Number: \_\_\_\_\_

**ANSWER ALL QUESTIONS IN YOUR ANSWER BOOKLET PROVIDED**

## **SECTION A**

***ANSWER TRUE OR FALSE both in your answer booklet and question paper. The question paper must be tied loosely into the answer booklet.***

1. Wind turbine starts to produce power only when cut-out wind speed is reached.
2. The relationship between wind speed and rated power is called power curve.
3. Turbulence intensity increase with increasing height above ground level.
4. Thermal turbulence is caused by vertical wind shear and depends on the surface roughness.
5. For Darrieus rotor, an external power source is required to start the rotation.
6. Sonic anemometers have moving parts.
7. Raster data model is most appropriate when used to represent continuous data.
8. Geospatial data describe both the positions and characteristics of spatial features.
9. At very low wind speeds, the wind turbine can even become a power consumer.
10. The vertical wind shear is generally small in stable condition due to the heavy mixing.
11. Wind roses help site assessors understand where to site a tower relative to landform.
12. It is advisable to use an anemometer with a sine response for resource assessment.
13. Vector data are ideal for continuous features such as elevation and precipitation.
14. The primary causes of wind are the even heating of the earth and its atmosphere by solar radiation and the earth's rotation.
15. The distribution of the wind direction is important for the layout of a wind farm.

16. In fixed-speed wind turbines, capacitors may be switched to provide more apparent power as the wind power increases.
17. Common examples of data that fit into the raster data model include aerial photographs, satellite images, roads, scanned maps.
18. The best estimate of AEP is the calculated value from measured wind speed data and the power curve of a wind turbine.
19. VAWTs are sensitive to wind direction and do not require yaw systems.
20. Larger numbers of blades result in higher drag and produce more power.
21. Two-speed configuration has the benefit of reducing aerodynamic noise at low wind speeds.
22. Variable-speed operation is possible with any type of generator.
23. For stall control, the blades will be stalled, causing reduction in lift and hence tangential force.
24. Gearless wind power plants have advantages such as lower noise levels.
25. The more pronounced the roughness of the earth's surface, the more the wind will be slowed down.
26. A plot displaying the frequency of occurrence by direction is called a wind rose.
27. The wind power density is proportional to the swept area.
28. In the smock mill, the body can be turned by hand to face the wind when its direction changes.
29. Annual variations refer to variations in seasonal or monthly averaged wind speeds.
30. The blades of smock mill are designed to have a bit of an aerofoil shape.
31. The free atmosphere is the lowest part of the atmospheric boundary layer.
32. Wind gust is a short-term discrete event within a turbulent wind field.
33. Signal conditioners also supply power to the anemometer when required.
34. Projected coordinate system is expressed in longitude and latitude.

35. The logarithmic law is useful in flat terrain and stable conditions.
36. In GIS, polygons can be used for delineation of surface mines.
37. An equidistant projection represents areas in correct relative size.
38. A conformal projection preserves local shapes.
39. Lift force is an aerodynamic force perpendicular to direction of the free stream wind.
40. Frictional drag and obstructions near the earth's surface induce a phenomenon known as wind shear.
41. The concept of a starting threshold speed is applicable in Sonic anemometers.
42. In lift machines, the blade translation velocity cannot exceed the effective wind speed.
43. Sonic anemometers provide wind speed measurement from calm conditions upward.
44. Mountains and hills can be used to improve the power output from a wind farm.
45. Wind speed increases significantly with rising roughness lengths.
46. SODAR cannot be used to detect wind gusts.
47. Solidity is measured by the rotor area over blade area.
48. The power law is valid for neutral atmosphere and up to approximately 60 m height.
49. Pumped hydroelectric are used for smoothing power fluctuations on the order of seconds to minutes.
50. There is no need to turn downwind turbine into wind.

**SECTION B**

**Choose the correct answer from the options provided (A – D)**

51. The airflow above certain height which is considered largely free of surface influences is known as the \_\_\_\_\_
- a. geostrophic wind
  - b. gyroscopic wind
  - c. trophic wind
  - d. non-geostrophic wind
52. In generation of wind, what does heating and cooling of the atmosphere generates?
- a. Thermo line circulation
  - b. Radiation currents
  - c. Convection currents
  - d. Conduction currents
53. Wind shear exponent depends on several factors except
- a. time of day
  - b. roughness of the terrain
  - c. temperature gradients
  - d. none of the above
54. Geometric parameters that influence the aerodynamic performance of an aerofoil include
- a. mean camber line
  - b. maximum thickness
  - c. thickness distribution of the profile
  - d. all of the above
55. Low solidity rotors use which of the following force for rotation.
- a. Drag
  - b. Lift
  - c. Torque
  - d. Thrust
56. The annual energy production (AEP) can be estimated by the following methods except
- a. generator size
  - b. hub height
  - c. rotor area and wind map values

- d. manufacturer's curve of energy versus annual average wind speed
57. Surface layer is the air layer considered from the height of local obstruction to a height of about
- a. 50 m
  - b. 100 m
  - c. 150 m
  - d. 200 m
58. The wind intensity can be described by
- a. Reynolds number
  - b. Mach number
  - c. Beaufort number
  - d. Betz limit
59. Which of the following will not have an impact on the wind turbine designs output?
- a. Blade angle
  - b. Rotor weight
  - c. Blade size
  - d. None of the above
60. Winds having following speed are suitable to operate wind turbines.
- a. 5 – 25 m/s
  - b. 10 – 35 m/s
  - c. 20 – 45 m/s
  - d. 30 – 55m/s

## SECTION C

Answer only one question in this section

### QUESTION 1

- a) What is Remote Sensing? [2 marks]
- b) List four ancient windmill and briefly describe one of them. [6 marks]
- c) Briefly explain the components of GIS [4 marks]
- d) State the two principal methods of achieving variable speed operation and briefly describe one of them. [6 marks]
- e) State three advantages and disadvantages of horizontal axial wind turbines. [6 marks]
- f) Estimate the annual production of a 12 m diameter horizontal axis wind turbine operating at standard atmospheric conditions ( $\rho = 1.225 \text{ kg/m}^3$ ) in 8 m/s average wind speed regime. You are to assume that the site wind speed probability density is given by the Rayleigh density distribution. [4 marks]
- i. Calculate the wind speed at 100 m if the wind speed at 50 m is 8 m/s and the shear exponent is 0.21. [2 marks]

### QUESTION 2

- a) Why do we refer to the energy from wind farm as non-dispatchable? [4 marks]
- b) Differentiate between drag and lift machine. [4 marks]
- c) State the various ways to improve fixed speed wind turbines and briefly describe one of them. [6 marks]
- d) State three advantages and disadvantages of vertical axial wind turbines. [6 marks]
- e) Briefly explain four environmental impacts of wind energy systems. [4 marks]
- f) Analysis of time series data for a given site has yielded an average velocity of 6 m/s. It is determined that a Rayleigh wind speed distribution gives a good fit to the wind data.
- i. Based on a Rayleigh wind speed distribution, estimate the number of hours that the wind speed will be between 9.5 and 10.5 m/s during the year. [3 marks]
- ii. Using a Rayleigh wind speed distribution, estimate the number of hours per year that the wind speed is above 16 m/s. [3 marks]

**Examiner: D. Yellezuome/ I. Osei**