KIBABII UNIVERSITY

2017/2018 ACADEMIC YEAR

THIRD YEAR SECOND SEMESTER

MAIN EXAMINATIONS

FOR THE DEGREE OF BACHELOR OF SCIENCE IN RENEWABLE ENERGY AND BIOFUELS TECHNOLOGY

COURSE CODE: IET 312

COURSE TITLE: Wind and Wave Energy

DATE: 17/10/2018 TIME:

INSTRUCTIONS TO CANDIDATES

Answer question ONE and any other two questions

This paper consists of 2 printed pages. Please Turn over

Question One

(a) Outline the key requirements to be considered during the site selection process for a wind farm project [7 Marks]

(b) State and describe the functions of the main components of a commercial horizontal axis wind turbine [6 Marks]

(c) Explain how energy from the sun causes sea waves [5 Marks]

(d) Determine the wind power passing through a wind turbine with the following conditions: [5 Marks]
Turbine radius = 0.2m, Wind speed = 3 m/s, Air density = 1.23 kg/m^3

(e) The Betz Limit (or Betz' Law) specifies the theoretical maximum power efficiency of any design of wind turbine. State the value as a percentage [1 Mark]

(f) HAWT (Horizontal Axis Wind Turbine) and VAWT (Vertical Axis Wind Turbine) designs have advantages and disadvantages over each other. State the advantages of each of the turbines [6 Marks]

Question Two

(a) A particular form of the log law for wind shear in the lower atmospheric boundary layer can be written as:

$$U_{(z)} = \frac{U^*}{k}[Ln(z/z_0]$$

(i) Describe carefully all the terms which appear in this equation and the conditions under which it applies [5 Marks]

(ii) Explain why this form of the log law is not normally applied directly [3 Marks]

(iii) State the form of the log law usually applied explaining any new variables you have introduced. State the height to which this relation can be considered accurate. [2 Marks]

(b) (i) A site has an annual mean wind speed of 7.5m/s at a measurement height of 50m. If the annual wind speed at the same location, but at a height of 10m, is 6m/s, estimate the effective surface roughness for the site. [8 Marks]

(ii) Name the terrain that characterizes the site [2 Marks]

Question Three

(a) Briefly describe the operating principles of

(i) An Oscillating Water Column [3 Marks]

(ii) A Tapchan scheme [3 Marks]

(b) (i) Explain the benefit of using offshore as opposed to onshore or near shore wave devices [8 Marks]

(ii) Name two near shore wave energy converters, which do not use the operating principles of either of the onshore devices discussed in part (a). [2 Marks]

(iii) State the characteristics of the Wells turbine that make it so suitable for use with wave energy converters [4 Marks]

Question Four

(a) Sketch a typical power curve of Horizontal axis wind turbine indicating on the graph the cut-in, rated, and cut-out wind speeds [10 Marks]

(b) Explain the reasons why the cut-in and cut-out wind speeds are imposed [10 Marks]

Question Five

A wind farm developer wishes to make an estimate of the long-term (10 year) mean wind speed at a potential wind farm site, at a wind turbine hub height of 60m. There is a Met Station at a distance of approximately 50km from the site. The developer has erected a single mast at the potential wind farm site to make measurements of hourly averaged wind speed and wind direction at 10m above ground level. The measurement campaign lasts for six months. The developer is to perform an MCP analysis using concurrent data at the Met Station and the mast in conjunction with long term wind speed statistics at the Met Station.

(a) Describe three variants of the MCP method s/he might use, and indicate the conditions under which each method is appropriate. **[7 Marks]**

(b) (i) Discuss what further step the developer must make to produce an estimate of the long-term mean wind speed at the wind turbine hub **[5 Marks]**

height.

(ii) Name additional data the developer will require regarding the site to do this accurately **[2 Marks]**

(c) Describe two improvements to the data available to the developer that would improve the estimate of the long-term mean wind speed at the site. **[6 Marks]**