FIJI NATIONAL UNIVERSITY

COLLEGE OF ENGINEERING, SCIENCE AND TECHNOLOGY

SCHOOL OF ELECTRICAL AND ELECTRONICS ENGINEERING

PROGRAMME: BACHELOR OF ENGINEERING (ELECTRICAL & RENEWABLE)
YEAR 4 (BENG 4)

EEE791 RENEWABLE ENERGY & NEW TECHNOLOGIES

FINAL EXAMINATION
SEMESTER 2, 2015

TOTAL MARKS: 100
No. of Pages: 5

Duration: 3 hours

DATE/TIME/ROOM – Refer to Timetable

INSTRUCTIONS TO CANDIDATES

1. You are allowed 10 minutes extra time during which you are not to write.
2. Begin each answer on a fresh new page and use both sides of the sheets.
3. Write your identification number on the top of each attached sheet.
4. Insert all written foolscaps, graph paper, drawing paperetc. in their correct sequenceand secure with string provided.
5. For all sheets of paper in which has been done, cross it through and you must attach to your answer script.
6. Write clearly the number(s) of the question(s) attempted on the top of each sheet.
7. A formula sheet has been attached at the back.
8. *There are FOUR (4) sections,* ***ALL SECTIONS ARE COMPULSORY.***

SECTION A [25 Marks]

1. Write short notes on the global energy scenario. Highlight the progress in the Renewable Energy sector globally. Finally, comment on the energy scenario in the PICs and our dependence on fossil fuels.

[5 marks]

2. Samoa is located at 13.83° South latitude and 171° West longitude. Find the length of day on September 10. **[5 marks]**

3. A solar cell with a dark current of 8×10^{-9} A at 300K delivers a short-circuit current of 50μA when exposed to 800 lux illumination. A solar power supply is required with 5V open-circuit voltage and 2mA short-circuit current when the illumination level is 400 lux. How many solar cells would be needed and how would they be connected? **[5 marks]**

4. For the system specs given below, carry out system sizing showing the possible arrangement of batteries and solar PV panels. Also, size the charge controller and inverter.

[10 marks]

Inverter Efficiency = 90%
Location = Suva
Inverter Voltage =12V
BP Solar panel 120W, I = 6.12A

Battery DOD = 50%
Peak sun hour = 4
Battery Capacity = 50Ah @ 6V
Consecutive days without sun light = 2

Load table:

Appliance	AC/DC	Watts	Duty cycle hour/day
4 Lights@10 W each	AC	40	5
TV	AC	40	5
Laptop	AC	150	2
Radio	AC	40	4
Lights	DC	12	4

SECTION B [25 Marks]

1. Elaborate on the types and operating principle of Concentrated Solar Power (CSPs). **[4 marks]**
2. Differentiate between cut-in and cut-out speed and also draw a typical power curve of a wind turbine. **[2 marks]**

3. Based on average speed data only, estimate the annual energy production from a horizontal axis wind turbine with a 12m diameter operating in a wind regime with an average wind speed of 8m/s. Assume that the wind turbine is operating under standard atmospheric conditions ($p = 1.225\ kg/m^3$). Assume a turbine efficiency of 0.4 **[4 marks]**

4. Determine the wind speed at a height of 40m over surface terrain with few trees using the logarithmic law, if the wind speed at a height of 10m is known to be 5m/s. ($z_0 = 100mm$) **[2 marks]**

5. From an analysis of wind speed data (hourly interval) average taken over a one year period, the weibull parameters are determined to be c = 6 m/s and k = 1.8.
   a) What is the average velocity at this site?
   b) Estimate the number of hours per year that the wind speed will be between 6.5 and 7.5 m/s during the year. **[6 marks]**

6. Four identical wind turbines that are lined up in a row 12 rotor diameters apart are experiencing wind parallel to the row of wind turbines. Use Katic's wake model to determine the speed of the wind approaching each of the wind turbines. Assume that k = 0.10 and that the thrust coefficient is 0.7. **[7 marks]**

SECTION C [25 Marks]

1. Define the term *biomass*. **[2 marks]**

2. Elaborate on pathways from biomass to useful energy. **[4 marks]**

3. Explain the following thermal power plant principles:
   i) Combined Heat and Power Plant (CHP) thermal power plant.
   ii) Integrated gasification combined cycle (IGCC) **[6 marks]**

4. Discuss Rankine and Brayton cycles. Comment on their efficiencies. **[3 marks]**

5. An Independent Power Producer (IPP) plans to build a 5MW biomass-fired steam Power Plant. The feedstock will be provided by the timber residues from a saw-mill that uses mahoghany and pine trees for furniture production.

i) Estimate the mass of saw-mill residues that will have to be delivered to the power plant everyday if the energy content of the residue, which has a wet basis moisture content of 40%, is 15MJ/kg. Assume the firebox has a 25% heat loss, the average temperature of the steam generated in the boiler is 380°C, and the electrical generator is 80% efficient. (Assume temperature of the exhaust gases is 40°C and the heat engine is operating at carnot efficiency). (Hint: carnot efficiency $\eta_C = 1 - T_C/T_h$) **[6 marks]**

ii) The moisture content requirement for feedstock for the power plant is 25% or less. If the feedstock is sun-dried to reduce its moisture content to this value, what mass of this dry feedstock will be required each day (24 hours) by the power plant? **[4 marks]**
(Hint: Research on this formula and use in this part for moisture content. This formula gives the energy or Calorific value depending on a certain percentage of moisture content.

$$E(w) = Eo\left[\frac{100 - w}{100}\right] - \frac{2.44w}{100}$$

SECTION D [25 Marks]

1. Elaborate upon thermo-chemical and bio-chemical processes (at least 2 for each) that could be utilized for biomass (waste) to energy conversion. **[3 marks]**

2. Tabulate the fuel properties that bio-fuels should have to serve as a good fuel for a diesel engine. **[3 marks]**
3. Explain how energy could be produced from the following, with its associated technology:
   i) Tidal energy
   ii) Wave energy **[4 marks]**

4. Discuss closed loop OTEC cycle. **[2 marks]**

5. Describe how geothermal energy could be generated. Explain global trends, associated risks and hazards. Also provide some potential sites in Fiji. **[4 marks]**

6. Briefly explain on the effects that could be encountered on a grid system if there is high penetration of intermittent sources like wind and solar energy. State as to how this problem could be encountered. You may explain using the correlation between daily demand and solar/wind output variation data. **[4 marks]**

7. Explain the **"Micro-grid concept"** and give some advantages of **"Embedded Generation"**.

   [3 marks]

8. Comment on the following relationships of variables in a Power System:

   i) Active power and frequency
   ii) Reactive power and voltage **[2 marks]**

THE END

Formula Sheet

1.

$$\delta = \delta_0 \sin\left[\frac{360(284+n)}{365}\right]$$

2. $N = \frac{2}{15}\cos^{-1}(-\tan\phi\tan\delta)$

$\phi = latitudes$

$\delta = declination$

3.

$$\frac{U(Z)}{U(Zr)} = \frac{\ln\left(\frac{Z}{Zo}\right)}{\ln\left(\frac{Zr}{Zo}\right)}$$

4.

$$V_{OC} = \frac{kT}{e}\ln\left(1+\frac{I_P}{I_0}\right)$$

5.

$$P_W(U) = \frac{1}{2}\rho A C_P \eta U^3$$

6.

$$p(U) = \frac{\pi}{2}\left(\frac{U}{\bar{U}^2}\right)\exp\left[-\frac{\pi}{4}\left(\frac{U}{\bar{U}}\right)^2\right]$$

$$F(U) = 1-\exp\left[-\frac{\pi}{4}\left(\frac{U}{\bar{U}}\right)^2\right]$$

7.

$$p(U) = \left(\frac{k}{c}\right)\left(\frac{U}{c}\right)^{k-1}\exp\left[-\left(\frac{U}{c}\right)^k\right]$$

$$F(U) = 1-\exp\left[-\left(\frac{U}{c}\right)^k\right]$$

8.

$$\frac{c}{U} = \left[0.568+\frac{0.433}{k}\right]^{-\frac{1}{k}}$$

9.

$$1-\frac{U_x}{U_0} = \frac{\left(1-\sqrt{1-C_T}\right)}{\left(1+2k\frac{x}{D}\right)^2}$$

10.

$$E(w) = Eo\left[\frac{100-w}{100}\right]-\frac{2.44w}{100}$$