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, 2016

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 paper etc. in their correct sequence and 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 global electricity production figures and the current percentage contribution by RE Technologies. State the challenges faced by countries in the deployment of RE Technologies. Also discuss the Pacific energy scenario and the current RE resources in existence and the potential. Finally, elaborate on the global warming and climate change impacts to the PICs. **[4 marks]**

2. Calculate the sunrise and sunset times on 1st May 2017 in Suva (latitude 18.1° South). **[4 marks]**

3. Find the length of the day on 14th March 2018 in:
   i) Suva (latitude 18.2° South) and in
   ii) Oslo (latitude 60° North) **[4 marks]**

4. A solar cell with a dark current of 100 nA at 300K delivers a short-circuit current of 300 mA when exposed to a certain illumination. A solar power supply is required with 12V open-circuit voltage and 6 A short-circuit current when the illumination level is increased by 50%. How many solar cells would be needed and how would they be connected? **[4 marks]**

5. 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. **[9 marks]**

Inverter Efficiency = 90%
Location = Suva
Inverter Voltage =12V
BP Solar panel 150W, I = 8.12A
Battery DOD = 50%
Peak sun hour = 3.5
Battery Capacity = 100Ah @ 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. Describe the principle of operation of the following:
   - Parabolic Trough Power Plant
   - Solar power tower
   - Grid-connected PV System **[3 marks]**

2. 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.
   i) What is the average velocity at this site?
   ii) Estimate the number of hours per year that the wind speed will be between 4 and 6 m/s during the year.
   iii) Estimate the number of hours per year that the wind speed is above 10 m/s **[5 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 combined power coefficient and turbine efficiency of 0.3. **[3 marks]**

4. Determine the wind speed at a height of 60m over surface terrain with few trees, if the wind speed at a height of 10m is known to be 5m/s. For your estimate, use two different wind speed estimation methods. **[3 marks]**

5. 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.
   a) Based on Rayleigh wind speed distribution, estimate the number of hours that the wind speed will be between 9 and 11 m/s during the year.
   b) Using a Rayleigh wind speed distribution, estimate the number of hours per year that the wind speed is equal to or above 14 m/s. **[4 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. Elaborate on currently available pathways to extract useful energy from biomass. **[4 marks]**

2. Explain the following thermal power plant principles:
   i) Combined cycle power plants.
   ii) Integrated gasification combined cycle (IGCC) **[4 marks]**

3. Provide details of the following processes with regards to harnessing of biomass:
   i) Pyrolysis
   ii) Fermentation
   iii) Anaerobic Digestion **[3 marks]**

4. An Independent Power Producer (IPP) plans to build a 10MW 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]**

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

5. About 3 million tonnes of sugarcane are harvested each year in Fiji over a 6-month period. What power could a bagasse-fired steam generator produce during this period if the overall bagasse to electricity efficiency for this plant is 15%? Assume one tonne of cane produces 0.275 tonnes of bagasse. (Calorific value of bagasse is 15MJ/kg). **[4 marks]**

## SECTION D [25 Marks]

1. Explain how Wave energy is generated using a CETO device. **[2 marks]**

2. State the technology used to harness Tidal Energy. **[2 marks]**

3. Discuss open loop OTEC cycle. **[3 marks]**

4. Tabulate the fuel properties that bio-fuels should have to serve as a good fuel for a diesel engine. **[3 marks]**

5. Explain the dry steam, flash steam and binary cycle for a geothermal power plant. **[3 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 some operational strategies and some technical solutions to overcome instabilities due to intermittent RE resources. **[4 marks]**

7. Elaborate on three advantages of **"Embedded Generation"**. **[3 marks]**

8. Explain **"Load flow analysis"** and the importance of it. **[3 marks]**

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

   i) kW requirement and frequency
   ii) kVar requirement and voltage **[2 marks]**

THE END