FIJI NATIONAL UNIVERSITY

COLLEGE OF ENGINEERING, SCIENCE AND TECHNOLOGY

SCHOOL OF ELECTRICAL AND ELECTRONICS ENGINEERING

PROGRAMME: BACHELOR OF ENGINEERING (ELECTRICAL & RENEWABLE)
YEAR 3 (BENG 3)

EEE784 POWER GENERATION

FINAL EXAMINATION

SEMESTER 1, 2017

TOTAL MARKS: 100
No. of Pages: 6

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. *There are Four (4) sections,* ***ALL SECTIONS ARE COMPULSORY.***

SECTION A Short Answer Questions [25 Marks]

1. Compare "**Centralised Generation and Distributed Generation**". **[2 marks]**

2. Describe what you understand by the term "**Inter-connected System**" with regards to a power system and give two advantages of it. **[2 marks]**

3. Explain the following systems of a "**Diesel Power Plant**".

   i) Exhaust System
   ii) Starting system **[2 marks]**

4. Explicate the term "**synchronizing**" and state any 4 requirements of it. **[2 marks]**

5. How does a "**Governor**" and a "**Prime-mover**" work in collaboration to control frequency in a power system? **[2 marks]**

6. Define "**Reverse Power Condition**". **[1 mark]**

7. Explain the term "**Power Factor**" and elaborate on the significance of high power factor to power generation costs. **[2 mark]**

8. Elaborate on the term "**Spinning Reserves**" and explain the essence of it. **[2 mark]**

9. Define "**Tariffs**". **[1 mark]**

10. Describe the term "**Capacity factor**". **[2 mark]**

11. Comment on the functions of the following in a thermal power plant:
    i) Condensor
    ii) Air Preheater **[2 marks]**

12. Discuss any 6 components of a substation. **[3 marks]**

13. Explain any four components of a hydro power plant. **[2 marks]**

SECTION B [25 Marks]

1. A 3 jet pelton wheel produces an output power of 12.5MW from a head of 415m if head loss is 3% of total height, and the turbine efficiency is 90% and the nozzle area is 191.13cm^2 what is the power at the nozzle and the efficiency of the generator? **[5 marks]**

2. A Hydroelectric plant is supplied from a catchment area of 400 km^2 with an annual rainfall of 1200 mm and head of 300 m. Consider a yield factor of 50% and load factor of 70 %. Calculate the power produced and the capacity of the power plant if the power plant has an efficiency of 85 %. **[4 marks]**

3. A mountain stream flows down the slopes of the mountain to a village 125 m below. A hydropower schemes is planned for the village that will consist of a power-house at the foot of the mountain, fed by water diverted from a weir that is built at the top of the mountain. The narrowest part of the stream on the mountain has a cross-sectional area of 5 m x 4 m, and a flow velocity of 0.75 m/s.
   Assume 20% of the water is diverted at the weir to the powerhouse.
   i) Draw a diagram of the scheme that starts from the stream at the top of the mountain to the tailrace of the powerhouse. **[2 marks]**
   ii) Calculate the power at the jet if the head loss is 25m. **[2 marks]**
   iii) Calculate the efficiency of the turbine if the output power is 2000kW and the efficiency of the generator is 90%. **[2 marks]**

4. A 6 MVA, 50 Hz, 3-phase star connected synchronous generator having a synchronous reactance of 25 % is running at1500 rpm and is excited to give 11000 V. Calculate the synchronizing power per two mechanical degree of displacement and the corresponding synchronizing torque. **[5 marks]**

5. When two generators are connected in parallel and are jointly supplying the demand in a small power system, the load is shared according to the set points of their governors. Suppose in a small power system, two generators A and B rated at 100MW and 200MW respectively supply a load of 200MW. Both generators are fitted with governors having a droop of 4% and a no-load set point of 52Hz

   i) Using trigonometry, find out the load taken by each of the generators (A and B). **[3 marks]**

   ii) Determine the system frequency **[2 marks]**

SECTION C [25 Marks]

1. About 3 million tonnes of sugarcane are harvested each year in Fiji over a 6-monthperiod.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]**

2. Sketch and describe the operating cycle of an "Integrated Gasification Combined Cycle Power Plants" (CCPP). **[3 marks]**

3. An Independent Power Producer (IPP) plans to build a 20MW 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.

   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 boiler has a 75% efficiency, the average temperature of the steam generated in the boiler is 380°C, and the electrical generator is 85% efficient. (Assume temperature of the exhaust gases is 40°C and the heat engine is operating at carnot efficiency). **[5 marks]**

4. A table containing energy usage information for a Maximum Demand customer is given below:

Tariff Description	Reading type	Meter Number	Reading		Usage	Billed Days
			Present	Previous		
MD Step3	Normal Reading	HM00025:1	35837495	34683812	1153683	28
MD Consumption		HM00025:2	00002643	000000000	2643	28
Reactive Units	Normal Reading	HM00025:3	73979240	73455177	524063	28

Table 1.0

To assist you with the bill calculation, the following information is also given below:

Demands between 75KW – 500KW	Tariff Price – VAT Exclusive
Demand Charge - dollars per kW per month	$38.19
Energy Charge cents per kWh per month	31.63 cents
Excess Reactive Energy - cents per kVarh per month	1.30 cents

Table 2.0

- Allowed Reactive Energy = 0.62 x Total kWh (for the relevant billing period). Any reactive power which is used over this calculated 'Allowed Reactive Energy' figure is the 'Excess Reactive Energy' and is chargeable at a rate of $0.4180 /kVarh.

For the information provided above, calculate the bill for the Maximum Demand customer that has an opening balance of $20,000.00 DR (owing) showing a step by step calculation and also taking VAT into account. **[5 marks]**

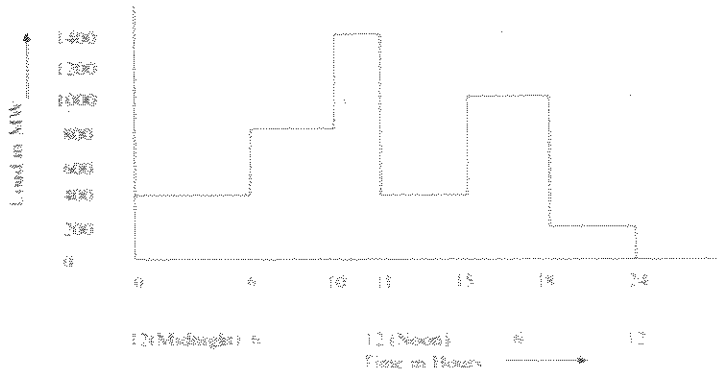
5. Discuss any three different types of substations. **[2 marks]**

6. Briefly outline the arrangement of a double bus-bar system in a substation. **[3 marks]**

7. Explain earthing grids. Briefly illustrate the arrangement. **[3 marks]**

SECTION D **[25 Marks]**

1. The load curve of a large power station is given below.



With the aid of the curve, answer the following questions:

i) What is the base load and peak load of the power station?
ii) Calculate the units generated per day.
iii) Calculate the load factor.
iv) Draw the load duration curve. **[5 marks]**

2. The peak load on a power station is 60MW. The load having maximum demand of 30, 20, 15 and 10MW are connected to the power plant. The capacity of the power plant is 80 MW and the annual load factor is 0.80. Estimate:
   a) The average load on the power plant
   b) The energy supplied per year

c) The demand factor
d) The diversity factor
e) The utilization factor
f) The plant capacity factor **[6 marks]**

3. A power station has a maximum demand of 20 MW. The annual load factor is 40%, and the plant capacity factor is 35%. Determine the reserve capacity of the plant. **[4 marks]**

4. A single phase 230 V 50Hz induction motor draws 15A at 0.6 power factor. Determine the line current and power factor when an 80μF capacitor is connected across the line. **[4 marks]**

5. A 250V, 50Hz single phase supply feeds the following loads:

i) Incandescent lamps taking a current of 10A at unity power factor
ii) Fluorescent lamps taking 8A at a power factor of 0.7 lagging
iii) A 3kVA motor operating at full load and at a power factor of 0.8 lagging

Determine:

a) The total current **[2 marks]**
b) The overall power factor **[1 marks]**
c) The total power **[1 mark]**
d) Find the value of the capacitor needed to improve the overall power factor to 0.975 lagging. **[2 marks]**

THE END