THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND COMMUNICATIONS ENGINEERING

FIRST SEMESTER EXAMINATION (2021)

EE441 POWER SYSTEMS PLANNING AND RELIABILITY

FINAL YEAR ELECTRICAL ENGINEERING – POWER (BEEP 4)

TIME ALLOWED: 3 HOURS

INFORMATION FOR STUDENTS

1. THIS IS AN OPEN BOOK EXAM. Answer all questions.
2. All answers must be written in the **ANSWER BOOK** supplied.
3. There are five (5) questions. Marks per question are indicated
4. COMPLETE THE DETAILS REQUIRED ON THE FRONT COVER OF YOUR ANSWER BOOK – **DO THIS NOW and SIGN** on the space provided.
5. Complete the details in Examination Slip provided. **DO THIS NOW** and **SIGN** on the space provided.
6. Only drawing instruments, calculators and laptops with textbooks are permitted on your desk.
7. Mobile phones are **NOT** permitted. All phones are to be **SWITCHED OFF**.
8. If you are found cheating in the Examination the penalties specified by the University shall apply.
9. You have **TEN (10) MINUTES** to read the paper.
   You must not begin writing during this time.

QUESTION ONE (30 marks)

(a) Morobe Provincial Government proposed for power station to supply Wafi-Golpi Mine. It is initially planned that the power station will have a maximum demand of 200 MW with a load factor of 30%. The power station is to be supplied by one of the following schemes:

(i) A gas turbine power plant in conjunction with a hydro-electric power plant, the latter supplying a 200 x 10^6 kWh per annum with a maximum output of 100 MW,

(ii) A gas turbine power plant to be located at the mine site capable of supplying the whole load, and

(iii) A hydro-station capable of supplying the whole load but transmitted over a distance from Mongi Hydro Electric Power in Pindiu, Fincshhafen District to the mine site.

Compare the overall cost per kWh generated, assuming the following data in **Table Q1a**:

Table Q1a

	Gas	Hydro
Capital cost/kW installed	K2,500	K4, 600
Interest and depreciation on Capital Investment	12%	13%
Transmission Cost/kWh	negligible	0.5%
Operating Cost/kWh	6%	1.4%

QUESTION ONE Cont'd

(b) A load having a maximum value of 200 MW can be supplied by a hydro-electric plant or a gas power plant. The costs are given in **Table Q1b**.

Table Q1b

Plant	Capital cost/kW installed	Operating cost/kWh	Investment
Gas Power Plant	K1200	6%	7%
Hydro Power Plant	K4300	3%	9%

Calculate the minimum load factor above which the hydro-electric power plant will be more economical.

QUESTION TWO (20 marks)

A plant has 3 generators and their capacity and cost functions are as follow:

Unit 1:

$C_1 = 561 + 7.92\,P_1 + 0.002562\,P_1^2$ \$/h $\qquad 150 \leq P_1 \leq 600$ MW

Unit 2:

$C_2 = 310 + 7.85\,P_2 + 0.00294\,P_2^2$ \$/h $\qquad 100 \leq P_2 \leq 400$ MW

Unit 3:

$C_3 = 94 + 9.56\,P_3 + 0.005784\,P_3^2$ \$/h $\qquad 50 \leq P_3 \leq 200$ MW

What unit or combinations of units could the supply most economically a load of 700MW? Tabulate your results.

QUESTION THREE (20 marks)

(a) Using **Table Q3**, apply (i) a 3-month moving average, (ii) a 5-month moving average to estimate the energy output for January the following year.

(b) Plot the actual energy outputs and the two moving averages computed in (a) on the same graph. Comment on the graph plotted.

(c) Apply the weighted moving average of 60%, 20%, 15%, and 5% to the last four consecutive data to do an estimate for January the following year. Tabulate your results.

(d) Using **Table Q3**, apply the exponential smoothing of (i) $\alpha = 0.3$ and (ii) $\alpha = 0.5$ to forecast the energy output for January the following year.

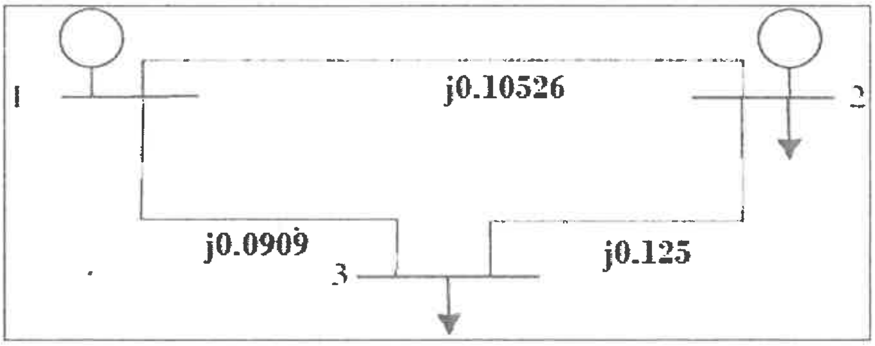
(e) Plot your results of energy output obtained using the two exponential smoothing in Part (d) and the actual values on the same graph. Comment on your results.

Table Q3

Month	Power Demand (MW)	Month	Power Demand (MW)
January	209	July	223
February	211	August	286
March	216	September	230
April	227	October	275
May	220	November	188
June	280	December	312

QUESTION FOUR (30 marks)

Consider a three-bus system as shown in **Figure Q4**. The details are given in **Tables Q4a** and **Table Q4b**. Take bus 1 as the slack bus with $\theta = 0^0$. Calculate the power flow in MW on a 100 MVA base.



Fiqure Q4

Table Q4a

Bus no.	**Bus Type**	**PD (MW)**	**QD (MVAr)**	**PG (MW)**
1	Slack	0	0	Unknown
2	PV	10	5	65
3	PQ	90	30	0

Table Q4b

Line No.	**From Bus**	**To Bus**	**X (p.u)**	**Rating (MVA)**
1	1	2	Specified in Diagram	250
2	2	3		250
3	1	3		150