The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering

Study Programme	Master of Energy Management (MEM)
Name of the Examination	Final Examination
Course Code and Title	**DMX9403 Electrical Energy Utilities (EEU)**
Academic Year	2020
Date	16th August 2020 (Sunday)
Time	13.30 hours– 16.30 hours (**IST**)
Duration	**03 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **five (5)** questions. **Answer all questions.**
3. All questions carry equal marks
4. Answer for each question should commence from a new page.
5. **Relevant data/charts/ codes are provided.** Use appropriate assumptions if required stating them clearly.
6. This is a Closed Book Test (CBT).
7. Answers should be in clear handwriting.
8. Do not use Red color pen.

QUESTION 01 (20 marks)

A company has recorded a maximum demand of 600 kVA at the Power Factor (PF) of 0.82 lagging.

a) Calculate the Active and Reactive Power demands of the company.

(04 marks)

b) Calculate the new PF by installing 100 kVAr capacitors.

(04 marks)

c) Calculate the Active, Reactive, and Maximum Power (Apparent Power) demands after improving the Power Factor.

(04 marks)

d) Discuss the benefits of Power Factor improvements of the company from the company's point of view and from the utility's point of view.

(04 marks)

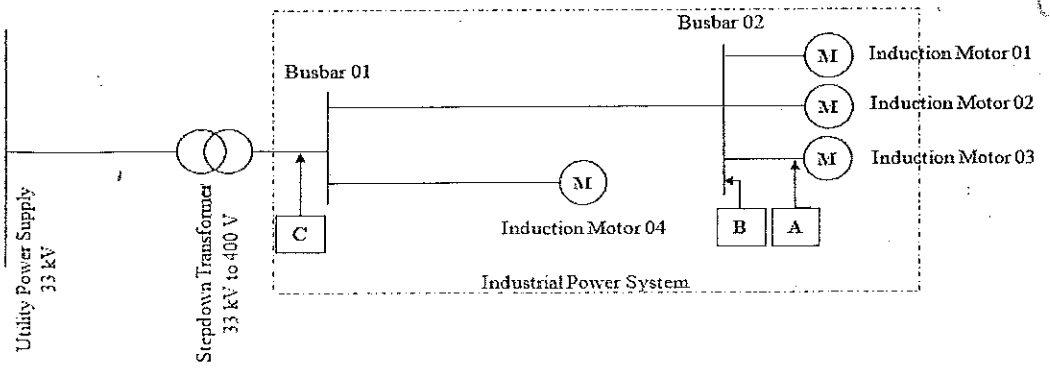

Figure Q1

e) **Figure Q1** shows a schematic diagram of an industrial power system. By carefully observing the diagram, list the advantages and disadvantages of installing a capacitor bank/s for the individual equipment (ex: locations such as A) and for the main supply (location C).

(04 marks)

QUESTION 02 (20 marks)

a) An ideal transformer has no energy losses. But in real (In practical) transformers, energy is dissipated in various ways. Briefly discuss the types of transformer losses.

(04 marks)

b) A company decides to install a new product line to increase its production capacity. Assuming that you are the Industrial Engineer in the company, list five (05) parameters that you consider on selecting a motor for the new product line.

(04 marks)

c) Briefly discuss four (04) types of Motor Losses.

(04 marks)

d) As the demand charges constitute a considerable portion of the electricity bill, from user angle too there is a need for integrated load management to effectively control the maximum demand. Briefly discuss five (05) measures of maximum demand control in the industry.

(04 marks)

e) List five (05) common causes of voltage unbalance in any electricity distribution system.

(04 marks)

QUESTION 03 (20 marks)

a) Explain the way of identifying/ calculating the energy losses due to leakages in the compressed air distribution network, by using suitable sketches.
Identify all key steps of the process. You may use symbols/ sketches/ for the ease of illustration.

(6 marks)

b) A team of auditors have conducted a Leak Detection Program in an apparel manufacturing factory and obtained the data shown in **table 1**. The factory consists of 3 main departments: namely Sewing, Cutting and Finishing. The purpose of the study is to identify the financial losses due to the leakages in the compressed air storage (receiver tank) and the distribution network.
During the time when the test was conducted, all machines and instruments at the end use were closed from the valves. **Refer *Annexure 1*** for details related to the electricity tariff.
The factory operates from 8am to 6pm (10 hours a day) for 330 days per year.

Table 1

Test	Condition	Compressor Input Power (kW)	Cut-in Pressure (bar)	Cut-off Pressure (bar)	Compressor Operating time (s)	Compressor Idling time (s)
1	Entire distribution network is closed/ isolated from the header	215	6	7	50	675
2	Distribution line to the "Sewing" department is open	215	6	7	50	163
3	Distribution line to the "Cutting" department is open	215	6	7	50	217
4	Distribution line to the "Finishing" department is open	215	6	7	50	468

I. Calculate the annual energy loss (in kWh) in the storage system (receiver tank and header).

(2 marks)

II. Calculate the annual energy loss (in kWh) in the distribution network to the Sewing department starting from the header.

(2 marks)

III. Calculate the annual energy loss (in kWh) in the distribution network to the Cutting department starting from the header.

(2 marks)

IV. Calculate the annual energy loss (in kWh) in the distribution network to the Finishing department starting from the header.

(2 marks)

V. Calculate the annual total energy loss (in kWh) for the entire compressed air system.

(2 marks)

VI. Assuming the factory has a contract demand of 800kVA and a maximum demand of 675kVA, what is the tariff system applicable for them, as per Annexure 01?

(2 marks)

VII. Based on the tariff selected, calculate the potential cost saving (in LKR) of fixing the leaks identified during the audit.

(2 marks)

You may use suitable assumptions in your calculations, stating them clearly.

QUESTION 04 (20 marks)

An investor has hired you as a consultant to provide a lighting design for the office constructed by him, for a new software development BPO. The investor is very keen on both energy efficiency and compliance and has insisted you do an evaluation, providing the recommendations based on the requirement shared by the architect.

It is important to meet 500 Lux of illumination on the working plane, with the office operational from 8 a.m. to 6 p.m. for 25 days a month. The cost of disposing LED and CFL lamps could be ignored in the calculations.

Consider the average cost of electricity to be 23 LKR/kWh. You may use suitable assumptions in your calculations (if needed) stating them clearly. You may also disregard the impact due to time value of money in the life cycle cost calculation.

General Information	Length of the office floor	40m
	Width of the office floor	10m
	Utilization factor for the installation	0.75
	Maintenance factor (Light Loss Factor)	0.80
Option-01 (CFL)	Power consumption	23W
	Efficacy	50 lm/W
	Lifetime	6000 hours
	Capital cost (purchasing price)	750 LKR/ lamp
Option-02 (LED)	Power consumption	15W
	Efficacy	95 lm/W
	Lifetime	18000 hours
	Capital cost (purchasing price)	2500 LKR/ lamp

a) Discuss the advantages and disadvantages of using LED over CFL

(2 marks)

b) Calculate the number of CFL light fittings required to meet the specified illuminance of 500 Lux.

(3 marks)

c) Assuming a timeframe of 18,000 hours, calculate the Lifecyle Cost (Initial cost+ operational (electricity) Cost) for Option 01 - CFL.

(4 marks)

d) Calculate the number of LED light fittings required to meet the specified illuminance of 500 Lux.

(3 marks)

e) Assuming a timeframe of 18,000 hours, calculate the Lifecyle Cost (Initial cost+ operational (electricity) Cost) for Option 02 - LED.

(4 marks)

f) As the consultant, which option would you recommend to the client? Justify your answer

(2 marks)

g) What is the annual saving to be achieved if your selection is implemented, in comparison to the other option provided by the architect?

(2 marks)

QUESTION 05 (20 marks)

a) Discuss energy efficiency options of fans.

(2 marks X 3 = 6 marks)

b) Describe the performance parameters of pumps.

(2 marks X 3 = 6 marks)

b) A centrifugal water pump generates a flow rate of 9.0 m^3/h at a speed of 1450 rev/min. The pressure gauges installed at the suction and delivery pipes show a pressure rise of 3.5 bars. The inside diameters of the suction and delivery pipes are 50 mm and 40 mm respectively. Determine the head and fluid power generated by the pump. If the torque at the shaft is 7.2 Nm. Estimate the efficiency of the pump neglecting the difference in elevations.

Hint:

$$H = \frac{p}{\rho g} + \frac{V^2}{2g} + Z$$

$$Pump\ efficiency = \frac{Power\ of\ fluid}{Power\ of\ shaft}$$

(8 marks)

Annexure-01

Electricity Tariff – Industrial Category

Customer Category I-1

This rate shall apply to supplies at each individual point of supply delivered and metered at 400/230 Volt nominal and where the contract demand is less than or equal to 42 kVA.

Table 2- Tariff Applicable for Industrial- 1 Customers

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Consumption per month (kWh)	Energy Charge (LKR/kWh)	Fixed Charge (LKR/month)	Maximum Demand Charge per Month (LKR/kVA)
<301	10.80	600.00	–
>300	12.20		

Customer Category I-2

This rate shall apply to supplies at each individual point of supply delivered and metered at 400/230 Volt nominal and where the contract demand exceeds 42 kVA.

Table 3- Tariff Applicable for Industrial-2 Customers

Table 3 - Tariff Applicable for Industrial - 2 Customers

Time Intervals	Energy Charge (LKR/kWh)	Fixed Charge (LKR/month)	Maximum Demand Charge per month (LKR/kVA)
Peak (18.30-22.30)	20.50	3,000.00	1,100.00
Day (5.30-18.30)	11.00		
Off-peak (22.30-05.30)	6.85		

Customer Category I-3

This rate shall apply to supplies at each individual point of supply delivered and metered at 11,000 Volt nominal and above and where the contract demand exceeds 1000 kVA

Table 4 - Tariff Applicable for Industrial-3 Customers

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Time Intervals	Energy Charge (LKR/kWh)	Fixed Charge (LKR/month)	Maximum Demand Charge per month (LKR/kVA)
Peak (18.30-22.30)	23.50	3,000.00	1,100.00
Day (5.30-18.30)	10.25		
Off-peak (22.30-05.30)	5.90		