



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 8 Examination in Engineering: August 2022

Module Number: EE8206

Module Name: Electrical Installations II

[Three Hours]

[Answer all questions, each question carries 10 marks]

- Q1 a) i) Briefly explain the term Extra Low Voltage (ELV) system according to the British standard.
- ii) What are the equipments of the three-layer hierarchical model in network design?

[4 Marks]

- b) A three-story building in Colombo was constructed under the hotel and residence category. The ground floor is the reception and office area, the 1<sup>st</sup> floor is the conference hall and the second floor has rooms. The reception area has 3 data outlets, 2 Wi-Fi points, 3 analog phone points, 3 IP phone points, 3 indoor cameras, 1 PTZ camera and 4 outdoor cameras, and 2 IPTV points.

The first floor has 4 data outlets, 4 Wi-Fi points, 2 analog phone points, 6 indoor CCTV camera points, and 4 IPTV points. The second floor has 10 rooms and each room has one data outlet, one analog phone point, one Wi-Fi point, and one IPTV point. Also, 3 CCTV cameras are installed in the corridor of the third floor.

All the abbreviations have their usual meanings.

- i) Categorize data, Wi-Fi, voice, CCTV, and IPTV outlets for each floor. Use the structure of Table Q1 to answer.
- ii) The Building requires a PABX for voice communication. How many IP phones and analog phones can be set as extensions for PABX?
- iii) Data outlets, Wi-Fi and IPTV points are patched in the same 24 port Cat 6A patch panels of floor distribution racks in each floors. Two racks are installed in each floor as data rack and security rack. Data, Wi-Fi and IPTV patch panels are

installed in data racks. How many patch panels are required to patch data, Wi-Fi and IPTV points in each data racks of each floor?

- iv) CCTV outlets are patched in the security rack in each floor. How many 24 patch panels are required to patch CCTV outlets in each security racks?

[6 Marks]

- Q2 a) i) Explain why it is important to install a lightning protection system in a building. State the standard that can be followed in designing a lightning protection system in Sri Lanka.
- ii) Briefly describe four natural components that can be used in designing a lightning protection system in a building and their importance over separate lightning protection system installation.

[4 Marks]

- b) Length, width, and height of a building at the Faculty of Engineering, University of Ruhuna are 50 m, 15 m, and 15 m respectively. Table Q2 shows the dimensions' criteria of the lightning protection levels with rolling sphere method. Consider the minimum lightning current peak value of 3 kA and maximum lightning current peak value of 200 kA.

- i) Determine the lightning protection level and the radius of the rolling sphere.
- ii) Does the building need protection against side strikes on walls? Justify your answer.
- iii) Identify the best applicable earthing type for this building and justify your answer.
- iv) Surge Protective Devices (SPD) are installed in parallel to the electrical or electronic devices to be protected in an electrical installation of a building. Briefly describe, how SPD works in the presence and absence of an overvoltage.

[6 Marks]

Q3 a) Consider a rectangular-shaped office room, whose width, length, and height are 15 ft, 60 ft, and 10 ft respectively.

- i) Estimate the required cooling capacity needed for the room using the simplified method. The number of people usually occupying the room is 60. Assume that each person produces 500 BTU/hr amount of heat.
- ii) Table Q3 shows the details of three air conditioners named as A, B, and C whose specifications are properly matched with the installation requirements calculated in part a) i). It lists the capacity and the unit price of each air conditioner. The unit of capacity is in BTU and the price is in Sri Lankan rupees.  
By considering the data in Table Q3, select the most appropriate air conditioner capacity and calculate the number of units, and the total price of the air conditioners.
- iii) Clearly mention the reason for your selection among the air conditioners A, B, and C.

[4 Marks]

b) Compare the Cross and Back to Back natural ventilation.

[2 Marks]

c) Fire Detection and Protection is one of the required systems in modern buildings.

- i) Define the term fire protection and list six components in a fire detection system.
- ii) Sketch the placement of smoke detectors on its plan view for a rectangular space whose dimensions are 31.8 m in length and 21.2 m in width. Consider the particular area as a free space.

[4 Marks]

Q4 a) Emergency power supplies are intended for essential life protection in case of main power failures.

- i) State best practices of placing distribution boards and installing wiring system for an emergency lighting system of a building.
- ii) Discuss the conclusions on the quality of a battery bank, based on the measurements taken from Battery Impedance Testing.

- iii) State the main reason for the importance of the elevator manufacturer's confirmation about the regenerative power installation before sizing and installing UPS for the elevator.
- iv) Automatic Rescue Device (ARD) is a special device installed in Elevators. What is the purpose of installing such a device?

[4 Marks]

b) The total demand of a factory is 45 kVA whose operating line to line voltage is 400 V. The set of essential loads of the factory has been identified as a motor, set of luminaries, an elevator, and a fire pump.

- i) Calculate the input power required for the motor to operate at its operating point. Table Q4 shows the motor name plate data.
- ii) Calculate the total power supply to the motor in kVA, if the power factor of the motor is 0.865 lagging.
- iii) Calculate the power required by the motor at start, if a Variable Speed Drive (VFD) is used to reduce the power at start by a factor of 1.25.

**Hint: Power of the motor at start in kVA = VFD factor \* Total power supplied to the motor in kVA**

- iv) Calculate the total demand of the motor, by taking the both Motor utilization factor and the Motor simultaneous factor as 0.8.
- v) The design currents for the elevator, luminaries, and fire pump have been found as 19.49 A, 5.04 A, and 7.22 A respectively. (i.e. The design currents are stated based on total power demand in kVA after considering utilization factor, simultaneous factor, and power factor).  
Calculate the total kVA demand of the lift, luminaries, and fire pump.
- vi) Calculate the total kVA demand of the essential loads, including motor, elevator, luminaries, and fire pump.
- vii) By considering the future increase in load demand as 10% of the present total kVA demand, select the size of the emergency power generator for the factory to supply the mentioned essential loads. Available generators at the market are 20 kVA, 25 kVA, 30 kVA, 35 kVA.

[6 Marks]

Q5 a) Energy and cost saving methods of a manufacturing industry have been identified as introducing a special tariff system called 'Time of use tariff' and **Building management system (BMS)**.

Discuss the possibility of energy and cost saving through BMS.

[2 Marks]

b) The manufacturing industry manager decided to modify the systems of the manufacturing industry with BMS in Heating, Ventilation and Air Conditioning system and install a separate metering to check the power consumption.

Power consumption for the year 2021; before the modification in HVAC system with BMS was 250 kW per year and the power consumption after the modification is 150 kW per year in 2022.

- i) Calculate the power saving per year comparing the data given in 2021 and 2022.
- ii) What is the percentage of power saving in 2022 due to improvement in HVAC system compared to 2021?
- iii) Calculate the energy saving for the year 2022 in kWh, if the factory works continuously for 365 days.
- iv) Calculate the cost saving for the year 2022 due to energy saving in the HVAC system. Consider the unit price of the energy for peak hours is Rs 2/kWh. Assume that the particular HVAC system is used only in peak hours.
- v) If the manager spent Rs 880,000.00 to install the automated system for HVAC, calculate the pay-back period for the particular installation.

**Hint: Pay Back Period (In years) = Cost for install the automated system for HVAC / Cost saving for the year**

[5 Marks]

c) The special cooling process at the manufacturing industry to be set at 23 Celsius. But, at an instant, temperature sensors read the temperature as 25 Celsius.

With the aid of a block diagram, elaborate the control process of the cooling system to maintain the temperature at 23 Celsius in the newly installed controlled system.

[3 Marks]

**Table Q1: Outlets distribution**

Outlet	Ground Floor	1 <sup>st</sup> Floor	2 <sup>nd</sup> Floor
Data			
Wi-Fi			
IP Phone			
Analog Phone			
CCTV			
IPTV			

**Table Q2: Dimensions' criteria of the lightning protection levels with rolling sphere method**

Lightning protection level	Interception criteria				
	Minimum lightning current peak value	Probability of the actually upcoming lightning current to be higher than the minimum lightning current peak value	Maximum lightning current peak value	Probability of the actually upcoming lightning current to be less than the maximum lightning current peak value	Radius of the rolling sphere
I	3 kA	99%	200 kA	99%	20 m
II	5 kA	97%	150 kA	98%	30 m
III	10 kA	91%	100 kA	97%	45 m
IV	16 kA	84%	100 kA	97%	60 m

Table Q3: Details of the air conditioners

Name of Air Conditioner Unit	Capacity of a single Air Conditioner (BTU)	Price of a single unit (Rs)
A	24000	360,999.00
B	34000	540,499.00
C	48000	583,999.00

Table Q4: Motor name plate data

Description	Data
Full load capacity	5 kW
Motor efficiency at full load	96%
Motor operating point	4 kW
Motor efficiency at its operating point of 4 kW	95.5%