



# UNIVERSITY OF RUHUNA

## Faculty of Engineering

End-Semester 8 Examination in Engineering: September 2023

Module Number: EE8206

Module Name: Electrical Installations II

[Three Hours]

[Answer all questions, each question carries 10 marks]

- Q1 a) i) Implementation of a Structured Cabling System (SCS) for a building offers many advantages to its owners and the occupants. List two of them and briefly explain them.
- ii) Illustrate sketches to elaborate on the "Interconnection" and "Cross-connection" in the network rack in a telecommunication room under SCS subsystems.

[4 Marks]

- b) To facilitate the increased intake of Computer Engineering students, a new three-storied building was proposed to be built in the faculty premises. Requirements of the extra low voltage systems were discussed during a department board meeting and those requirements are listed in Table Q1.

- i) Use the table structure below to categorize the number of Data, Voice, CCTV and Wi-Fi outlets of each floor.

Type of Outlet	Ground Floor	1 <sup>st</sup> Floor	2 <sup>nd</sup> Floor
Data			
Wi-Fi			
IP phone			
CCTV			

- ii) During the meeting, it was suggested to physically separate the CCTV network from the other networks. Therefore, two numbers of racks were proposed to be placed inside the telecommunication rooms on each floor named IT and Security.

Select the suitable type of patch panel (8Port,12Port,24Port, etc.) and determine the number of patch panels required for each IT and security rack.

- iii) Draw the schematics drawing for the CCTV system of the building by clearly denoting each component.

[6 Marks]

- Q2 a) i) Briefly describe the types of sources of damage and the types of losses with respect to the threat of lightning
- ii) An external lightning protection system of a building comprises three

subsystems. Specify them along with their respective functions.

[4 Marks]

- b) Plan and the Elevation of a roof slab arrangement of a building is given in Figure Q2.b) i) All dimensions in this figure are given in millimeters. Considering the building requires Class II lightning protection system, determine the followings.
- Protection Angle ( $\alpha$ ) to be covered by Air Finial to protect the cooling tower. It was found that, to protect the cooling tower, an area of 10 m radius around the air finial is required at roof slab level.
  - Minimum Height ( $h$ ) of the Air Finial (lightning arrester) from Roof Slab level. The protection angle vs the height characteristic for different lightning protection systems is given in Figure Q2. b) ii).
  - If a Copper Mesh is used to protect the roof slab area, what should be the minimum size of the mesh? Assume there are no objects on roof slab area
  - Taking into consideration the copper mesh design in iii), draw a sketch of a suitable Air Termination System for the building's roof slab area, including all necessary details.

[6 Marks]

- Q3 a) i) Inverter type Air conditioners (ACs) are more energy efficient than non-inverter type ACs. Explain the difference between the two types, with the help of graphs.
- ii) Calculate the total required fresh air rate for an auditorium building designed in the shape of a circle, with one half dedicated to the stage and the other half for the seating area as shown in Figure Q3.a). The auditorium has a radius of 140 feet. Refer to TABLE 6.1 - Minimum Ventilation Rates in the Breathing Zone for the calculation.

[3 Marks]

- b) i) Briefly explain the difference between a conventional fire detection system and an addressable fire detection system.
- ii) Select and place Smoke Detectors, Heat detectors, Manual call Points and Fire Alarm (Siren) in suitable locations in the given floor plan of Figure Q3b). Assume the hall has a flat Ceiling.
- iii) What are the two major types of fire hydrant systems in high rise buildings? Explain the difference between these two types.
- iv) Indicate the portable fire extinguishers layout for lecture hall in Figure Q3.b).

[7 Marks]

- Q4 a) i) What is a Backup Power System?
- ii) The critical electrical loads of a building during power failures have been identified as follows;
- Security Camera System (1250 W)
  - Server/Data Racks (1750 W)
  - Emergency Lights (18 W x 10 Nos.)
- Calculate the Capacity of an UPS required for the building allocating 20%

capacity for future expansions.

Hint: Available UPSs in the Market: 600VA, 1.2kVA, 2kVA, 3kVA, 5kVA, 7kVA

- iii) According to the Employer's Requirements, the UPS mentioned in ii) must operate for one hour during a main power failure. Suppose 12V, 20 Ah batteries that can operate at 99% efficiency are available. Calculate the size of the Battery bank and the number of batteries required to be connected with the UPS.

[6 Marks]

- b) i) Briefly explain the three ways that electric power generators can be classified based on their mode of operation.
- ii) Details of the Power Supply requirement for an Elevator in a Commercial Building are as follows.
- Electricity Supply for Machine Room at Roof top: 400 V, 3 Phase, 50 Hz
  - Power of the Motor: 5 kW
  - Power for Lighting & Control: 200 W

Determine the current rating of the Circuit Breaker to be used with the Elevator power supply.

[4 Marks]

- Q5 a) i) What are the five types of inputs and outputs (IO) of a Building Management System (BMS) point schedule? Give two examples for each point type.
- ii) Categorize the analog sensors, according to the output type and briefly explain their dereferences.
- iii) Draw the diagram for three layered BMS architecture.

[5 Marks]

- b) Control and monitoring requirement for a BMS of a Six storied apartment building is given below.

#### Basement floor

- Fire protection pump set with Main Electric, Engine-driven pump, and Jockey pump (all the three statuses of each pump)
- The Water level of the fire protection water tank
- The water level of the main water tank.
- Water consumption of all the 12 apartments (3 per each typical floor)
- Electrical consumption of all 12 apartments (3 per each typical floor)

#### Ground floor

- BMS Workstation

#### Typical floor (1st to 4th)

- Control of the exhaust fan system on each floor (VFD)
- Control of staircase and common area lighting (2 circuits per each floor)

- i) Assume three Direct Digital Controller (DDC) Panels are to be installed on the basement floor, 1st floor, and 3rd floor. Populate the I/O point schedule for DDC panels and indicate the cable type required for each sensor/control

device.

- ii) The BMS is to be connected with the Fire alarm and CCTV system. Draw the schematic diagram of the BMS System.

[5 Marks]

Table Q1.

<u>Ground Floor</u>	<u>First Floor</u>
<p><i>Entrance Lobby</i></p> <p>3 Nos of dome type CCTV</p> <p><i>Lecture hall-1</i></p> <p>1 Computer</p> <p>1 Wi-Fi access point.</p> <p><i>Lecture hall-2</i></p> <p>1 Computer</p> <p>1 Wi-Fi access point.</p> <p><i>Senior Lecturer rooms (8 Nos)</i></p> <p>1 IP Phone per room.</p> <p>1 Computer per room.</p> <p>1 Wi-Fi access point for every 4 rooms.</p> <p><i>Lecturer rooms (6 Nos)</i></p> <p>1 IP phone.</p> <p>1 Computer per room.</p> <p>1 Wi-Fi access point for every 3 rooms.</p>	<p><i>Entrance Lobby</i></p> <p>3 Nos of dome type CCTV cameras</p> <p>4 Nos of bullet type CCTV cameras</p> <p><i>Electronic Lab</i></p> <p>10 Nos of computers</p> <p>2 Nos of IP phones</p> <p>20 Data outlets for lab tables</p> <p>2 Nos of Wi-Fi access points</p>
	<p><u>Second floor</u></p> <p><i>Entrance Lobby</i></p> <p>3 Nos of dome type CCTV cameras.</p> <p><i>Computer Lab</i></p> <p>6 Nos of CCTV Cameras</p> <p>50 Computers</p> <p>6 Nos of Wi-Fi Access points.</p> <p>4 IP phones</p>

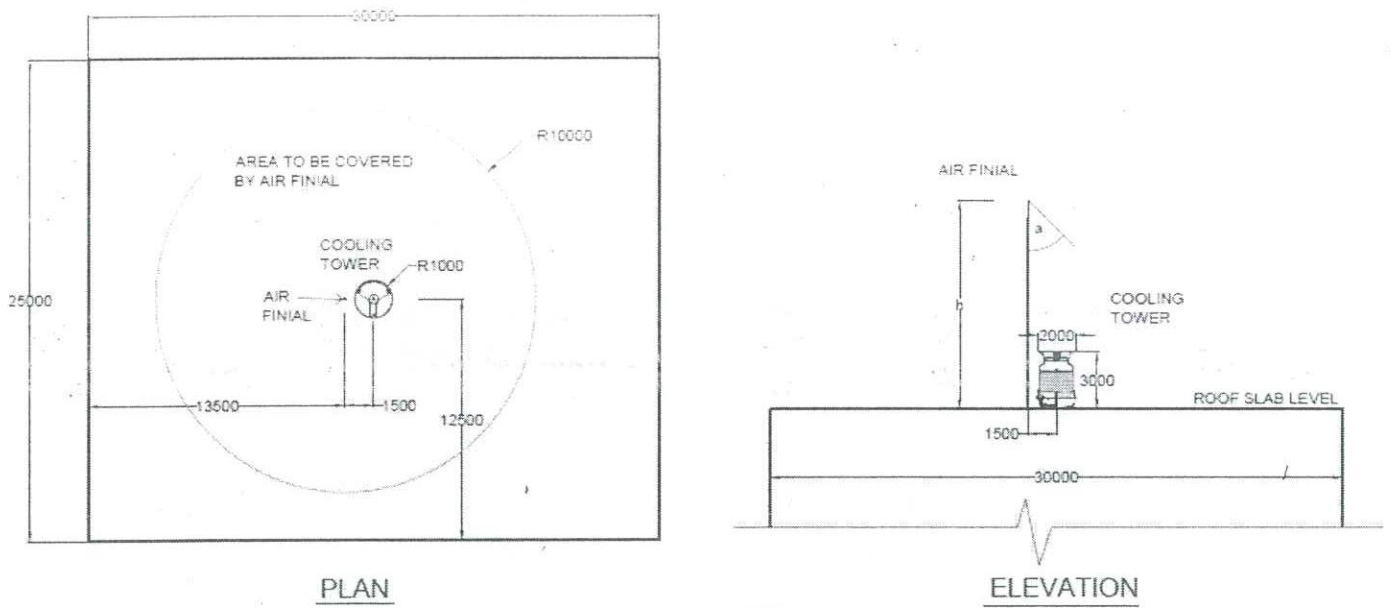
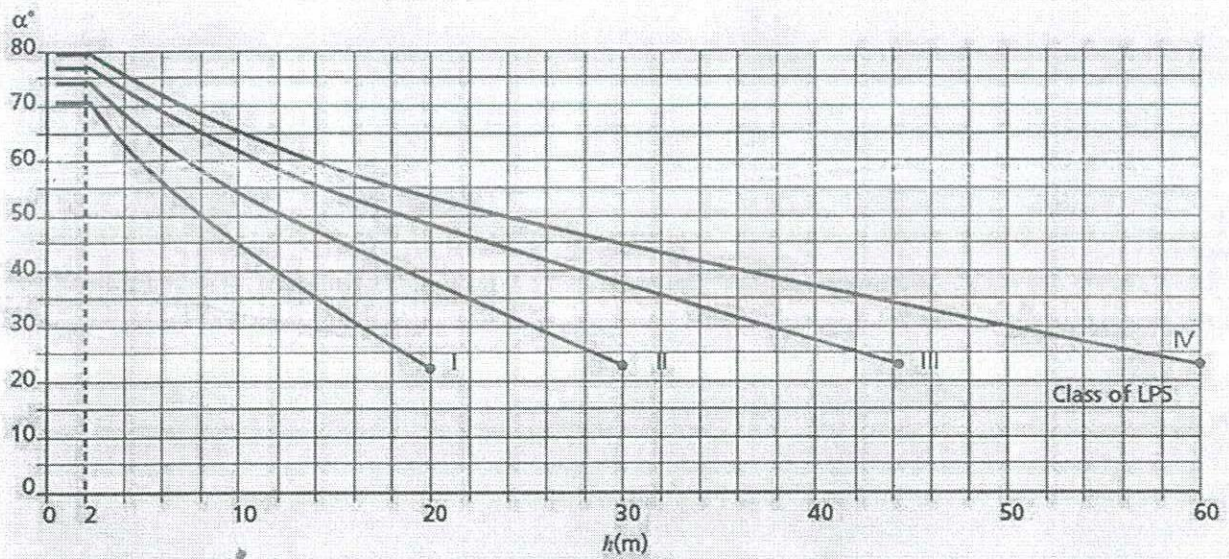


Figure Q2.b i).



- Note 1 Not applicable beyond the values marked with ●  
Only rolling sphere and mesh methods apply in these cases
- Note 2  $h$  is the height of air-termination above the reference plane of the area to be protected
- Note 3 The angle will not change for values of  $h$  below 2m

Figure Q2.b ii).

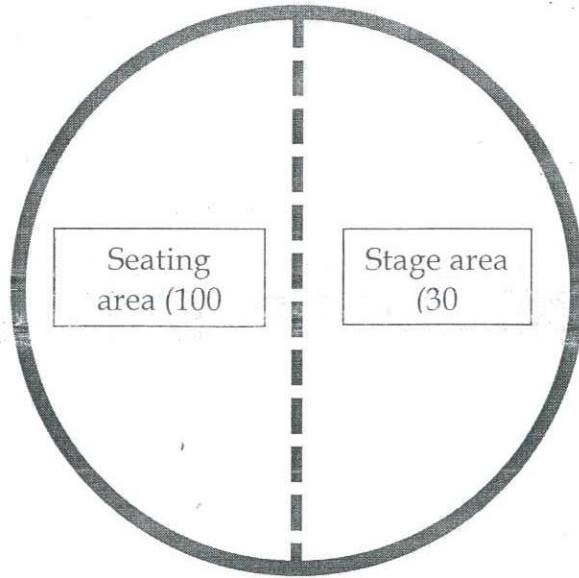
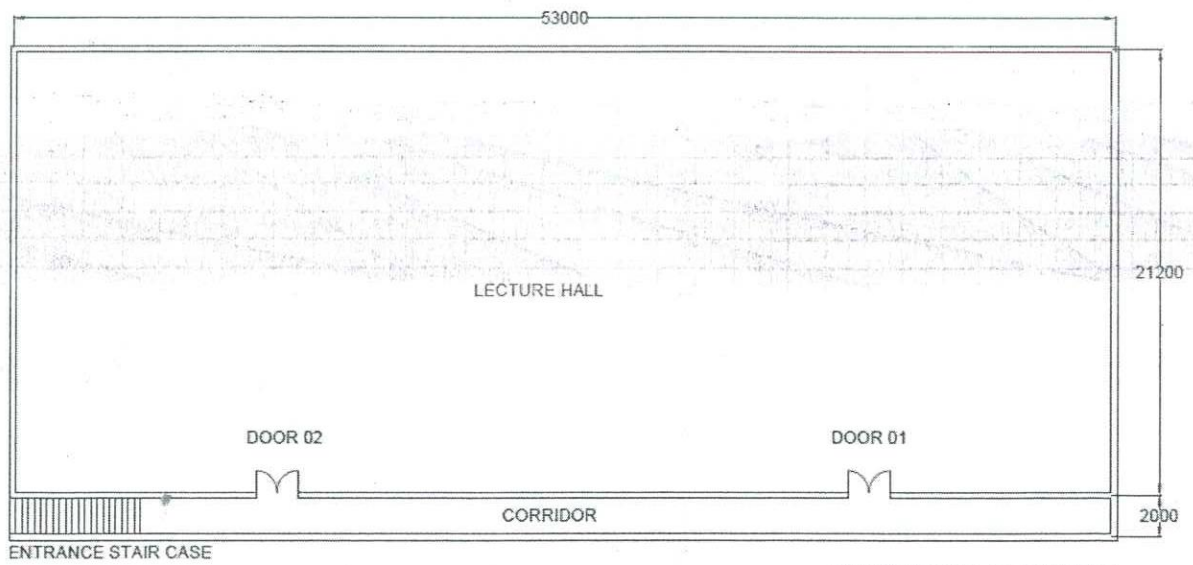


Figure Q3.a).



Note: All dimension are in millimeters

Figure Q3.b).

**TABLE 6.1**  
**Minimum Ventilation Rates In Breathing Zone**  
*(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)*

Occupancy Category	People Outdoor Air Rate $R_p$		Area Outdoor Air Rate $R_A$		Notes	Default Values		
	cfm/person	L/s*person	cfm/ft <sup>2</sup>	L/s*m <sup>2</sup>		Occupant Density (see Note 4)	Combined Outdoor Air Rate (see Note 5)	
						#/1000 ft <sup>2</sup> (#/100 m <sup>2</sup> )	cfm/person	L/s*person
<b>Correctional Facilities</b>								
Cell	5	2.5	0.12	0.6		25	10	4.9
Day room	5	2.5	0.06	0.3		30	7	3.5
Guard stations	5	2.5	0.06	0.3		15	9	4.5
Booking/waiting	7.5	3.8	0.06	0.3		50	9	4.4
<b>Educational Facilities</b>								
Daycare (through age 4)	10	5	0.18	0.9		25	17	8.6
Classrooms (ages 5-8)	10	5	0.12	0.6		25	15	7.4
Classrooms (age 9 plus)	10	5	0.12	0.6		35	13	6.7
Lecture classroom	7.5	3.8	0.06	0.3		65	8	4.3
Lecture hall (fixed seats)	7.5	3.8	0.06	0.3		150	8	4.0
Art classroom	10	5.0	0.18	0.9		20	19	9.5
Science laboratories	10	5.0	0.18	0.9		25	17	8.6
Wood/metal shop	10	5	0.18	0.9		20	19	9.5
Computer lab	10	5	0.12	0.6		25	15	7.4
Media center	10	5	0.12	0.6	A	25	15	7.4
Music/theater/dance	10	5.0	0.06	0.3		35	12	5.9
Multi-use assembly	7.5	3.8	0.06	0.3		100	8	4.1
<b>Food and Beverage Service</b>								
Restaurant dining rooms	7.5	3.8	0.18	0.9		70	10	5.1
Cafeteria/fast food dining	7.5	3.8	0.18	0.9		100	9	4.7
Bars, cocktail lounges	7.5	3.8	0.18	0.9		100	9	4.7
<b>General</b>								
Conference/meeting	5	2.5	0.06	0.3		50	6	3.1
Corridors	-	-	0.06	0.3		-		
Storage rooms	-	-	0.12	0.6	B	-		
<b>Hotels, Motels, Resorts, Dormitories</b>								
Bedroom/living room	5	2.5	0.06	0.3		10	11	5.5
Barracks sleeping areas	5	2.5	0.06	0.3		20	8	4.0
Lobbies/prefunction	7.5	3.8	0.06	0.3		30	10	4.8
Multi-purpose assembly	5	2.5	0.06	0.3		120	6	2.8
<b>Office Buildings</b>								
Office space	5	2.5	0.06	0.3		5	17	8.5
Reception areas	5	2.5	0.06	0.3		30	7	3.5
Telephone/data entry	5	2.5	0.06	0.3		60	6	3.0
Main entry lobbies	5	2.5	0.06	0.3		10	11	5.5
<b>Miscellaneous spaces</b>								
Bank vaults/safe deposit	5	2.5	0.06	0.3		5	17	8.5
Computer (not printing)	5	2.5	0.06	0.3		4	20	10.0
Pharmacy (prep. area)	5	2.5	0.18	0.9		10	23	11.5
Photo studios	5	2.5	0.12	0.6		10	17	8.5

**TABLE 6.1 (Continued)**  
**Minimum Ventilation Rates in Breathing Zone**

*(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)*

Occupancy Category	People Outdoor Air Rate $R_p$		Area Outdoor Air Rate $R_A$		Notes	Default Values		
	cfm/person	L/s•person	cfm/ft <sup>2</sup>	L/s•m <sup>2</sup>		Occupant Density (see Note 4)	Combined Outdoor Air Rate (see Note 5)	
						#/1000 ft <sup>2</sup> (#/100 m <sup>2</sup> )	cfm/person	L/s•person
Shipping/receiving	-	-	0.12	0.6	B	-	-	-
Transportation, waiting	7.5	3.8	0.06	0.3		10	8	4.1
Warehouses	-	-	0.06	0.3	B	-	-	-
<b>Public Assembly Spaces</b>								
Auditorium seating area	5.0	2.5	0.06	0.3		150	5	2.7
Places of religious worship	5.0	2.5	0.06	0.3		120	6	2.8
Courtrooms	5.0	2.5	0.06	0.3		70	6	2.9
Legislative chambers	5.0	2.5	0.06	0.3		50	6	3.1
Libraries	5.0	2.5	0.12	0.6		10	17	8.5
Lobbies	5.0	2.5	0.06	0.3		150	5	2.7
Museums (children's)	7.5	3.8	0.12	0.6		40	11	5.3
Museums/galleries	7.5	3.8	0.06	0.3		40	9	4.6
<b>Retail</b>								
Sales (except as below)	7.5	3.8	0.12	0.6		15	16	7.8
Mall common areas	7.5	3.8	0.06	0.3		40	9	4.6
Barber shop	7.5	3.8	0.06	0.3		25	10	5.0
Beauty and nail salons	20	10	0.12	0.6		25	25	12.4
Pet shops (animal areas)	7.5	3.8	0.18	0.9		10	26	12.8
Supermarket	7.5	3.8	0.06	0.3		8	15	7.6
Coin-operated laundries	7.5	3.8	0.06	0.3		20	11	5.3
<b>Sports and Entertainment</b>								
Sports arena (play area)	-	-	0.30	1.5		-	-	-
Gym, stadium (play area)	-	-	0.30	1.5		30	-	-
Spectator areas	7.5	3.8	0.06	0.3		150	8	4.0
Swimming (pool and deck)	-	-	0.48	2.4	C	-	-	-
Disco/dance floors	20	10	0.06	0.3		100	21	10.3
Health club/aerobics room	20	10	0.06	0.3		40	22	10.8
Health club/weight rooms	20	10	0.06	0.3		10	26	13.0
Bowling alley (seating)	10	5.0	0.12	0.6		40	13	6.5
Gambling casinos	7.5	3.8	0.18	0.9		120	9	4.6
Game arcades	7.5	3.8	0.18	0.9		20	17	8.3
Stages, studios	10	5.0	0.06	0.3	D	70	11	5.4

**GENERAL NOTES FOR TABLE 6.1**

- Related Requirements:** The rates in this table are based on all other applicable requirements of this standard being met.
- Smoking:** This table applies to no-smoking areas. Rates for smoking-permitted spaces must be determined using other methods.
- Air Density:** Volumetric airflow rates are based on an air density of 1.2 kg<sub>a</sub>/m<sup>3</sup> (0.075 lb<sub>a</sub>/ft<sup>3</sup>), which corresponds to dry air at a barometric pressure of 101.3 kPa (1 atm) and an air temperature of 21 °C (70 °F). Rates may be adjusted for actual density, but such adjustment is not required for compliance with this standard.
- Default Occupant Density:** The default occupant density shall be used when actual occupant density is not known.  
 Default: Combined Outdoor Air Rate (per person). This rate is based on the default occupant density.
- Unlisted Occupancies:** If the occupancy category for a proposed space or zone is not listed, the requirements for the listed occupancy category that is most similar in terms of occupant density, activities, and building construction shall be used.
- Residential facilities, Health care facilities, and Vehicles:** Rates shall be determined in accordance with Appendix E.

**ITEM-SPECIFIC NOTES FOR TABLE 6.1**

- For high school and college libraries, use values shown for *Public Spaces – Libraries*.
- Rate may not be sufficient when stored materials include those having potentially harmful emissions.
- Rate does not allow for humidity control. Additional ventilation or dehumidification may be required to remove moisture.
- Rate does not include special exhaust for stage effects, e.g., dry ice vapors, smoke.