UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 8 Examination in Engineering: January 2026

Module Number: ME8301 **Module Name: Building Services Engineering**

[Three Hours]

[Answer **five questions**, each question carries **twelve marks**]

[Provide neat sketches where necessary; make reasonable assumptions and state them clearly]

Q1 a) "Measuring sound levels (noise) is important for several practical, scientific, and regulatory reasons" Explain the statement.

[2.0 Marks]

b) What is building acoustics?

[2.0 Marks]

c) A pump room of a hotel is 5 m x 4 m in plan and 4 m high. It has four brickwork walls, a concreate floor and a concrete ceiling. The pumps are placed centrally within the room and their overall output power level (SWL) is 80 dBA. Calculate the followings;

(i) The room sound absorption constant,

(ii) The reverberation time for the pump room,

(iii) The sound pressure level that will be produced in the pump room at 1000 Hz, when the pumps are operating, close to the pumps and also generally within the room.

[8.0 Marks]

Note:

Absorption constant = $\frac{S\ \bar{\alpha}}{1-\bar{\alpha}}$ (m^2)

Reverberation Time = $\frac{0.161\,V}{S\,\bar{\alpha}}$ (s)

$SPL = SWL + 10\ log_{10}\left(\frac{Q}{4\pi r^2} + \frac{4}{R}\right)$ (dB)

All symbols represent their usual meaning.

Table Q1(c) Absorption Coefficients of Common Materials

Material	*Absorption coefficient at*					
	125 Hz	*250 Hz*	*500 Hz*	*1000 Hz*	*2000 Hz*	*4000 Hz*
25 mm plaster, 18 mm plasterboard, 75 mm cavity	0.3	0.3	0.6	0.8	0.75	0.75
18 mm board floor on timber joists	0.15	0.2	0.1	0.1	0.1	0.1
Brickwork	0.05	0.04	0.04	0.03	0.03	0.02
Concrete	0.02	0.02	0.02	0.04	0.05	0.05
12 mm fibreboard, 25 mm cavity	0.35	0.35	0.2	0.2	0.25	0.3
Plastered wall	0.01	0.01	0.02	0.03	0.04	0.05
Pile carpet on thick underfelt	0.07	0.25	0.5	0.5	0.6	0.65
Fabric curtain hung in folds	0.05	0.15	0.35	0.55	0.65	0.65
15 mm acoustic ceiling tile, suspended 50 mm mineral fibre wool or glass fibre matt	0.5	0.6	0.65	0.75	0.8	0.75
50 mm polyester acoustic blanket, metallized film	0.25	0.55	0.75	1.05	0.8	0.7
50 mm glass fibre blanket, perforated surface finish	0.15	0.4	0.75	0.85	0.8	0.85

Q2 a) "Lighting plays a crucial role in the design of a building because it affects function, comfort, safety, energy use, and the overall user experience." Explain the statement giving examples.

[2.0 Marks]

b) Explain clearly how **incandescent** and **fluorescent** lamps are used in present-day buildings, and why their usage has changed over time.

[2.0 Marks]

c) A new drawing office of dimensions 25 m x 10 m and 5 m high has a white ceiling and mainly light stone colour walls. The working plane is considered to be 1.5 m above the floor level. Bear fluorescent tube light fittings with two 58W, 1500 mm lamps are to be used. It has 5100 lighting design lumens. Their nominal spacing-to-height ratio is 1.75 and total power consumption is 140 W. Use the Lumen design method and determine the following,

(i) The number of luminaires needed,

(ii) The layout of the luminaires

(iii) The electrical loading per square meter of floor area

[8.0 Marks]

Table Q2(c)1 Illuminance requirement for different Applications

Application	*Illuminance (lx)*
Emergency lighting	0.2
Suburban street lighting	5
Dwelling	50–150
Corridors	100
Rough tasks with large-detail storerooms	200
General offices, retail shops	400
Drawing office	600
Prolonged task with small detail	900

Table Q2(c)2 Luminance factors for painted surfaces

Surface	*Typical colour*	*Luminance factor range (%)*
Ceiling	White, cream	70–80
Ceiling	Sky blue	50–60
Ceiling	Light brown	20–30
Walls	Light stone	50–60
Walls	Dark grey	20–30
Walls	Black	10
Floor	—	10

Table Q2(c)3 Utilization factors for a bare fluorescent tube fitting with two 58 W 1500 mm lamps (%)

Luminance factors		*Room index*								
Ceiling	*Walls*	*0.75*	*1*	*1.25*	*1.5*	*2*	*2.5*	*3*	*4*	*5*
70	50	48	53	59	64	71	75	79	83	86
70	30	40	46	51	57	64	69	73	78	82
70	10	35	40	46	51	59	64	68	74	78
50	50	43	48	52	57	63	67	70	74	76
50	30	37	41	46	51	57	62	65	70	73
50	10	33	37	42	46	53	58	61	67	70
30	50	39	42	46	50	55	59	61	65	67
30	30	34	37	42	46	51	55	58	62	65
30	10	30	33	38	42	48	52	55	59	62

Q3 a) Air quality is determined by various factors, primarily the presence and concentration of **major pollutants**, which are influenced by human activities, natural events, weather, and geography. What are the major air pollutants?

[1.0 Marks]

b) What are the indoor air quality safe practices?

[2.0 Marks]

c) The Faculty of Engineering is being proposed a new gymnasium at the premises where C_0 is 0.3 decipol. The given space is to be 15 m long, 10 m wide and 5 m high. It has no exterior windows. There will be between 20 – 35 simultaneous users of the facility. This is no smoking area and all the furnishings and building materials will have the low-pollution emission. At the peak usage, all the occupants will be highly active. Calculate the outdoor air ventilation rate, from the Fanger method, that will be required so that 75% of the occupants will be satisfied. Justify your answer considering the energy economy and comfort.

[6.0 Marks]

Note :

Fanger Equation;

$$Q = \frac{10\,x\,G}{C_i - C_0}$$

Q - rate of supply of outdoor air (l/s)

G – Biological effluent pollution load

C_i – The perceived air pollution within the enclosure (decipol)

C_0 – The perceived air pollution of outdoor air (decipol)

PD – The percentage of the occupants who are dissatisfied.

$$C_i = \frac{112}{(5.98 - lnPD)^4}$$

Table Q3(c) 1 The biological effluent pollution load

Normal occupancy	0.1 olf/m^2
40% of occupants as smokers	0.7 olf/m^2
Low pollution with absence of smoking	0.2 olf/m^2

Table Q3(c) 2 Olf values for human activities

Human activity	Number of olfs
Sedentary	1
Active	5
Highly active	11
Average for a smoker	6
During smoking	25

d) In the building sanitary systems, it is required to maintain the equilibrium of the trap seals and preventing trap seals from negative pressure. Discuss three types of sanitary systems with suitable sketches.

[3.0 Marks]

Q4 a) Answer the following questions using the Figure Q4(a) which is a plan of a house.

i) Write down the diversity factor equation of electrical wiring installation and briefly explain each term in the equation.

ii) Copy the Figure Q4(a) to your answer sheet (a clear sketch should be enough) and show how you can design an electrical circuit to this house. (Sketch electrical outlets, lights etc on the figure. No need to show electrical wires.) Explaining the importance and how to use diversity factor in electrical circuit design using your design in this part.

[4.0 Marks]

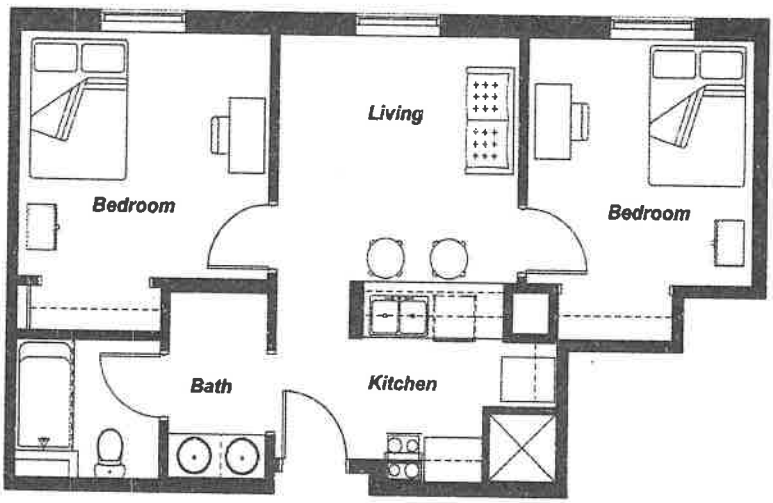

Figure Q4(a)

b) You are assigned to design an electrical circuit for a small house for approximately four people. The electrical system is a single phase system inside conduits. Total connected load is 40 A and a diversity factor of 1.5 can be applied to the circuit. Supply voltage of the electrical wiring should be 230V and voltage drop should not increase more than 2.5% of supply voltage at the end of the wires.

i) Allocating 20% from maximum expected current for future load, calculate the current demand that should be used for the design.

ii) A total length of 300m wire is needed for the design. The wires will be placed inside a conduit with an expected temperature of 30 ^{0}C. Select a suitable wire for the electrical wiring system.

[4.0 Marks]

c) You are assigned to design an electrical circuit for a large financial office for lightning and power for other machines. The electrical system is a three phase system inside conduits. The office operates 24 hours in full capacity. Total 50 A maximum current from the wire is expected. Supply voltage of the electrical wiring should be 400V and voltage drop should not increase more than 2.5% of supply voltage at the end of the wires.

i) Allocating 20% from maximum expected current for future load, calculate the current demand that should be used for the design.

ii) A total length of 1000m wire is needed for the design. The wires will be placed inside a conduit with an expected temperature of 35 ^{0}C. Select a suitable wire for the electrical wiring system.

[4.0 Marks]

Q5 a) i) What are the four types of HVAC systems based on the working fluid used in the thermal distribution system?

[2.0 Marks]

ii) With the aid of appropriate schematic diagrams, briefly explain all-air HVAC systems, clearly distinguishing between single-duct and dual-duct systems.

[4.0 Marks]

b) Figure Q(5) shows the arrangement of two spaces in a building which requires air conditioning. The maximum occupancy of the art classroom and the lobby area are 50

people and 08 people respectively. The conditioned spaces should be provided with adequate ventilation to maintain the indoor air quality (IAQ).

Equation for Breathing Zone Outdoor Air Flow: $V_{bz} = R_p x P_z + R_a x A_z$

Note: Refer the Table Q(5) for necessary data. All the notations given have their usual meaning

i) Calculate the required outdoor air flow rates for the two spaces, using ventilation rate procedure.

[2.0 Marks]

ii) Calculate the minimum exhaust rate required in the art classroom.

[1.0 Marks]

iii) If a single exhaust fan is used to remove air from both the art classroom and the lobby, with airflow from the lobby sweeping to the art classroom through the interconnecting door, calculate the additional outdoor air that must be supplied to the art classroom to balance the flow rates.

[2.0 Marks]

iv) Referring to Question (iii), briefly justify why the combined exhaust air from both spaces must be discharged through the art classroom and not the lobby.

[1.0 Marks]

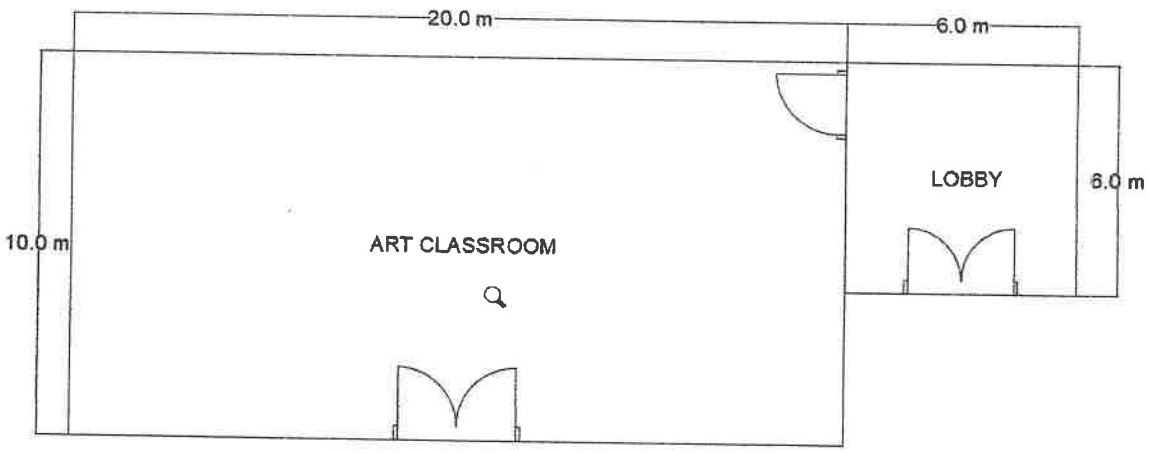

Figure Q5: Building layout

Table Q5: Minimum outdoor air and exhaust rates

Occupancy Category	People Outdoor Air Rate (R_p) (l/s)	Area Outdoor Air Rate (R_a) (l/s.m^2)	Minimum Exhaust Air Rate (l/s.m^2)	Air Class
Lobby	3.8	0.3	-	1
Art Classroom	5.0	0.9	3.5	2
Lecture Room	3.8	0.3	-	1