UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 8 Examination in Engineering: September 2023

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

[Three Hours]

[Answer **all questions**, each question carries **12 marks**]

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

Q1 a) What is the importance of acoustics of buildings?

[2.0 Marks]

b) Explain the difference between echo and reverberation.

[2.0 Marks]

c) A plant room of the marine building is 6 m x 4 m in plan and 4 m high. It has four brickwork walls, a concreate floor and a concrete ceiling. An air compressor is placed centrally within the plant room and its overall output power level (SWL) is 85 dBA. Calculate the followings.

(i) The room sound absorption constant.

(ii) The reverberation time for the plant room.

(iii) The sound pressure level that will be produced in the plant room at 1000 Hz, when the compressor is operating, close to the compressor 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.

Q1 continues to page 2...

'1 continues from page 1...

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) "Natural lighting has been proven to increase health and comfort levels for building occupants." Explain this statement giving examples.

[2.0 Marks]

b) Define the following terms used in lighting system design.

(i) Utilization Factor.

(ii) Maintenance Factor.

(iii) Colour-rendering.

(iv) Luminaire.

[2.0 Marks]

c) A supermarket of dimensions 30 m x 20 m and 5 m high has a white ceiling and dark gray walls. The working plane is considered to be 1.5 m above the floor level. Bear fluorescent tube light fittings with two 58 W, 1500 mm lamps are to be used for illumination here. This lamp has 5100 lighting design lumens and the supermarket needs to be maintained 450 lx. Their nominal spacing-to-height ratio is 1.75 and total power consumption of each luminaire is 140 W. Use the Lumen design method and determine the following.

(i) The number of luminaires needed.

Q2 continues to page 3...

continues from page 2...

(ii) The layout of the luminaires.

(iii) The electrical loading per unit area the floor.

(iv) The circuit current.

[8.0 Marks]

Table Q2(c)1 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)2 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) A new office is being proposed for the first floor of a commercial building in a city where C_0 is 0.3 decipol. The given space is to be 18 m long, 10 m wide and 3.5 m high. It has closed windows. There will be 10 to 30 simultaneous users of the facility. There will not be any smoking and all the furnishings and building materials will have the low-pollution emission of 0.1 olf/m^2. At peak usage, all the occupants will be 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.

Q3 continues to page 4...

Q3 continues from page 3...

Note :

Fanger Equation;

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

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

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 satisfied.

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

Table Q3(a)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(a)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

[4.0 Marks]

b) Explain with the aid of sketches the following plumbing designs for a cold water supply system in a house.

i) Pipes in a zone design.

ii) Pipes in a trunk and branch system design.

iii) Pipes in a parallel design.

[3.0 Marks]

c) What are the active and passive fire protection systems?

[2.0 Marks]

d) What are the **five** main groups of portable fire extinguishers? How they are useful as the first-aid in different classes of fire.

[3.0 Marks]

Q4 a) Briefly explain the diversity factor of an electrical wiring installation.

[2.0 Marks]

b) You are assigned to design an electrical circuit for a light system in a large hall. The electrical system is a single-phase system, which consists of live wire and neutral wire of same size. Total 10 A demand of light bulbs to be connected to the electrical wiring. 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 wire.

i. At a given time, only a maximum of 8 A demand of light bulbs is expected. Allocating 20% from 8 A current for future load, calculate the current demand that should be used for the design.

[2.0 Marks]

ii. A total length of 200 m wire is needed for the design. The wires will be placed inside a conduit at a temperature of 40 ^{0}C. Select a suitable wire for the electrical wiring system.

[3.0 Marks]

Table Q4(b)1: Cable size, current rating and voltage drop (Inside trunking & conduit)

Single phase one cable AC & DC		Three phase three or four core cable		Number & diameter / (mm)	Cross section / (mm^2)
Current / (A)	Volt drop per m / (mV / m)	Current /(A)	Volt drop per m/ (mV / m)		
11	41	9	35	1/1.13	1
13	28	12	24	1/1.38	1.5
18	17	16	15	1/1.78	2.5
24	11	22	9.1	7/0.85	4
31	7	27	6	7/1.04	6
40	4.1	37	3.6	7/1.35	10
53	2.6	47	2.2	7/1.70	16
60	1.7	53	1.5	7/2.14	25
74	1.2	65	1	19/1.53	35

Table Q4(b)2: Temperature factor.

Temp factor	1.02	1	0.97	0.94	0.91	0.88	0.77	0.63
^{0}F	77	86	95	104	113	122	1131	140
^{0}C	25	30	35	40	45	50	55	60
K	298.15	303.15	308.15	313.15	318.15	323.15	328.15	333.15

Q4 continues to page 6...

Q4 continues from page 5...

c) A four-star hotel needs a water storage tank sufficient for their occupants and visitors. It has 200 two-bed rooms and 100 single-bed rooms. 200 visitors use the hotel every day without staying in the rooms. Note that, it is advisable to have 2 days water storage for the hotel. Calculate the capacity of the storage tank required for the hotel.

Table Q4(c) Water supply requirement as per the building type

Sl No.	Type of Building	Consumption per Day, litres
(1)	(2)	(3)
i)	Factories where bath rooms are required to be provided	45 per head
ii)	Factories where no bath rooms are required to be provided	30 per head
iii)	Hospital (including laundry):	
	a) Number of beds not exceeding 100	340 per head
	b) Number of beds exceeding 100	450 per head
iv)	Nurses' homes and medical quarters	135 per head
v)	Hostels	135 per head
vi)	Hotel (up to 4 Star)	180 per head
vii)	Hotel (5 Star and above)	320 per head
viii)	Offices	45 per head
ix)	Restaurants	70 per seat
x)	Cinemas, concert halls and theatres	15 per seat
xi)	Schools:	
	a) Day schools	45 per head
	b) Boarding schools	135 per head
NOTE — For calculating water demand for visitors a consumption of 15 litres per head, per day may be taken.		

[5.0 Marks]

Q5 a) Briefly explain the difference between natural and mechanical ventilation of a building. Provide **two** examples for each.

[01 Mark]

b) What are the design steps and considerations you would take when designing a mechanical ventilation system for a kitchen in a restaurant (including the ductwork).

[02 Marks]

c) The length and width of a rectangular office space are 18.5 m and 8 m, respectively. The building envelope is well insulated for air conditioning, thus reducing the total heat gain to 180 W/m^2. The office has the capacity to accommodate 30 people and the space is to be air conditioned to 24°C and 50% RH. Average outdoor air conditions are found to be 32°C and 70% RH at the standard atmospheric pressure of 1.013 bar. If the air leaving the cooling coil of the air conditioner has 90% RH and the sensible heat

Q5 continues to page 7...

...continues from page 6...

ratio (RSHR) of the room is 0.75. Draw the process on the psychrometric chart provided and calculate the following.

(Density of Air (ρ_{air}) = 1.204 kg/m^3 and Specific Heat Capacity of Air (C_p) = 1.005 kJ/kg/K)

The equation for the Indoor Air Quality (IAQ) in the breathing zone is as follows.

$$V_{bz} = R_p x P_z + R_a x A_z$$

Note: All the notations given have their usual meaning.

i) The minimum outdoor air requirement to maintain the given indoor air quality condition.

[02 Marks]

ii) The supply air volume flow rate.

[02 Marks]

iii) The temperature of air entering the cooling coil after mixing.

[02 Marks]

iv) Apparatus dew point and the coil-by-pass factor.

[01 Marks]

v) Total coil load and the coil sensible heat ratio.

[02 Marks]

Table Q5: Minimum Ventilation Rates in Breathing Zone

	People Outdoor Air Rate R_p		**Area Outdoor Air Rate R_a**	
Occupancy Category	**cfm/ person**	**L/s· person**	**cfm/ft^2**	**L/s·m^2**
Office Buildings				
Breakrooms	5	2.5	0.12	0.6
Main entry lobbies	5	2.5	0.06	0.3
Occupiable storage rooms for dry materials	5	2.5	0.06	0.3
Office space	5	2.5	0.06	0.3
Reception areas	5	2.5	0.06	0.3
Telephone/data entry	5	2.5	0.06	0.3

PSYCHROMETRIC CHART

NORMAL TEMPERATURES

SI METRIC UNITS

Barometric Pressure 101,325 kPa

SEA LEVEL