UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: September 2023

Module Number: CE4251 **Module Name: Building Services Engineering**

[Three Hours]

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

Q1.

a) List out four factors to be considered in providing circulation to facilitate the movement of people through, around and between buildings and other parts of the built environment.

[2.0 Marks]

b) List four types of safety features available in modern lifts (elevators) and identify the role of each feature in providing a safe vertical movement for passengers.

[2.0 Marks]

c) You are required to design a lift (elevator) system for a 20-storey (excluding ground floor) mid-range type apartment building. The ground floor is designed for a shopping space whereas the remaining twenty floors are designed for apartment living. Each floor (from 1st floor to 20th floor) contains eight units of two-bedroom apartments. The floor-to-floor height of the building is 4m. Building owner's objective is to maximize the passenger service providing lifts. Design a suitable lift system for this building including a zoning arrangement if required. Your answer should contain the number of lifts, the size and capacity of a lift and the shaft size. Use information given in Data Sheets 1, 2 and 3. Any assumption made should be clearly mentioned and justified.

[4.0 Marks]

d) What are the challenges of providing lift services in complex mix use towers?

[2.0 Marks]

e) Briefly discuss how sustainability concepts can be used in designing lift systems for skyscrapers.

[2.0 Marks]

Q2.

a) The green building concept is intended to deliver improved sustainability in the construction sector. Explain, giving examples, the economic, environmental, and social benefits that green building offers.

[3.0 Marks]

b) Can the early involvement of all project stakeholders make a building design and construction sustainable? Discuss your rationale.

[3.0 Marks]

c) "Not all green buildings are, and need to be, the same." Elaborate this statement with examples.

[3.0 Marks]

d) Briefly describe, using sketches, one possible method that can be applied for indoor water conservation in a skyscraper.

[3.0 Marks]

Q3.

a) What is meant by 'Travel Distance' and 'Direct Distance' according to the Fire Regulations of the Construction Industry Development Authority, Sri Lanka?

[2.0 Marks]

b) Explain using suitable sketches how the spread of fire is expected to be limited by a good fire compartmentation practice in designing a high-rise building.

[2.0 Marks]

c) There can be potential conflicts between fire safety designs in buildings and green building designs. Do you agree with this statement? Justify your answer.

[2.0 Marks]

b) Briefly describe how sprinkler systems function, giving details of the different types of operating systems available.

[2.0 Marks]

c) You are required to design an automatic sprinkler system for a two-storey paint factory. There are two identical rooms at each level. Inside space of a room is 25m long and 20m wide. Assume that the sprinkler system can function without any structural obstructions such as beams and columns. Design and sketch a suitable arrangement for the sprinkler system by following standard spacing of sprinkler heads. Use information given in the Data Sheet 4.

[4.0 Marks]

Q4.

An office is located in a single-storey building with dimensions 30m x 16.5 m. The plan of the building is shown in Figure Q4. Building consists of steel framed glass windows, with a flat roof. There are three sets of windows (1.2m x1.5m each) and two door openings (2.5 m x 2.2 m and 0.9 m x 2.2 m). The height of the building is 4 m.

a) Select a suitable orientation for this building (assuming the North direction by yourself, and wind direction is not necessary to consider) to minimize the external thermal gains so that it will be possible to provide thermal comfort without air conditioning. Give reasons for your selection.

[3.0 Marks]

b) Determine the total cooling load capacity required to air condition the building. You can assume that 20 staff, 8 computers and 5 printers will be there in the building. Each computer will emit 25W of heat while a printer will emit 10W. In addition, 20 bulbs each emitting 10W will serve the building. Use Data Sheet 6 in answering the question. State any assumptions made.

[5.0 Marks]

c) Discuss possible actions, which could be taken during design and pre-construction stages of a building to avoid or minimize future air conditioning costs.

[2.0 Marks]

d) What is meant by the comfort zone on a psychometric chart? Discuss the necessary modifications required to bring the indoor environment of cold weather countries into the comfort zone.

[2.0 Marks]

Q5. a) List four parameters to be considered when designing a pipe network to supply cold water to a building.

[2.0 Marks]

b) A copper cold-water distributing pipe having an actual length of 15m, with six elbows in the run, is discharging water under a constant head of water of 6m. Check weather 35mm outside diameter pipe is sufficient to discharge 2*l*/s. Use information given in Data Sheet 5. Any assumption made should be clearly mentioned and justified.

[4.0 Marks]

c) Discuss how the water seal of a sanitary appliance is lost due to self-siphonage and induced siphonage. Mention an arrangement to prevent each of these issues.

[3.0 Marks]

d) Draw a diagram to illustrate a fully ventilated one pipe system for sanitary drainage. List two advantages of this system compared to a single stack system.

[3.0 Marks]

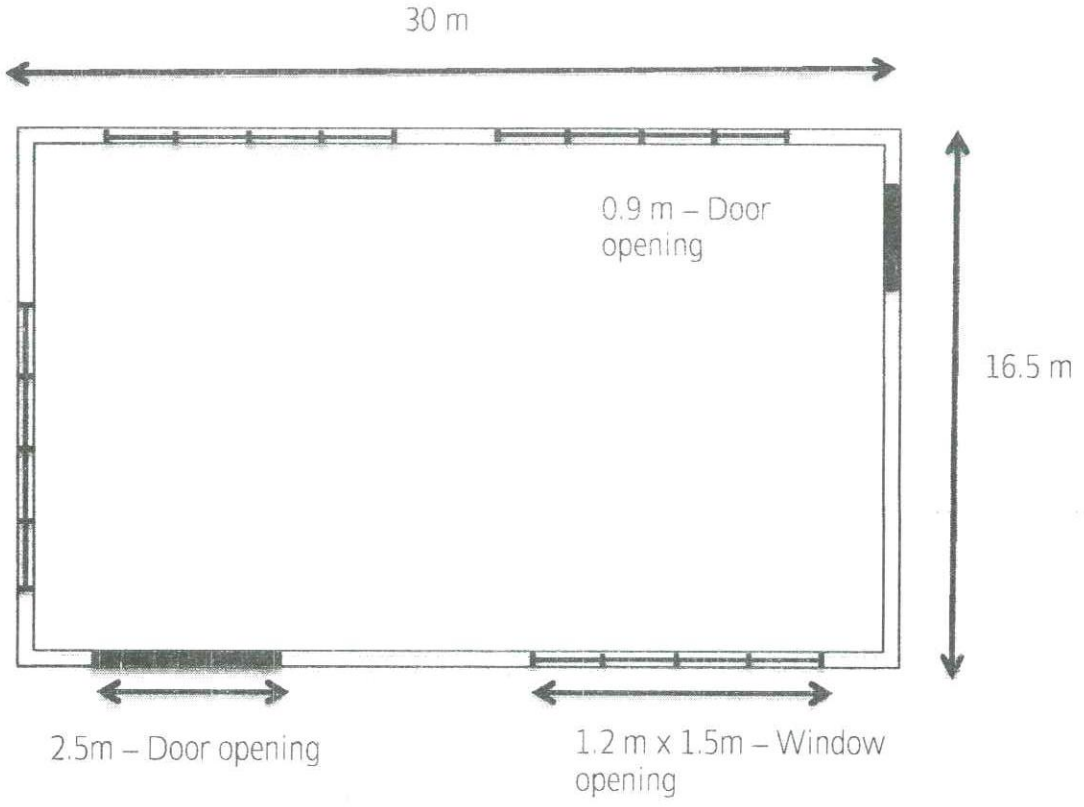


Figure Q4: Building Layout

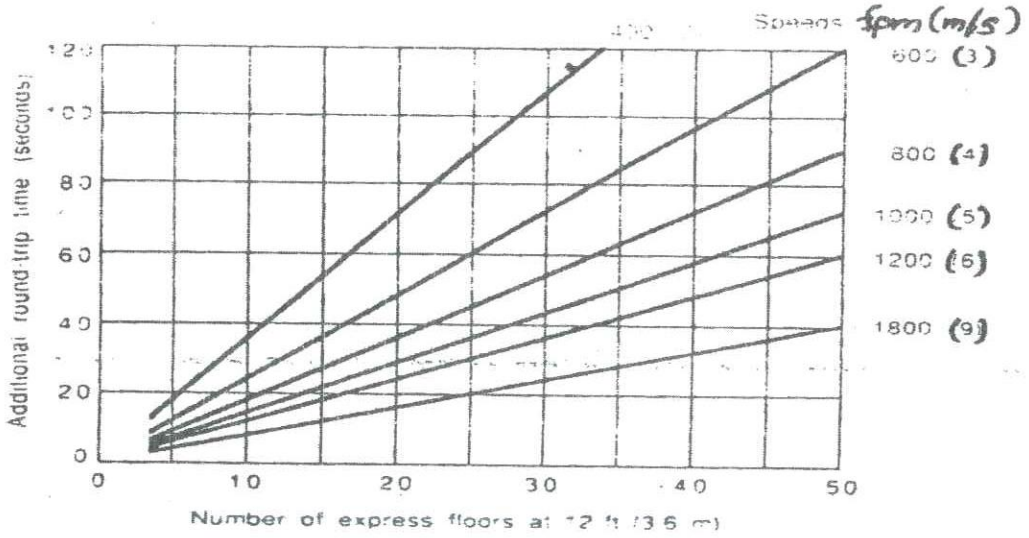
Elevator Speeds for Various Occupancies

Travel Distance		Offices and Hotels		Retail Stores		Apartments	
ft	*m*	*fpm*	*m/s*	*fpm*	*m/s*	*fpm*	*m/s*
0-60	0-20	200-400	1-2	200	1	100	0.5
60-120	20-36	300-400	1.5-2	200-300	1-1.5	200	1
120-240	36-72	500-600	2.5-3	200-400	1-2	200-400	1-2
240-500	72-150	800-1000	4-5				

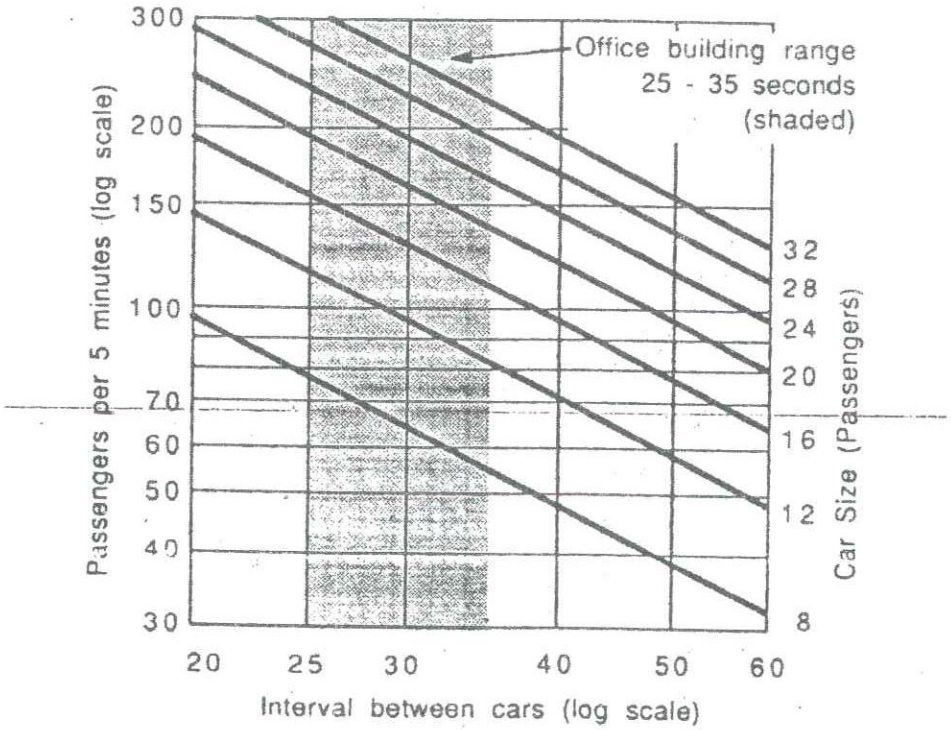
fpm: feet per minute

Design Parameters for Elevators

Building type	Population Density		% Population Handled in 5 minutes	Average Interval Seconds
	ft^2/person	m^2/person		
Offices				
Prestige, single tenant	300	12	12-17	25-30
Investment downtown	100-110	9-10	12-14	30-35
Investment suburban	90-100	8-9	12-14	30-45
Apartment				
Prestige	1.5 per bedroom		5-7	50-70
Midrange	2 per bedroom		6-8	60-80
Low rental	2-3 per bedroom		6-8	80-120
Hotels				
4-5 star	1.5-2 per room		12-15	40-60
3 and less star	1.5-2 per room		10-12	50-70



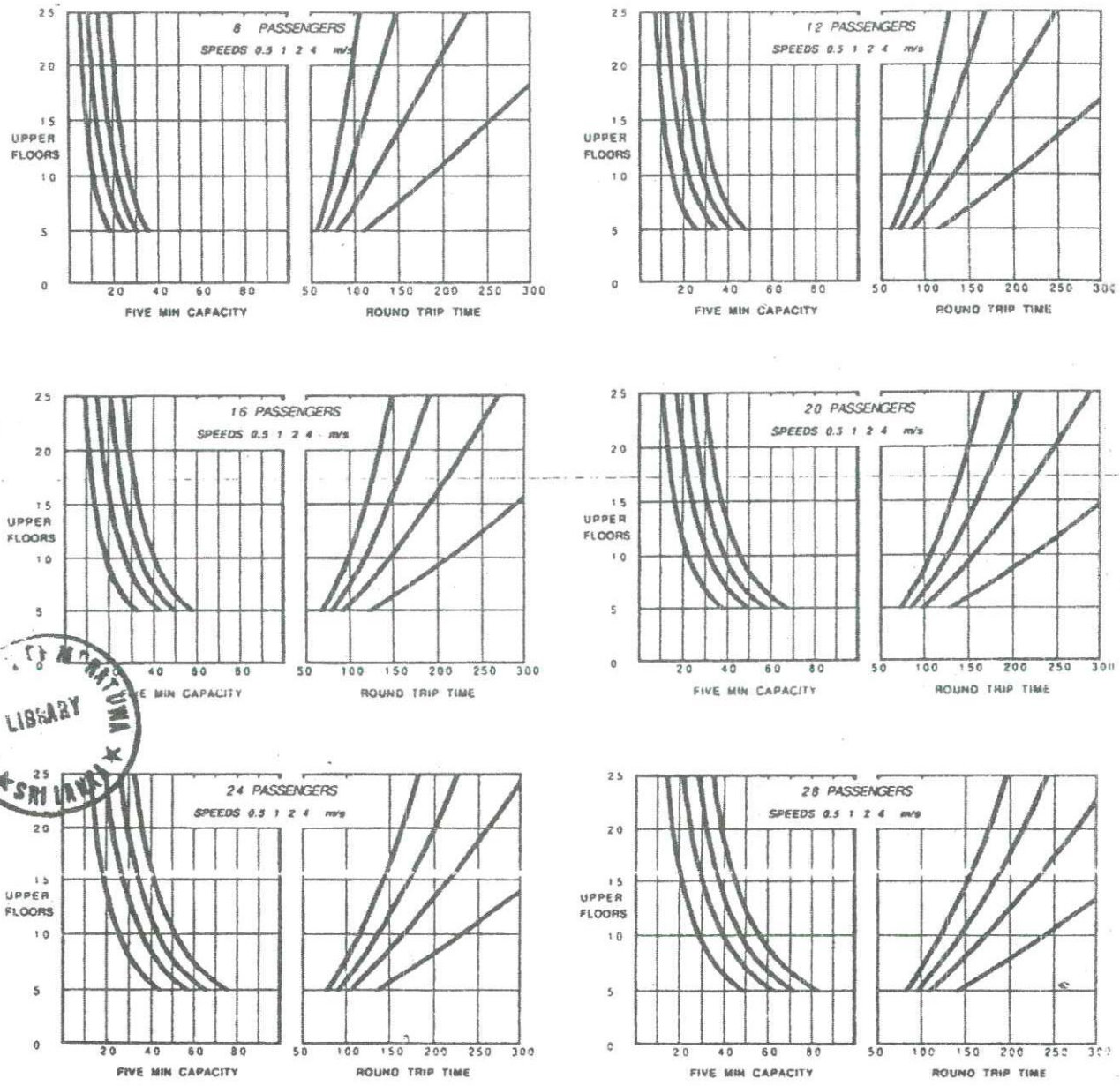
. Additional time to be added to the round-trip time when a car operates express through the lower floors of a building. The additional time is calculated as twice the distance divided by the speed, and therefore allows for both the up and down travel through the express zone at rated car speed.



The five-minute handling capacity of sets of various sized elevator cars, plotted against the interval between them. First determine the required handling capacity of the group. Enter the graph from the left, and continue across to find the intersection of an acceptable car size and interval. If the required capacity is too high for an acceptable solution, try zoning. If it is too low, then the building is less than optimum size for elevatoring. Once a size and interval is determined, refer to Fig. 25.7.2 to determine the round-trip time of cars of various speeds. The number of cars required in the group is the round-trip time divided by the required interval.

Approximate Sizes and ratings of Elevator Cars

Capacity		*Passengers*		*Inside W x D*		*Shaft W x D*	
lb	*kg*	*Max*	*Average*	*in*	*mm*	*in*	*Mm*
2000	900	12	10	68 x 51	1700 x 1300	89 x 83	2200 x 2100
2500	1150	16	13	82 x 51	2100 x 1300	102 x 83	2550 x 2100
3000	1350	20	16	82 x 55	2100 x 1400	102 x 88	2550 x 2200
3500	1600	24	19	82 x 66	2100 x 1650	102 x 96	2550 x 2400
4000	1800	28	22	92 x 66	2300 x 1650	114 x 96	2850 x 2400



The round trip time, and five-minute carrying capacity, for single elevator cars from 8 to 28 passenger nameplate capacity, and speeds from 100 to 800 fpm (0.5 to 4 m/s). All upper floors are assumed to have equal attraction. Figures are based on up peak conditions. Assumptions made about door operations and landing dwell times are intended to reflect good conditions. Slight to moderate downgrading is likely with nonstandard conditions such as extended door-open times and narrow or deep car shape.

Data Sheet 4

Sprinkler arrangements

S= design spacing of sprinkler on range pipes
- Max. 4.6 m extra light hazard
- Max. 4.0 m ordinary hazard
- Max. 3.7 m extra high hazard

D= distance between rows of sprinklers

S x D =
- 21 m^2 or less, extra light hazard
- 12 m^2 or less, ordinary hazard
- 9 m^2 or less, extra high hazard

Classification of occupancies

Extra light hazard
Hospitals, hotels, libraries, museums, nursing homes, offices, prisons, schools, colleges

Ordinary hazard (Group I)
Butchers, breweries, cement works, cafes

Ordinary hazard (Group II)
Bakeries, chemical works (ordinary), engineering works, laundries, garages, potteries, shops

Ordinary hazard (Group III)
Aircraft factories (excluding hangars), boot and shoe factories, carpet factories, clothing factories, departmental stores, plastic factories, printing rooms, saw mills, warehouses

Group III (Special)
Cotton mills, distillers, film and television studios, match factories

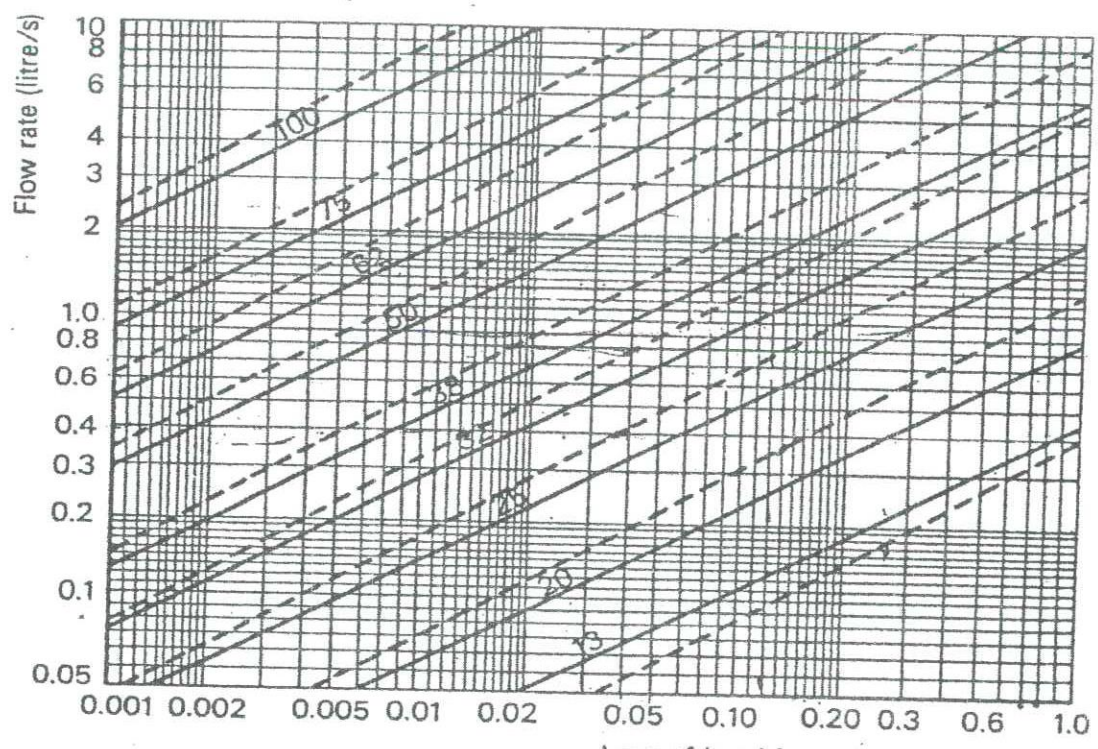
Extra high hazard
Celluloid works, foam plastics and rubber factories, paint and varnish factories, wood and wood works, high piled storage risks, oil flammable liquid hazard

Data Sheet 5

Equivalent length for frictional resistance

Copper/Plastic pipe nominal outside diameter (mm)	Meter run of pipe	
	Elbow	Tee
15	0.5	0.6
22	0.8	1.0
28	1.0	1.5
35	1.4	2.0
42	1.7	2.5
54	2.3	3.5
62	3.0	4.5
76	3.4	5.8
108	4.5	8.0

Galvanized steel pipe nominal outside diameter (mm)	Meter run of pipe		
	Elbow	Bend	Tee
15	0.5	0.4	1.2
20	0.6	0.5	1.4
25	0.7	0.6	1.8
32	1.0	0.7	2.3
40	1.2	1.0	2.7
50	1.4	1.2	3.4
65	1.7	1.3	4.2
80	2.0	1.6	5.3
100	2.7	2.0	6.8



copper lead and plastics – – – –
galvanised steel. ———

Pipe-sizing chart

Data Sheet 6

	Item	Quantity		Factor		BTU/hr
				*90 **	*95**	
1	Window exposed to Sun	N or E NW W NE & SW	sqft sqft sqft sqft	42 77 85 57	47 80 100 60	=
2	All windows not included in item 1		sqft	20	25	=
3	Wall exposed to Sun (wall considered in item 1)	Light construction Heavy construction	lnft lnft	60 40	70 50	=
4	All exterior walls not included in item 3		lnft	22	27	=
5	Partitions	All interior walls adjacent to an unconditioned space	lnft	20	30	=
6	Ceiling or Roof (use only one)	Ceiling with unconditioned space Ceiling with no insulation Attic space with insulation Flat roof with no insulation Ceiling below with insulation Roof no insulation	sqft sqft sqft sqft sqft sqft	1 8 5 7 3 14	3 10 3 8 3 16	=
7	Floor	Over unconditioned space	sqft	2	3	=
8	People	Including allowances for ventilation through unit	No	..... x 1000		=
9	Light & Electrical equipment		W	..... x 3.41		=
10	Doors or Arches continuously open to unconditioned space		Nos	..... x 250		=
					Total cooling load	=

*:- outside design condition of

1 BTU (British Thermal Unit)/hr=0.2931 Watt