Refrigeration and Air conditioning Engineering.
3rd year – refrigeration and Air conditioning Course

M.Sc. Zahraa F. Hussain

COOLING LOAD ESTIMATION

Lecture -4

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Example 2.

A single-family detached house shown in Fig. 1a is located in Iraq- Baghdad. The **Wall** **is built from of 13 mm cement plaster, 20 cm common brick and 10 mm gypsum plaster**. While the **Partition** is built from **10 cm common brick** and **10 mm gypsum plaster on both sides**. The **Roof** is built from outside to inside from **10 mm cement tail**, **130 mm sand**, **10 mm Expanded polyurethane**, **Asphalt shingles**, **150 mm concrete** and **20 mm gypsum**. The floor consist from outer to inner from carp, cement tile of 25 mm thick., heavy concert of 15 cm thick. Ceiling height is 3 m *Fenestration*. Clear single glass, 3 mm thick. Assume closed, medium-color well fitted, aluminum frame. *Doors* made of wood of 25 mm thickness. *Occupancy*. Four persons, based on two for the master bedroom and one for each additional bedroom. Assign to the living room. L*lights.* Assume 480 W for the kitchen, and 480 W for living room, assign 50% to bed room 1, 25% for bedrooms 2 and 3. *Appliances* : there is one TV,PC laptop, laser printer, and Coffee brewer in living room, The construction of the house is considered medium. Find the sensible, latent, and total cooling load; size the cooling unit; and compute the air quantity for each room.

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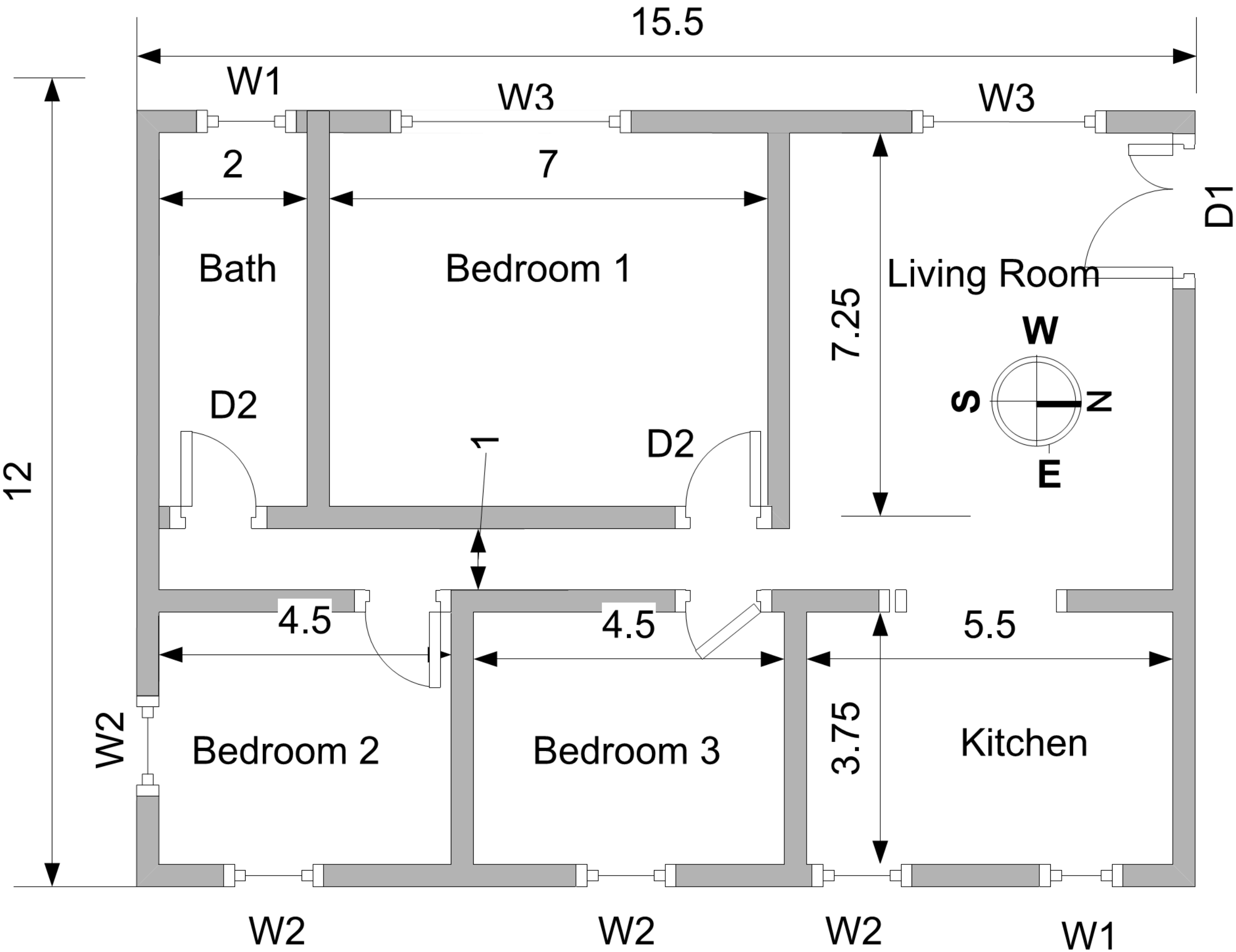

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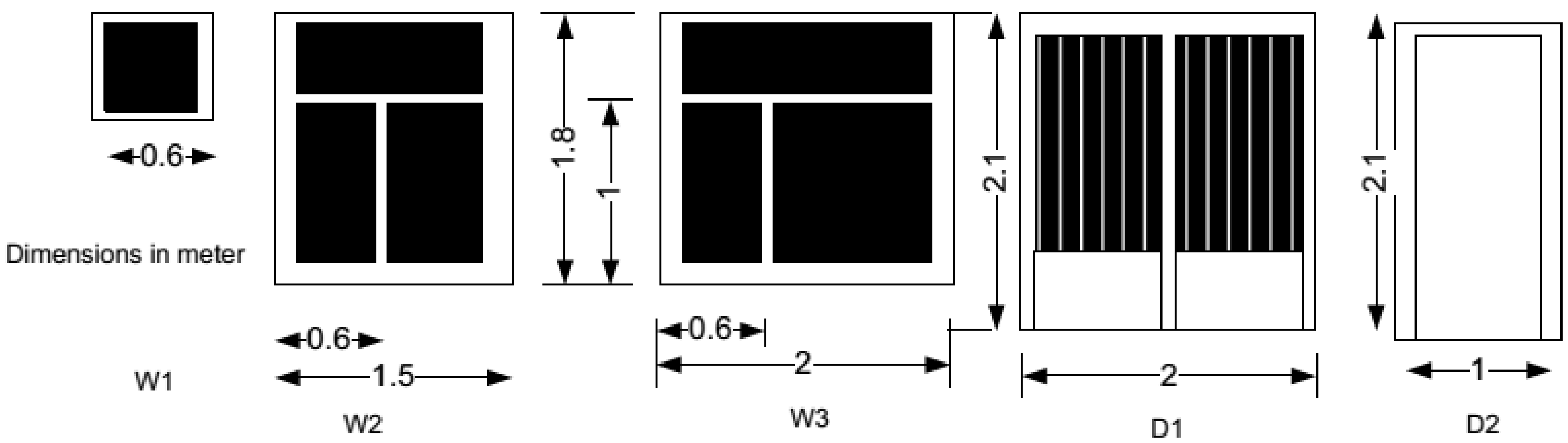
0.6
Dimensions in meter
W1
0.6
1.5
W2
1.8
1
0.6
2
W3
2.1
2
D1
2.1
1
D2

Solution:

The cooling load must be made on a room-by-room basis to determine the proper distribution of air. The calculations follow the procedure outlined in the section on Load Components. The using of thermal resistance R is not like the use of the thermal conductivity k, since the thermal resistance depends on a given material thickness, while the thermal conductivity does not depends on the material thickness, Let takes an example, If we have two thicknesses of **Stucco**, the first one is **25 mm** and the second is **10 mm,** find the heat transfer coefficient and the thermal resistance for both thicknesses.

Table 19 Properties of building materials

Description	L mm	K W/mK	P kg/m³	R m²K/W	Mass kg/m²
Outside surface resistance, Summer	---	0.000	---	0.059	0.00
Outside surface resistance, winter	---	0.000	---	0.041	
Stucco	25	0.692	1858	0.037	47.34
Face brick	100	1.333	2002	0.076	203.50
Face brick	100	1.333	2002	0.076	203.50
Clay tile	100	0.571	1121	0.178	113.70
low density concrete block	100	0.381	609	0.266	61.98
high density concrete block	100	0.813	977	0.125	99.06
Common brick	100	0.727	1922	0.140	195.20
high density concrete	100	1.731	2243	0.059	227.90
Clay tile	200	0.571	1121	0.352	227.90
low density concrete block	200	0.571	609	0.352	123.46
high density concrete block	200	1.038	977	0.196	198.62
Common brick	200	0.727	1922	0.279	390.40
high density concrete	200	1.731	2243	0.117	455.79
high density concrete	300	1.731	2243	0.176	683.20
high density concrete	50	1.731	2243	0.029	113.70
high density concrete	150	1.731	2243	0.088	341.60
low density concrete	100	0.173	641	0.587	64.90
low density concrete	150	0.173	641	0.880	97.60
low density concrete	200	0.173	641	1.173	130.30
low density concrete block (filled)	200	0.138	288	1.467	58.56
high density concrete block (filled)	200	0.588	849	0.345	172.75
low density concrete block (filled)	300	0.138	304	2.200	92.72
high density concrete block (filled)	300	0.675	897	0.451	273.28
Inside surface resistance		0.000		0.121	0.00
Plaster or gypsum	20	0.727	1602	0.026	30.74
Ceiling air space	---	0.000	---	0.176	0.00
Asphalt Roll Roofing			1120	0.09	
Carpet and Fibrous Pad				1.20	
Carpet and Rubber Pad	25			0.71	
Ceramic Tile	7			0.05	
Concrete Tile	10	0.27	1921	0.037	23
Sand	130		1681	0.016	21
Sand	160		1681	0.019	27
Cement plaster	13		1680	0.05	105.6
Expanded polyurethane		0.04	16		

The Wall

10 mm gypsum plaster

K=0.727 W/m.K

$$R_1 = \frac{\Delta x}{K} = \frac{0.01}{0.727} = 0.0137\ m^2K/W$$

$$W_1 = 30.74 * \frac{10}{20} = 15.37 \frac{kg}{m^2}$$

200 mm common brick

$$R_2 = 0.279\ m^2K/W$$

$$W_2 = 390.4 \frac{kg}{m^2}$$

13 mm cement plaster

$$R_3 = 0.05 \frac{m^2K}{W}$$

$$W_3 = 105.6\ \frac{kg}{m^2}$$

$$R_i = \frac{1}{h_i} = \frac{1}{8.3} = 0.1204\ m^2K/W \quad R_o = \frac{1}{h_o} = \frac{1}{17} = 0.0588\ m^2K/W$$

$$R_t = R_o + R_1 + R_2 + R_3 + R_i$$

$$R_t = 0.1204 + 0.0137 + 0.279 + 0.05 + 0.0588 =$$

$$R_t = 0.5219\ m^2K/W$$

$$U_o = \frac{1}{R_t} \quad U_w = \frac{1}{0.5219} = 1.916\ W/m^2K$$

The weight of the wall

$$W_t = 105.6 + 390.4 + 15.37 = 511.37\ \frac{\text{kg}}{\text{m}^2}$$

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Cement plaster	13		1680	0.05	105.6
Expanded polyurethane		0.04	16		

The Wall (partition)

10 mm gypsum plaster

K=0.727 W/m.K

$$R_1 = \frac{\Delta x}{K} = \frac{0.01}{0.727} = 0.0137\ m^2K/W$$

$$W_1 = 30.74 * \frac{10}{20} = 15.37\frac{kg}{m^2}$$

100 mm common brick

$$R_2 = 0.140\ m^2K/W$$

$$W_2 = 95.20\frac{kg}{m^2}$$

10 mm gypsum plaster

K=0.727 W/m.K

$$R_3 = \frac{\Delta x}{K} = \frac{0.01}{0.727} = 0.0137\ m^2K/W$$

$$W_3 = 30.74 * \frac{10}{20} = 15.37\frac{kg}{m^2}$$

$$R_i = \frac{1}{h_i} = \frac{1}{8.3} = 0.1204\ m^2K/W$$

$$R_t = R_i + R_1 + R_2 + R_3 + R_i$$

$$R_t = 0.1204 + 0.0137 + 0.140 + 0.0137 + 0.1204 =$$

$$R_t = 0.4082\ m^2K/W$$

$$U_o = \frac{1}{R_t} :$$

$$U_w = \frac{1}{0.4082} = 2.45\ W/m^2K$$

The weight of the wall

$$W_t = 15.37 + 95.20 + 15.37 = 125.94\ \frac{\text{kg}}{\text{m}^2}$$

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Ceiling air space	---	0.000	---	0.176	0.00
Asphalt Roll Roofing			1120	0.09	
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Sand	160		1681	0.019	27
Cement plaster	13		1680	0.05	105.6
Expanded polyurethane		0.04	16		

The Roof

10 mm concrete tail

$$R_1 = 0.037\ m^2K/W$$

$$W_1 = 23\ \frac{kg}{m^2}$$

130 mm sand

$$R_2 = 0.016 m^2K/W$$

$$W_2 = 21\ \frac{kg}{m^2}$$

10 mm Expanded polyurethane

$$R_3 = \frac{\Delta x}{K} = \frac{0.01}{0.04} = 0.25\ m^2\ K/W$$

Asphalt shingles

$$R_4 = 0.09 m^2K/W$$

150 mm concrete

$$R_5 = 0.088\ m^2K/W$$

$$W_5 = 341.6\ \frac{kg}{m^2}$$

20 mm gypsum plaster

$$R_6 = 0.026\ m^2K/W$$

$$W_6 = 30.74\ \frac{kg}{m^2}$$

$R_o = \frac{1}{h_o} = \frac{1}{17} = 0.0588\ m^2K/W \quad R_i = \frac{1}{h_i} = \frac{1}{8.3} = 0.1204\ m^2K/W$

$R_t = R_0 + R_1 + R_2 + R_3 + R_4 + R_5 + R_6 + R_i$

$R_r = 0.1204 + 0.037 + 0.016 + 0.25 + 0.09 + 0.088 + 0.026 + 0.0588 =$
$R_t = 0.6862\ m^2K/W$

$U_o = \frac{1}{R_t}$: $\quad U_r = \frac{1}{0.6862} = 1.457\ W/m^2K$

The weight of the Roof

$W_t = 23 + 21 + 341.6 + 30.74 = 416.34 \frac{kg}{m^2}$

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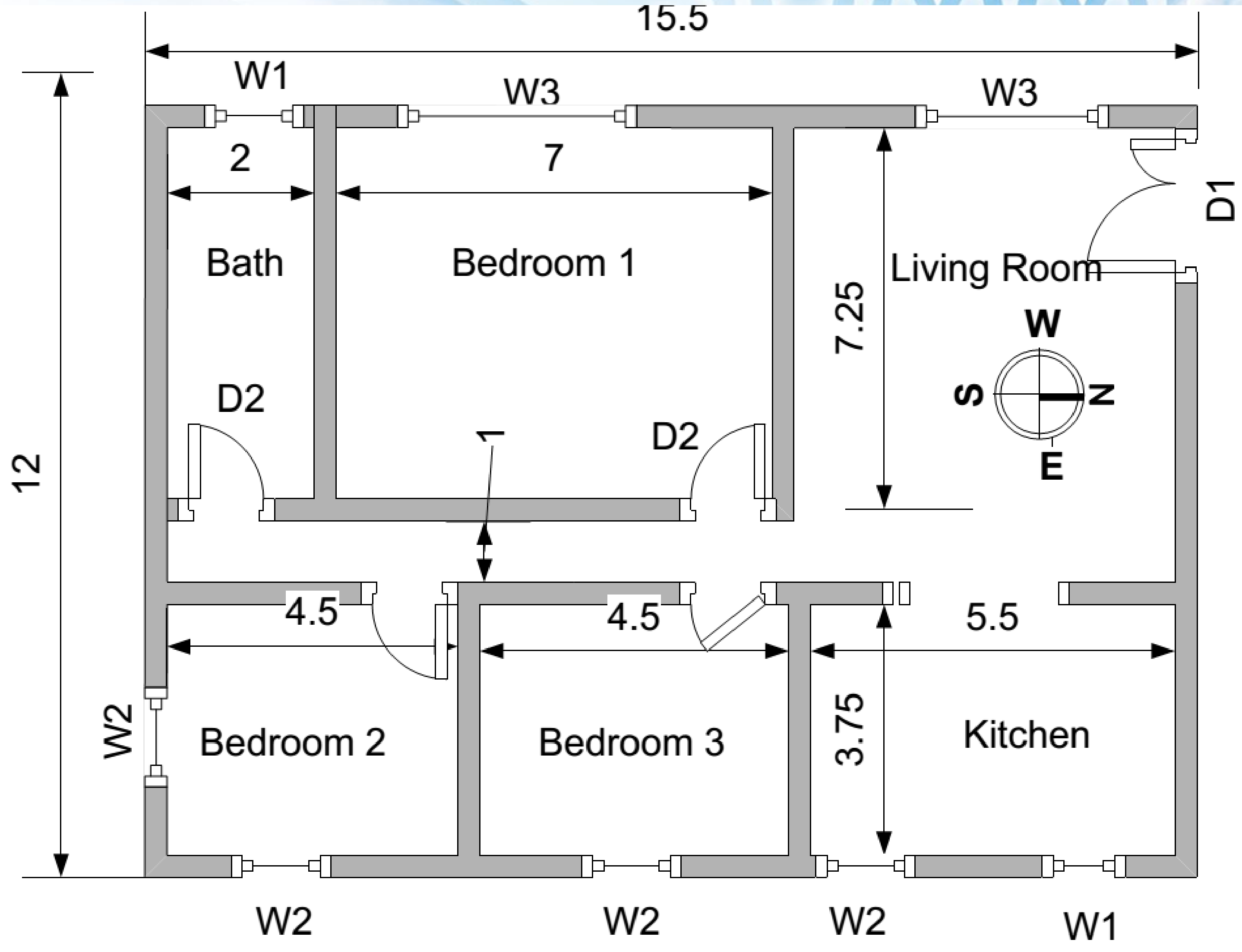
Outer wall		Partition	Roof		Window	Door
U	W	U	U	W	U	U
$W/m^2.K$	kg/m^2	$W/m^2.K$	$W/m^2.K$	kg/m^2	$W/m^2.K$	$W/m^2.K$
1.916	511	2.45	1.457	416	6.42	3.92



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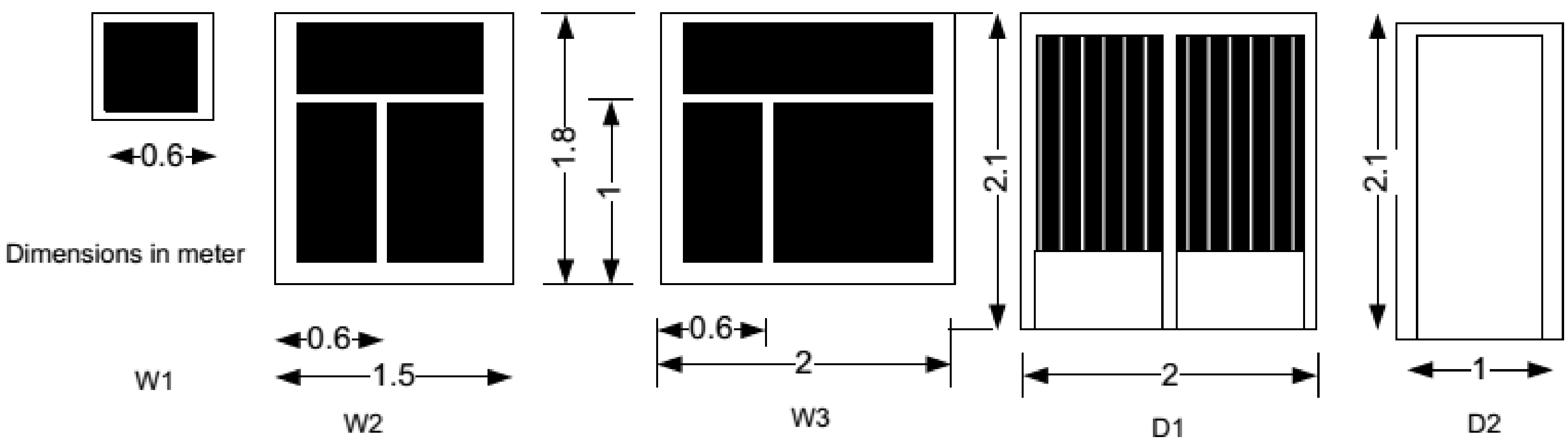

0.6
Dimensions in meter
W1
0.6
1.5
W2
1.8
1
0.6
2
W3
2.1
2
D1
2.1
1
D2

Area of Building

Room name	Net area of outer Walls (m^2)				Windows					Floor (m^2)	Roof (m^2)	Partition
	W	E	N	S	W	E	N	S	Door			
Bed R1	17.4	-	-	-	3.6	-	-	-	2.1	50.75	50.75	18.9
Living room	12.9	-	20.55		3.6	-	-	-	4.2	45.38	45.34	16.5
Bed R2	-	10.8	-	8.55	-	2.7	-	2.7	2.1	16.88	16.88	11.4
Bed R3	-	10.8		-		2.7			2.1	16.88	16.88	11.4 11.25
Kitchen	-	13.44	11.25	-	-	2.7 0.36			-	20.63	20.63	11.25

Appliance & Lights & People

Appliances

	People	Lights		appliances			
applications							
Bed R1	2	120					
Living R	4	480		TV	Pc	Print.	coffe
Bed R2	1	120					
Bed R3	1	120					
Corridor							
Kitchen		480					

The outside design conditions for summer is 45°C DBT and 15% RH with daily range of 18.7°C, 1.5°C and 84% RH for winter.

Equivalent temperature difference:

To calculate the equivalent temperature difference for any wall or roof at any orientation, the following procedures must be considered:

This sample of calculation is for West wall

No.		W	N	E	S	H
1	Calculate the weight of wall or roof per m^2	511.37	511.37	511.37	511.37	416
2	Select the equivalent temperature difference (T15)	5.6	1.7	11.1	8.3	15.6
3	Select the outdoor design conditions for summer(T1)	45	45	45	45	45
4	Select the outdoor design conditions for winter(T1)	1.5	1.5	1.5	1.5	1.5
5	Find the yearly range	45-1.5	43.5	43.5	43.5	43.5
6	Find the daily range (Table 1)	18.7	18.7	18.7	18.7	18.7
7	Find the difference between (outdoor design condition for month at 3P.M.)	45-25	20	20	20	20
8	Find the correction of equivalent temp. diff. (T16A)	7.2	7.2	7.2	7.2	7.2
9	Find the equivalent temperature difference for wall or roof exposed to the sun (Dtem) (Step 8+step 2)	5.6+7.2 =12.8	8.9	18.3	15.5	22.8
10	Find equivalent temperature difference for same wall or roof in shade (DTes)(T15+step 8)	1.7+7.2 =8.9	8.9	8.9	8.9	8.9
11	Find the maximum solar radiation maximum solar heat gain through glass for wall (Rs) (T12A)	517	69	517	95	776
12	Find the maximum solar heat gain through glass for wall facing or horizontal for roofs, for July at 40 North latitud (Rm) T12B)	511	44	511	322	675

- **Equivalent temperature difference for West wall & Roof**

1	Calculate the weight of wall or roof per m_2	511
2	Select the equivalent temperature difference (T15)	5.6
3	Select the outdoor design conditions for summer	45
4	Select the outdoor design conditions for winter	1.5
5	Find the yearly range	43.5
6	Find the daily range (Table 1)	18.7
7	Find the difference between (outdoor design condition for month at 3P.M.)	20
8	Find the correction of equivalent temp. diff.	7.2
9	Find the equivalent temperature difference for wall or roof exposed to the sun (Dtem)	**12.8**
10	Find equivalent temperature difference for same wall or roof in shade (DTes)	**8.9**
11	Find the maximum solar radiation maximum solar heat gain through glass for wall (Rs)	**517**
12	Find the maximum solar heat gain through glass for wall facing or horizontal for roofs, for July at 40 North latitud (Rm)	**511**

$$\Delta t_e = 0.78 \frac{R_s}{R_m} . \Delta t_{em} + (1 - 0.78) \frac{R_s}{R_m} . \Delta t_{es}$$

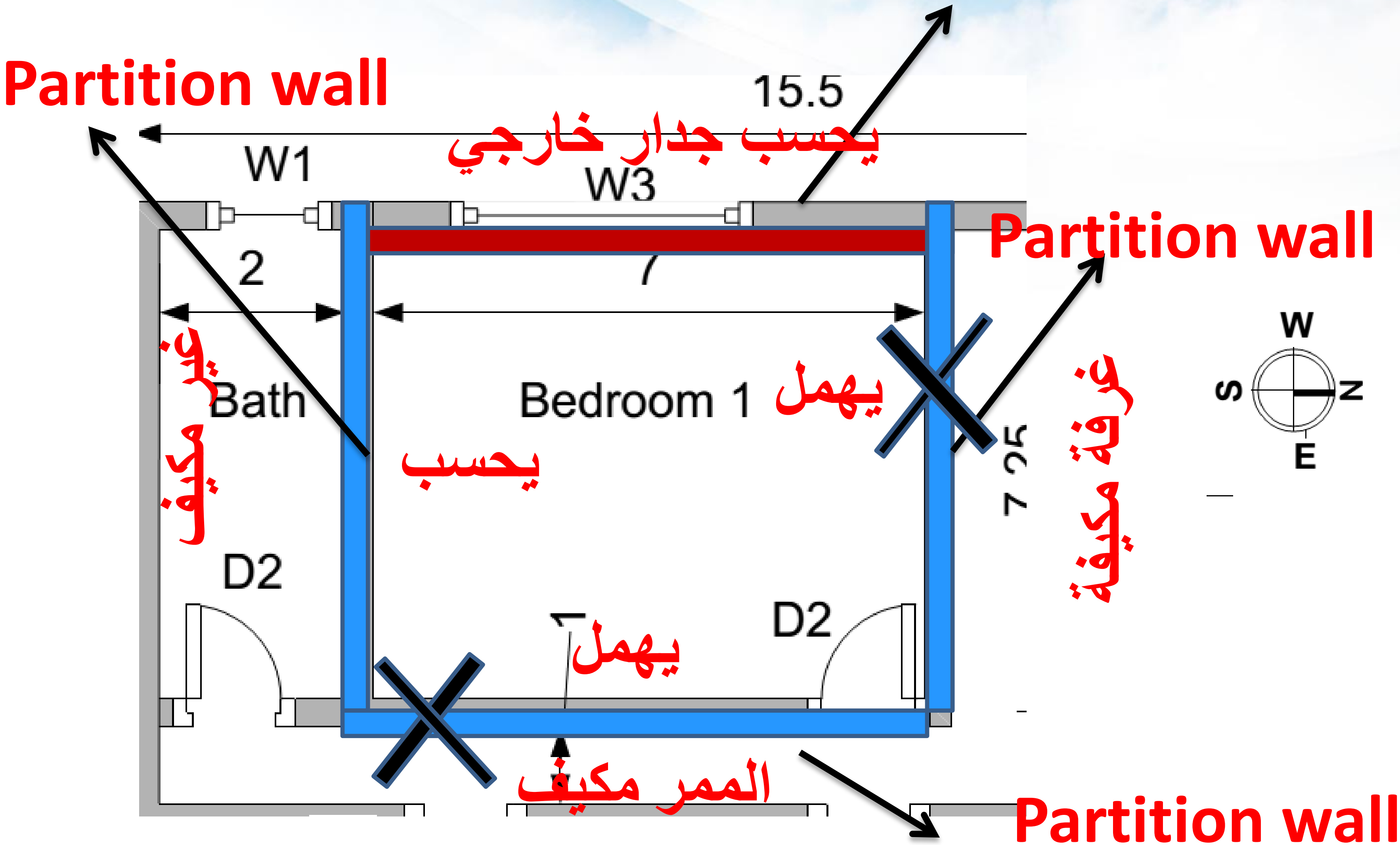
for west wall

$$\Delta t_e = 0.78 \frac{517}{511} . 12.8 + (1 - 0.78) \frac{517}{511} . 8.9 = 12.08$$

for roof

$$\Delta t_e = 0.78 \frac{776}{675} . 22.8 + (1 - 0.78) \frac{776}{675} . 8.9 = 22.7$$

Bedroom1



Outer wall
Partition wall
15.5
يحسب جدار خارجي
W1
W3
2
7
Partition wall
Bath
Bedroom 1
يهمل
يحسب
غير مكيف
غرفة مكيفة
W
S
N
E
D2
D2
يهمل
الممر مكيف
Partition wall

Bedroom1

Solar Heat gain Glass

$$Q_{s/g} = SolHG.\ A_g\ .F$$

Factor 1.7 for steel sash		
Window area	m2	
Solar Heat gain	W/m^2	T(12A)
Heat gain from windows	W	

$$Q_{t/g} = U\ A_{g/d}\ (T_o - T_i)$$

Outdoor, indoor		
Window or door area	m^2	
Glass heat transfer coefficient	$W/m^{2\,o}C$	T(20)
Solar transmission window and door	W	

SUMMER

Solar and transmission heat gain glass

$$Q_{s/g} = SolHG\ A_g\ F$$
$$Q_{t/g} = U\ A_{g/d}\ (T_o - T_i)$$

Table (12A) Solar Irradiance (EDN) and Solar Heat Gain Factors (SHGF) for 32° North Latitude

Time of Year	Exposure	6	7	8	9	10	11	Noon	1	2	3	4	5	6
JULY 23 & MAY 21	N	69	63	44	41	44	44	44	44	44	**41**	44	63	69
	NE	293	413	388	281	145	50	44	44	44	**41**	38	28	13
	E	315	489	517	457	312	139	44	44	44	**41**	38	28	13
	SE	132	259	315	315	262	167	69	44	44	**41**	38	28	13
	S	13	28	38	44	63	85	95	85	63	**44**	38	28	13
	SW	13	28	38	41	13	44	44	167	262	**315**	315	259	132
	W	13	28	38	41	44	44	44	139	312	**457**	517	489	315
	NW	13	28	38	41	44	44	44	50	145	**281**	388	413	293
	Horizontal	47	208	388	555	675	744	776	744	675	**555**	388	208	47
AUG 24 & APR 20	N	19	25	35	41	41	**44**	44	44	41	**41**	35	25	19
	NE	174	**341**	315	208	85	44	44	44	41	**41**	35	25	6
	E	208	464	**521**	467	322	145	44	44	41	**41**	35	25	6
	SE	0	309	**495**	407	353	259	123	47	57	**41**	35	25	6
	S	6	25	41	85	148	183	**199**	183	148	**85**	41	25	6
	SW	6	25	35	41	41	47	123	259	353	**407**	401	309	117
	W	6	25	35	41	41	44	44	145	322	**467**	**521**	464	208
	NW	6	16	35	41	41	44	44	44	85	**208**	315	**325**	174
	Horizontal	19	148	338	508	631	710	**741**	710	631	**508**	338	148	19

West= 467 W/m2

SUMMER

TABLE 20-TRANSMISSION COEFFICIENT U-WINDOWS, SKYLIGHTS, DOORS & GLASS BLOCK WALLS W/m2 °C

	Vertical Glass							Horizontal Glass			
	Single	Double			Triple			Single		Double (6mm)	
Air Space Thickness (in.)	0	6	13	19-25	6	13	19-25	Summer	Winter	Summer	Winter
Without Storm Windows	6.42	3.46	3.12	3.01	2.33	2.04	1.93	4.88	7.95	2.84	3.98
With Storm Windows	3.07							2.44	3.64		

		Solar Gain windows								
	Eq	**Q**	**=**	**SolHG.**		**A**		**F**		
Glass	**1**	**W/ window**	**=**	**467**	**×**	**3.6**	**×**	**1.7**	**=**	**2858.04**
		N/ window	**=**		**×**		**×**		**=**	**0**
		S/ window	**=**		**×**		**×**		**=**	**0**
		E/ window	**=**		**×**		**×**		**=**	**0**
	Transmission windows									
	2	**Q**	**=**	**(U) $W/m^2\ ^oC$**		**A**		**ΔT**	**=**	
		Q_window	**=**	**6.42**	**×**	**3.6**	**×**	**20**	**=**	**462.24**

Outer Wall & Exposed Roof & Partition

3- **Solar and Transmission Gain- Walls**

$Q_{s/W} = U \quad A \quad \Delta t_e$		
Equivalent temp. diff.		
Wall area	m^2	Table 19
Wall heat transfer coefficient	$W/m^{2o}C$	
Solar Transmission Gain- Walls	W	

Solar and Transmission Gain **Roofs** and Floors

A- Exposed Roof

The exposed roof subjected to the outdoor conditions and solar radiation, so the equivalent temperature difference is used to calculate the heat flow to the building through the roof.

$Q_{s/R} = U \quad A \quad \Delta t_e$		
Equivalent temp. diff.		
Roof area	m^2	
Roof heat transfer coefficient	$W/m^{2o}C$	Table 19
Solar Transmission Gain- Roof	W	

$Q_{t/P} = U \quad A_P \quad (T_o - T_i - 9)$	
Outdoor, indoor	
Partition area	m^2
Partition heat transfer coefficient	$W/m^{2o}C$
Solar Transmission – Partition	W

Outer Wall & Exposed Roof & Partition

$Q_w = U_w A_w . \Delta t_e$ *for outer wall*

$Q_r = U_r A_r . \Delta t_e$ *for Roof*

$Q_{t/p} = U\ A_p(T_o - T_i - 9)$ $for\ partition$

		Solar and Transmission Gain								
Waals, Floor and Roof		Q	=	(U)W/m^2 °C		A	x	ΔT_e		
	3	W/Wall	=	1.916	×	17.4	×	12.08	=	**402.728**
		/Wall	=		×		×		=	**0**
		/Wall	=		×		×		=	**0**
		/Wall	=		×		×		=	**0**
	4	Roof	=	1.457	×	50.75	×	22.7	=	**1678.5**
		Floor	=		×		×		=	**0**
	5	Partitions	=	2.45	×	21.75	×	11	=	**586.163**

ΔT_e

6a. Sensible Heat Gain

$Q_s = No \cdot Sen.HG \cdot F$		
F=1 for men, 0,8 women, 0,75 children		
Sen H.G.	W/m^2	T(26)
Number of People	-	
Sensible Heat Gain	W	

6.b Latent Heat gain

$Q_l = No \cdot Lat.HG \cdot F$		
F=1 for men, 0,8 women, 0,75 children		
Lat H.G.	W/m^2	T(26)
Number of People	-	
Sensible Heat Gain	W	

Appliances : No appliance in bed room 1

Lights. Assume 480 W for the kitchen, and 480 W for living room, assign 50% to bed room 1, 25% for bedrooms 2 and 3

TABLE 26 -HEAT GAIN FROM PEOPLE

Degree of Activity		Total Heat, W		Sensible Heat, W	Latent Heat, W	% Sensible Heat that is Radiant	
		Adult Male	Adjusted, M/F[a]			Low V	High V
Seated at theatre	Theatre, matinee	115	95	65	30		
Seated at theatre, night	Theatre, night	115	105	70	35	60	27
Seated, very light work	Offices, hotels, apartments	130	115	70	45		
Moderately active office work	Offices, hotels, apartments	140	130	75	55		
Standing, light work; walking	Department store; retail store	160	130	75	55	58	38
Walking, standing	Drug store, bank	160	145	75	70		
Sedentary work	Restaurant	145	160	80	80		
Light bench work	Factory	235	220	80	140		
Moderate dancing	Dance hall	265	250	90	160	49	35
Walking 4.8 km/h; light machine work	Factory	295	295	110	185		
Bowling	Bowling alley	440	425	170	255		
Heavy work	Factory	440	425	170	255	54	19
Heavy machine work; lifting	Factory	470	470	185	285		
Athletics	Gymnasium	585	525	210	315		

	Heat Gain									
People		Q	=	Nos.		SenHG		F	=	
	6a	Sensible	=	2	×	75	×	1	=	**150**
	6b	Latent	=	2	×	55	×	1	=	**110**
App.	8a	Sensible	=		×		×		=	**0**
	8b	Latent	=		×		×		=	**0**
Lig	7			m^2		W		F		
		Light	=	1	×	240	×	1.25	=	**300**
				Nos.		W				
	9	Elec. motor	=		×		×		=	**0**

Infiltration

ii- Depending on the crack length L_C

Depends on figure 6 , for single hung window or door, crack length can be calculated as follows:

$L_C=2.(H+W)$

While for double hung window or door

$LC=2.(H+W)+H$

IOA = L_C. V			
	Volume flow rate/ m	Lit/s per Person	T(24)
	Number of window and doors	-	
	Outdoor air	Lit/s	

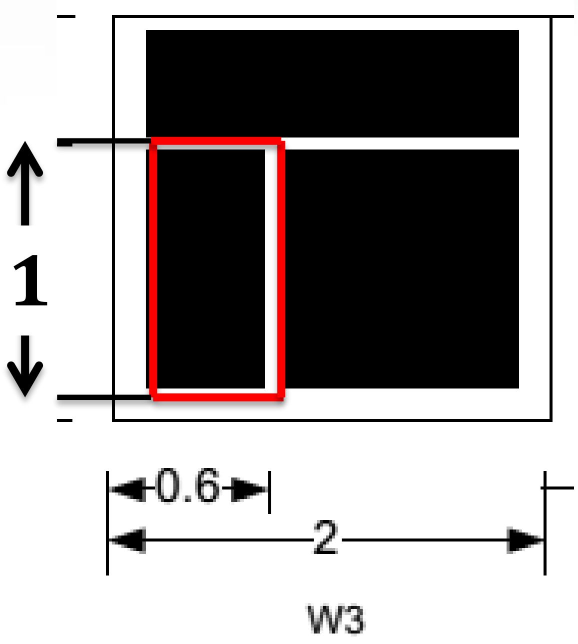
- **Fenestration. Clear single glass, 3 mm thick. Assume closed, medium-color well fitted, aluminum frame.**

Depending on the crack length LC

- Single hung window or door in Bedroom1

$$L_C = 2.(H+W)$$

$$L_c = 2(0.6 + 1) = 3.2$$



Msc. Zahraa F. Hussain

TABLE 24a-DOUBLE HUNG WINDOWS-UN LOCKED ON WINDWARD SIDE

Type of Double Hung Window	Lit /s per meter of Crack length											
	Wind Velocity m/s											
	1.4		2.8		4.2		5.6		7		8.4	
	No W-Strip	W-Strip	No W-Strip	W-Strip	No W-Strip	W-Strip	No W-Strip	W-Strip	No W-Strip	W-Strip	No W-Strip	W-Strip
Wood Sash												
Average Window	0.2	0.1	0.5	0.3	1.0	0.6	1.5	0.9	2.1	1.3	2.7	1.6
Poorly Fitted Window	0.7	0.2	1.8	0.5	2.9	0.9	4.0	1.3	5.1	0.3	6.5	2.4
Poorly Fitted-with Storm Sash	0.4	0.1	0.9	0.2	1.4	0.5	2.0	0.7	2.5	0.9	3.3	1.2
Metal Sash	0.5	0.2	1.2	0.5	1.9	0.8	2.7	1.2	3.6	1.6	4.4	2.0

Volume flow rate /per meter = 0.3 lit/s per meter

6- Ventilation (W3):

i- Outdoor air ventilation depending on the number of people:

$V = No. R_P$		
Volume flow rate/ person	Lit/s per Person	T(25)
Number of People	-	
Outdoor air	Lit/s	

ii- Outdoor air ventilation depending on the floor area

$V = A. R_a$		
Volume flow rate/ person	Lit/s per m^2	T(25)
Floor area	m^2	
Outdoor air	Lit/s	

TABLE 25-VENTILATION STANDARDS

Space type	Rp (L/s-per)	Ra (L/s-m2)	Space type	Rp (L/s-per)	Ra (L/s-m2)
Art classroom	5	0.9	Legislative chambers	2.5	0.3
Auditorium seating area	2.5	0.3	Libraries	2.5	0.6
Bank vaults/safe deposit	2.5	0.3	Lobbies	2.5	0.3
Barber shop	7.5	0.3	Lobbies/perfection	3.8	0.3
Barracks sleeping areas	2.5	0.3	Main entry lobbies	2.5	0.3
Bars, cocktail lounges	3.8	0.9	Mall common areas	3.8	0.3
Beauty and nail salons	10	0.6	Media Centre	5	0.6
Bedroom/Living Room	2.5	0.3	Multi-purpose assembly	2.5	0.3
Booking/waiting	3.8	0.3	Multi-use Assembly	3.8	0.3
Bowling alley (seating)	5	0.6	Museums (Children's)	3.8	0.6
Cafeteria / fast food dining	3.8	0.9	Museums/Galleries	3.8	0.3
Cell	2.5	0.6	Music/theatre/dance	5	0.3
Classrooms (age 9 plus)	5	0.6	Office space	2.5	0.3
Classrooms (ages 5-8)	5	0.6	Pet shops (animal areas)	3.8	0.9
Coin operated laundries	3.8	0.3	Pharmacy (prep. area)	2.5	0.9
Computer (not printing)	2.5	0.3	Photo studios	2.5	0.6
Computer Lab.	5	0.6	Places of religious worship	2.5	0.3
Conference / meeting	2.5	0.3	Reception areas	2.5	0.3
Corridors	0	0.3	Restaurant dining rooms	3.8	0.9
Courtrooms	2.5	0.3	Sales (except as below)	3.8	0.6
Day care (through age 4)	5	0.9	Science laboratories	5	0.9
Dayroom	2.5	0.3	Shipping/Receiving	0	0.6
Disco/dance floors	10	0.3	Spectator areas	3.8	0.3
Gambling casinos	3.8	0.9	Sports arena (play area)	0	0.3
Game arcades	3.8	0.9	Stages, studios	5	0.3
Guard stations	2.5	0.3	Storage rooms	0	0.6
Gym, stadium (play area)	0	0.3	Supermarket	3.8	0.3
Health club/aerobics room	10	0.3	Swimming (pool & deck)	0	2.4
Health club/weight rooms	10	0.3	Telephone/data entry	2.5	0.3
Lecture Classroom	3.8	0.3	Transportation waiting	3.8	0.3
Lecture Hall (fixed seats)	3.8	0.3	Warehouses	0	0.3
Kitchen/ restaurant		4	Wood/metal shop	5	0.9
Kitchen/ residence		2	Toilet		2

		Lc	=	Nos.	x	fac	(L	+	H)	+	H	
Vent & infilt.	10	Lc		1		2	(0.6	+	1)	+	0	**3.2**
		IOA	=	**3.2**	×	0.3				=		**0.96**
	11	V	=	2	x	2.5			1	=		**5**
		VOA	=	0.95 Lit/s	+	5				=		**5.96**
		OASH	=	F	x	VOA		x	ΔT	=		
	11a	OASH	=	1.21	×	5.96		×	20	=		**144.23**
	11b	OALH	=	3000	×	5.96		×	0.001	=		**17.88**
	11c	OATH	=	OASH	+	OALH		=		=		**162.11**

Msc. Zahraa F. Hussain

Room load

11- ROOM SENSIBLE HEAT **RSH**

$$RSH = \sum equs.(1,2,3,4,5,6a,7,8a,9)$$

12- ROOMLATENT HEAT **RLH**

$$RLH = \sum equs.(6b,8b)$$

13- ROOM TOTAL HEAT **RTH**

RTH= RSH + RLH

11	RSH	=	**Sum all equations(Sensible heat)**	+		=	**6137.67**
12	RLH	=	**Sum all equations(Latent heat)**	+		=	**110**
13	RTH	=	RSH	+	RLH	=	**6247.67**

14- **TOTAL SENSIBLE HEAT** **TSH**

TSH=RSH + (OASH (eques. 10 a and 11a))

15- **TOTAL LATENT HEAT** **TLH**

TLH=RLH + (OALH(eques. 10 b and 11b))

16- **GRANG TOTAL HEAT** **GTH**

GTH = TSH + TLH

14	TSH	=	RSH	+	OASH	=	**6281.9**
15	TLH	=	RLH	+	OALH	=	**127.88**
16	GTH	=	TSH	+	TLH	=	**6409.78**

$$\boldsymbol{Room\ load = \frac{GTH\ (kW)}{3.5} = \frac{6.40978}{3.5} = (\ 1.9\ )TR} \qquad \cong \mathbf{2\ TR}$$