Refrigeration and Air conditioning Engineering.

3rd year – refrigeration and Air conditioning Course

Lecture -7- part1

Heating Load Estimation

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1.8 HEATING LOAD ESTIMATION

The heating load evaluation is the foundation for selecting the heating equipment. Normally, the heating load is estimated for the winter design temperatures (Table 2) usually occurring at night; therefore, no credit is taken for the heat given off by internal sources (people, lights, etc.). This estimate must take into account the heat loss thru the building structure surrounding the spaces and the heat required to offset the outdoor air which may infiltrate and/or may be required for ventilation.

HIGH ALTITUDE LOAD CALCULATIONS

Since air conditioning load calculations are based on liters of air necessary to handle a load, a decrease in density means an increase in Lit/s required to satisfy the given sensible load.

1- Heat Loss – Glass And Door

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

$Where$

$Q_{t/g}$ = Solar transmission window and door — W

U = Glass heat transfer coefficient — $W/m^2{}^\circ C$ (T20)

$A_{g/d}$ = Window or door area — m^2

$(T_i - T_o)$ = Outdoor, indoor Temperature — $^\circ C$

2. HEAT LOSS – WALLS AND ROOFS

$$Q_{t/R} = \mathrm{U}\ \mathrm{A_R}\ (\mathrm{T_i} - \mathrm{T_o})$$

Where

$Q_{t/R}$ = Solar transmission Roof Or Wall — W

U = Roof or Wall heat transfer coefficient — W/m^2°C (T19)

A_R = Roof or Wall area — m^2

$(T_i - T_o)$ = Outdoor, indoor Temperature — °C

3. HEAT LOSS –FLOORS

a– FLOOR AREA

$$Q_{t/F} = \mathbf{U\ A_F\ (T_i - 10)}$$

Where

$Q_{t/F}$ = Solar transmission Floor — W

U = Floor heat transfer coefficient — $W/m^2{}^\circ C$ (T19)

A_F = Floor area — m^2

$(T_i - 10)$ = indoor Temperature — $^\circ C$

3. HEAT LOSS –FLOORS

b- FLOOR EDGES

$$Q_{t/F} = 0.8\ P\ (T_i - 10)$$

Where

$Q_{t/F}$ = Solar transmission Floor — W

0.8 = Factor — $W/m°C$

P = Floor perimeter — m

$(T_i - 10)$ = indoor Temperature — °C

Room perimeter can be calculated as follows
P= 2×(L+W)

4. Heat Transmission Partition

$$\mathbf{Q_{t/P} = U\ A_P\ (T_i - T_o - 9)}$$

Where

$Q_{t/P}$ = **Solar transmission Partition** — W

U = ***Partition heat transfer coefficient*** — $W/m^2 °C$ **(T19)**

A_P = ***Partition area*** — m^2

$(T_i - T_o)$ = **Outdoor, indoor Temperature** — °C

5- Infiltration

5. INFLITRATION

i- Depending on windows or doors area:

IOA = No *V*		
Volume flow rate /per door or wind	**Lit/s per Door or wind)**	3) T(22)
Number of window and door	-	
Outdoor air	Lit/s	

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

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

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

$$IOA = No\ L_c\ V$$

Volume flow rate/ m	.	T(24)
Number of window and doors	-	
Outdoor air	Lit/s	

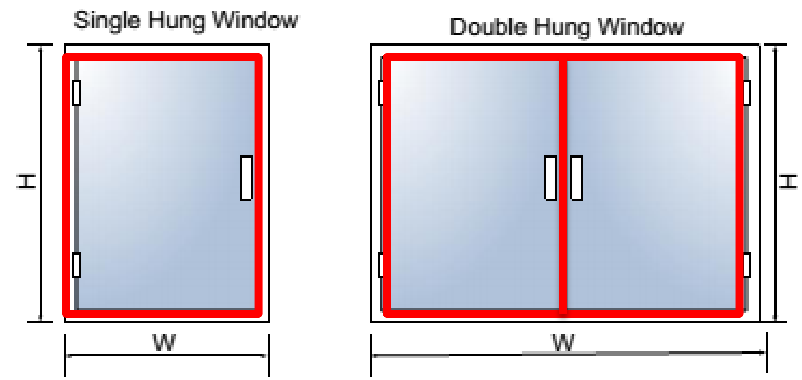

Figure 6 single and double hung windows

6- Ventilation:

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/area	Lit/s per m^2	T(25)
Floor area	m^2	
Outdoor air	Lit/s	

iii- VOA= IOA +V

A- Outdoor Air Sensible heat OASH

$$Q_s = 1.2\ VOA\ (T_i - T_o)$$

T_i, T_o	Outdoor, indoor	°C
VOA	Ventilation rate	Lit/s
1.2	Factor	
Q_s	Outdoor Air Sensible heat	W

B- Outdoor Air Latent Heat OALH

$$Q_l = 3000\ VOA\ (g_i - g_o)$$

g_i, g_o	Moisture content	kgw/kga
VOA	Ventilation rate	Lit/s
3000	Factor	
Q_l	Outdoor Air Sensible heat	W

C- Outdoor air Total Heat OATH

$$Q_T = 1.2\ VOA\ (h_i - h_o)$$

h_i, h_o	enthalpy	Kj/kg
VOA	Ventilation rate	Lit/s
1.2	Factor	
Q_T	Outdoor Air Sensible heat	W

6- TOTAL HEATING LOAD

$$\sum Q_g + Q_d + Q_{wall} + Q_{Floor} + Q_{Roof} + Q_{Ventilation}$$

Example 3.

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 Heating load; size the heating unit; and compute the air quantity for each room.

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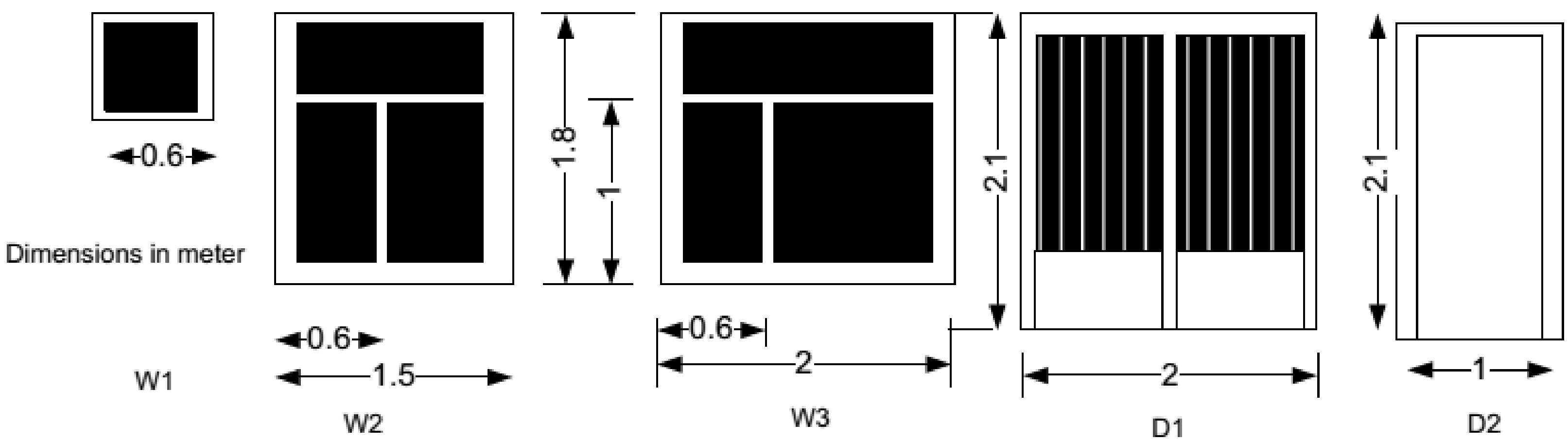
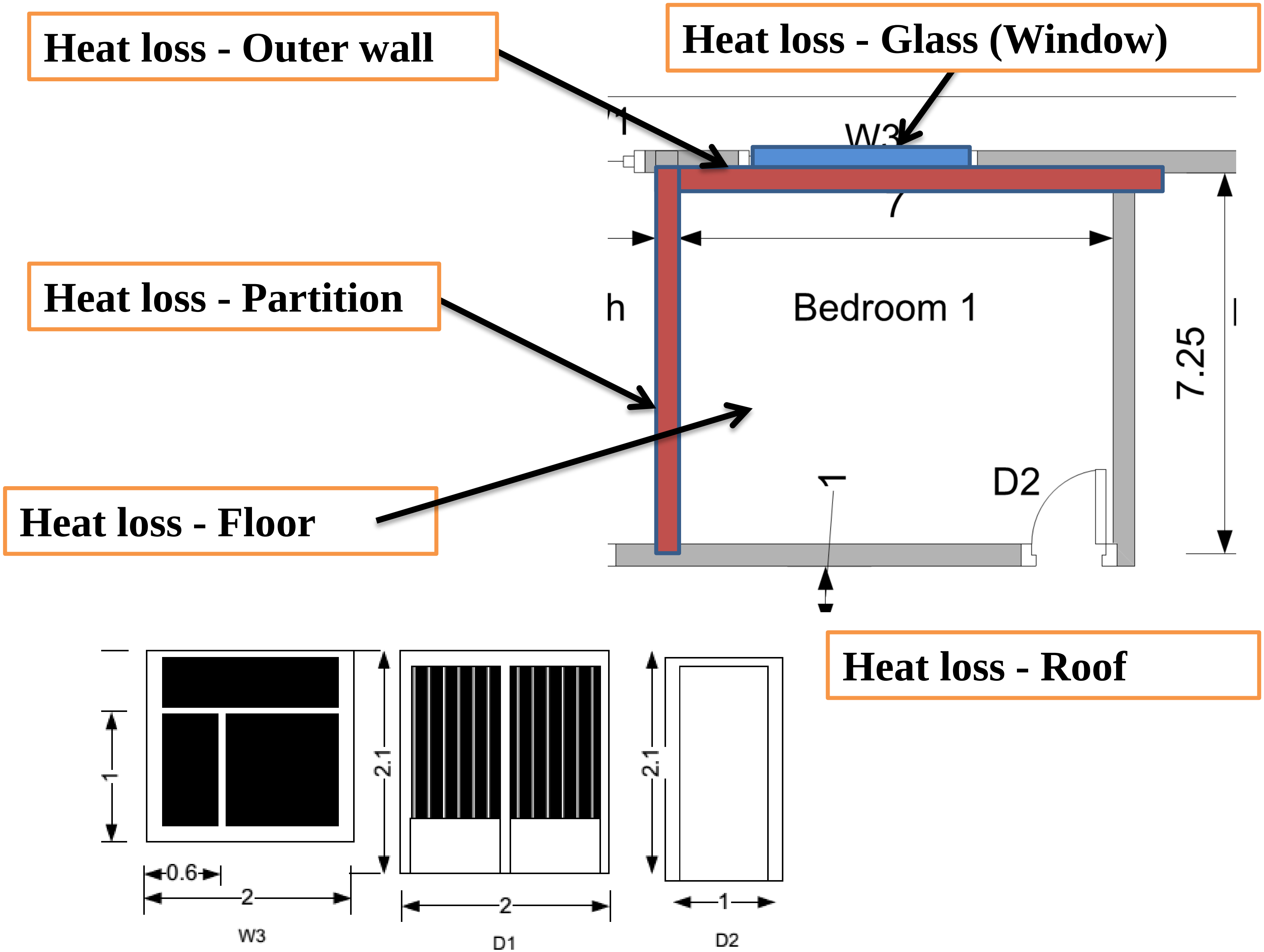


0.6
Dimensions in meter
W1
0.6
1.5
W2
1.8
1
0.6
2
W3
2.1
2
D1
2.1
1
D2

Area of Building

Room name	Net area of outer Walls (m^2)				Windows					Floor (m^2)	Roof (m^2)	Perimeter	Partition
	W	E	N	S	W	E	N	S	Door				
Bed R1	17.4	-	-	-	3.6	-	-	-	2.1	50.75	50.75	2(7+7.25)=28.5	21.5
Living room	12.9	-	20.55		3.6	-	-	-	4.2	45.38	45.34	27.5	-
Bed R2	-	10.8	-	8.55	-	2.7	-	2.7	2.1	16.88	16.88	16.5	11.4
Bed R3	-	10.8		-		2.7			2.1	16.88	16.88	16.5	11.4 11.25



Heat loss - Outer wall
Heat loss - Glass (Window)
Heat loss - Partition
Heat loss - Floor
Heat loss - Roof
W3
h
Bedroom 1
D2
7.25
1
0.6
2
2.1
W3
D1
D2

The floor consist from outer to inner from carp, cement tile of 25 mm thick., heavy concert of 15 cm thick

Description	L mm	K W/mK	P kg/m³	R m²K/W	Mass kg/m²
high density concrete	150	1.731	2243	0.088	341.60
Inside surface resistance	---	0.000	---	0.121	0.00
Carpet and Rubber Pad	25			0.71	
Concrete Tile	10	0.27	1921	0.037	23

Carpet

$$R_{\text{Carprt}} = 0.71\ m^2K/W$$

Concrete Tile

$$x = 250\ mm$$

$$k_{\text{tile.}} = 0.1$$

$$R_{\text{tile.}} = \frac{x}{k} = \frac{0.025}{0.27} = 0.1\ m^2K/W$$

high density concrete

$$x = 150\ mm$$

$$R_{\text{Conc}} = 0.088\ m^2K/W$$

Inside resistance

$$R_i = 0.121\ \frac{m^2K}{W}$$

Overall heat transfer coefficient and weight of exposed roof

$$R_e = R_i + R_{carpt} + R_{tile} + R_{conc}$$

$$R_e = 0.121 + 0.71 + 0.1 + 0.088 = 1.019$$

$$U_{floor} = \frac{1}{1.019} = 0.98\ W/m^2K$$

Outer wall	Partition	Roof	Window	Door	Floor
U	U	U	U	U	U
W/m².K	W/m².K	W/m².K	W/m².K	W/m².K	W/m².K
1.916	2.45	1.457	6.42	3.92	0.98

Heating Load Building: Home Room name: Bed Room 1
Indoor Design condition 23℃ & RH 50 %
Outdoor Design condition 1.5 ℃ & RH 84%

	Heat Loss								
Eq	Q		U		A		ΔT		
1	Q/ Glass	=	6.42	×	3.6	×	21.5	=	496.908 W
2	Q/ Door	=		×		×		=	0
3	Q/Wall	=	1.916	×	17.4	×	21.5	=	716.776 W
4	Q/Roof	=	1.457	×	50.75	×	21.5	=	1589.77 W
5	Q/Partitions	=	2.45	×	21.75	×	12.5	=	666 W

Floor									
	Q		U		A		ΔT		
6	Q/Floor edges	=	0.8	×	28.5	×	13	=	296.4 W
7	Q/Floor base area	=	0.98	×	50.75	×	13	=	647

Ventilation and infiltration

	Lc	=	Nos.	x	fac		(L +	H)		+	H		
	Lc		1		2		0.6	1			0		3.2
	IOA	=	3.2	×	0.3					=		0.96	
	V	=	2	x	2.5			1		=		5	
	VOA	=	Lit/s	+				Lit/s		=		5.96	
			F		VOA			ΔT					
7	OASH	=	1.21	×	5.96		×	21.5		=		155.049	W
			F		VOA			$\Delta\omega$					
8	OALH	=	3000	×	5.96		×	0.00506		=		90.4728	W
	OATH	=		+			=			=		245.522	W
10	Total Load	=								=		3068	W