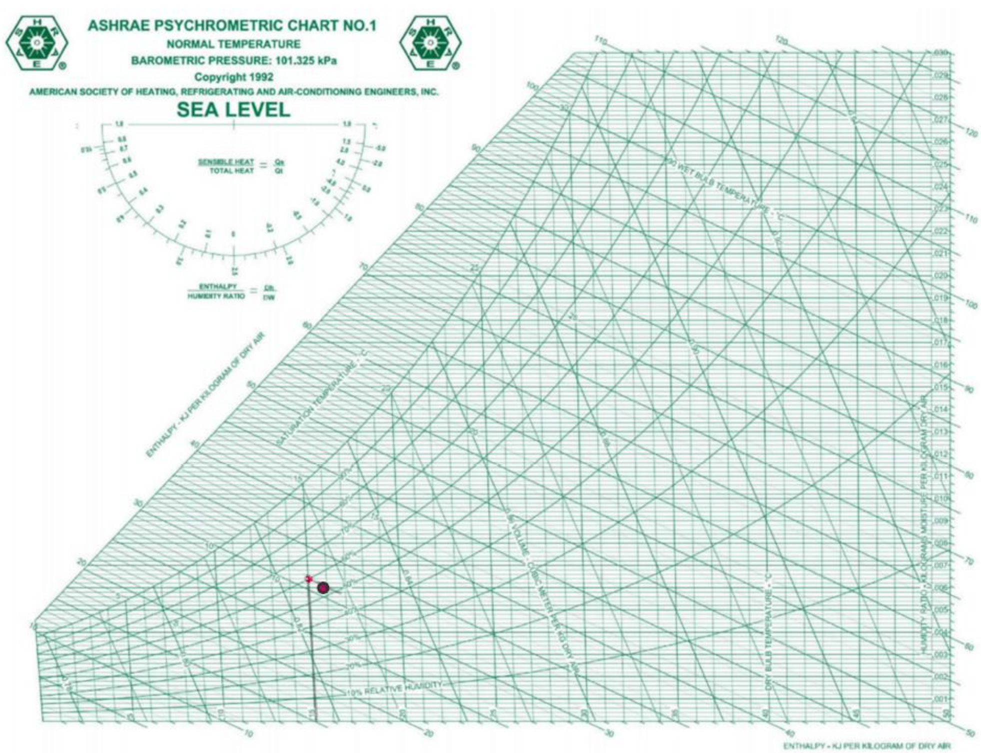
Week Assignment 9

Question 1

Use a weather forecast website, and utilize the psychrometric chart and the formula we went through in the class to determine the absolute humidity, the wet-bulb temperature and the mass of water vapour in the air in Classroom A (Aula A) of Piacenza campus in the moment that you are solving this exercise (provide the inputs that you utilized)

Solution
On 2 December 2019, 10pm
Effective Temperature = 8^0C
Atmospheric Pressure = 102 kPa
Relative Humidity = 92%



Absolute Humidity (ω) = 0.006 ($\frac{kg_{vapour}}{kg_{dry\ air}}$)
Wet bulb temperature = 7.2°C
Mass of water vapor, m_v= $\frac{P_v V_v}{R_v T}$

$$\phi = \frac{m_v}{m_g} = \frac{P_v}{P_g}$$

At 8°C, P_g = 1.07 kPa (from steam table)

SATURATED STEAM - TEMPERATURE TABLE

T °C	P bar	Spec. vol. m^3-kg Sat. liq. v_f X1000	Sat. vap. v_g	Int. Ener. kJ/kg Sat. liq. u_f	Sat. vap. u_g	Enthalpy kJ/kg Sat. liq. h_f	Sat. vap. h_g	Entropy kJ-(kg°K) Sat. liq. s_f	Sat. vap. s_g
0.01	0.0061	1.0002	206.1	0.01	2376	0.01	2501	0	9.156
4	0.0081	1.0001	157.2	16.79	2381	16.79	2509	0.061	9.051
5	0.0087	1.0001	147.1	21.00	2383	21	2511	0.0762	9.026
6	0.0093	1.0001	137.7	25.21	2384	25.21	2512	0.0912	9.000
8	0.0107	1.0001	120.9	33.61	2387	33.61	2516	0.1212	8.950
10	0.0123	1.0001	106.4	42.01	2389	42.01	2520	0.151	8.901
11	0.0131	1.0007	99.86	46.19	2391	46.19	2522	0.1658	8.876
12	0.0140	1.0007	93.79	50.40	2392	50.4	2523	0.1806	8.852

$P_v = \phi \ X \ P_g$ = 0.92 X 1.07 = 0.9844 kPa
R_v = 0.4615

Volume (Aula A) = 10 X 20 X 3 = 600 m^2

$m_v = \frac{0.9844 \ X \ 600}{0.4615 \ X \ 281}$ = 4.55 kg

Question 2

Utilize the same methodology we went through in the class and determine the sensible and latent load corresponding to internal gains, the ventilation, and the infiltration in a house with a *good* construction quality and with the same geometry as that of the example which is located in Brindisi, Italy

BRINDISI, Italy WMO#: **163200**

Lat: **40.65N** Long: **17.95E** Elev: **10** StdP: **101.2** Time Zone: **1.00 (EUW)** Period: **86-10** WBAN: **99999**

Annual Heating and Humidification Design Conditions

	Coldest Month	Heating DB 99.6%	Heating DB 99%	Humidification DP/MCDB and HR 99.6% DP	99.6% HR	99.6% MCDB	99% DP	99% HR	99% MCDB	Coldest month WS/MCDB 0.4% WS	0.4% MCDB	1% WS	1% MCDB	MCWS/PCWD to 99.6% DB MCWS	PCWD
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)
(1)	2	2.9	4.1	-5.1	2.5	7.2	-3.0	3.0	7.4	13.4	10.2	12.4	10.6	3.4	250

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

	Hottest Month	Hottest Month DB Range	Cooling DB/MCWB 0.4% DB	0.4% MCWB	1% DB	1% MCWB	2% DB	2% MCWB	Evaporation WB/MCDB 0.4% WB	0.4% MCDB	1% WB	1% MCDB	2% WB	2% MCDB	MCWS/PCWD to 0.4% DB MCWS	PCWD
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)
(2)	8	7.1	32.8	23.6	31.1	24.3	29.9	24.3	27.2	29.7	26.3	29.0	25.6	28.3	4.2	180

	Dehumidification DP/MCDB and HR 0.4% DP	0.4% HR	0.4% MCDB	1% DP	1% HR	1% MCDB	2% DP	2% HR	2% MCDB	Enthalpy/MCDB 0.4% Enth	0.4% MCDB	1% Enth	1% MCDB	2% Enth	2% MCDB	Hours 8 to 4 & 12.8/20.6
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)
(3)	26.3	21.8	29.2	25.4	20.7	28.5	24.7	19.7	27.9	86.0	30.1	82.2	29.1	78.5	28.3	1236

Extreme Annual Design Conditions

	Extreme Annual WS 1%	2.5%	5%	Extreme Max WB	Extreme Annual DB Mean Min	Mean Max	Standard deviation Min	Standard deviation Max	n-Year Return Period Values of Extreme DB n=5 years Min	n=5 years Max	n=10 years Min	n=10 years Max	n=20 years Min	n=20 years Max	n=50 years Min	n=50 years Max
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)
(4)	11.3	9.9	8.7	31.4	0.4	37.3	1.4	3.0	-0.6	39.4	-1.4	41.1	-2.2	42.8	-3.2	44.9

Solution
Room height, h=2.5m
Good construction quality – 2 occupants, 1 bedroom
Conditioned floor area = 200 m^2
Wall Area = 144 m^2

Internal Gains
$\dot{Q}ig_{sensible}$ = 136 + 2.2 X A_{cf} + 22N_{oc} = 136 +2.2(200)+22(2) = 620 W
$\dot{Q}ig_{latent}$ = 20 + 0.22 X A_{cf} + 12N_{oc} = 20 + 0.22(200) + 12(2) = 88 W

Infiltration
A_{es} (exposed surface area) = 200+144 = 344 m^2

A_{ul} (unit leakage area for good quality construction) = 1.4 $\frac{cm^2}{m^2}$

Table 3 Unit Leakage Areas

Construction	Description	A_{ul}, cm^2/m^2
Tight	Construction supervised by air-sealing specialist	0.7
Good	Carefully sealed construction by knowledgeable builder	1.4
Average	Typical current production housing	2.8
Leaky	Typical pre-1970 houses	5.6
Very leaky	Old houses in original condition	10.4

A_L (Leakage area) = A_{es} X A_{ul} = 344 X 1.4 = 481.6 cm^2

Table 5 Typical IDF Values, L/(s·cm²)

H, m	Heating Design Temperature, °C					Cooling Design Temperature, °C			
	−40	−30	−20	−10	0	10	30	35	40
2.5	0.10	0.095	0.086	0.077	0.069	0.060	0.031	0.035	0.040
3	0.11	0.10	0.093	0.083	0.072	0.061	0.032	0.038	0.043
4	0.14	0.12	0.11	0.093	0.079	0.065	0.034	0.042	0.049
5	0.16	0.14	0.12	0.10	0.086	0.069	0.036	0.046	0.055
6	0.18	0.16	0.14	0.11	0.093	0.072	0.039	0.050	0.061
7	0.20	0.17	0.15	0.12	0.10	0.075	0.041	0.051	0.068
8	0.22	0.19	0.16	0.14	0.11	0.079	0.043	0.058	0.074

Heating Design Temperature = 4.1 °C
Cooling Design Temperature = 31.1 °C

Volume

$V_{infiltration_{heating}}$ = A_L X $IDF_{heating}$ = 481.6 X 0.065 = 31.304 $\frac{L}{s}$

$V_{infiltration_{cooling}}$ = A_L X $IDF_{cooling}$ = 481.6 X 0.0317 = 15.266 $\frac{L}{s}$

Ventilation

$\dot{v}_v$ = 0.05 A_{cf} +3.5 (N_{br} +1) = 0.05(200) + 3.5(1+1) = 17 $\frac{L}{s}$

$\dot{Q}_{infiltration_{heating}}$= 31.304 +17 = 48.304 $\frac{L}{s}$

$\dot{Q}_{infiltration_{cooling}}$= 15.266+17= 32.266 $\frac{L}{s}$

$\dot{Q}_{inf-ventilation_{heating_{sensible}}}$ = $C_{sensible}\ \dot{v}\ \Delta T_{heating}$ = 1.23 X 48.304 X (20-4.1) = 944.681 W

$\dot{Q}_{inf-ventilation_{cooling_{sensible}}}$ = $C_{sensible}\ \dot{v}\ \Delta T_{cooling}$ = 1.23 X 32.266 X (31.1-24) = 281.779 W

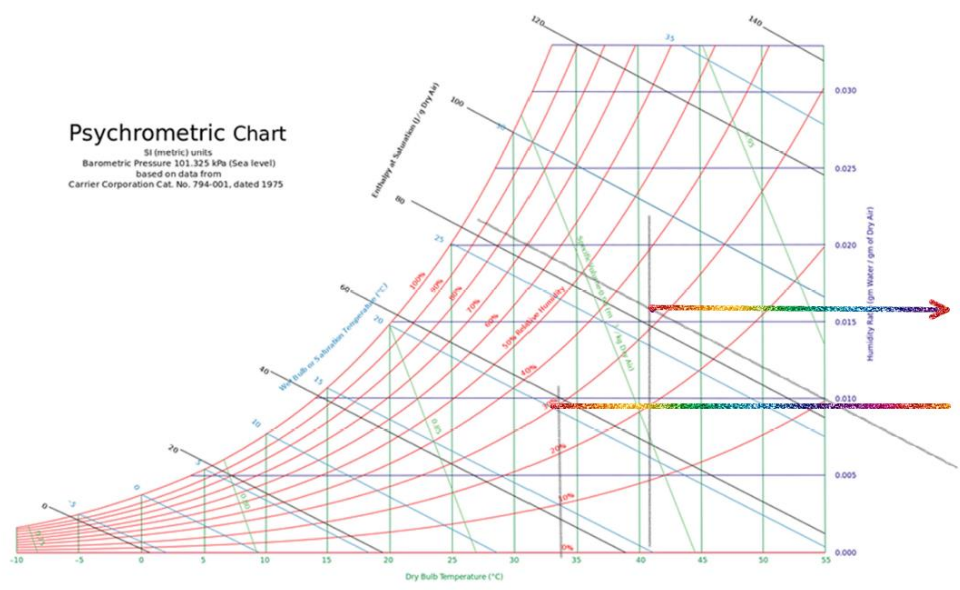
For latent load calculation, we need $\Delta\omega_{cooling}$

Refer to psychometric chart (DB = 31.1℃, WB = 24.3℃

ω_{out} = 0.016

ω_{in} = 0.0093

$\Delta\omega_{cooling}$ = 0.0067



Therefore,

$\dot{Q}_{inf-ventilation_{cooling_{latent}}}$ = $C_{latent}\ \dot{v}\ \Delta\omega_{cooling}$ = 3010 X 32.266 X 0.0067 = 650.708 W