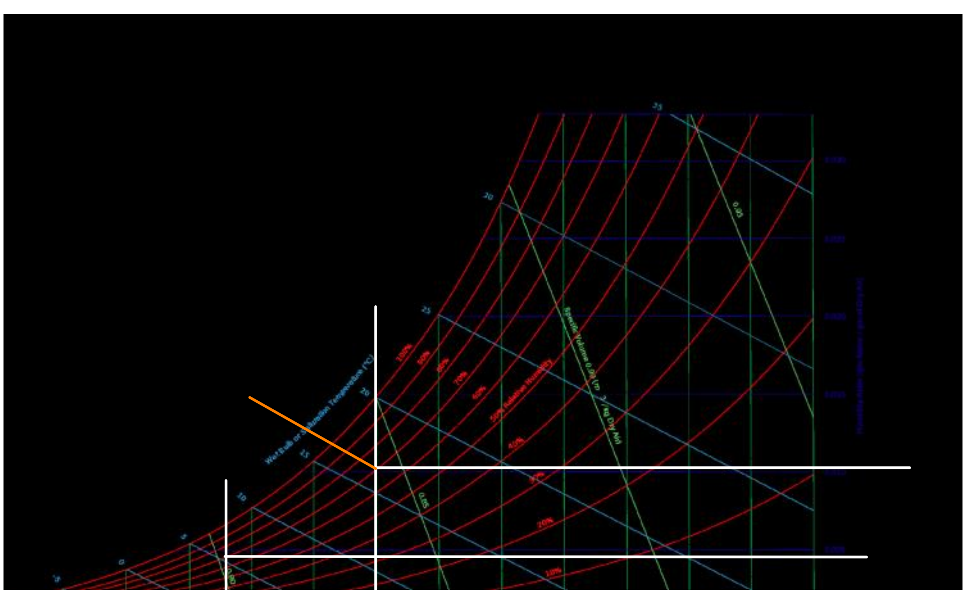
Week-9

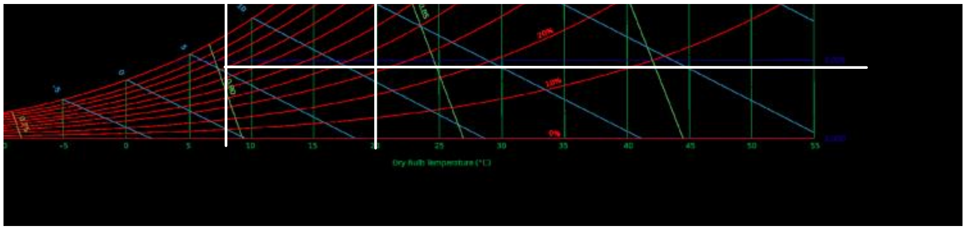
Task 1

Use a weather forecast website, and utilize the psychometric chart and the formula we went through in the class to determine the absolute humidity, the wet-bulb temperature and the mass of water vapor 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)

The weather today in Piacenza
Tuesday, 03 December 2019

	1:00 pm	14:00	4:00 pm	18:00	8:00 pm	21:00	22:00
	LightCloud	LightCloud	PartlyCloud	LightCloud	Sun	Sun	Sun
Effective temperature	9 ° C	10 ° C	8 ° C	6 ° C	4 ° C	2 ° C	2 ° C
Perceived temperature	7 ° C	10 ° C	6 ° C	4 ° C	2 ° C	0 ° C	0 ° C
Rainfall	0 mm	0 mm	0 mm	0 mm	0 mm	0 mm	0 mm
Humidity	67 %	65 %	69 %	70 %	75 %	83 %	87 %
Atmospheric pressure	1025 hPa	1025 hPa	1025 hPa	1026 hPa	1027 hPa	1027 hPa	1028 hPa
Wind intensity	15 km / h	14 km / h	9 km / h	9 km / h	7 km / h	8 km / h	8 km / h
Wind direction	IS	IS	IS	IS	SELF	SELF	SELF
Probability of fog	0 %	0 %	0 %	0 %	0 %	0 %	0 %
Dew point	3 ° C	3 ° C	3 ° C	1 ° C	-1 ° C	0 ° C	-1 ° C
Clouds	21 %	13 %	42 %	15 %	2 %	3 %	3 %
Low clouds	11 %	7 %	42 %	15 %	2 %	3 %	3 %
Medium clouds	18 %	12 %	2 %	0 %	1 %	0 %	0 %
High clouds	0 %	0 %	0 %	0 %	0 %	0 %	0 %





At 18:00 humidity of Piacenza is 70% and effective temperature is 6 ˚C
So outdoor humidity ratio from psychometric chart is 0.0045

$$\omega_{\mathrm{out}} = 0.0045 \frac{\mathrm{kg_{water}}}{\mathrm{kg_{dryAir}}}$$

In the class(Indoor)

Indoor humidity ratio from psychometric chart is 0.0105 (indoor temperature in winter is 20˚C)

$$\omega_{\mathrm{in}} = 0.0105 \frac{\mathrm{kg_{water}}}{\mathrm{kg_{dryAir}}}$$

Wet bulb temperature : 17˚C

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

$P_{g20^\circ C}$= 0.0173 bar= 1.73 kPa

t (°C)	P	ρ_l	ρ_g	h_l	h_g	r	s_l	s_g	ϕ	ν_l ($\times 10^3$)	ν_g ($\times 10^3$)
0.01	0.0061173	999.78	0.004855	0.00	2500.5	2500.5	0.00000	9.1541	9.1541	1.00022	205990
	0.0065716	999.85	0.005196	4.18	2502.4	2498.2	0.01528	9.1277	9.1124	1.00015	192440
	0.0070605	999.90	0.005563	8.40	2504.2	2495.8	0.03064	9.1013	9.0707	1.00010	179760
	0.0075813	999.93	0.005952	12.61	2506.0	2493.4	0.04592	9.0752	9.0292	1.00007	168020
	0.0081359	999.95	0.006364	16.82	2507.9	2491.1	0.06112	9.0492	8.9881	1.00005	157130
5	0.0087260	999.94	0.006802	21.02	2509.7	2488.7	0.07626	9.0236	8.9473	1.00006	147020
	0.0093537	999.92	0.007265	25.22	2511.5	2486.3	0.09133	8.9981	8.9068	1.00008	137650
	0.0100209	999.89	0.007756	29.42	2513.4	2484.0	0.10633	8.9729	8.8666	1.00011	128940
	0.0107297	999.84	0.008275	33.61	2515.2	2481.6	0.12127	8.9479	8.8266	1.00016	120850
	0.0114825	999.77	0.008824	37.80	2517.1	2479.3	0.13615	8.9232	8.7870	1.00023	113320
10	0.012281	999.69	0.009405	41.99	2518.9	2476.9	0.15097	8.8986	8.7477	1.00031	106320
	0.013129	999.60	0.010019	46.18	2520.7	2474.5	0.16573	8.8743	8.7086	1.00040	99810
	0.014027	999.49	0.010668	50.36	2522.6	2472.2	0.18044	8.8502	8.6698	1.00051	93740
	0.014979	999.37	0.011353	54.55	2524.4	2469.8	0.19509	8.8263	8.6313	1.00063	88090
	0.015988	999.24	0.012075	58.73	2526.2	2467.5	0.20969	8.8027	8.5930	1.00076	82810
15	0.017056	999.09	0.012837	62.92	2528.0	2465.1	0.22424	8.7792	8.5550	1.00091	77900
	0.018185	998.93	0.013641	67.10	2529.9	2462.8	0.23873	8.7560	8.5173	1.00107	73310
	0.019380	998.76	0.014488	71.28	2531.7	2460.4	0.25317	8.7330	8.4798	1.00124	69020
	0.020644	998.58	0.015380	75.47	2533.5	2458.1	0.26757	8.7101	8.4426	1.00142	65020
	0.021979	998.39	0.016319	79.65	2535.3	2455.7	0.28191	8.6875	8.4056	1.00161	61280
20	0.023388	998.19	0.017308	83.84	2537.2	2453.3	0.29621	8.6651	8.3689	1.00182	57778

$$P_V = \phi \times P_g = 0.70 \times 1.73 = 1.211\ kPa$$

$$m_v = \frac{P_v V}{R_v T}$$

$R_v = 0.4615$

The estimated dimensions of Aula A is: 10×22×4 m

$$m_v = \frac{P_v V}{R_v T} = \frac{2.38 \times (10 \times 22 \times 4)}{0.4615 \times (273 + 20)} = 15.49$$

Task 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

$\dot{Q}_{ig_s}$ =136+2.2×A_{cf}+22×N_{oc}= 136+2.2×200+22×2=620 W

$\dot{Q}_{ig_l}$ =20+2.2×A_{cf}+12×N_{oc}= 136+2.2×200+22×2= 88W

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= (200+144) 1.4= 481.6 cm

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		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB		
				99.6%			99%			0.4%		1%				
		99.6%	99%	DP	HR	MCDB	DP	HR	MCDB	WS	MCDB	WS	MCDB	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	(1)

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

	Hottest Month	Hottest Month DB Range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB		
			0.4%		1%		2%		0.4%		1%		2%				
			DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	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	(2)

	Dehumidification DP/MCDB and HR									Enthalpy/MCDB						Hours 8 to 4 & 12.8/20.6	
	0.4%			1%			2%			0.4%		1%		2%			
	DP	HR	MCDB	DP	HR	MCDB	DP	HR	MCDB	Enth	MCDB	Enth	MCDB	Enth	MCDB		
	(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	(3)

Extreme Annual Design Conditions

	Extreme Annual WS			Extreme Max WB	Extreme Annual DB				n-Year Return Period Values of Extreme DB								
					Mean		Standard deviation		n=5 years		n=10 years		n=20 years		n=50 years		
	1%	2.5%	5%		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	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	(4)

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

By finding hottest and coolest temperature we can find IDF.

$IDF_{heating}$= 0.072 $IDF_{cooling}$= 0.032

$$\dot{V}_{infiltration_{heating}} = A_L \times \text{IDFheating} = 481.6 \times 0.072 = 34.67\ \frac{L}{s}$$

$$\dot{V}_{infiltration_{cooling}} = A_L \times \text{IDFheating} = 481.6 \times 0.032 = 15.41\ \frac{L}{s}$$

$$Q_v = 0.05 A_{cf} + 3.5(N_{br} + 1)$$

where

Q_v = required ventilation flow rate, L/s
A_{cf} = building conditioned floor area, m^2
N_{br} = number of bedrooms (not less than 1)

$$\dot{V}_{ventilation} = 0.05 \times 200 + 3.5 \times 2 = 17\ \frac{L}{s}$$

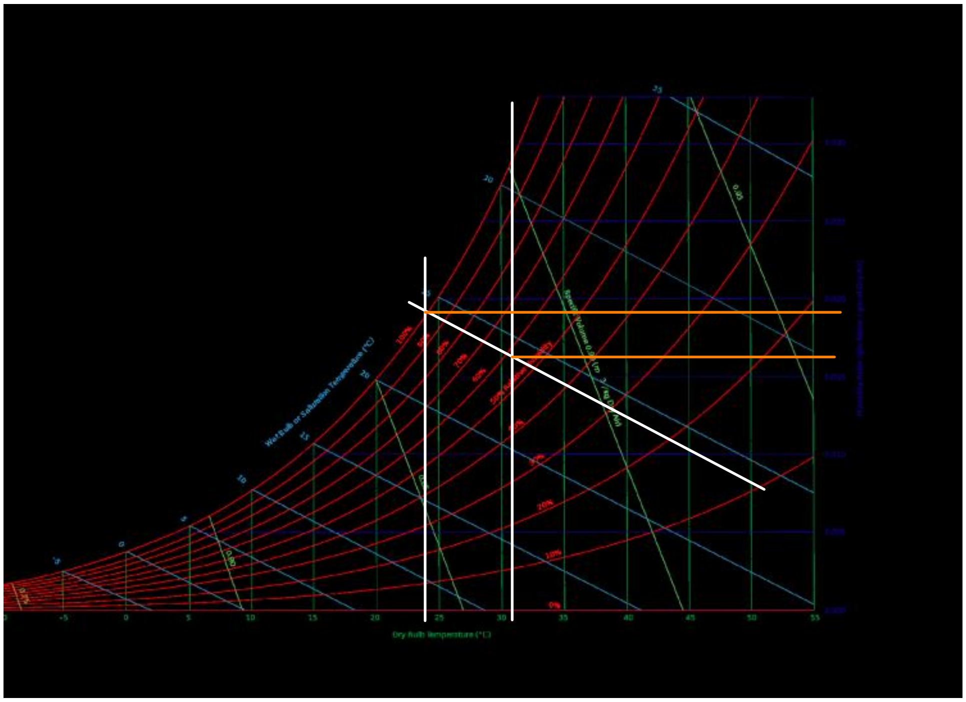
$$\dot{V}_{inf-ventilation_{heating}} = 34.67 + 17 = 51.67\ \frac{L}{s}$$

$$\dot{V}_{inf-ventilation_{cooling}} = 15.41 + 17 = 32.41\ \frac{L}{s}$$

$C_{sensible} = 1.23$ $C_{latent} = 3010$

$$\dot{Q}_{inf-ventilation_{cooling_{sensible}}} = C_{sensible} \dot{V} \Delta T_{Cooling} = 1.23 \times 32.41 \times (31.1 - 24) = 283.0365\ W$$

[redacted]



From the chart and info of city: $\omega_{out} = 0.017 \qquad \omega_{in} = 0.019$

$\dot{Q}_{inf-ventilation_{cooling_{latent}}} = C_{latent}\dot{V}\Delta\omega_{Cooling}$ =3010×32.41×0.002= 195.11 W