POLITECNICO
MILANO 1863

Politecnico di Milano University
M.Arch Sustainable Architecture and Landscape Design
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WEEKLY SUBMISSION - TASK 09

01. 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 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)
Umidità: Relative humidity
Pressione atmosferica: Air total pressure (1 hPa: 0.1 kPa)
Temperatura effettiva: temperature to be utilized.

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

ANSWERS:

01.

Aula A = 10mx5mx4m
Temperature = 8°C
Saturation pressure of water = 1.07299 kPa
Atmospheric pressure = 1020 hPa = 102 kPa
Relative Humidity = 92%

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

$P\_v = \phi \, x \, P\_g = 0.92 \, x \, 1.07299 = 0.99 \, kPa$ ⟶ Partial Pressure Water Vapor

$P\_a = P - P\_v = 102 \, kPa - 0.99 \, kPa = 101.01 \, kPa$ ⟶ Partial Pressure Dry Air

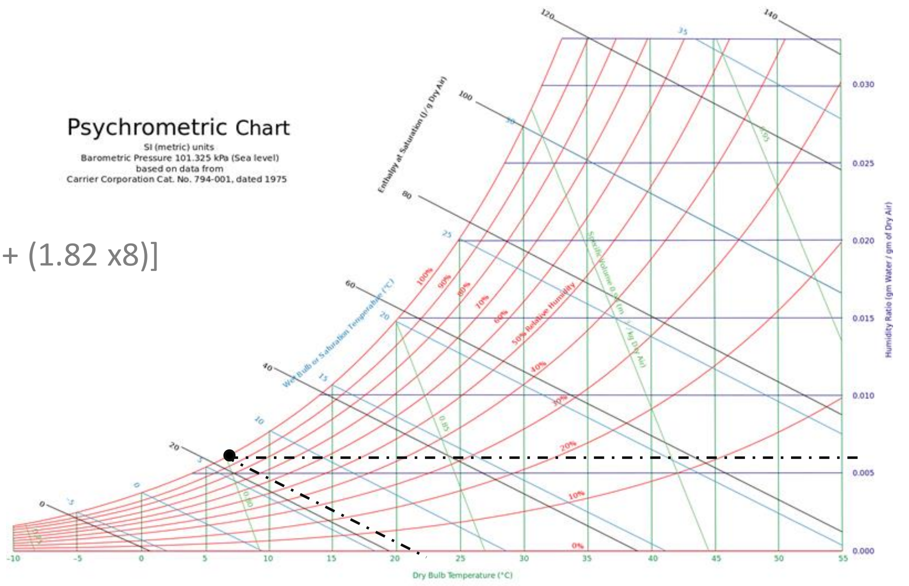
BY FORMULAS:

Specific Humidity / Absolute Humidity:

$$\omega = 0.622\frac{P_v}{P_a} = 0.622\frac{0.99}{101.01} \quad \boxed{= 0{,}0061\frac{kg_{vapour}}{kg_{dryAir}}}$$

Wet-Bulb Temperature:

Enthalpy: $h = h_a + \omega h_v$



$$h = h_a + \omega h_v$$

$$h = 1.005 \text{ x } 8 + 0.0061 \text{ x } [(2501 + (1.82 \text{ x}8)]$$

$$h = 8.04 + 0.0061 \text{ x } [2515.5]$$

$$h = 8.04 + 15.3445$$

$$\boxed{h = 23.384\frac{kJ}{kg_{dryAir}}}$$

With enthalpy $\simeq$ 23.5, through the chart we have that:

$\boxed{\text{Wet-Bulb Temperature} \simeq 6.5}$

Mass of Water Vapor:

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

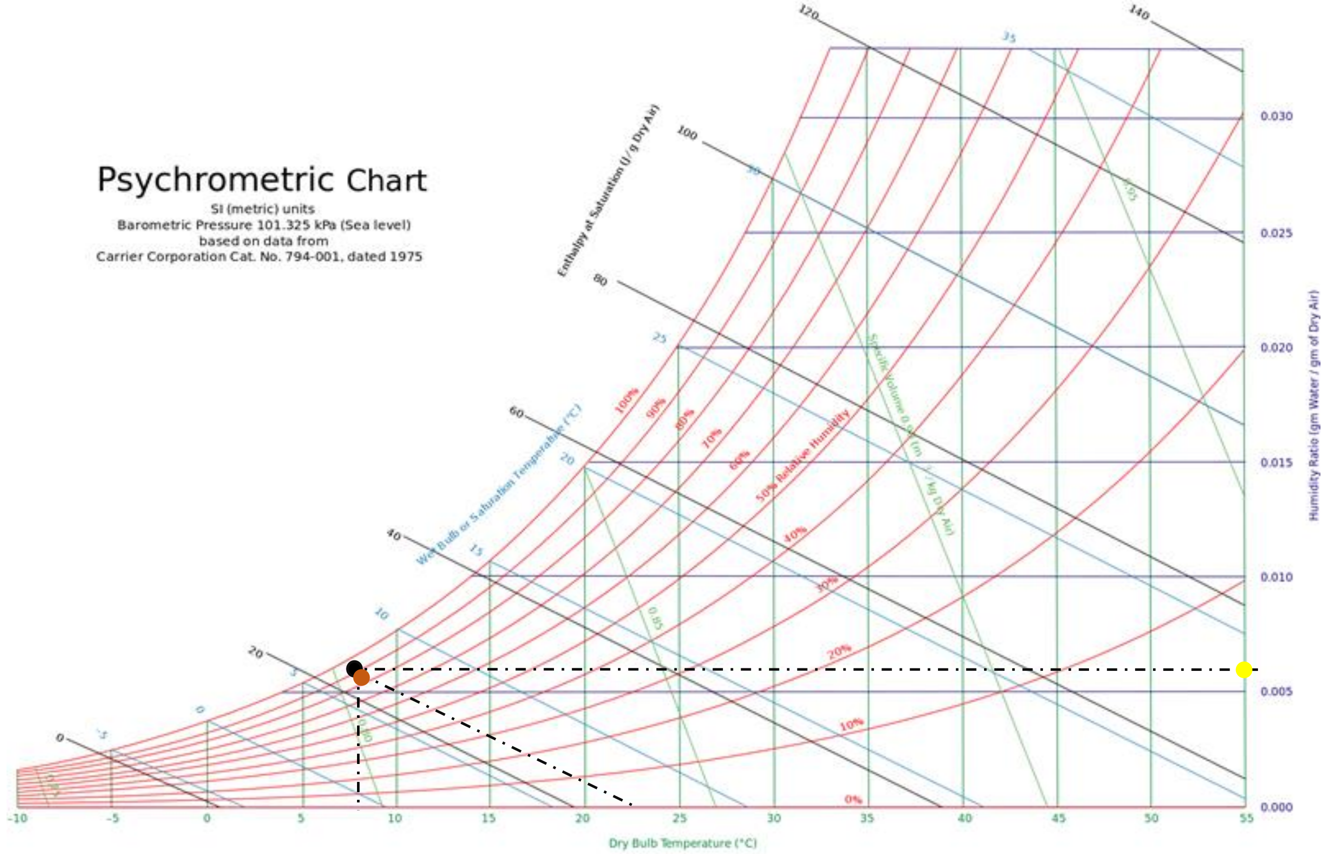
$$m_v = \frac{0.99\ x\ (10x5x4)}{0{,}4615\ x\ (273+8)} = \frac{198}{129.68} \quad \boxed{= 1.53 \text{ kg of water vapor}}$$

BY CHART:

Specific Humidity / Absolute Humidity $= 0{,}0061\dfrac{kg_{vapour}}{kg_{dryAir}}$

Wet-Bulb Temperature = Wet-Bulb Temperature $\simeq$ 6.5

Mass of Water Vapor $=$ 1.50 kg of water vapor



- Wet-Bulb Temperature $\simeq 6.5$
- Absolute Humidity = $0{,}0060 \frac{kg_{vapour}}{kg_{dryAir}}$
- Mass of Water Vapor $= 1.50$ kg of water vapor

02.

Building height = 2.5m
Floor area = 200 m²
Number of occupants = 2
Number of bedrooms = 1
Wall area = 144 m²

Comfortable thermal condition – Summer: 24°C
Comfortable thermal condition – Winter: 20°C

$$\Delta T_{cooling} = 31.1 - 24 = 7.1\ °C$$
$$\Delta T_{heating} = 20 - 4.1 = 15.9\ °C$$

Internal Gains:

$$\dot{Q}_{ig_{sensible}} = 136 + 2.2A_{cf} + 22N_{oc}$$

$$\dot{Q}_{ig_{sensible}} = 136 + 2.2\ x\ 200 + 22\ x\ 2$$

$$\boxed{\dot{Q}_{ig_{sensible}} = 620\ W}$$

$$\dot{Q}_{ig_{latent}} = 20 + 0.22A_{cf} + 12N_{oc} = 20 + 0.22\ x\ 200 + 12\ x\ 2 = 88\ W$$

$$\dot{Q}_{ig_{latent}} = 20 + 0.22\ x\ 200 + 12\ x\ 2$$

$$\boxed{\dot{Q}_{ig_{latent}} = 88\ W}$$

Infiltration:

Good Construction $\longrightarrow$ $A_{ul} = 1.4 \dfrac{cm^2}{m^2}$

$$\Delta T_{cooling} = 31.1 - 24 = 7.1\ °C$$
$$\Delta T_{heating} = 20 - 4.1 = 15.9\ °C$$

$$A_{es}\ (\text{wall} + \text{roof}) = 144 + 200 = 344\ m^2$$

$$A_L = A_{es}\ x\ A_{ul} = 344\ x\ 1.4 = 481.6\ cm^2$$

$$IDF_{\text{heating}} = 0.065 \frac{L}{s.cm^2}$$
$$IDF_{cooling} = 0.050 \frac{L}{s.cm^2}$$

$$\dot{Q}_{i_{heating}} = A_L\ x\ IDF = 481.6\ x\ 0.063 \boxed{= 30.34 \frac{L}{s}}$$

$$\dot{Q}_{i_{cooling}} = A_L\ x\ IDF = 481.6\ x\ 0.032 \boxed{= 15.41 \frac{L}{s}}$$

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

Ventilation:

$$\dot{Q}_v = 0.05A_{cf} + 3.5(N_{br} + 1)$$

$$\dot{Q}_v = 0.05\ x\ 200 + 3.5\ x\ 2$$

$$\dot{Q}_v = 17 \frac{L}{s}$$

$$\dot{Q}_{inf-ventilation_{heating}} = 30.34 + 17 \boxed{= 47.34 \frac{L}{s}}$$

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

$$\dot{Q}_{inf-ventilation_{heatingsensible}} = C_{sensible}\ \text{x V x}\ \Delta T_{\text{heating}} == 1.23\ \text{x}\ 47.34\ \text{x}\ 15.9 \boxed{= 925.82\ W}$$

$$\dot{Q}_{inf-ventilation_{heatinglatent}} = C_{latent}\ \text{x V x}\ \Delta\omega_{heating} = 3010\ x\ 47.34\ x\ 0.0046 \boxed{= 655.47\ \text{W}}$$

$$\dot{Q}_{inf-ventilation_{coolingsensible}} = C_{sensible}\ \text{x V x}\ \Delta T_{\text{cooling}} = 1.23\ x\ 32.41\ x\ 7.1 \boxed{= 283.04\ W}$$

$$\dot{Q}_{inf-ventilation_{coolinglatent}} = C_{latent}\ \text{x V x}\ \Delta\omega_{cooling} = 3010\ x\ 32.41\ x\ 0{,}0045 \boxed{= 438.99\ W}$$

$$\Delta\omega_{heating} = 0.0075 - 0.0029 = 0.0046$$
$$\Delta\omega_{cooling} = 0.0143 - 0.0098 = 0.0045$$