Week 9

Task 1 Use a weather forecast website, and utilize the psychrometric chart and the formula we went through in the class to determine the absoloute humidity, the wet-bulb temperature and the mass of water vapour in the air in Class Room A (Aula A) of Piacenza campus in the moment that you are solving this exercise (provide the inputs that you utilized)

Weather Forecast Website example

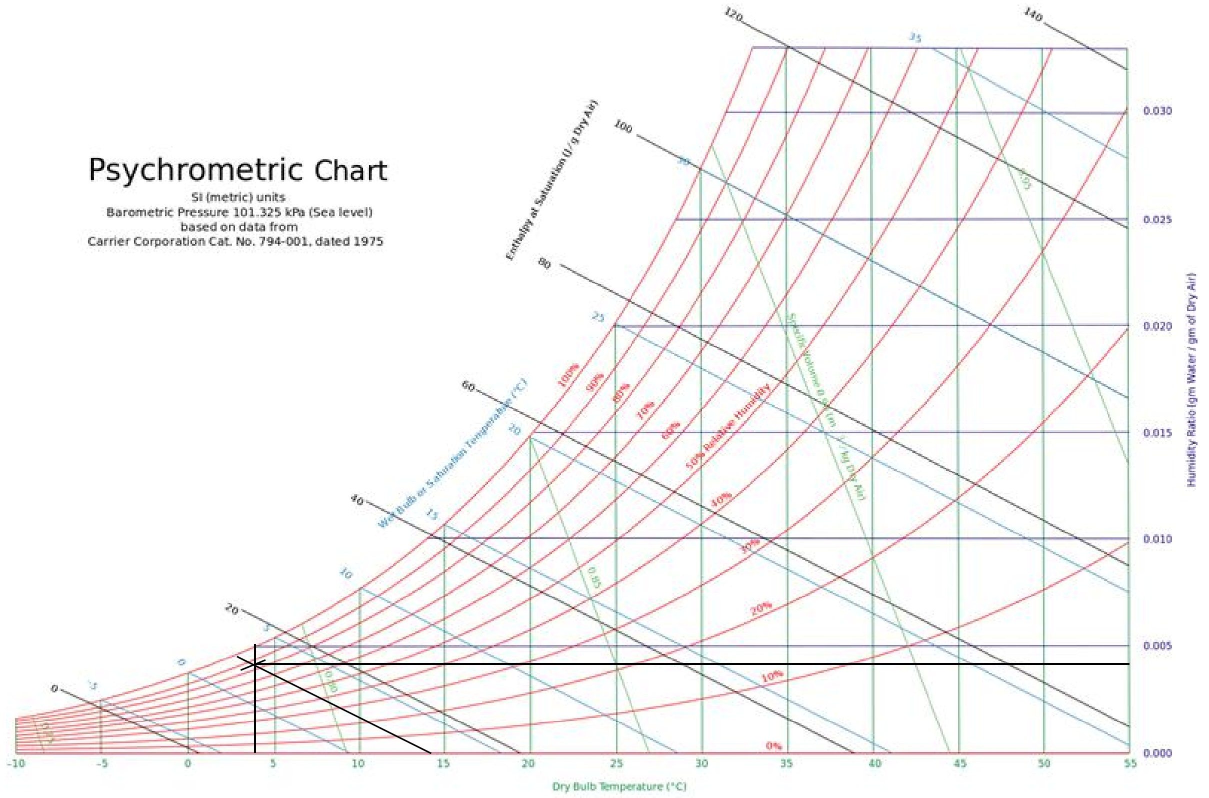
Umidità: Relative humidity, Pressione atmosferica: Air total pressure (1 hPa: 0.1 kPa), Temperatura effettiva: temperature to be utilized.

Il tempo oggi in Piacenza
Martedì, 03 Dicembre 2019

	13:00	14:00	16:00	18:00	20:00	21:00	22:00
	LightCloud	LightCloud	PartlyCloud	LightCloud	Sun	Sun	Sun
Temperatura effettiva	9°C	10°C	8°C	6°C	4°C	2°C	2°C
Temperatura percepita	7°C	10°C	6°C	4°C	2°C	0°C	0°C
Precipitazioni	0 mm	0 mm	0 mm	0 mm	0 mm	0 mm	0 mm
Umidità	67 %	65 %	69 %	70 %	75 %	83 %	87 %
Pressione atmosferica	1025 hPa	1025 hPa	1025 hPa	1026 hPa	1027 hPa	1027 hPa	1028 hPa
Intensità del vento	15 km/h	14 km/h	9 km/h	9 km/h	7 km/h	8 km/h	8 km/h

From the chart, we can know some data at 20：00

Umidita(relative humidity): **ϕ=75%** ; Pressione atmosferica: Air total pressure: **P=1027hpa=102.7kpa**; Temperatura effettiva(temperature)：**T=4℃=277K**



From the psychrometric chart, we can know that:

Humidity ratio: $\omega = 0.004$ kg water/kg of dry air

Wet bulb of temperature: $T_{\text{wet}-bulb} = 3^{o}C$

$$\omega = 0.622\frac{\mathrm{P_v}}{\mathrm{P_a}} = 0.622\frac{\mathrm{P_v}}{\mathrm{P - P_v}} = 0.004,\ \mathrm{P} = 102.7kpa \rightarrow \mathrm{P_v} = 0.656kpa$$,

For ideal gases: $m = \frac{PV}{R_{sp}T}$, so for air; $m_a = \frac{P_a V_a}{R_a T}$,

And from the table we know : $R_a = 0.287, R_v = 0.4615$

$$P_a = P - P_v = 102.7 - 0.656 = 102.04kpa$$

If we define the volume of classroom AULA is V_a

$$m_a = \frac{P_a V_a}{R_a T} = \frac{102.04 V_a}{0.287 \times 277} = 1.28 V_a$$ kg of dry air

$$m_v = \frac{P_v V_a}{R_v T} = \frac{0.656 V_a}{0.4615 \times 277} = 0.005 V_a$$ kg of water vapour

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

Q:

A building with a height of 2.5 m and an average construction quality, considering two occupants and one bed room calculate, and a conditioned floor area of 200 m2 and wall area is 144 m2, calculate the internal gains, infiltration, and ventilation loads.

ANSWER:

- **About the internal gains:**

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

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

- **About infiltration:**

Table 3 Unit Leakage Areas

Construction	Description	A_{ul}, cm²/m²
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

From the table, we can know when the building under a good construction, unit leakage areas are 1.4 cm2/m2, $A_{ul} = 1.4 cm^2 / m^2$

Exposed surface = Wall area +roof area ,so $A_{es} = 200 + 144 = 344 m^2$

The leakage area $A_L = A_{ul} A_{es} = 344 \times 1.4 = 481.6 cm^2$

Table 5 Typical IDF Values, L/(s·cm^2)

H, m	Heating Design Temperature, °C −40	−30	−20	−10	0	Cooling Design Temperature, °C 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

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	(1)

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	(2)

	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	(3)

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	(4)

From the second table, we can know that in Brindisi, the heating design temperature is 4.1℃, the cooling design temperature is 31.1℃.

From the first table, we can know:

$$IDF_{heating} = 0.065\frac{L}{s.cm^2}, IDF_{cooling} = 0.032\frac{L}{s.cm^2}$$

$$V_{\inf iltration_{heating}} = A_L \times IDF_{heating} = 481.6 \times 0.065 = 31.304 L/s$$

$$V_{\inf iltration_{cooling}} = A_L \times IDF_{cooling} = 481.6 \times 0.032 = 15.411 L/s$$

- **About ventilation**

$$q_{ig,s} = 136 + 2.2A_{cf} + 22N_{oc} = 136 + 2.2 * 200 + 22 * 2 = 620 \text{ W}$$

$$q_{ig,l} = 20 + 0.22A_{cf} + 12N_{oc} = 20 + 0.22 * 200 + 12 * 2 = 88 \text{ W}$$

$$A_{ul} = 1.4 \text{ cm}^2/\text{㎡}$$

$$A_{es} = A_{wall} + A_{roof} = 200 + 144 = 344 \text{ ㎡}$$

$$A_L = A_{es} * A_{ul} = 344 + 1.4 = 481.6 \text{ cm}^2$$

$\mathrm{T_{cooling}} = 24\ ℃, \mathrm{T_{heating}} = 20\ ℃$

In Brindisi, Italy,

$\Delta\mathrm{T_{cooling}} = 31.1 - 24 = 7.1\ ℃,$

$\Delta\mathrm{T_{heating}} = 20 - (-\ 4.1) = 24.1\ ℃$

DR=7.1℃

$$\mathrm{IDF_{heating}} = 0.073\frac{\mathrm{L}}{\mathrm{s} \cdot \mathrm{cm}^2}$$

$$\mathrm{IDF_{cooling}} = 0.033\frac{\mathrm{L}}{\mathrm{s} \cdot \mathrm{cm}^2}$$

$$\mathrm{Q_{i,heating}} = A_L * \mathrm{IDF_{heating}} = 481.6 * 0.073 = 35.16\frac{\mathrm{L}}{\mathrm{s}}$$

$$\mathrm{Q_{i,cooling}} = A_L * \mathrm{IDF_{cooling}} = 481.6 * 0.033 = 15.89\frac{\mathrm{L}}{\mathrm{s}}$$

$$\mathrm{Q_v} = 0.05A_{cf} * 3.5(\mathrm{N_{br}} + 1) = 0.05 * 200 + 3.5(1 + 1) = 17\frac{\mathrm{L}}{\mathrm{s}}$$

$$\mathrm{Q_{i-v,heating}} = \mathrm{Q_{i,heating}} + \mathrm{Q_v} = 15.16 + 17 = 52.16\frac{\mathrm{L}}{\mathrm{s}}$$

$$\mathrm{Q_{i-v,cooling}} = \mathrm{Q_{i,cooling}} + \mathrm{Q_v} = 15.89 + 17 = 32.89\frac{\mathrm{L}}{\mathrm{s}}$$

$\mathrm{C_{sensible}} = 1.23, \mathrm{C_{latent}} = 3010, \Delta\omega_{\mathrm{cooling}} = 1.23 * 32.89 * 7.1 = 287.25\ \mathrm{W}$

$$\dot{\mathrm{q}}_{\mathrm{inf-ventilation_{coolingsensible}}} = \mathrm{C_{sensible}} * \mathrm{Q_{i-v,cooling}} * \Delta\mathrm{T_{cooling}}$$

$$= 1.23 * 32.89 * 7.1 = 287.25\ \mathrm{W}$$

$$\dot{\mathrm{q}}_{\mathrm{inf-ventilation_{coolinglatent}}} = \mathrm{C_{latent}} * \mathrm{Q_{i-v,cooling}} * \Delta\omega_{\mathrm{cooling}}$$

$$= 3010 * 32.89 * 0.0039 = 386.13\ \mathrm{W}$$

$$\dot{\mathrm{q}}_{\mathrm{inf-ventilation_{coolinglatent}}} = \mathrm{C_{sensible}} * \mathrm{Q_{i-v,heating}} * \Delta\mathrm{T_{heating}}$$

$$= 1.23 * 52.16 * 24.1 = 1546.09\ \mathrm{W}$$