

Principles of Energy Balance in Environmental Systems

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Lecture 6

- 1. Conduction and convection**
2. Calculating boundary layer conductance
3. Measurement of the driving gradient
4. Modelling convective heat transfer

PSYCHROMETRIC CHART

FOR ENVIRONMENTAL PLANT PHYSIOLOGY

ELEVATION 1500 METERS

BAROMETRIC PRESSURE: 84.557 kPa

Temp °C	SWVP kPa
-20	0.12
-18	0.15
-16	0.18
-14	0.21
-12	0.24
-10	0.29
-8	0.33
-6	0.39
-4	0.45
-2	0.53
0	0.61
2	0.71
4	0.81
6	0.94
8	1.07
10	1.23
12	1.40
14	1.60
16	1.82
18	2.06
20	2.34
22	2.64
24	2.98
26	3.36
28	3.78
30	4.24
32	4.75
34	5.32
36	5.94
38	6.62
40	7.38
42	8.20
44	9.10
46	10.09
48	11.16
50	12.34

Saturation Water Vapor Pressure (SWVP) curve

$$SWVP = 0.6108 \exp((17.27 * T)/(237.3+T))$$

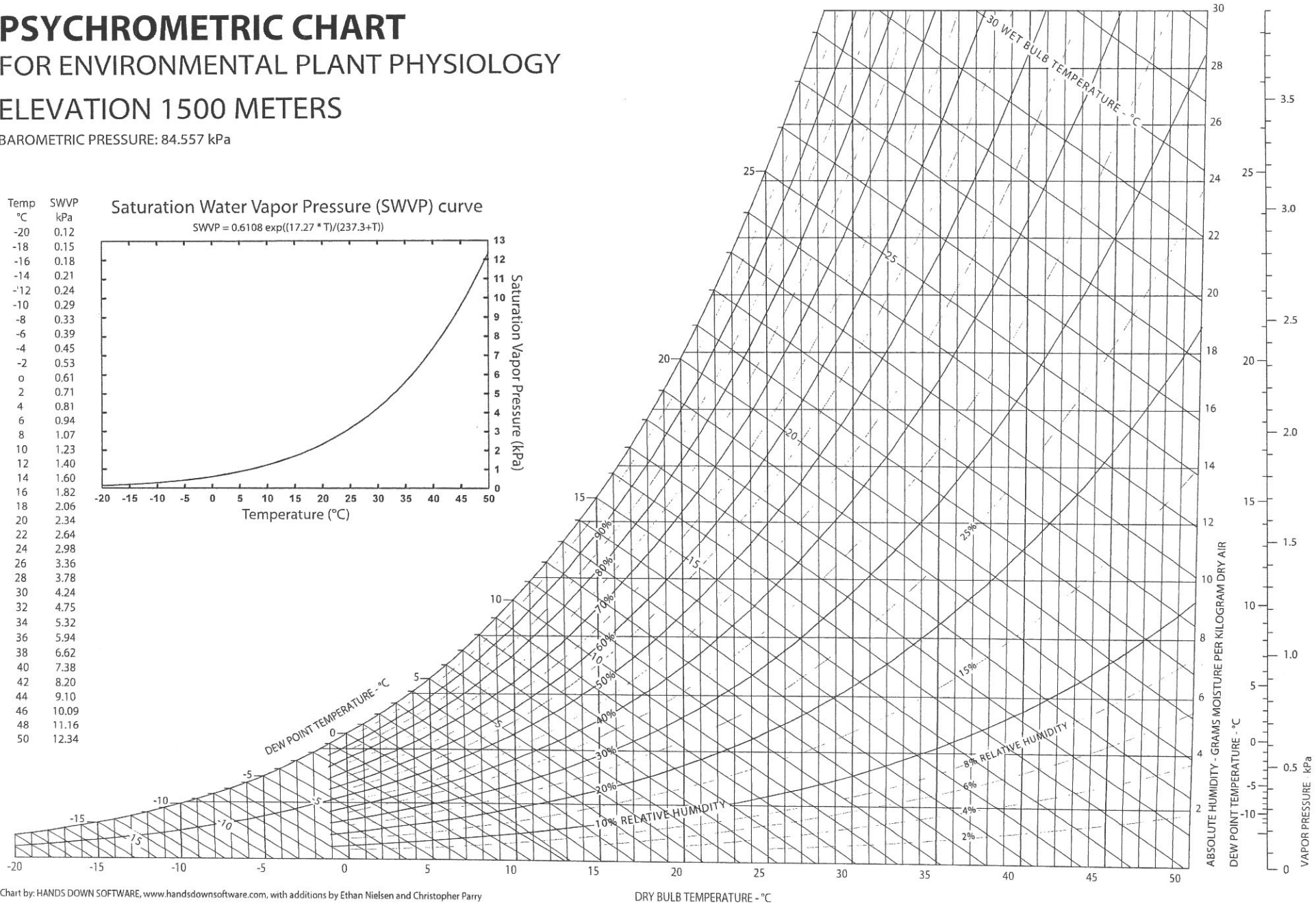
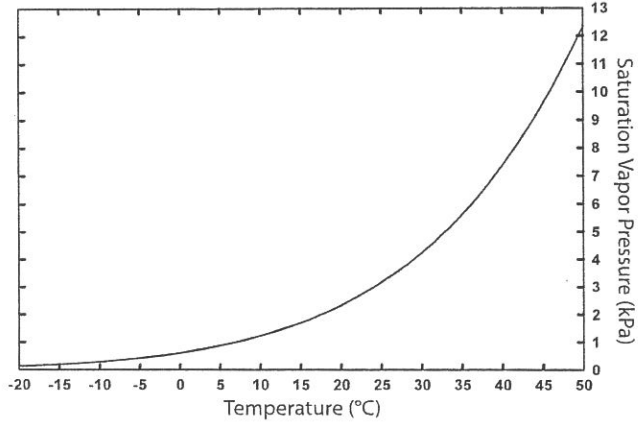


Chart by: HANDS DOWN SOFTWARE, www.handsdownsoftware.com, with additions by Ethan Nielsen and Christopher Parry

TERMINOLOGY

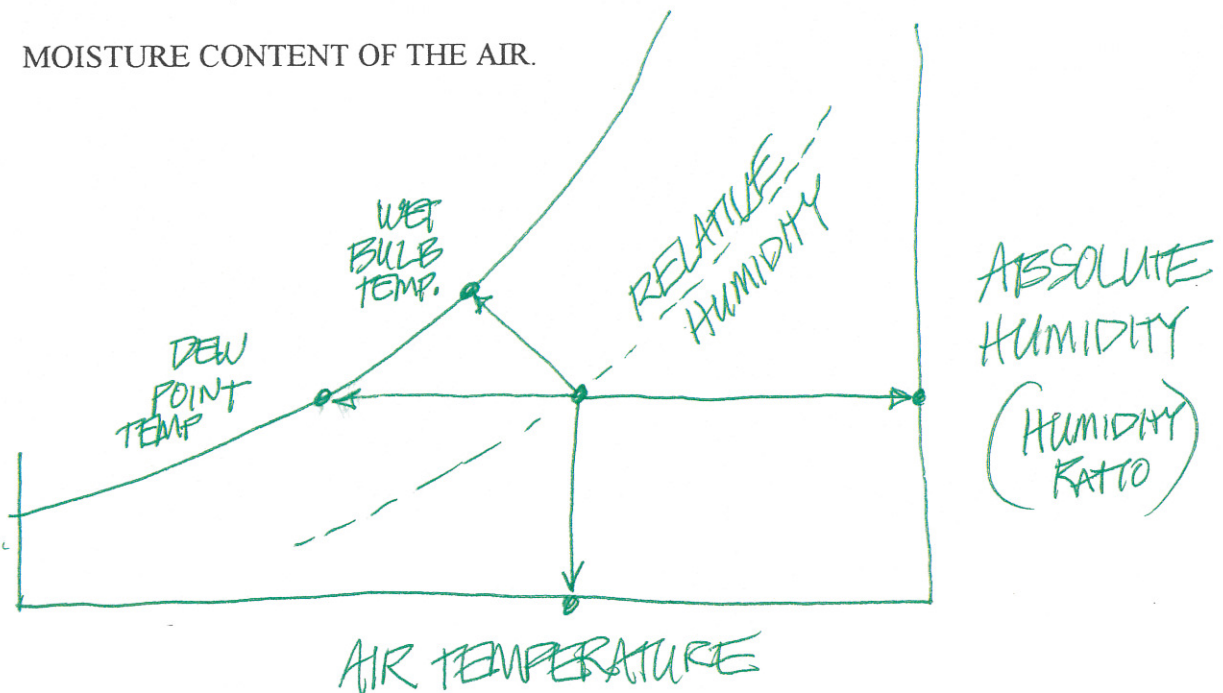
1. **DRY BULB TEMPERATURE:**
ACTUAL AIR TEMPERATURE

2. **WET BULB TEMPERATURE:**
TEMPERATURE OF A MOIST AND FREELY EVAPORATING SENSOR

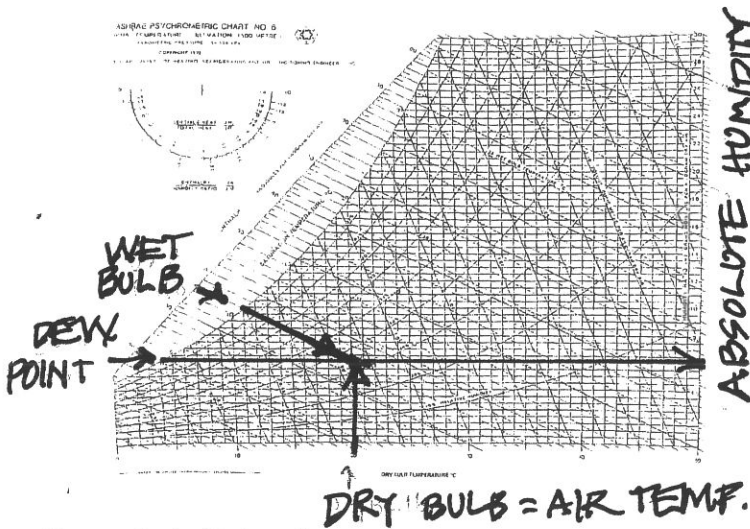
3. **RELATIVE HUMIDITY:**
THE RATIO OF WATER VAPOR PRESENT IN AIR TO THE AMOUNT OF WATER VAPOR PRESENT IN WATER SATURATED AIR (AT THE SAME T.) EXPRESSED IN %.

4. **DEW POINT:**
THE TEMPERATURE AT WHICH WATER VAPOR CONDENSATION TAKES PLACE IN DRY AIR. (= SATURATION TEMPERATURE)

5. **HUMIDITY RATIO (ABSOLUTE HUMIDITY):**
MOISTURE CONTENT OF THE AIR.



How to use a psychrometric chart to determine the 5 primary moisture parameters when any two of the 5 are known



ABSOLUTE HUMIDITY
ALSO: DEW POINT

Example 1: Determine moisture parameters from wet and dry bulb measurements:

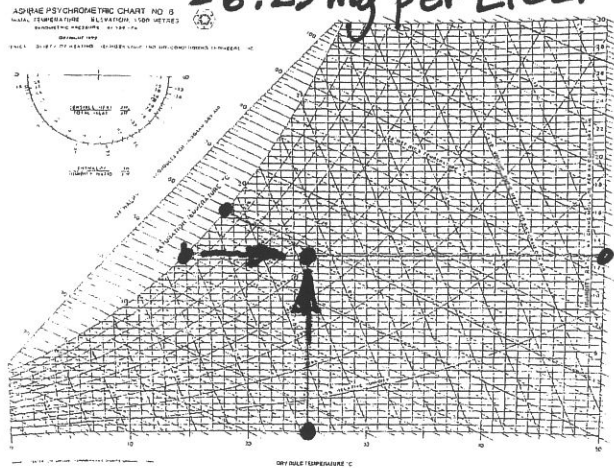
Dry = 20° C
Wet = 11° C

Relative Humidity = 35%
Dew Point = 4.5° C
Absolute Humidity = 6.25 g H₂O/kg Air
*= 6.25 g per m³
= 6.25 mg per Liter*

Example 3: Determine moisture parameters from Relative Humidity and Air Temperature:

RH = 80%
Air Temp = 5° C

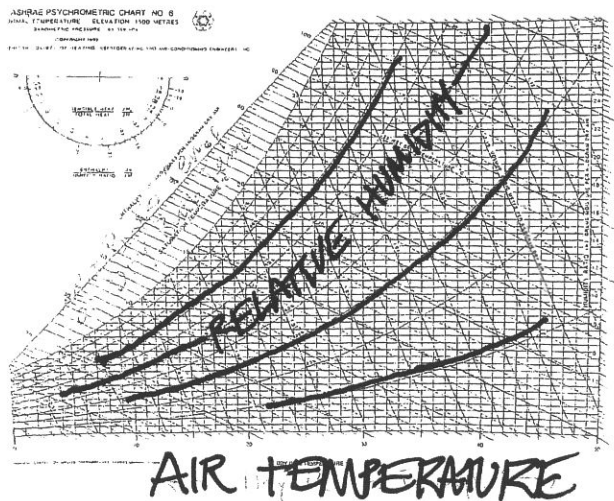
Wet Bulb Temp. = 3.5° C
Dew Point = 2° C
Absolute Humidity = 5.25 g H₂O/kg Air



Example 2: Determine moisture parameters from Dew Point temperature and Dry Bulb Temperature (Air Temp.) measurements:

Air Temp = 25° C
Dew Point Temp = 15° C

Relative Humidity = 51%
Wet Bulb Temp = 18.6° C
Absolute Humidity = 13 g H₂O/kg Air



Absolute Humidity

The five cardinal points on a psychrometric chart are:

1. Dry Bulb Temperature
2. Wet Bulb Temperature
3. Relative Humidity
4. Dew Point Temperature
5. Absolute Humidity

AIR DENSITY AT 1500 m ELEVATION
≈ 1 kg per m³

TYPICAL VALUES

* SINGLE LEAF

$$\text{FLUX} = \text{DRIVING GRADIENT} * \text{CONDUCTANCE}$$

$$\begin{aligned} \text{TRANSPIRATION} &= \Delta H * \text{STOMATAL CONDUCTANCE} \\ &= (H_i - H_a) * g_{H_2O} \end{aligned}$$

	<u>TYPICAL</u>	<u>RANGE</u>
TRANSPIRATION RATE	5 mmol m ⁻² s ⁻¹	0-20 mmol m ⁻² s ⁻¹
	0.10 g m ⁻² s ⁻¹	0-0.35 g m ⁻² s ⁻¹
	100 mg m ⁻² s ⁻¹	0-350 mg m ⁻² s ⁻¹

DRIVING GRADIENT	2 kPa	0-5 kPa
DIMENSIONLESS	0.02	0-0.05

STOMATAL CONDUCTANCE	0.3 mol m ⁻² s ⁻¹	0-0.9 mol m ⁻² s ⁻¹
	300 mmol m ⁻² s ⁻¹	0-900 mmol m ⁻² s ⁻¹

0 = COMPLETELY CLOSED
 0.3 = OPEN
 0.9 = WIDE OPEN