

Calculating the Dew-Point and Wet-Bulb Temperature of Air

Introduction

Atmospheric air contains varying levels of water vapor. Weather reports often quantify the water content of air with its relative humidity; this is the amount of water in air, divided by the maximum amount of water air can hold at the same temperature.

Given the temperature and the relative humidity of air, you can calculate

- the temperature below which water condenses out of air - this is known as the dew-point
- the coldest temperature you can achieve through evaporative cooling - this is known as the wet-bulb temperature

Both quantities can be calculated with Maple 2016's [ThermophysicalData](#) package, and visualized on a psychrometric chart.

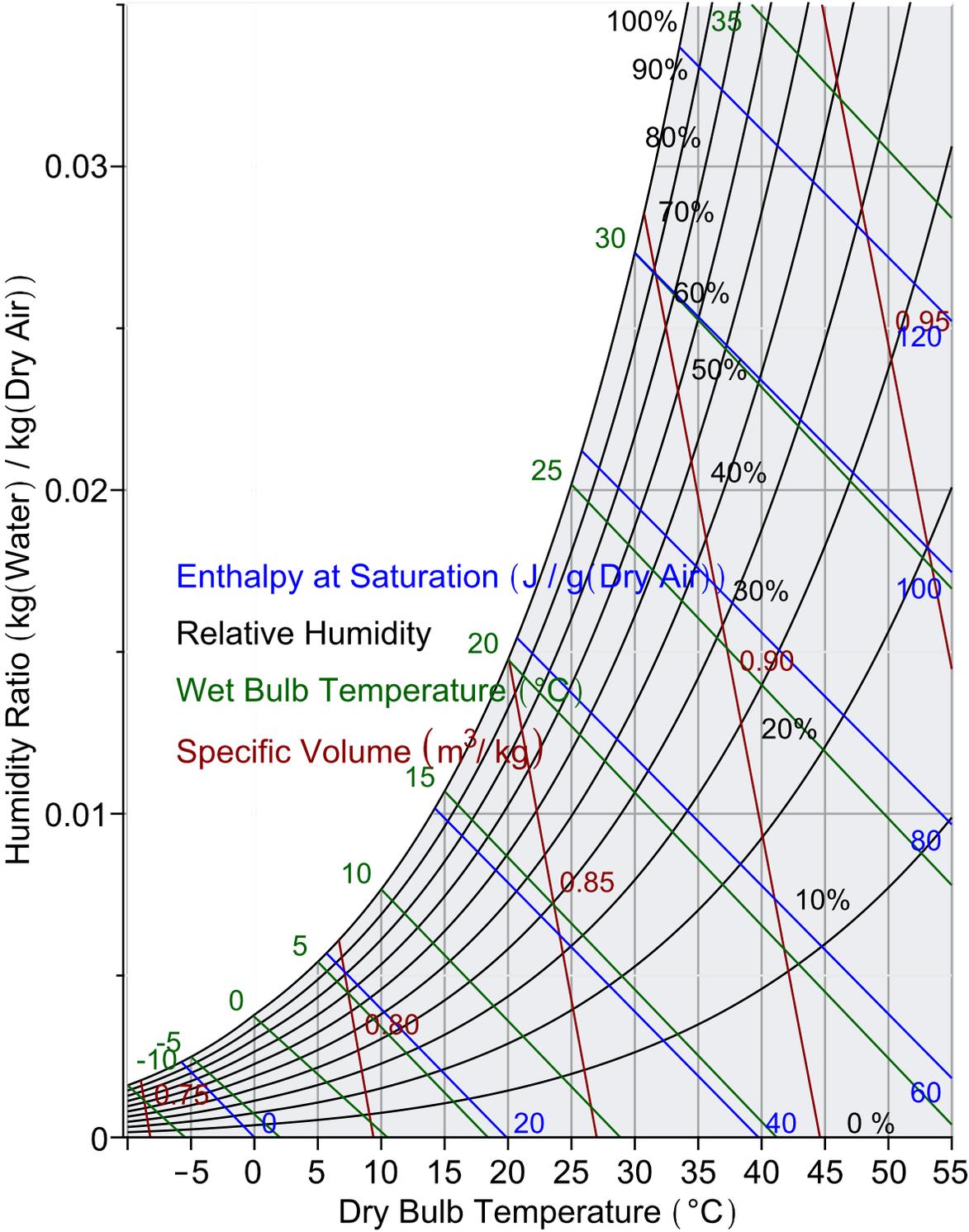
```
> restart :  
with( ThermophysicalData ) :  
with( plots ) :
```

Psychrometric Chart

A psychrometric chart gives the properties of humid air. Since the properties of dry and water vapor change with air pressure, a psychrometric chart is only valid at a stated pressure.

```
> air_press := 101325Pa :  
p1 := PsychrometricChart( pressure = air_press)
```

Psychrometric Chart



The x-axis is the Dry Bulb Temperature - this is the temperature you measure with a shielded thermometer, and is generally the temperature given by weather reports. The y-axis is the humidity ratio - this is the mass of water per unit mass of dry air.

The chart also gives lines of constant

- enthalpy at saturation,
- relative humidity,
- wet-bulb temperature,
- and specific volume.

Weather reports generally give the relative humidity (the actual water-content of air divided by the water content of air at saturation) and the dry-bulb temperature.

Given the dry-bulb temperature, relative humidity and air pressure, you can calculate the humidity ratio.

```
> dry_bulb_temp := 298K :  
  relative_humidity := 0.6 :
```

```
humidity_ratio := Property( W, HumidAir, Tdb = dry_bulb_temp, pressure = air_press, R  
  = relative_humidity)
```

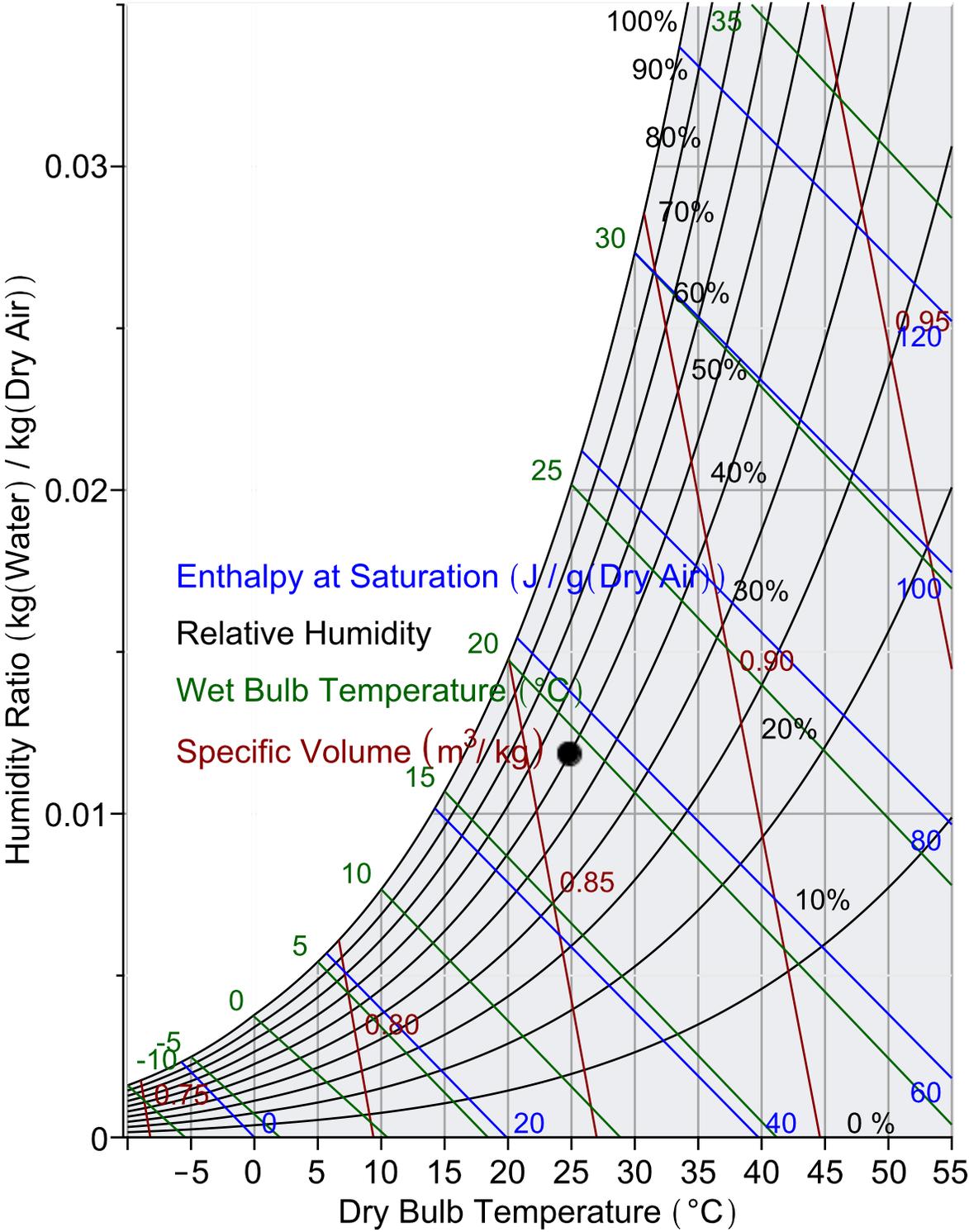
```
  humidity_ratio := 0.01184052342
```

(2.1)

We can now plot the point on the psychometric chart.

```
> p2 := plots:-pointplot( convert~( [dry_bulb_temp, humidity_ratio], unit_free ), symbol  
  = solidcircle, symbolsize = 15 ) :  
plots:-display( p1, p2)
```

Psychrometric Chart



Dew-Point Temperature

The dew-point temperature is the temperature below which water condenses out of air.

> dew_point_temp := Property(D, HumidAir, Tdb = dry_bulb_temp, pressure = air_press, R = relative_humidity)

dew_point_temp := 289.7128005 K

(3.1)

You can also read the dew-point temperature directly from a Psychrometric chart. Simply draw a horizontal line from the current point until you hit the 100% relative humidity line, and then read the temperature. This is illustrated by the green line on the chart below.

> p3 :=

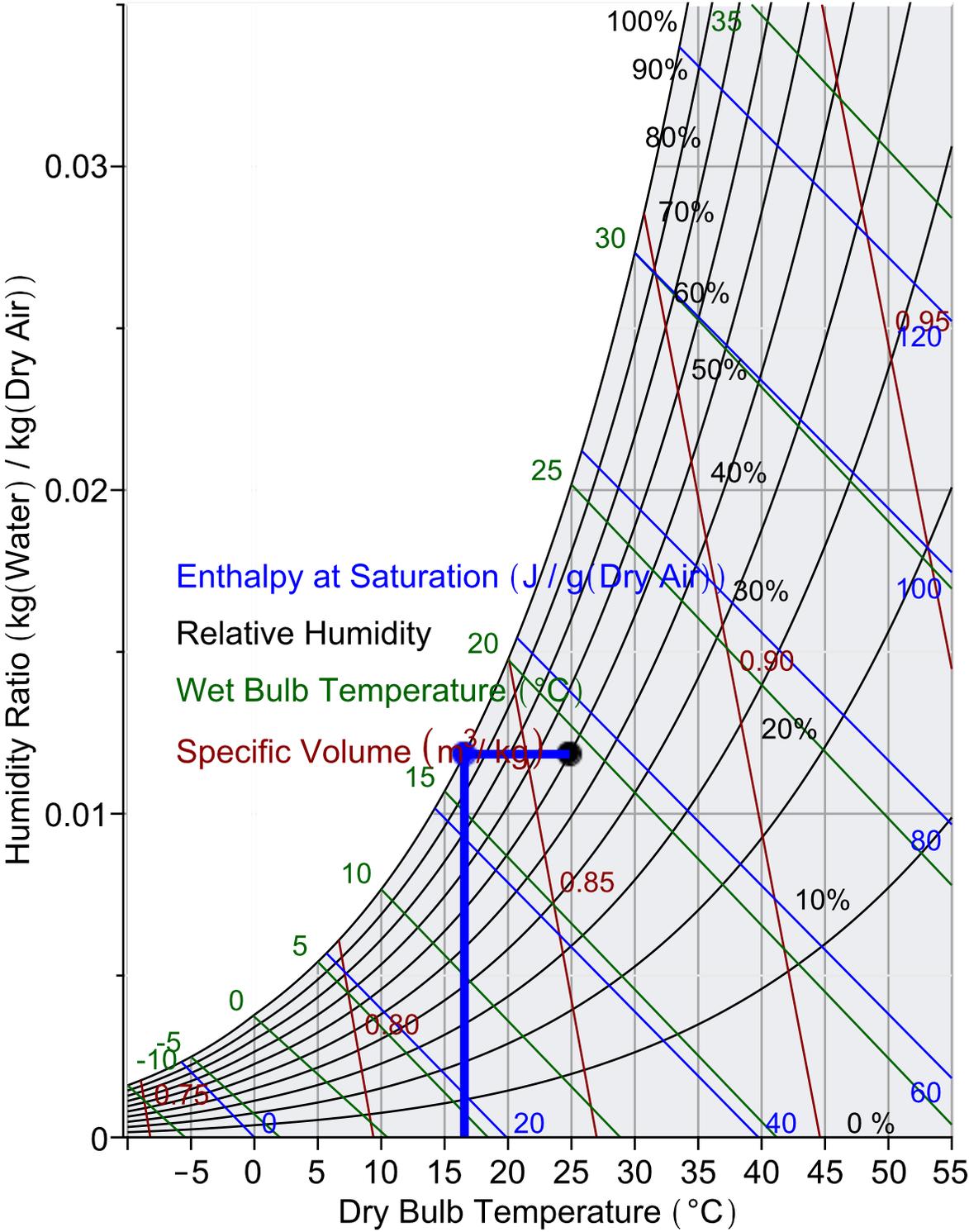
```
pointplot( convert~( [ [dry_bulb_temp, humidity_ratio], [dew_point_temp, humidity_ratio] ], unit_free ), symbol = solidcircle, symbolsize = 10, connect = true, color = blue, thickness = 4 ),
```

```
pointplot( convert~( [dew_point_temp, humidity_ratio], unit_free ), symbol = solidcircle, symbolsize = 15, color = blue ),
```

```
pointplot( convert~( [ [dew_point_temp, humidity_ratio], [dew_point_temp, 0] ], unit_free ), symbol = solidcircle, symbolsize = 10, connect = true, color = blue, thickness = 4 ) :
```

```
display( p1, p2, p3 )
```

Psychrometric Chart



Wet-Bulb Temperature

The wet-bulb temperature is the coldest temperature you can get through evaporative cooling. This can be physically measured by wrapping the bulb of a thermometer in a wet rag; as the water

evaporates, latent heat is removed and the temperature drops.

```
> wet_bulb_temp := Property( Twb, HumidAir, Tdb = dry_bulb_temp, pressure = air_press, R  
= relative_humidity)
```

```
wet_bulb_temp := 292.4874035 K
```

(4.1)

You can also read the wet-bulb temperature from a Psychrometric chart. From the current point, draw a line parallel to the lines of constant wet-bulb temperature, until you reach the 100% relative humidity line, and then read the temperature. This is illustrated by the green line on the chart below.

```
> humidity_ratio_wet_bulb := Property( W, HumidAir, Tdb = wet_bulb_temp, pressure  
= air_press, R = 1 ) :
```

```
p4 :=
```

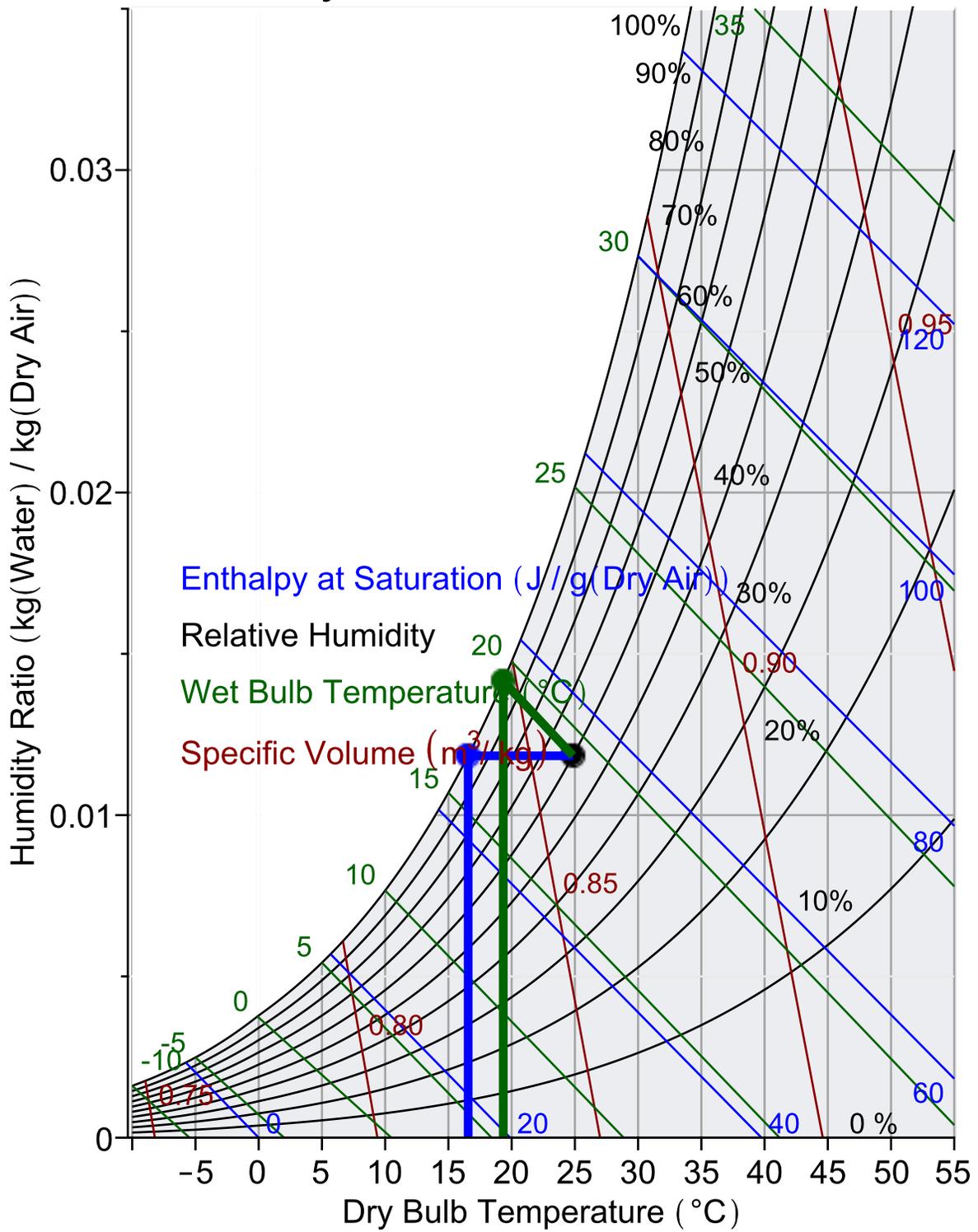
```
pointplot( convert~( [ [dry_bulb_temp, humidity_ratio], [wet_bulb_temp,  
humidity_ratio_wet_bulb]], unit_free ), symbol = solidcircle, symbolsize = 10, connect  
= true, color = "DarkGreen", thickness = 4 ),
```

```
pointplot( convert~( [wet_bulb_temp, humidity_ratio_wet_bulb], unit_free ), symbol  
= solidcircle, symbolsize = 15, color = "DarkGreen" ),
```

```
pointplot( convert~( [ [wet_bulb_temp, humidity_ratio_wet_bulb], [wet_bulb_temp, 0]],  
unit_free ), symbol = solidcircle, symbolsize = 10, connect = true, color = "DarkGreen",  
thickness = 4 ) :
```

```
display( p1, p2, p3, p4)
```

Psychrometric Chart



>