



BRIEF DOCUMENTATION ON THE MATHCAD™ CALCULATION SHEET

MOIST AIR WEBPROPS.MCD

The nine attached pages show what the user of the calculation sheet gets to see when using it. They are succinctly described in the following:

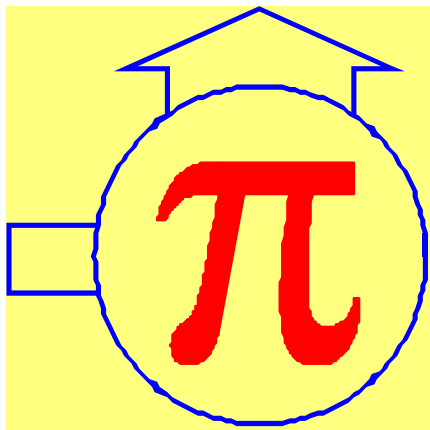
- Page 1 This is the opening page which, besides the contact address of the author, also includes a disclaimer regarding the use of the calculation sheet.
- Page 3 This page shows what the calculation sheet does in general. A list of the combination of inputs (triplets), with the respective units of each variable, describes the seven different possible sets of inputs. A complete set of thermodynamic and transport property values is output for each valid input triplet. They are also described in this page with the respective units of each variable. It shows the user where background information can be found. It also alerts the user for limitations that must be taken into account when using this calculation sheet.
- Pages 4...10 Display the seven sets of available public functions (The program that actually carries out the calculations is not available to the user). An editable field with the three variables (the input triplet) is where the user enters the input values. The user shall be careful not to change the names of these variables, but only their values within valid ranges. The tables with the output values answer automatically to any change in the input triplet, if the calculation is set to automatic (the user may change this setting).

The calculation sheet itself has no help features, and will produce short but informative messages on errors generated during the execution or due to unacceptable input values.

Users willing to get access to the calculating program shall contact the author for arrangements.

Zurich, 20041021

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MOIST AIR PSYCHROMETRY

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MOIST AIR PSYCHROMETRY

This MathCad Sheet provides the means to calculate thermodynamic and transport properties of moist air, under conditions common in air conditioning applications.

Seven combinations of inputs are possible with the units as follows:

Altitude [m]	Dry-Bulb Temperature [°C]	Relative Humidity [%]
Altitude [m]	Dry-Bulb Temperature [°C]	Humidity Ratio [g.kg _{DA} ⁻¹]
Altitude [m]	Dry-Bulb Temperature [°C]	Enthalpy [kJ.kg _{DA} ⁻¹]
Altitude [m]	Dry-Bulb Temperature [°C]	Dew-Point Temperature [°C]
Altitude [m]	Dry-Bulb Temperature [°C]	Wet-Bulb Temperature [°C]
Altitude [m]	Enthalpy [kJ.kg _{DA} ⁻¹]	Relative Humidity [%]
Altitude [m]	Enthalpy [kJ.kg _{DA} ⁻¹]	Humidity Ratio [g.kg _{DA} ⁻¹]

For each valid triplet, the sheet returns the complete set of thermophysical properties of interest for air conditioning calculations as:

Dry-Bulb Temperature	°C
Pressure	kPa
Relative Humidity	%
Dew-Point	°C
Wet-Bulb Temperature	°C
Enthalpy	kJ.kg _{DA} ⁻¹
Humidity Ratio	g.kg _{DA} ⁻¹
Humidity Ratio at Sat¹	g.kg _{DA} ⁻¹
Dry Air Enthalpy²	kJ.kg _{DA} ⁻¹
Spec. Thermal Capacity	kJ.kg _{DA} ⁻¹ .K ⁻¹
Dynamic Viscosity	Pa.s
Thermal Conductivity	W.m ⁻¹ .K ⁻¹
Specific Volume	m ³ .kg _{DA} ⁻¹
Density	kg.m ⁻³
Prandtl Number	-
Schmidt Number	-
Partial Pressure of Vapour	kPa
Vapour Diffusion Coeff.	m ² .s ⁻¹

Notes:

¹ This is the humidity ratio for saturation along the Wet-Bulb Isotherm;

² This is the DRY air enthalpy at the same dry-bulb temperature of the air.

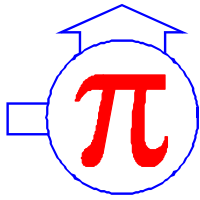
Detailed background information regarding the methods and equations used in this calculation sheet are available on the web at:

www.mrc-eng.com/Downloads/Moist_Air_Props_English.PDF

or directly from the author at the address given above.

Only limited range checking is done on the input values. A modified output value in regard to its input value, indicates that that input value was either out of range of acceptable values, or outright wrong e.g. a negative humidity ratio or relative humidity. It is always convenient to check values before input for correctness, for example by looking up a diagram. Error messages are issued for most invalid input pairs. The user shall carefully check the validity of the input values to obtain correct results.

Public Functions



General Set of Moist Air Properties,
given

Temperature [°C]
Altitude [m]
and Relative Humidity [%]

INPUT VALUES

Altitude := 0

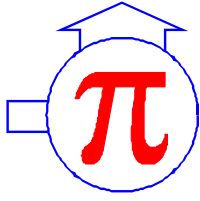
Temperature := 45.0

RelHumidity := 28

ShowProps(Altitude, Temperature, RelHumidity, 1) =

"Dry-Bulb Temperature	[°C] "	45
"Pressure	[kPa] "	101.32516
"Relative Humidity	[%] "	28
"Dew-Point Temperature	[°C] "	22.27
"Wet-Bulb Temperature	[°C] "	28.03
"Specific Enthalpy	[kJ/kgDA] "	89.257
"Humidity Ratio	[g/kgDA] "	17.018
"Humidity Ratio at Saturation	[g/kgDA] "	24.265
"Dry Air Enthalpy	[kJ/kgDA] "	45.289
"Specific Thermal Capacity	[kJ/(kgDA.K)] "	1.022
"Dynamic Viscosity	[Pa.s] "	19.04·10 ⁻⁶
"Thermal Conductivity	[W/(m.K)] "	27.11·10 ⁻³
"Specific Volume	[m ³ /kgDA] "	925.78·10 ⁻³
"Density	[kg/m ³] "	1.0985
"Prandtl Number	[-] "	717.7·10 ⁻³
"Schmidt Number	[-] "	608.2·10 ⁻³
"Partial Pressure of Vapour	[kPa] "	2.68511
"Vapour Diffusion Coefficient	[m ² /s] "	28.49539·10 ⁻⁶

Public Functions



General Set of Moist Air Properties,
given

Temperature [°C]
Altitude [m]
and Humidity Ratio [g.kg_{DA}⁻¹]

INPUT VALUES

Temperature := 18.0

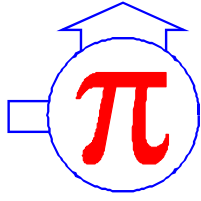
Altitude := 0

HumidityRatio := 7.0

ShowProps(Altitude, Temperature, HumidityRatio, 2) =

"Dry-Bulb Temperature	[°C] "	18
"Pressure	[kPa] "	101.32516
"Relative Humidity	[%] "	54.416
"Dew-Point Temperature	[°C] "	8.68
"Wet-Bulb Temperature	[°C] "	12.7
"Specific Enthalpy	[kJ/kgDA] "	35.842
"Humidity Ratio	[g/kgDA] "	7
"Humidity Ratio at Saturation	[g/kgDA] "	9.186
"Dry Air Enthalpy	[kJ/kgDA] "	18.108
"Specific Thermal Capacity	[kJ/(kgDA.K)] "	1.012
"Dynamic Viscosity	[Pa.s] "	17.9·10 ⁻⁶
"Thermal Conductivity	[W/(m.K)] "	25.24·10 ⁻³
"Specific Volume	[m ³ /kgDA] "	833.78·10 ⁻³
"Density	[kg/m ³] "	1.2078
"Prandtl Number	[-] "	718.2·10 ⁻³
"Schmidt Number	[-] "	608.9·10 ⁻³
"Partial Pressure of Vapour	[kPa] "	1.12316
"Vapour Diffusion Coefficient	[m ² /s] "	24.34718·10 ⁻⁶

Public Functions



General Set of Moist Air Properties,
given

Temperature [°C]
Altitude [m]
and Enthalpy [kJ.kg_{DA}⁻¹]

INPUT VALUES

Temperature := 30.0

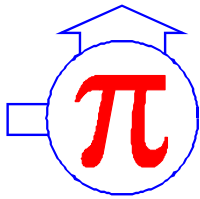
Altitude := 0

Enthalpy := 50.0

ShowProps(Altitude, Temperature, Enthalpy, 3) =

"Dry-Bulb Temperature	[°C] "	30
"Pressure	[kPa] "	101.32516
"Relative Humidity	[%] "	29.259
"Dew-Point Temperature	[°C] "	10.18
"Wet-Bulb Temperature	[°C] "	17.8
"Specific Enthalpy	[kJ/kgDA] "	50
"Humidity Ratio	[g/kgDA] "	7.753
"Humidity Ratio at Saturation	[g/kgDA] "	12.821
"Dry Air Enthalpy	[kJ/kgDA] "	30.185
"Specific Thermal Capacity	[kJ/(kgDA.K)] "	1.013
"Dynamic Viscosity	[Pa.s] "	18.47·10 ⁻⁶
"Thermal Conductivity	[W/(m.K)] "	26.12·10 ⁻³
"Specific Volume	[m ³ /kgDA] "	869.28·10 ⁻³
"Density	[kg/m ³] "	1.1593
"Prandtl Number	[-] "	716.3·10 ⁻³
"Schmidt Number	[-] "	609·10 ⁻³
"Partial Pressure of Vapour	[kPa] "	1.24208
"Vapour Diffusion Coefficient	[m ² /s] "	26.15568·10 ⁻⁶

Public Functions



General Set of Moist Air Properties,
given

Temperature [°C]
Altitude [m]
and Dew-Point Temperature [°C]

INPUT VALUES

Temperature := 29.7

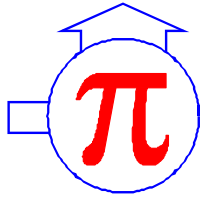
Altitude := 0

DewPointTemp := 17.0

ShowProps(Altitude, Temperature, DewPointTemp, 4) =

"Dry-Bulb Temperature	[°C] "	29.7
"Pressure	[kPa] "	101.32516
"Relative Humidity	[%] "	46.424
"Dew-Point Temperature	[°C] "	17
"Wet-Bulb Temperature	[°C] "	21.08
"Specific Enthalpy	[kJ/kgDA] "	60.992
"Humidity Ratio	[g/kgDA] "	12.176
"Humidity Ratio at Saturation	[g/kgDA] "	15.798
"Dry Air Enthalpy	[kJ/kgDA] "	29.883
"Specific Thermal Capacity	[kJ/(kgDA.K)] "	1.017
"Dynamic Viscosity	[Pa.s] "	18.39·10 ⁻⁶
"Thermal Conductivity	[W/(m.K)] "	26.04·10 ⁻³
"Specific Volume	[m ³ /kgDA] "	874.5·10 ⁻³
"Density	[kg/m ³] "	1.1574
"Prandtl Number	[-] "	718.3·10 ⁻³
"Schmidt Number	[-] "	608.5·10 ⁻³
"Partial Pressure of Vapour	[kPa] "	1.93705
"Vapour Diffusion Coefficient	[m ² /s] "	26.10978·10 ⁻⁶

Public Functions



General Set of Moist Air Properties,
given

Temperature [°C]
Altitude [m]
and Wet-Bulb Temperature [°C]

INPUT VALUES

Temperature := 29.7

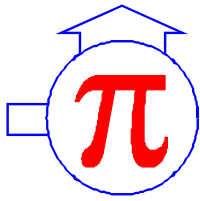
Altitude := 0.0

TwetBulb := 20.0

ShowProps(Altitude, Temperature, TwetBulb, 5) =

"Dry-Bulb Temperature	[°C] "	29.7
"Pressure	[kPa] "	101.32516
"Relative Humidity	[%] "	40.869
"Dew-Point Temperature	[°C] "	15
"Wet-Bulb Temperature	[°C] "	20
"Specific Enthalpy	[kJ/kgDA] "	57.206
"Humidity Ratio	[g/kgDA] "	10.694
"Humidity Ratio at Saturation	[g/kgDA] "	14.755
"Dry Air Enthalpy	[kJ/kgDA] "	29.883
"Specific Thermal Capacity	[kJ/(kgDA.K)] "	1.016
"Dynamic Viscosity	[Pa.s] "	18.41·10 ⁻⁶
"Thermal Conductivity	[W/(m.K)] "	26.06·10 ⁻³
"Specific Volume	[m3/kgDA] "	872.46·10 ⁻³
"Density	[kg/m3] "	1.1584
"Prandtl Number	[-] "	717.6·10 ⁻³
"Schmidt Number	[-] "	608.7·10 ⁻³
"Partial Pressure of Vapour	[kPa] "	1.70527
"Vapour Diffusion Coefficient	[m2/s] "	26.10978·10 ⁻⁶

Public Functions



General Set of Moist Air Properties,
given

Enthalpy [kJ.kg_{DA}⁻¹
Altitude [m]
and Relative Humidity [%]

INPUT VALUES

Enthalpy := 25.85

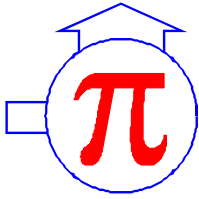
Altitude := 0.0

RelHumidity := 100

ShowProps(Altitude, Enthalpy, RelHumidity, 6) =

"Dry-Bulb Temperature	[°C] "	8.46
"Pressure	[kPa] "	101.32516
"Relative Humidity	[%] "	100
"Dew-Point Temperature	[°C] "	8.46
"Wet-Bulb Temperature	[°C] "	8.46
"Specific Enthalpy	[kJ/kgDA] "	25.85
"Humidity Ratio	[g/kgDA] "	6.895
"Humidity Ratio at Saturation	[g/kgDA] "	6.895
"Dry Air Enthalpy	[kJ/kgDA] "	8.506
"Specific Thermal Capacity	[kJ/(kgDA.K)] "	1.012
"Dynamic Viscosity	[Pa.s] "	17.44·10 ⁻⁶
"Thermal Conductivity	[W/(m.K)] "	24.52·10 ⁻³
"Specific Volume	[m ³ /kgDA] "	806.23·10 ⁻³
"Density	[kg/m ³] "	1.2489
"Prandtl Number	[-] "	720·10 ⁻³
"Schmidt Number	[-] "	608.6·10 ⁻³
"Partial Pressure of Vapour	[kPa] "	1.10659
"Vapour Diffusion Coefficient	[m ² /s] "	22.94943·10 ⁻⁶

Public Functions



General Set of Moist Air Properties,
given

Enthalpy [kJ.kg_{DA}⁻¹]
Altitude [m]
and Humidity Ratio [g.kg_{DA}⁻¹]

INPUT VALUES



Enthalpy := 25.85

Altitude := 0.0

HumidityRatio := 0.15



ShowProps(Altitude, Enthalpy, HumidityRatio, 7) =

"Dry-Bulb Temperature	[°C] "	25.31
"Pressure	[kPa] "	101.32516
"Relative Humidity	[%] "	754·10 ⁻³
"Dew-Point Temperature	[°C] "	-34.19
"Wet-Bulb Temperature	[°C] "	8.57
"Specific Enthalpy	[kJ/kgDA] "	25.85
"Humidity Ratio	[g/kgDA] "	150·10 ⁻³
"Humidity Ratio at Saturation	[g/kgDA] "	6.947
"Dry Air Enthalpy	[kJ/kgDA] "	25.468
"Specific Thermal Capacity	[kJ/(kgDA.K)] "	1.007
"Dynamic Viscosity	[Pa.s] "	18.35·10 ⁻⁶
"Thermal Conductivity	[W/(m.K)] "	25.88·10 ⁻³
"Specific Volume	[m ³ /kgDA] "	845.49·10 ⁻³
"Density	[kg/m ³] "	1.1829
"Prandtl Number	[-] "	713.9·10 ⁻³
"Schmidt Number	[-] "	609.8·10 ⁻³
"Partial Pressure of Vapour	[kPa] "	24.33·10 ⁻³
"Vapour Diffusion Coefficient	[m ² /s] "	25.44266·10 ⁻⁶

