Introduction to Mathcad 15 – part 2

Plots

It is import ant to be able to visualize the result in other forms than just tables and numbers. Mathcad offers a wide variety of plots and graphs to help you present calculations in better forms.

To place a graph in your Mathcad workbook you can use a shortcut, graph toolbar or use the ***Insert->graph*** menu. The simplest graphs are of course 2D X-Y Plots, but they will be the most useful during this course.

Example

Using the calculations from the first workbook, plot a graph of **volume versus temperature** for ideal gas. When it's done open properties and create axis labels.

Now assume that V=const and plot a pressure versus temperature graph. Present both pressure and volume change at the same graph. Place the values of volume and pressure on two separate axis.

Useful thing about plots created with Mathcad is the possibility to read coordinates of some(the ones that created a plot) points of the plot. To do this, right-click on the plot and use the command *Trace*.

Symbolic calculations

Mathcad allows users to perform wide variety of symbolic calculations. Appropriate commands can be found on *Symbolic toolbar* or in the *symbolic menu.*

Menu SYMBOLICS/Evaluate:

- symbolically – performs calculation on symbols
- floating point – performs symbolic calculation, but if only it's possible returns a number as a result (for example calculate the value of PI – use ***ctrl+shift+P*** *and floating point command)*
- complex – returns a complex expressions if it is possible

For description of the commands form symbolic toolbar use Mathcad Help.

Another part of symbolics in Mathcad are calculus operations. Mathcad can calculate differentials, integrals, limits and gradients. All this commands can be found in calculus toolbar. **IMPORTANT!** To perform symbolic calculations you must use the symbol of ARROW from symbolic toolbar, NOT EQUAL sign from keyboard.

Examples

1. In the following expression substitute x=√5 and y=3, then calculate value of this expression:

$$\frac{3\cdot\sin(x) + x^{5\cdot y} - 10x^{2}}{\mathrm{tg}\left(y^{2}\right) - x^{3}}$$

2. Expand F(x) and G(x) to Taylor series of rank 10.

F(x)=ln(sinx), G(x)=ln(cosx)

3. Calculate differential, third differential and undefined integral of the function H(x)=ln(x^3)
4. Knowing that heat capacity can be calculated as $\int_{T0}^{T1} F(T)dT$ and for steam heat capacity is given by the function: $F(T) = 32{,}23 + 1.92 * 10^{-3}T + 10.55 * 10^{-6}T^{2}$
    a. calculate medium heat capacity for temperature range 298-1000K
    b. create a plot Cp(T) for the given range.

Equations and system of equations

In fact we can put three groups of problems into this category. Finding root of polynomials, maximizing and minimizing functions and solving equations and their systems.

Solving equations:

Type the equation, remember to use ***ctrl + =*** or an ***equal sign from Boolean toolbar***. Then use *solve* command from the symbolic toolbar. Mathcad returns vector with the roots of equation.

Another way to solve the equations in form of polynomials is to create a vector with polynomial coefficients and use command ***polyroots***.

Example

Find roots of following equations. Use solve or polyroots method (where it is possible). Create plots of all curves.

- $4x^2 + 3x - 5 = 3$
- $\sin\left(x^2\right) + 2\,|x| + 1 = 5$
- $5x^5 - 4x^3 + 7x^2 - 3 = 0$

Solving system of equations

To solve a system of equations (or inequalities) in Mathcad you can use a block solve method.

First define the guess values for all searched unknowns. Then use the command ***Given*** and place all constraints below it. To close a block use the command ***Find(x,y,z…).***

In case of system of linear equations matrix method can be used. You need to specify two matrixes A and B for the equation system in form of: Ax=B. Then use the command ***lsolve(A,B).***

For linear systems Mathcad can solve up to 500 unknowns and up to 200 for nonlinear systems.

Minimizing/maximizing function

In fact this problem could be solved with one command (min f(x) = max(-f(x))), but Mathcad offers both of them as a built-in functions. *Minimize/maximize* works exactly the same as command *Find* so they need specifying guess values for all the unknowns and placing all constraints between the ***Given*** and ***Minimize/Maximize*** command.

Practical example 1:

The task is to calculate gas volume (SO_2) using ideal and real gas equation (use the van der Waals & Redlich-Kwong equations). Create a plot comparing calculated results (ideal and real gas).

Find the temperature range at which, each equation can be applied.

Pressure: 10MPa

T_c = 430K

P_c = 7.873*10^6 Pa

van der Waals equation:

$$\left(p + \frac{a}{V_m^2}\right)(V_m - b) = RT$$

where:

$$a = \frac{27(RT_c)^2}{64p_c}, b = \frac{RT_c}{8p_c}$$

Redlich-Kwong equation:

$$p = \frac{RT}{V_m - b} - \frac{a}{\sqrt{T}V_m(V_m + b)}$$

where:

$$a = \frac{0{,}42748R^2{T_c}^{2.5}}{p_c}, \quad b = \frac{0{,}08662RT_c}{p_c}$$

Practical example 2:

1. Calculate mean diameter for the given system of solids.
2. Calculate u_{mf} and u_t for the system presented below. Prepare a graph of $u_{mf}(d_p)$ and $u_t(d_p)$.

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Pipe diameter, m	**0,077**
Gas densit, kg/m^3	**1,25**
*Gas viscosity, Pa*s*	**1,8*10^{-6}**
Superficial velocity, m/s	**12**
Solid density, kg/m^3	**1200**
Sphericity	**0,62**

UZIARNIENIE

dp, mm	%
0,150	**3**
0,100	**7**
0,080	**74**
0,040	**8**
0,030	**5**
0,020	**3**

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References:

1. Matchad user guide
2. R. Motyka, D.Rasała – MATHCAD – od obliczeń do programowania