AGH University of Science and Technology

Topic: ***SPATIAL FIGURES***	
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1. Introduction

Matlab software is very suitable tool to visualize data with use of plots.

For example, you can compare sets of data, track changes in data over time, or show data distribution.

In my presentation I simply used *plot3* function to accomplish plots of 3D geometric figures, plotting sets of coordinates connected by line segments, specified by X, Y and Z vectors.

Moreover, I provided surface and volume calculator for input arguments and also I introduce to derivatives of spatial figures functions to e.g. find maximum/minimum of surfaces areas and volumes.

2. Theoretical description

First let me introduce you to basic geometry and let's define volumes and surface areas mathematical formulas for figures that won't be included in derivations part in further consideration:

a) *cube*

```
cube_volume = side^3

cube_surface_area = 6*side^2
```

b) *sphere*

```
sphere_volume = 4/3*pi*radius^3

sphere_surface_area = 4*pi*radius^2
```

❖ *Cube and sphere aren't considered in derivation part because it is obvious that the bigger side/radius of figure, the bigger it's volume/surface area*

Now let us take under consideration 3D figure of which we can define *1st derivative*. Volume and surface areas looks as follows:

c) cylinder

```
cylinder_volume = cylinder_height*pi*cylinder_radius^2
```

```
cylinder_surface_area = 2*pi*cylinder_radius^2+2*pi*cylinder_radius*cylinder_height
```

We obviously assume that every argument, variable is >0 (*otherwise we couldn’t see them)*

3. Volumes and surface areas calculations

Using *Matlab Software,* we proceed to achieve proper values, starting creating input argument code following way below:

a) for cube:

```
side = input("Enter side length of cube: ")
```

then we use input side to calculate volumes and surface areas then displaying it in command window with following code:

```
cube_volume = side^3
cube_surface_area = 6*side^2
fprintf("Volume of the cube is: %f\n",cube_volume)
fprintf("Surface of the cube is: %f\n",cube_surface_area)
```

version of MATLAB used: R2020b Update 1 (9.9.0.1495850) 64-bit (win64) September 30, 2020

In command window, we should see following results (for example let’s take *side length* equal *2*):

```
Command Window
>> SPATIAL_FIGURES
Enter side length of cube: 2

side =

     2


cube_volume =

     8


cube_surface_area =

    24

Volume of the cube is: 8.000000
Surface of the cube is: 24.000000
```

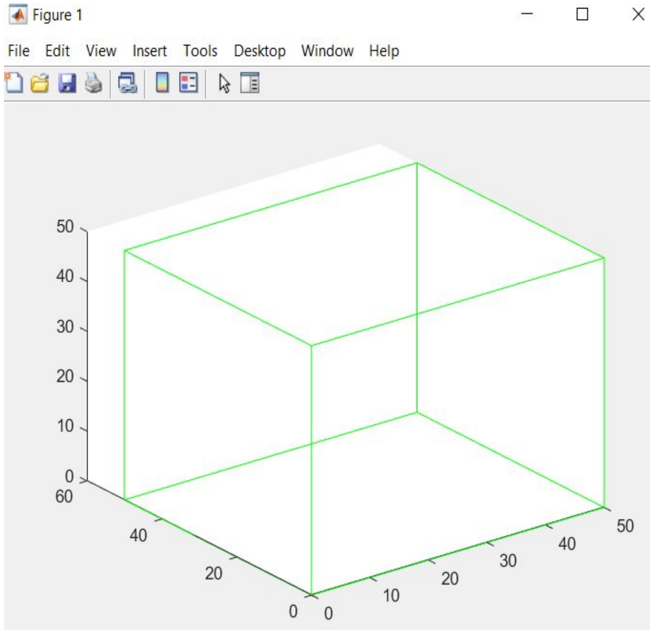
We can clearly see it result matches mentioned formulas

To visually display default cube, we use *plot3* tool as follows:

```
plot3([x(i) x(i)],y,[z(i) z(i)],'g');
```

- *description of plotting in x,y,z coordinates, with 'g' describing green edges*

(full code for cube is provided at listings of particular codes for given 3D figures)



4. Extrema of functions using 1st derivative

To get maximum or minimum volume/surface area of given figure function,we simply express domain of argument, we use 1st derivative of figure function, we compare it to *0,* to find it's roots and we plug proper root to 1st derivative function if we want explicit value of maximum/minimum.

To provide such solution in *Matlab* environment, we use '*syms*' from *Symbolic Math Toolbox,* which creates symbolic variables and functions.

For example, to find 1 derivative *of* volume function of *cylinder,* we proceed as follows:

1) We provide proper assumptions

```
assume(cylinder_radius >0)
```

2) We describe relating spatial figure function

```
cylinder_volume = cylinder_height*pi*cylinder_radius^2
```

3) We define new function to calculate 1st derivative, taking as arguments volume function and dependent variable, using *diff* built-in function

```
d_cuboid_volume = diff(cuboid_volume, cuboid_side)
```

As a result, we achieved 1st derivative formula of *cylinder* volume function:

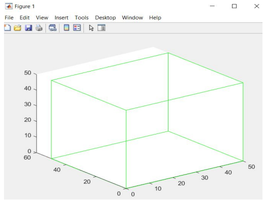
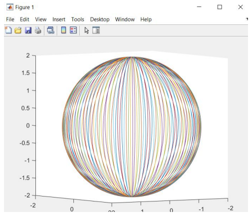
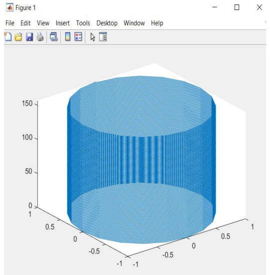
Command Window

```
cylinder_volume =

pi*cylinder_height*cylinder_radius^2


d_cylinder_volume =

2*pi*cylinder_height*cylinder_radius
```

Which matches mathematical formula for 1st derivative of *cylinder* volume:

$$\frac{\mathrm{d}}{\mathrm{d}r} V_{cylinder} = \frac{\mathrm{d}}{\mathrm{d}r}(\pi r^2 h) = 2\pi r h$$

5. List of all project files

Cube volume and surface area functions	cube_file1.m	
Plot of 3D cube	cube_file2.m	
Sphere volume and surface area functions	sphere_file1.m	
Plot of 3D sphere	sphere_file2.m	
Cylinder volume and surface area functions	cylinder_file1.m	
Plot of 3D cylinder	cylinder_file2.m	
Volume and surface area derivation functions	cylinder_file3.m	
All-in-one file	**SPATIAL_FIGURES.m**	

6. List of all used built-in functions

Base set built-in functions	*clc, clear, close all, fprintf, hold on, input, ones, plot3*
Additional functions	*assume, diff, syms*

7. Conclusions

- With use of *plot3* function you can create mainly *Line Plots* but also you can use it as a tool for making *Surface and Mesh Plots, Volume Visualizations, Polygons* and *Vector Fields*
- *'syms'* function which is part of *Symbolic Math Toolbox*™ provides functions for solving, plotting, and manipulating symbolic math equations. The toolbox provides functions in common mathematical areas such as calculus, linear algebra, algebraic and ordinary differential equations, equation simplification, and equation manipulation.
- Both functions helped me accomplish my concept of expressing spatial figures mathematically and visually and I personally think, it add some *color* in plain, technical environment, at the same time making it clear and easy to understand.

8. Links appendix

- https://www.mathworks.com/help/matlab/line-plots.html *18:01.2021, 22:22*
- https://www.mathworks.com/help/matlab/2-and-3d-plots.html?s_tid=CRUX_lftnav *18:01.2021, 22:21*
- https://www.mathworks.com/help/matlab/surfaces-polygons-and-volumes.html *18:01.2021, 22:20*
- https://www.mathworks.com/help/matlab/ref/plot3.html *18:01.2021, 22:20*
- https://www.mathworks.com/help/symbolic/index.html?s_tid=CRUX_lftnav *18:01.2021, 22:16*
- https://www.mathworks.com/help/symbolic/syms.html *18:01.2021, 22:16*
- https://www.mathworks.com/help/matlab/ref/ones.html *18:01.2021, 22:10*
- https://www.latex4technics.com/ *18:01.2021, 20:55*
- https://upel2.cel.agh.edu.pl/wiet/pluginfile.php/83361/mod_resource/content/1/CT_lecture_no_06.pdf *18:01.2021, 20:55 (password: =tT_comP1)*