Week 7 Tutorial 8

The purpose of this program is to demonstrate how to create a variety of 3D graphs in Matlab including `plot3()`, `scatter3()`, `stem3()`, `surf()`, `mesh()`, `contour3()`, and `contour()`. Finding the maximum of a function using the `fminsearch` function along with a contour plot will also be shown.

```
%  Always clear workspace variables before a new tutorial or program.
clear
clc
close all  % closes all figure windows
```

Edit the code below and update the variable named **`name`** with your name for this tutorial in the code below.

```
name="";
fprintf("Output for Tutorial_07_8 run by %s.\n\n", name)
```

Figure 1

Input

We'll compute some, to you, arbitrary values to plot as x, y, z, using `sin()`

```
% computing the x, y, and z coordinates to plot
t = 0:0.2:10;
x = t;
y = sin(t);
z = t.^1.5;
```

plot3() - Plain 3D Line

```
% Open Figure 1 and create a 2x2 grid of plots, activate the top left plot



% plot3() with a continuous line
plot3(x,y,z,'r-','linewidth',2)
% add a grid, title, and labels
grid on
title('plot3(x,y,z) with a Solid Line')
xlabel('x')
ylabel('y')
zlabel('z')
```

plot3() - 3D Line with Markers

As with `plot()`, we can add markers to our line.

```
% Activate the upper right subplot


% plot3() with a line and markers
```

```
plot3(x,y,z,'r-o','linewidth',2,'markersize',6,'markerfacecolor','b' ...
    ,'markeredgecolor','k')
% add a grid, title, and labels
grid on
title('plot3(x,y,z) with a Line and Markers')
xlabel('x')
ylabel('y')
zlabel('z')
```

stem3() - Curvy Markers with Stems

The `stem3()` plot shows the data points and their projection onto the x-y plane. This greatly enhances the ability of the reader to visualize how the 3 dimensions change.

```
% Activate the lower left subplot


stem3(x,y,z,'o','markersize',6, 'markerfacecolor','c','markeredgecolor','b')
% add a grid, title, and labels
grid on
title('stem3(x,y,z) with Solid Fill')
xlabel('x')
ylabel('y')
zlabel('z')
```

scatter3() - Curvy Markers

Notice, the `scatter3()` is identical to either a `plot3()` with only markers. However, `scatter3()` does not allow you to change the marker size.

```
% Activate the lower right subplot


scatter3(x,y,z,'o','markerfacecolor','c','markeredgecolor','b')
% add a grid, title, and labels
grid on
title('scatter3(x,y,z)')
xlabel('x')
ylabel('y')
zlabel('z')
```

Figure 2

In figure 2, we'll plot surface type plots including `mesh()`, `surf()`, `contour3()`, and `contour()`.

Input

Again, we'll create some seemingly arbitrary values to plot for x and y. For surface type plots, we will almost always use the `meshgrid()` function for computing x and y coordinates.

```
% Define the x and y vectors
```

```
x = -8:8;
y = x;

% Create 2 matrices for x and y of the same size to represent all the (x,y)
% coordinates on the surface.
[xGrid,yGrid] = meshgrid(x,y);
```

Recall that eps is the smallest distance between two values in MATLAB (smallest increment). Remember that we may need to avoid divide by zero errors resulting in NaN or inf values. We do that by adding eps to the denomintor which will have no discernable effect on the outcome.

```
r = sqrt(xGrid.^2 + yGrid.^2) + eps;
z = sin(r) ./ r;
```

meshgrid() - A 3D Plot Appearing as a Mesh Surface

```
% Open Figure 2 and create a 2x2 grid of plots, activate the top left plot



% creates a mesh graph (colored wireframe)
mesh(x,y,z)
% add a grid, title, and labels
grid on
title('mesh(x,y,z)')
xlabel('x')
ylabel('y')
zlabel('z')
```

surf() - A 3D Plot Appearing as a Solid Surface

```
% Activate the upper right subplot


% surf() creates a colored surface plot
surf(x,y,z)
% add a grid, title, and labels
grid on
title('surf(x,y,z)')
xlabel('x')
ylabel('y')
zlabel('z')
```

contour3() - A 3D Plot Appearing as a Surface of Rings

```
% Activate the lower left subplot


% contour3() creates a 3D contour plot with 25 contour lines
```

```
contour3(x,y,z,25)
% add a grid, title, and labels
grid on
title('contour3(x,y,z,25)')
xlabel('x')
ylabel('y')
zlabel('z')
```

contour() - A 2D Overhead View of `contour3()`

Despite the difference in naming convention (the lack of a 3 in the name), contour is still a 3D plot. However, the z value is shown in a much different perspective than one would expect for a 3D plot. In this plot, the z dimension is interpreted only by the color of the contoured lines but makes it much easier to identify maxima and minima.

```
% Activate the lower right subplot


% contour() creates a 2D contour plot with 25 contour lines
contour(x,y,z,25)
% add a grid, title, and labels
grid on
title('contour(x,y,z,25)')
xlabel('x')
ylabel('y')
zlabel('z')
```

The contour plot shows that the maximum of z(x,y) occurs at about (0,0). The fminsearch() function can be used to find a minimum or maximum. To find a maximum the function must first be negated and written using a vector cotaining the two independent variables.

Here, we create a negating function. Again we see the @(x) notation, we learned that this is a function handle and, as before, this one is a handle to an anonymous function. A function handle is merely a value or, a pointer to a place in computer memory. Therefore, just like any other value stored in memory, we can store the handle (pointer) to a function so we can reuse it. In this case, we're simply breaking up the code a bit to make it more digestible by human eyes.

```
% NegFunction = @ represents the notation for an annonymous function.  It
% creates a function named NegFunction(x) where x is a vector of independent
% variables.
negFunction =  @(x)((-1*sin(x(1)^2+x(2)^2+eps))/(x(1)^2+x(2)^2+eps));
```

The fminsearch() function here is taking two arguments, the function handle, and a 2 element vector containing the initial guess of the coordinates where the maximum occurs. We are using (0.1,0.1) which is very close so it should have no problem finding our answer very quickly.

```
% The values [0.1,0.1] are the initial guess of where the maximum occurs
[xyMaxVector,zMax] = fminsearch(negFunction,[0.1,0.1]);
```

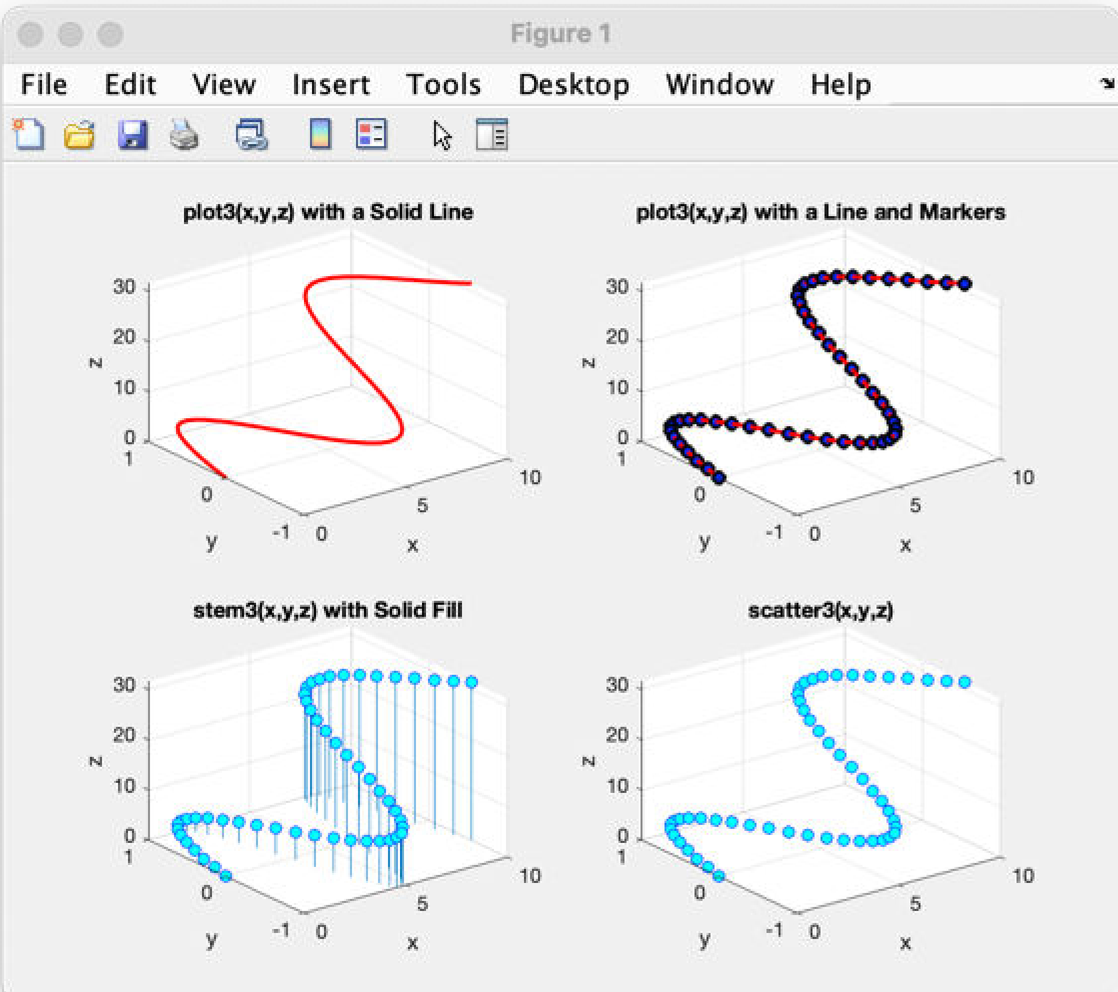
```
% Print out the maximum of the function along with the coordinates at which
% the maximum occurs.  Note that we must negate the z value to represent the
% maximum.
fprintf('The maximum value was z(%6.3f , %6.3f) = %2.0f\n', xyMaxVector(1), ...
    % xyMaxVector(2),-zMax)
```

Example Output:

Run this tutorial from the **Command Window** and ensure your output matches the following.

```
Output for Tutorial_07_8 run by Geoff Berl.

The maximum value was z(-0.000 , -0.000) =  1
```



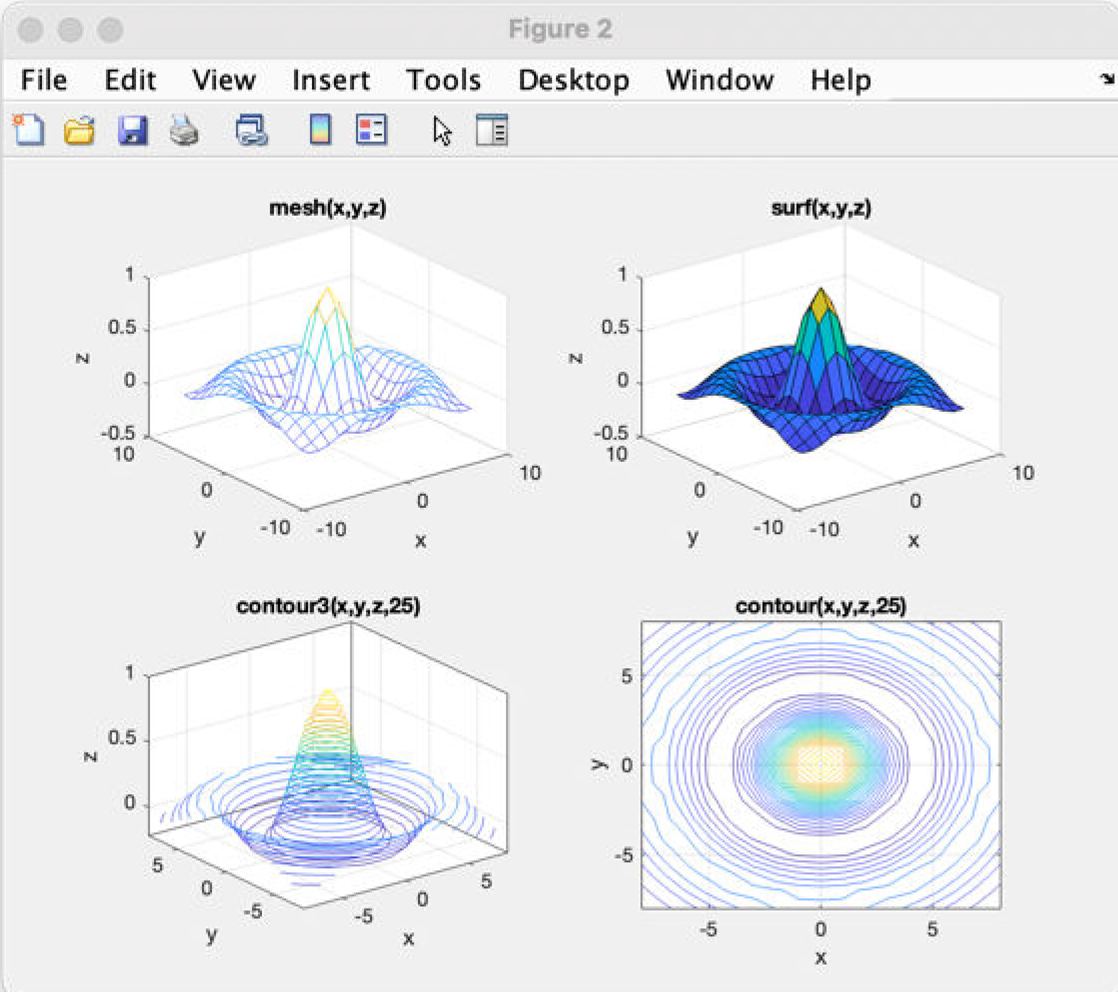


Figure 2
File Edit View Insert Tools Desktop Window Help
mesh(x,y,z)
surf(x,y,z)
contour3(x,y,z,25)
contour(x,y,z,25)
x
y
z