MATLAB Assignment 3 Solution

Introduction to Linear Algebra (Week 4) **Spring, 2019**

1. (*3D Graphics in* MATLAB)

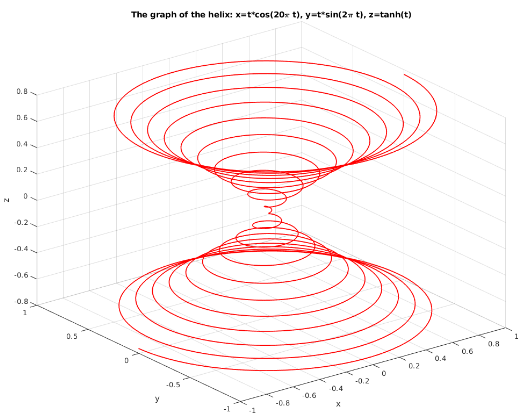
   (a) Referring to the followings, draw a graph of helix curve given by the vector equation

   $$\mathbf{c}(t) = (t\cos(20\pi t),\, t\sin(20\pi t),\, \tanh t)\,,$$

   where the parameter t varies from -1 to 1.

   Solution.

```
% assignment 3 1_(a)

t=-1:0.001:1; % t is a vector from -1 to 1 with increment 0.001
% Evaluate each value of given function.
x=t.*cos(20*pi*t);
y=t.*sin(20*pi*t);
z=tanh(t);

figure(1); clf(1);  % Make a first blank figure window

% Control the size of the font.
set(gca, 'Fontsize', 12);

plot3(x, y, z, 'Color', 'r', 'LineWidth', 1.3);     % Plot the vectorized function in 3D space
xlabel('x'); ylabel('y'); zlabel('z'); % Indicate each label as x, y, and z.
title('The graph of the helix: x=t*cos(20\pi t), y=t*sin(2\pi t), z=tanh(t)');
grid on;    % Display grids.
```



$\square$

(b) Referring to the followings, plot the surface(or mesh graph) of the graph given by

$$z = xe^{-x^2-y^2},$$

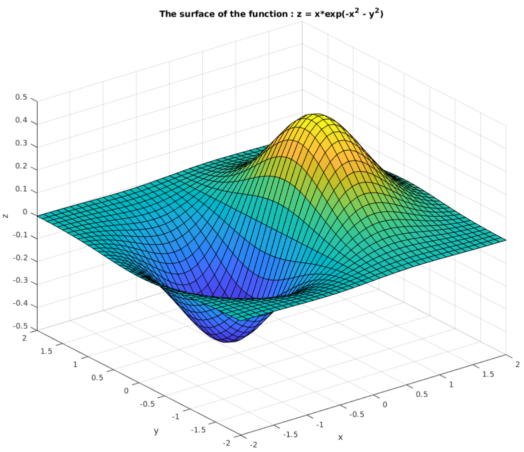
over the region in the xy-plane defined by $\mathcal{D} = \{(x, y) : -2 \le x \le 2, -2 \le y \le 2\}$.

i. Using the MATLAB built-in command `meshgrid`, construct two matrices, each of which consist of the x coordinates and y coordinates of the $\mathcal{D}$, respectively.

ii. Using the MATLAB built-in commands `surf` or `mesh`, create a 3D surface plot.

Solution.

```
% assignment 3 1_(b)

% create a equally-spaced vector x from -2 to 2 with increment 0.1.
x = -2 : .1 : 2;     % Or you may use x = linspace(-2, 2, 41);
% create a equally-spaced vector y from -2 to 2 with increment 0.1.
y = -2 : .1 : 2;     % Or you may use y = linspace(-2, 2, 41);

% To create a grid as two matrices X and Y, each of size 61*61,
% and write the xy-coordinates of each point in these matrices.
[X, Y] = meshgrid(x, y);          % Create a grid over he specified domain
Z = X .* exp(-X.^2 - Y.^2);     % Evaluate z with the given function.

figure(2); clf(2)            % Make a second blank figure window
set(gca, 'Fontsize', 12);    % Visual setting

surf(X,Y,Z);         % or use the command mesh(X,Y,Z)
xlabel('x'); ylabel('y'); zlabel('z'); % Indicate each label as x,y, and z
title('The surface of the function : z = x*exp(-x^2 - y^2)');
grid on              % Display grids
```



2. (*Supplement problem*)

(a) Plot the graph of the curve $\mathbf{M}(t)$ given by the parametric equations,

$$\mathbf{M}(t) = (x(t),\, y(t),\, z(t))\,, \qquad t \in [-1,\, 1]$$

where the $x(t)$, $y(t)$, $z(t)$ are defined as

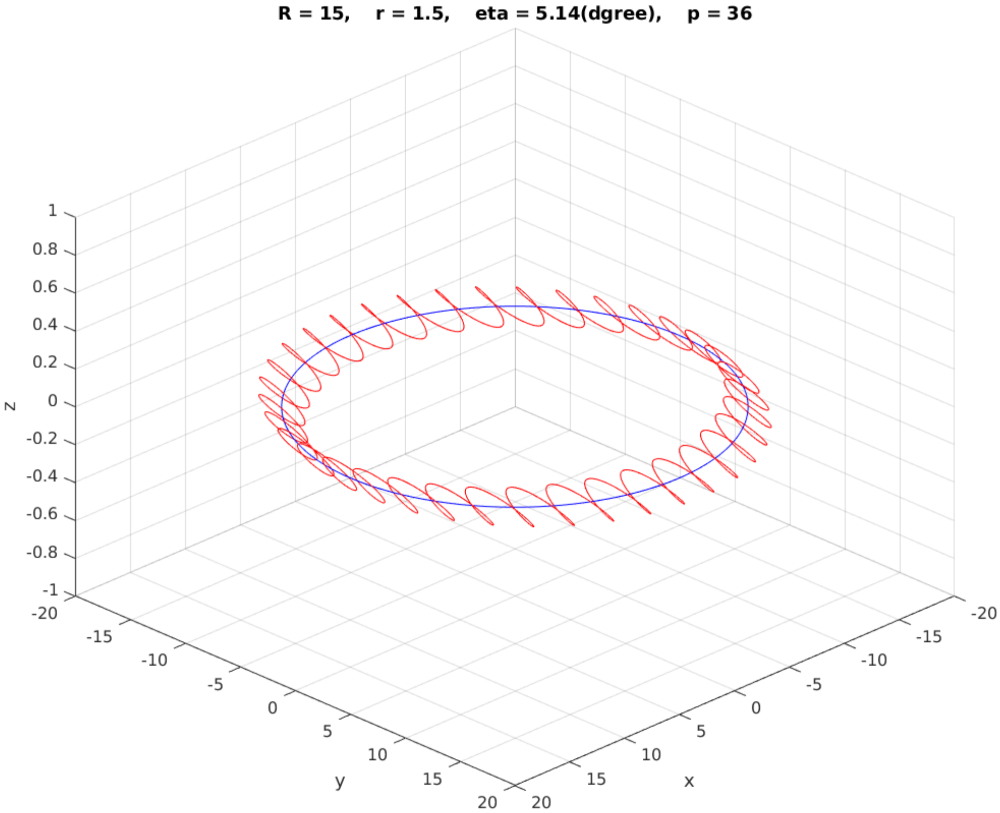
$$\begin{aligned} x(t) &= R\cos\phi + r\cos\theta\cos\eta, \\ y(t) &= R\sin\phi + r\sin\theta, \\ z(t) &= r\cos\theta\sin\eta, \end{aligned}$$

with **appropriate values** R, r, η and functions $\phi(t) = 2\pi t$, $\theta(t) = 2\pi t p$ with **appropriate** p. (You can choose R, r, η, p by your self)

[Note that if you choose the values such as $R \approx 1.5 \times 10^9$, $r \approx 4 \times 10^5$, $\eta = 5.14°$ and $p = 365.24$, then the curve represents the orbit of the Moon around the Earth.]

Solution.

```
% assignment 3 2(a)

% create a equally-spaced vector t from -1 to 1.
t = linspace(-1, 1, 5000);

% Parameter values
R = 1.5*10;   r = 1.5;  eta = 5.14*pi/180; p = 36;

% functions phi, theta
phi = 2*pi*t;
theta = 2*pi*t*p;

% Evaluate each value of given function.
x = R*cos(phi) + r*cos(theta).*cos(eta);
y = R*sin(phi) + r*sin(theta);
z = r*cos(theta).*sin(eta);

figure(3); clf(3);  % Make a blank figure window

% Control the size of the font.
set(gca, 'Fontsize', 12);

hold on
plot3(R*cos(2*pi*t), R*sin(2*pi*t), zeros(1,5000), 'b');
plot3(x, y, z, 'Color', 'r');     % Plot the vectorized function in 3D space
xlabel('x'); ylabel('y'); zlabel('z'); % Indicate each label as x, y, and z.
axis([-20,20,-20,20,-1,1]); view([1,1,1]);
title(sprintf('R = %g,    r = %g,    eta = %g(dgree),    p = %g', R, r, eta*180/pi, p));
grid on;    % Display grids.
```


R = 15,   r = 1.5,   eta = 5.14(dgree),   p = 36
z
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
y
-20
-15
-10
-5
0
5
10
15
20
x
20
15
10
5
0
-5
-10
-15
-20