KATHMANDU UNIVERSITY

DHULIKHEL KAVRE

COEG-304: Instrumentation and Control

Lab Sheet No. 1

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Level: UNG	

KATHMANDU UNIVERSITY
School of Engineering
Department of Electrical and Electronics Engineering

Instrumentation and Control Lab I

Introduction to MATLAB

1.1 Matrix operation

Example-1

For the matrix equation below, $AX = B$, determine the vector X.

$$\begin{bmatrix} 4 & -2 & -10 \\ 2 & 10 & -12 \\ -4 & -6 & 16 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} -10 \\ 32 \\ -16 \end{bmatrix}$$

Ans:

```
>>B=[-10;32;-16];
>> A=[4 -2 -10; 2 10 -12; -4 -6 16];
>> X=A\B

X =

    2.0000
    4.0000
    1.0000
```

1.2 Inverse of a matrix

Example-2

Use the **inv** function to determine the inverse of matrix A in Example 1.1 and then determine X. The following statements

Ans:

```
>> Y=inv(A)

Y =

    2.2000    2.3000    3.1000
    0.4000    0.6000    0.7000
    0.7000    0.8000    1.1000

>> X=Y*B
```

X =

2
4
1

1.3 Roots of polynomial

Example-3

Find the roots of the following polynomial.

$$s^6 + 9s^5 + 31.25s^4 + 61.25s^3 + 67.75s^2 + 14.75s + 15$$

Ans:

```
P=[1 9 31.25 61.25 67.75 14.75 15]

P =

    1.0000    9.0000   31.2500   61.2500   67.7500   14.7500   15.0000

>> r=roots(P)

r =

  -4.0000 + 0.0000i
  -3.0000 + 0.0000i
  -1.0000 + 2.0000i
  -1.0000 - 2.0000i
  -0.0000 + 0.5000i
  -0.0000 - 0.5000i
```

Example-4

The roots of a polynomial are $-1, -2, -3 \pm j4$. Determine the polynomial equation.

Ans:

```
>> Q=[-1 -2 -3+j*4 -3-j*4]

Q =

  -1.0000 + 0.0000i  -2.0000 + 0.0000i  -3.0000 + 4.0000i  -3.0000 - 4.0000i

>> p=poly(Q)

p =

     1     9    45    87    50
```

1.4 X-Y Plot

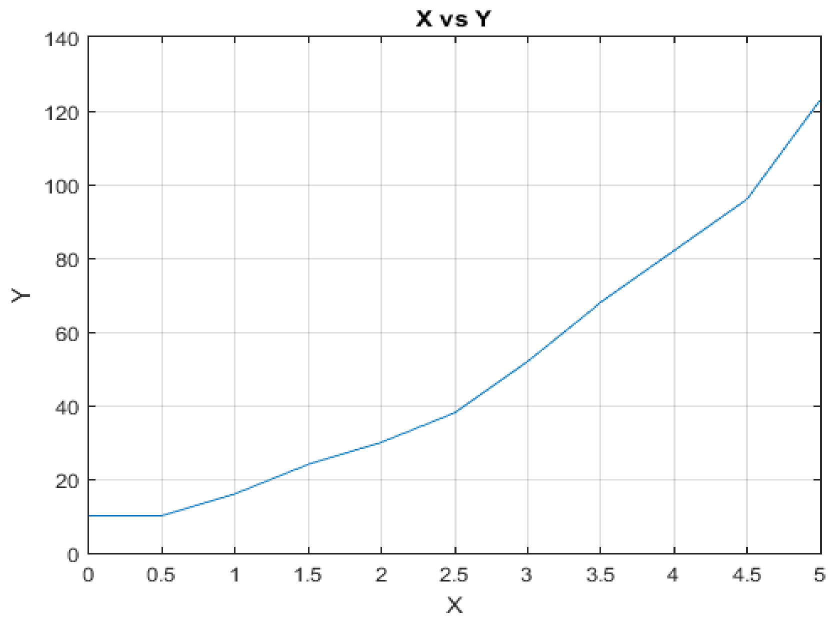
Example-5

Create a linear X-Y plot for the following variables.

x	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
y	10	10	16	24	30	38	52	68	82	96	123

Ans:

```
>> X=[0:0.5:5]

X =

        0    0.5000    1.0000    1.5000    2.0000    2.5000    3.0000    3.5000    4.0000    4.5000
5.0000

>> Y=[10 10 16 24 30 38 52 68 82 96 123]

Y =

    10    10    16    24    30    38    52    68    82    96   123

>> plot(X,Y), grid, xlabel('X'), ylabel('Y'), title('X vs Y')
```



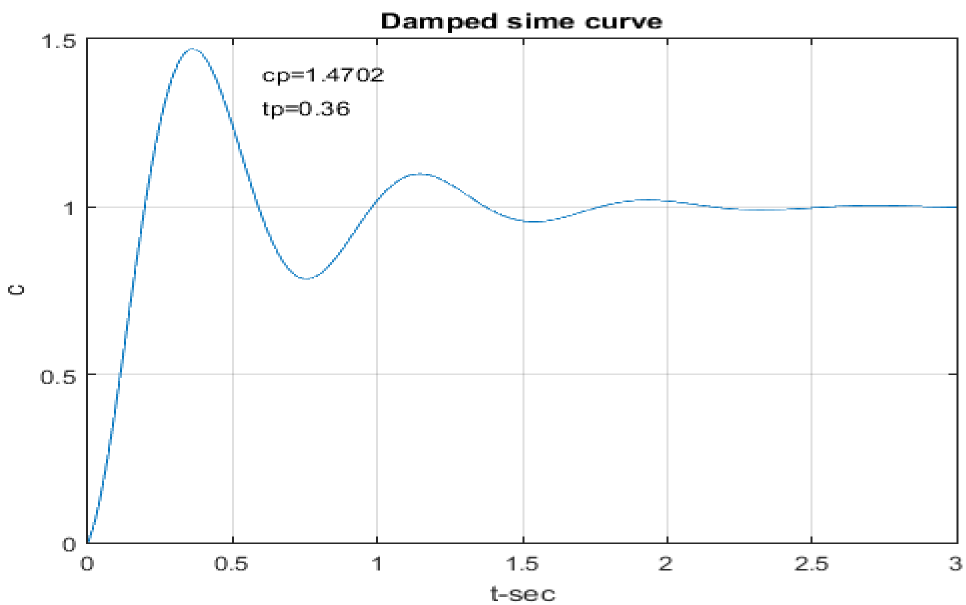
Example-6

Plot function $y = 1 + e^{-2t}\sin(8t - \pi/2)$ from 0 to 3 seconds. Find the time corresponding to the peak value of the function and the peak value. The graph is to be labeled, titled, and have grid lines displayed.

Remember to use .* for the element-by-element multiplication of the two terms in the given equation. The command [cp, k] = max(c) returns the peak value and the index k corresponding to the peak time. We use the following commands.

Ans:

```
>> t=0:0.005:3;
>> c=1+exp(-2*t).*sin(8*t-pi/2);
>> [cp,k]=max(c)

cp =

    1.4702


k =

    73

>> tp=t(k)

tp =

    0.3600

>> plot(t,c), xlabel('t-sec'),ylabel('c'),grid;
title('Damped sime curve');
text(0.6,1.4,['cp=', num2str(cptext(0.6,1.3,['tp=', num2str(tp)]);
```



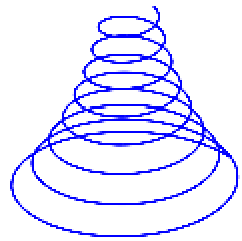
1.5 Three-Dimensional Plots

Example-7

Plot of a parametric space curve

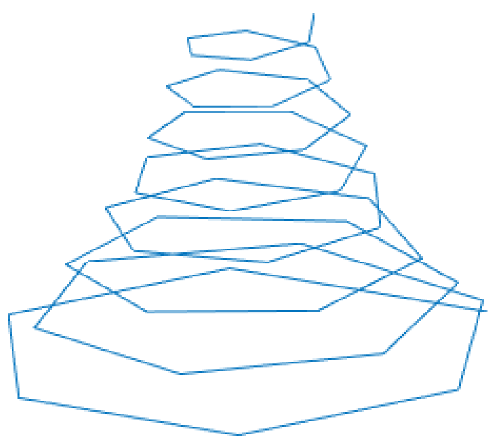
$x(t) = e^{-0.03t}\cos t,\quad y(t) = e^{-0.03t}\sin t,\quad z(t) = t$

```
t= 0:0.1:16*pi;
x=exp(–0.03*t).*cos(t);
y=exp(–0.03*t).*sin(t);
z=t;
plot3(x, y, z), axis off
```



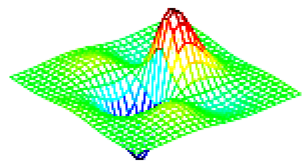
Ans:

```
t=0:01:16*pi;
x=exp(-0.03*t).*cos(t);
y=exp(-0.03*t).*sin(t);
z=t;
plot3(x,y,z),axis off
```



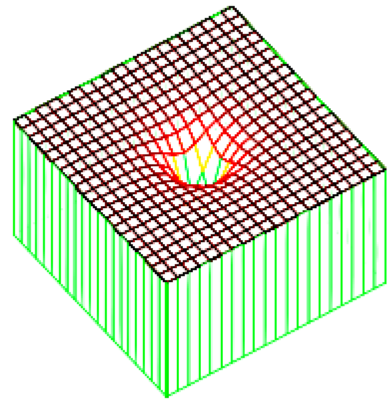
Plot of function $z = \sin x \cos y \, e^{-(x^2+y^2)^{0.5}}$
using mesh

```
t = –4:0.3:4;
[x,y] = meshgrid(t,t);
z = sin(x).*cos(y).*exp(–(x.^2+y.^2).^0.5);
mesh(x,y,z), axis off
```



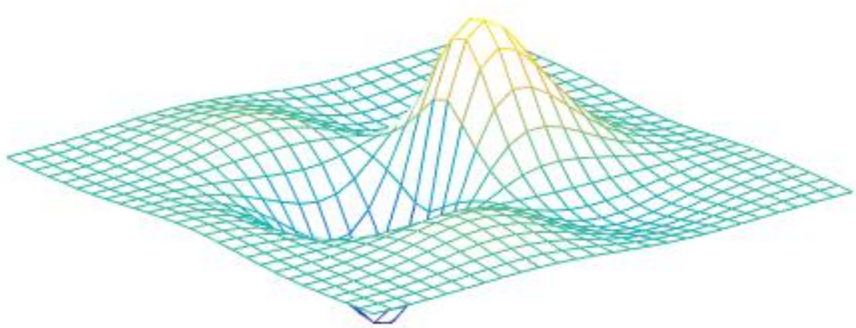
Plot of function $z = -0.1/(x^2+y^2+1)$
using meshz

```
x= –3:0.3:3; y=x;
[x, y]=meshgrid(x,y);
z=–0.1./(x.^2+y.^2+.1);
meshz(z) , axis off
view(–35, 60)
```



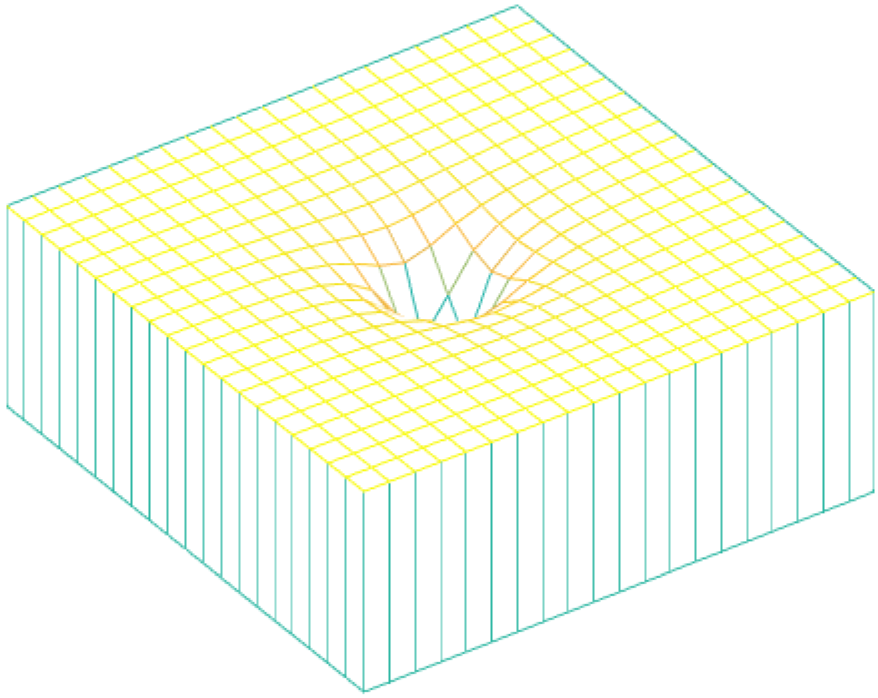
Ans:

```
t=-4:0.3:4;
[x,y]=meshgrid(t,t);
z=sin(x).*cos(y).*exp(-(x.^2+y.^2).^0.5);
mesh(x,y,z), axis off
```



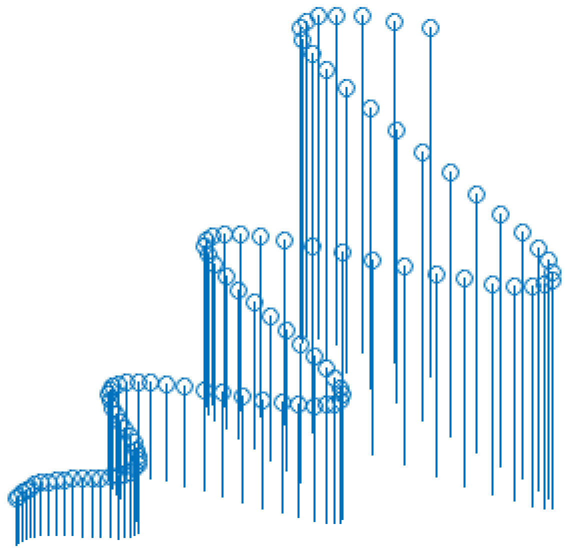
Ans:

```
x=-3:0.3:3;
y=x;
[x,y]=meshgrid(x,y);
z=-0.1./(x.^2+y.^2+.1);
meshz(z), axis off, view(-35,60)
```



Ans:

```
t=0:0.2:20;
x=t;
y=t.*cos(t);
z=exp(0.1*t);
stem3(x,y,z), axis off
```

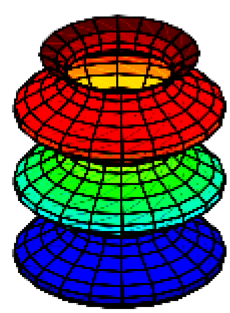


Cylindrical surface created by

p=3+sin t

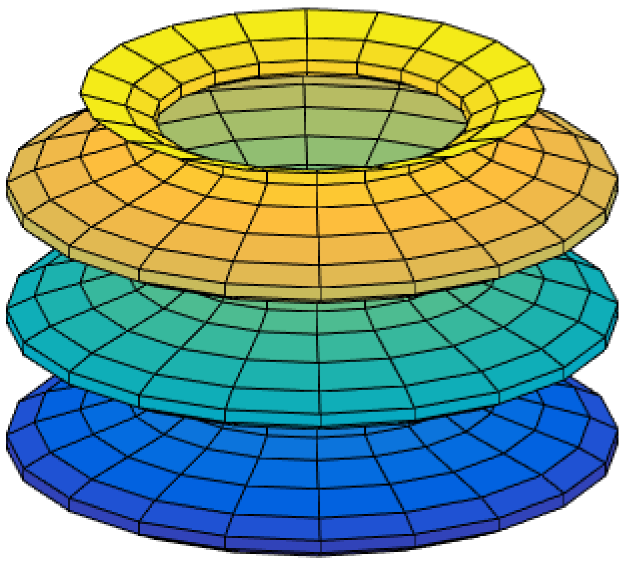
using cylinder function

```
t=0:pi/5:6*pi;
p=3+sin(t);
cylinder(p), axis off
```



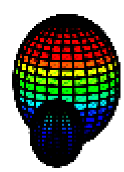
Ans:

```
t=0:pi/5:6*pi;
p=3+sin(t);
cylinder(p), axis off
```



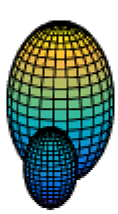
Plot of a unit sphere and a scaled sphere using sphere function

```
[x,y,z]=sphere(24);
subplot(2,2,2), surf(x–2, y–2, z–1);
hold on
surf(2*x, 2*y,2*z);
axis off
```



Ans:

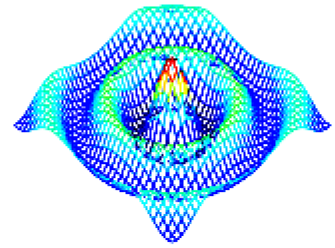
```
[x,y,z]=sphere(24);
subplot(2,2,2),surf(x-2,y-2,z-1);
hold on
surf(2*x,2*y,2*z);
axis off
```



Cartezian plot of Bessel function

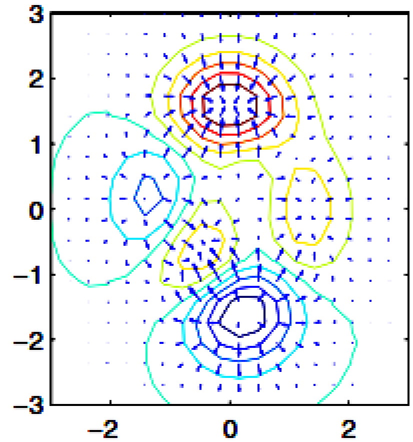
$J_0[x^2+y^2]^{1/2} \quad -12<x<12, \quad -12<y<12$

```
[x,y]=meshgrid(–12:.7:12, –12:.7:12);
r=sqrt(x.^2+y.^2);z= bessel(0,r);
m=[–45 60]; mesh(z,m), axis off
```



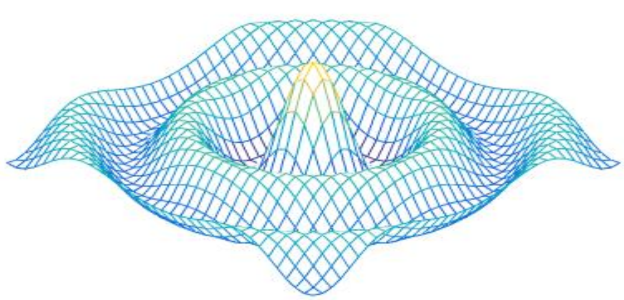
Contour lines and directional vectors using contour and quiver functions

```
[x,y,z]=peaks(20);
[nx, ny]=gradient(z,1,1);
contour(x,y,z,10)
hold on
quiver(x,y,nx,ny)
```



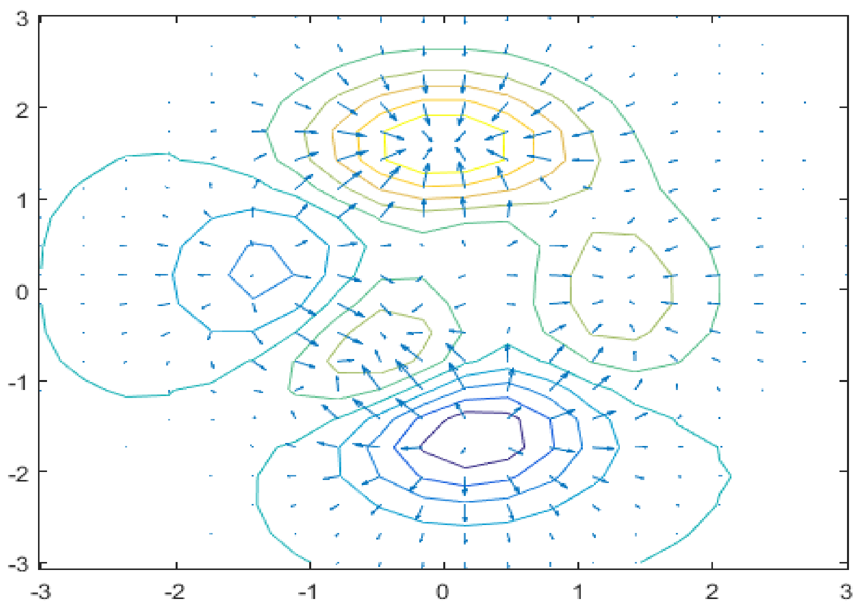
Ans:

```
[x,y]=meshgrid(-12:.7:12,-12:.7:12);
r=sqrt(x.^2+y.^2);
z=bessel(0,r);
z=besselj(0,r);
m=[-45 60];
mesh(z,m), axis off
```



Ans:

```
[x,y,z]=peaks(20);
[nx,ny]=gradient(z,1,1);
contour(x,y,z,10)
hold on
quiver(x,y,nx,ny)
```



1.6 Transfer Function

Example-8
Write a matlab code to obtain the following transfer function.

```
Transfer function:
    s + 4
--------------
s^2 + 2 s + 10
```

Ans:

```
>> num=[1 4]; den=[1 2 10];
sys=tf(num,den)

sys =

     s + 4
  --------------
  s^2 + 2 s + 10
```

Continuous-time transfer function.

Example-9

Find the poles and zeros of the following transfer function:

$$H(s) = \frac{s^3 + 11s^2 + 30s}{s^4 + 9s^3 + 45s^2 + 87s + 50}$$

Ans:

```
>> num=[1 11 30 0];
den=[1 9 45 87 50];
[z,p,k]=tf2zp(num,den)     %transfer function to zero and pole, k-gain. here k =1

z =

         0
   -6.0000
   -5.0000


p =

  -3.0000 + 4.0000i
  -3.0000 - 4.0000i
  -2.0000 + 0.0000i
  -1.0000 + 0.0000i


k =

     1
```

Example-10

A system has zeros at -6, -5, 0, poles at $-3 \pm j4$, -2, -1, and a gain of 1. Determine the system transfer function.

Ans:

```
>> z=[-6; -5; 0];
k=1;
i=sqrt(-1);
p=[-3+4*i;-3-4*i;-2;-1];
[num,den]=zp2tf(z,p,k)

num =

     0     1    11    30     0
```

den =

```
1    9    45    87    50
```

Example-11
Find the Laplace transform.

$$te^{-4t}$$

Ans:

```
>> syms t s;
laplace(t*exp(-4*t),t,s)

ans =

1/(s + 4)^2
```

Example-12
Find the inverse Laplace transform.

$$F(s) = \frac{s(s+6)}{(s+3)(s^2+6s+18)}$$

Ans:

```
>> syms s t;

ilaplace(s*(s+6)/((s+3)*(s^2+6*s+18)))

ans =


2*cos(3*t)*exp(-3*t) - exp(-3*t)
```