Table of Contents


```
% The purpose of this program is to illustrate examples of a wide
 swath of
% common Matlab use cases, most of which will be useful at some point
 in the
% semester.
%
%This script requires files containing the functions fun1D and fun2D.
```

Things illustrated during class

```
% installing matlab
% arrays, vector operations, etc.
% complex number manipulation, abs, angle, real, imaginary
% random number generation:  rand, randn, histograms
% publishing matlab content
```

Create some 1D and 2D data for plotting

independent coordinates

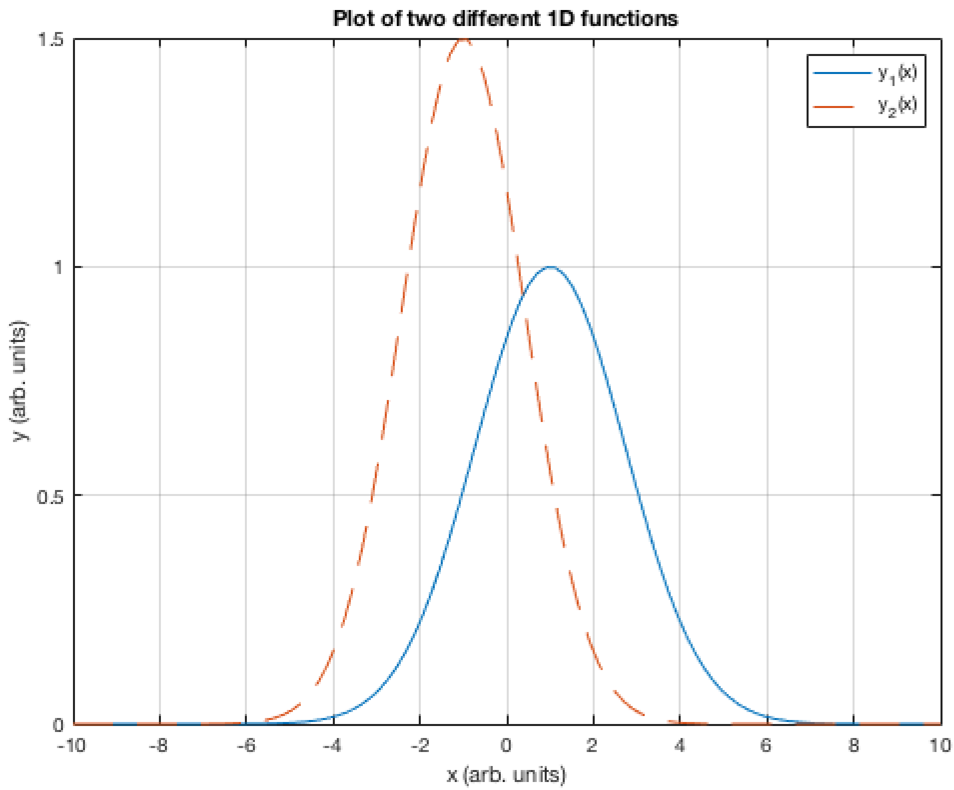
```
x=linspace(-10,10,100);     %100-point arrays for x and y
y=linspace(-10,10,100);
[X,Y]=meshgrid(x,y);        %2D function evaluations require true 2D
 grid of points

% function evaluations
y1=fun1D(x,1,1,3);
y2=fun1D(x,1.5,-1,2);
Z1=fun2D(X,Y,2,0,0,3,4);
Z2=fun2D(X,Y,5,2,-2,2,2);
```

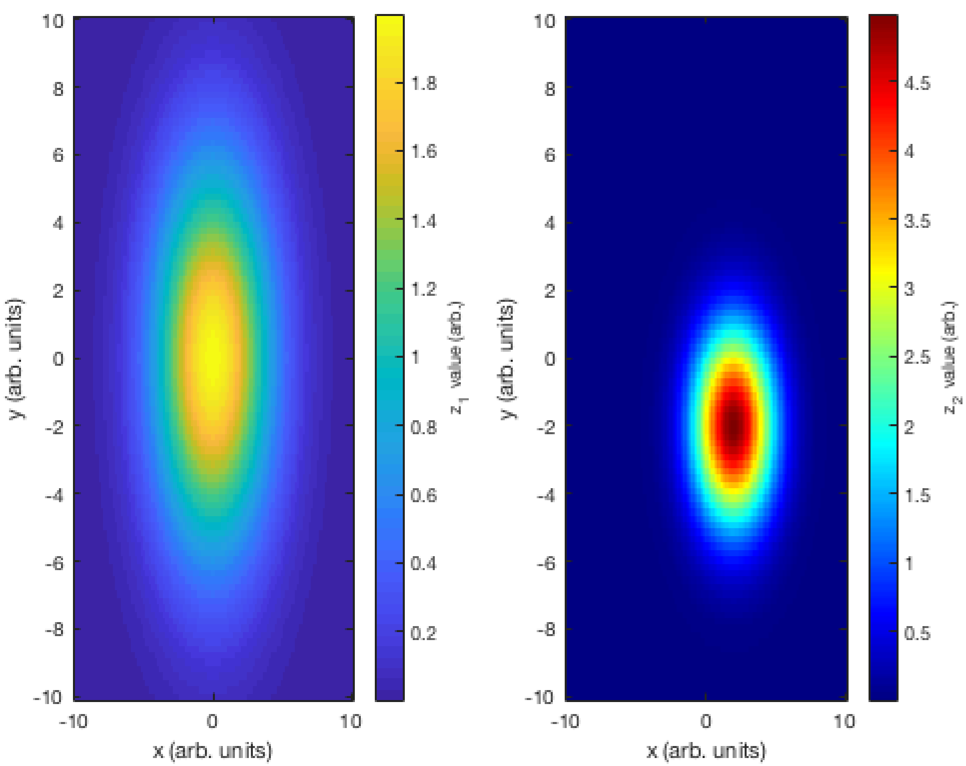
Plot various data

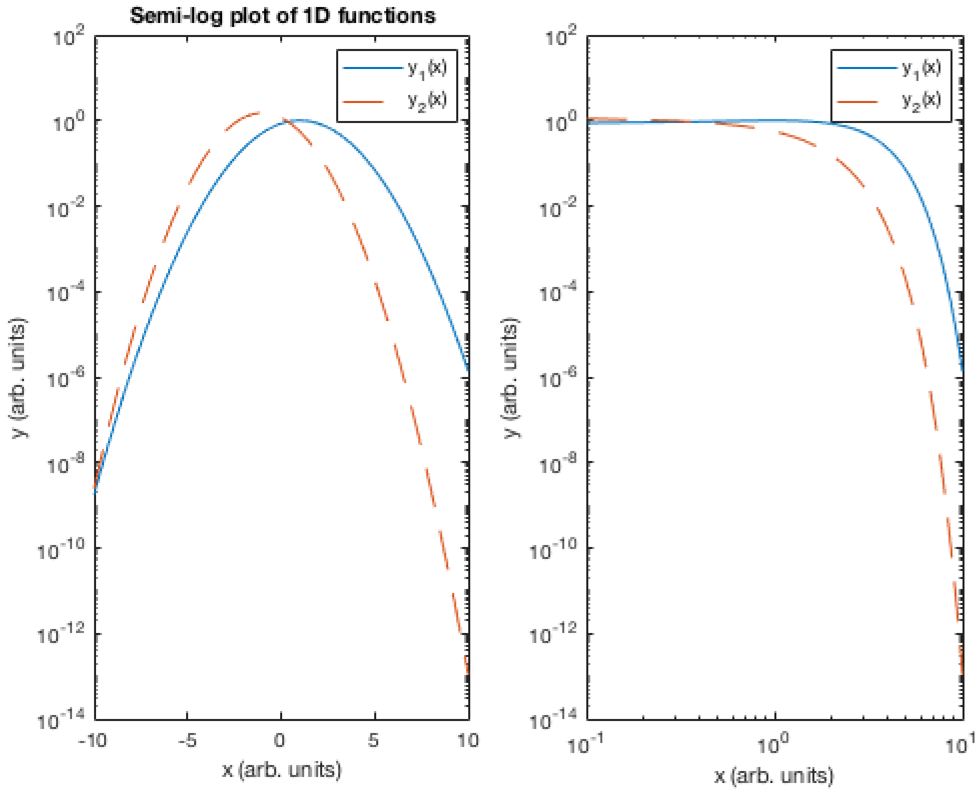
1D data

```
figure(1);
clf;                         %clear out the old figure (if applicable)
plot(x,y1,'-',x,y2,'--');
grid on;                     %add a grid
```

```
xlabel('x (arb. units)');
ylabel('y (arb. units)');
title('Plot of two different 1D functions')
legend('y_1(x)','y_2(x)')

% 2D data
figure(2);
clf;

ax1=subplot(1,2,1);
imagesc(x,y,Z1);                        %scaled image plots
 (recommended for 2D plots)
axis xy;                                %rearrange plot with a non-
inverted x-y axis
xlabel('x (arb. units)');
ylabel('y (arb. units)');
c=colorbar;                             %save colorbar handle so you
 can add labels to it
ylabel(c,'z_1 value (arb.)');

ax2=subplot(1,2,2);
imagesc(x,y,Z2);
axis xy;
xlabel('x (arb. units)');
ylabel('y (arb. units)');
c=colorbar;
colormap(ax2,jet(256));                 %switch colormap to jet and
 use 256 different shades (default is usually 64) - only do this for
 the second set of axes in the figure
ylabel(c,'z_2 value (arb.)');

% Logarithmic plotting example
figure(3);
clf;

% semilog plot
subplot(1,2,1);
semilogy(x,y1,'-',x,y2,'--');
xlabel('x (arb. units)');
ylabel('y (arb. units)');
title('Semi-log plot of 1D functions')
legend('y_1(x)','y_2(x)')

%log-log plot
subplot(1,2,2);
inds=find(x>0);                         %find indices where x>0
loglog(x(inds),y1(inds),'-',x(inds),y2(inds),'--');
xlabel('x (arb. units)');
ylabel('y (arb. units)');
legend('y_1(x)','y_2(x)')
```

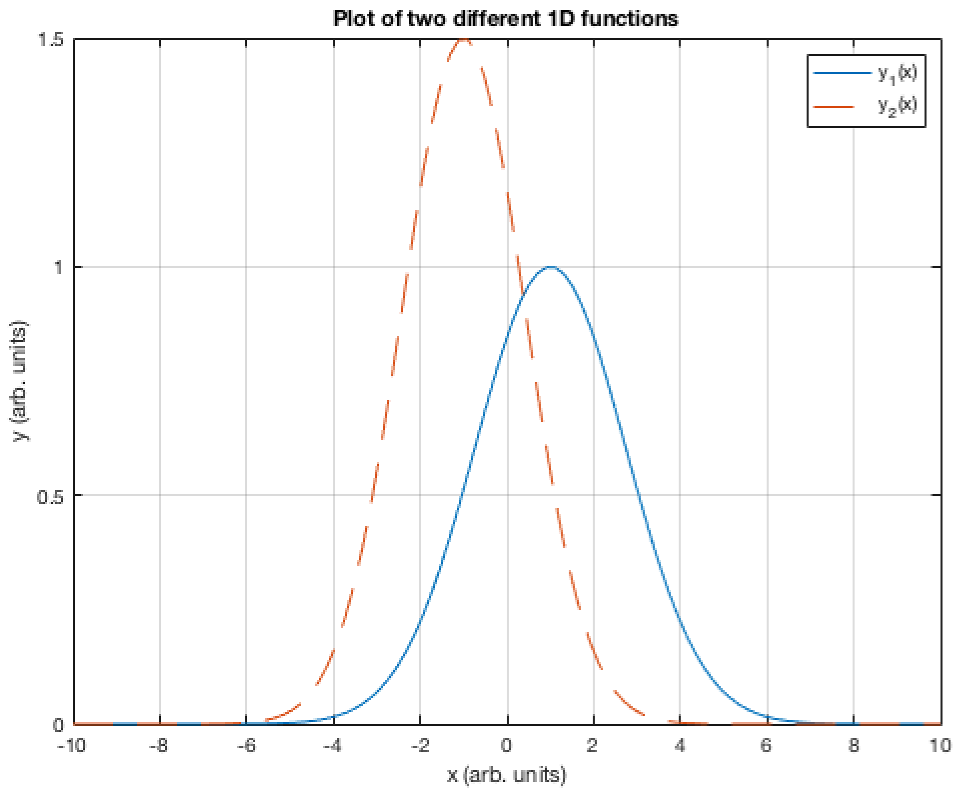

Plot of two different 1D functions
$y_1(x)$
$y_2(x)$
y (arb. units)
x (arb. units)
1.5
1
0.5
0
-10
-8
-6
-4
-2
0
2
4
6
8
10

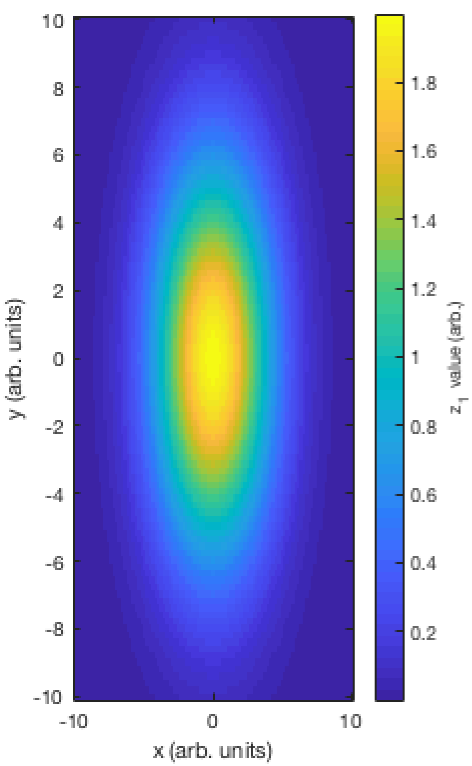

y (arb. units)
x (arb. units)
z_1 value (arb.)
y (arb. units)
x (arb. units)
z_2 value (arb.)

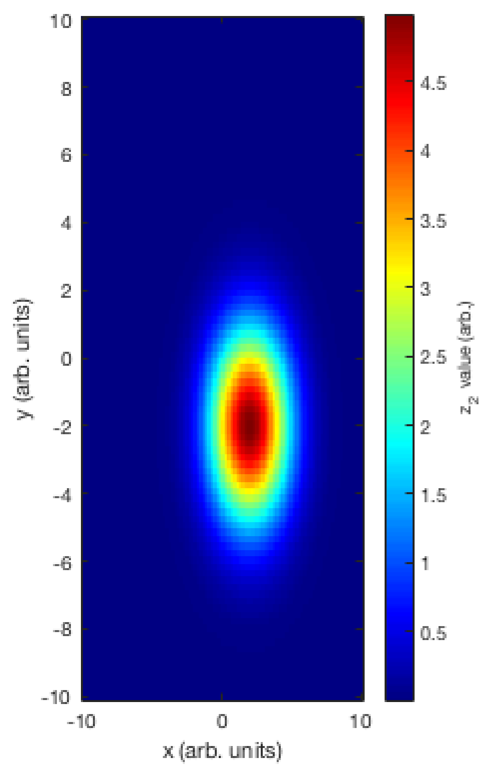


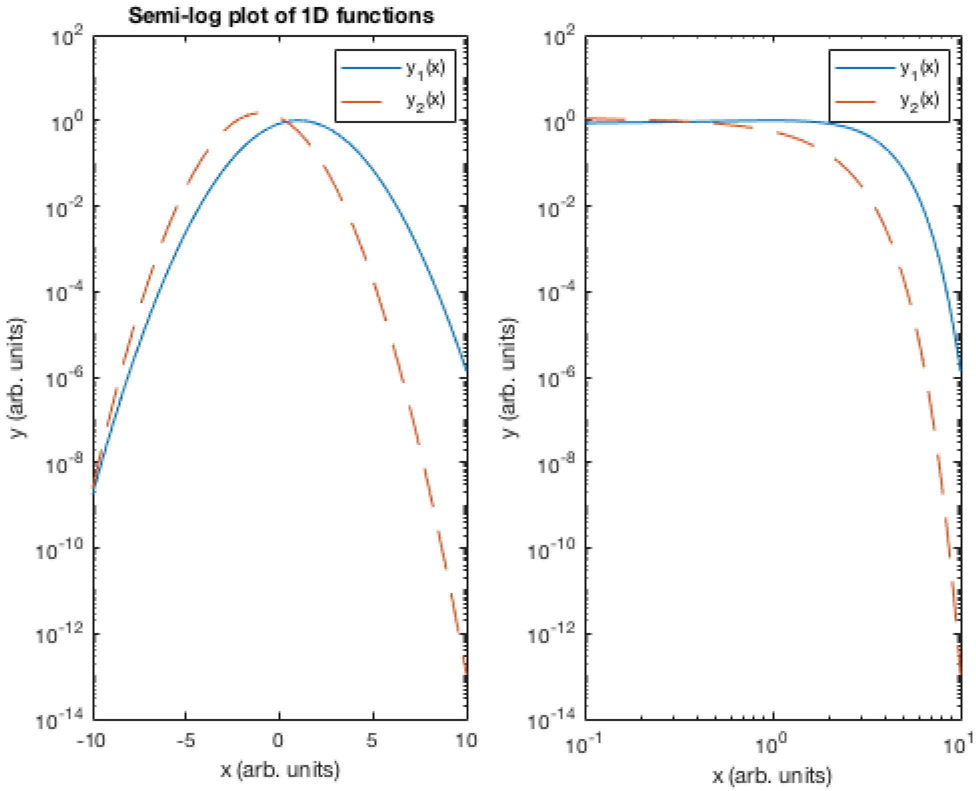
Print the plots to files that can be embedded in word processors

```
figure(1);
print('-depsc2','fig1.eps');            %print to postscript (vector
 graphics)
figure(2);
print('-dpng','fig2.png');              %png file (rasterized)
figure(3);
set(gcf,'PaperPosition',[0 0 11 5]);    %adjust the aspect ratio of
 the printed figure to fit on 11x5 "sheet of paper" (prevents figure
 squeezing)
print('-depsc2','fig3.eps');
```


Plot of two different 1D functions
y (arb. units)
x (arb. units)
y1(x)
y2(x)


y (arb. units)
x (arb. units)
z1 value (arb.)


y (arb. units)
x (arb. units)
z2 value (arb.)



Set up, evaluation, and solution of linear systems of equations. Manipulation of matrices.

```
% this matrix and vector represent the system of equations:
% 1)   x +  2y +  4z = 18
% 2)  2x + 12y -  2z =  9
% 3)  5x + 26y +  5z = 14
A=[1,  2, 4; ...    %notice that the ellipses in matlab allows you to
 continue a line
   2, 12,-2; ...
   5, 26, 5];       %A(i,j) is the coefficient of the ith variable in
 the jth equation
B=A';               %transpose of A

b=[18; 9; 14];      %this is the column vector representing the RHS of
 the system

% Some basic commands to display variables
disp('A = ');
disp(A);

disp('b = ');
disp(b);
```

```
% Compute some matrix properties and print them
disp('det(A) = ');
disp(det(A));

disp('trace(A) = ');
disp(trace(A));

disp('condition # of A = ');
disp(cond(A));

disp('transpose(A) = ');
disp(B);

disp('Aii (diagonal elements of A) = ');
disp(diag(A));

%matrix functions
disp('A*B (matrix multiplication) = ');
disp(A*B);

disp('Aij*Bij (scalar multiplication) = ');
disp(A.*B);

disp('5*A (multiplication) = ');
disp(5*A);

disp('Solution (x) of the system A*x=b:  ');
disp('x = ');
xvec=A\b;
disp(xvec);

disp('I (3x3 identity matrix) = ');
disp(eye(3));

disp('A^{-1} (inverse of A) = ')
disp(A\eye(3));                    %this is preferred over inv(A) (see
 matlab documentation)

%slicing and concatenation of array/matrices
disp('2nd row of A = ');
disp(A(2,:));

disp('2nd column of A = ');
disp(A(:,2));

disp('flat list (column vector) of matrix elements of A:  ')
disp(A(:));

disp('[A|A] (horizontal concatenation of A with itself):  ')
disp(cat(2,A,A));

disp('Vertical concatenation of A with itself:  ')
disp(cat(1,A,A));
```

```
disp('diagonal matrix:  ');
a1=10:-1:1;                          %count backward
a1=a1(:);                            %convert to column vector
disp(diag(a1,0));

disp('LU decomposition of A (A=L*U):  ')
[L,U]=lu(A);
disp('L = ');
disp(L);
disp('U = ');
disp(U);

disp('Eigenvalues of A = ');
[psi,lambda]=eig(A);
disp(lambda);
disp('Eigenvectors of A = ');
disp(psi(:,1));
disp(psi(:,2));
disp(psi(:,3));
```

```
A =
     1     2     4
     2    12    -2
     5    26     5

b =
    18
     9
    14

det(A) =
   40.0000

trace(A) =
    18

condition # of A =
  116.9115

transpose(A) =
     1     2     5
     2    12    26
     4    -2     5

Aii (diagonal elements of A) =
     1
    12
     5

A*B (matrix multiplication) =
    21    18    77
    18   152   312
    77   312   726
```

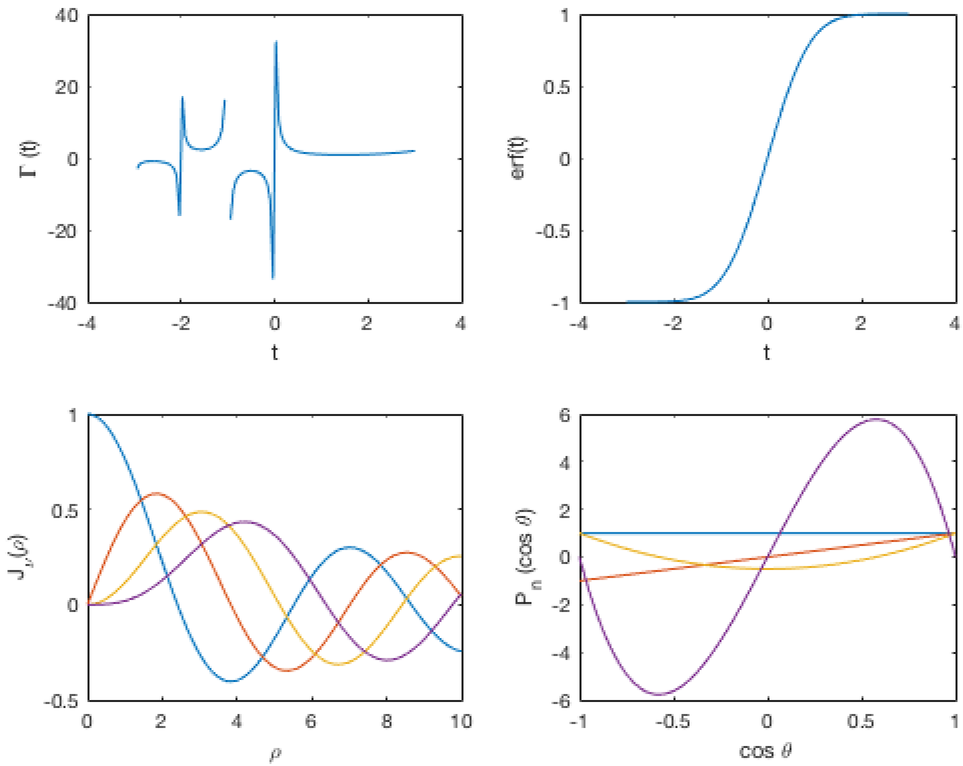
```
Aij*Bij (scalar multiplication) =
     1     4    20
     4   144   -52
    20   -52    25

5*A (multiplication) =
     5    10    20
    10    60   -10
    25   130    25

Solution (x) of the system A*x=b:
x =
   53.3500
   -8.8750
   -4.4000

I (3x3 identity matrix) =
     1     0     0
     0     1     0
     0     0     1

A^{-1} (inverse of A) =
    2.8000    2.3500   -1.3000
   -0.5000   -0.3750    0.2500
   -0.2000   -0.4000    0.2000

2nd row of A =
     2    12    -2

2nd column of A =
     2
    12
    26

flat list (column vector) of matrix elements of A:
     1
     2
     5
     2
    12
    26
     4
    -2
     5

[A|A] (horizontal concatenation of A with itself):
     1     2     4     1     2     4
     2    12    -2     2    12    -2
     5    26     5     5    26     5

Vertical concatenation of A with itself:
     1     2     4
     2    12    -2
     5    26     5
```

```
     1     2     4
     2    12    -2
     5    26     5

diagonal matrix:
    10     0     0     0     0     0     0     0     0     0
     0     9     0     0     0     0     0     0     0     0
     0     0     8     0     0     0     0     0     0     0
     0     0     0     7     0     0     0     0     0     0
     0     0     0     0     6     0     0     0     0     0
     0     0     0     0     0     5     0     0     0     0
     0     0     0     0     0     0     4     0     0     0
     0     0     0     0     0     0     0     3     0     0
     0     0     0     0     0     0     0     0     2     0
     0     0     0     0     0     0     0     0     0     1

LU decomposition of A (A=L*U):
L =
    0.2000    1.0000         0
    0.4000   -0.5000    1.0000
    1.0000         0         0

U =
    5.0000   26.0000    5.0000
         0   -3.2000    3.0000
         0         0   -2.5000

Eigenvalues of A =
   0.4090 + 0.0000i   0.0000 + 0.0000i   0.0000 + 0.0000i
   0.0000 + 0.0000i   8.7955 + 4.5216i   0.0000 + 0.0000i
   0.0000 + 0.0000i   0.0000 + 0.0000i   8.7955 - 4.5216i

Eigenvectors of A =
   -0.9823
    0.1791
    0.0556

   0.3740 - 0.1688i
   0.0581 + 0.1874i
   0.8906 + 0.0000i

   0.3740 + 0.1688i
   0.0581 - 0.1874i
   0.8906 + 0.0000i
```

Special functions, illustration of using greek letters in strings

```
t=linspace(-3,3,100);           %indep variable for gamma and erf
rho=linspace(0,10,100);         %radial independent variable
costh=linspace(-1,1,100);       %cos(theta) variable
```

```
figure(4);

subplot(2,2,1);
plot(t,gamma(t));                %gamma function
xlabel('t');
ylabel('\Gamma (t)');

subplot(2,2,2);
plot(t,erf(t));                  %error function
xlabel('t');
ylabel('erf(t)');

subplot(2,2,3);
plot(rho,besselj(0,rho),rho,besselj(1,rho),rho,besselj(2,rho),rho,besselj(3,rho))
   %first arg to bessel function is order, second is indep variable
xlabel('\rho');
ylabel('J_\nu(\rho)');

%associated legendre function
P0=legendre(0,costh);
P1data=legendre(1,costh);
P1=P1data(1,:);                  %pick the m=0 associated legendre
 function which is an ordinatry legendre polynomial
P2data=legendre(2,costh);
P2=P2data(1,:);
P3data=legendre(3,costh);
P3=P3data(3,:);
subplot(2,2,4);
plot(costh,P0,costh,P1,costh,P2,costh,P3);
xlabel('cos \theta');
ylabel('P_n (cos \theta)');
```



Demonstration of precision issues in matlab and formatted print statements (avoid subtracting number of vastly different magnitudes...)

```
epssingle=eps(single(1.0));      %single precision smallest interval
 from number 1.0

disp('1 (single precision):  ')
fprintf('%32.31f \n',single(1.0));
disp('1+eps (single precision):  ');
fprintf('%32.31f \n',single(1.0)+epssingle);
disp('1+eps/2 (single precision):  ');
fprintf('%32.31f \n\n',single(1.0)+epssingle/2);

disp('1 (double precision):  ')
fprintf('%32.31f \n',double(1.0));
disp('1+double(eps) (single precision eps):  ');
fprintf('%32.31f \n',double(1.0)+double(epssingle));
disp('1+double(eps)/2.0 (single precision eps):  ');
fprintf('%32.31f \n',double(1.0)+double(epssingle)/2);
```

```
1 (single precision):
1.0000000000000000000000000000000
1+eps (single precision):
```

```
1.00000011920928955078125000000000
1+eps/2 (single precision):
1.00000000000000000000000000000000

1 (double precision):
1.00000000000000000000000000000000
1+double(eps) (single precision eps):
1.00000011920928955078125000000000
1+double(eps)/2.0 (single precision eps):
1.00000005960464477539062500000000
```

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