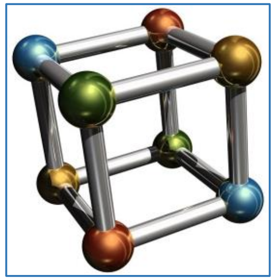
다양한 2차원 그래프



매트랩 이해 및 실습

최병조

임베디드시스템공학과

강의 주제

• Matlab의 역사와 간단한 사용법	• 다항식, 커브 피팅, 인터폴레이션
• 배열, 행렬 만들기와 소리 다루기	• 3차원 그래프 그리기
• 행렬과 그림 다루기	• GUIDE로 GUI 만들기
• 라이브스크립트, 웹 게시, 엑셀 연동	• 애니메이션 GUI
• 2차원 그래프 그리기 기초	• 앱 디자이너로 GUI 만들기
• **다양한 2차원 그래프 그리기**	• GUI 프로젝트 발표
• 함수 만들기	• MuPAD로 수학 문제 풀기
• 중간고사	• 기말고사

You will be able to

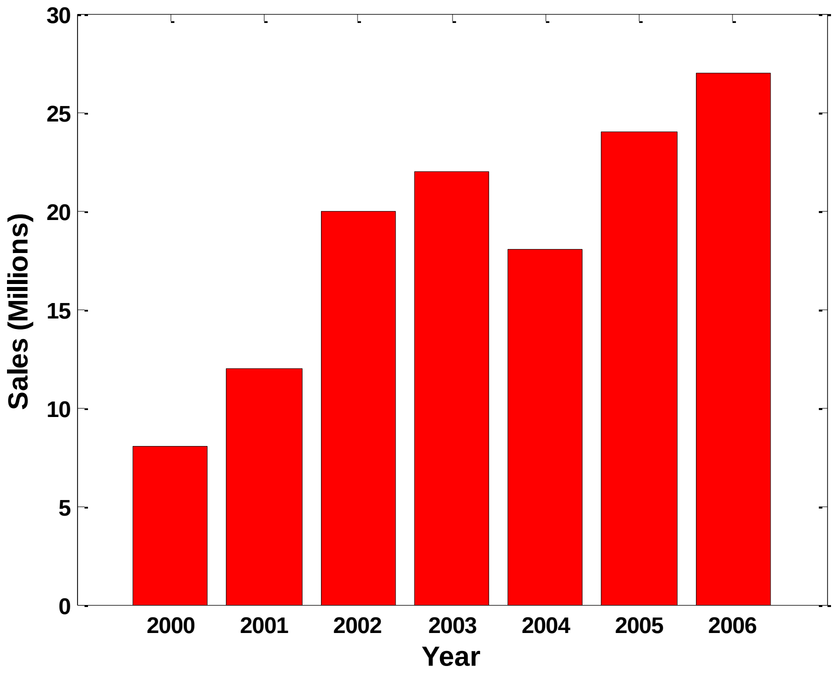
- Visualize data using various plots including bar, stem, stairs, pie, histogram and polar plots,
- Use patch plots with colors,
- Generate an animated graph.

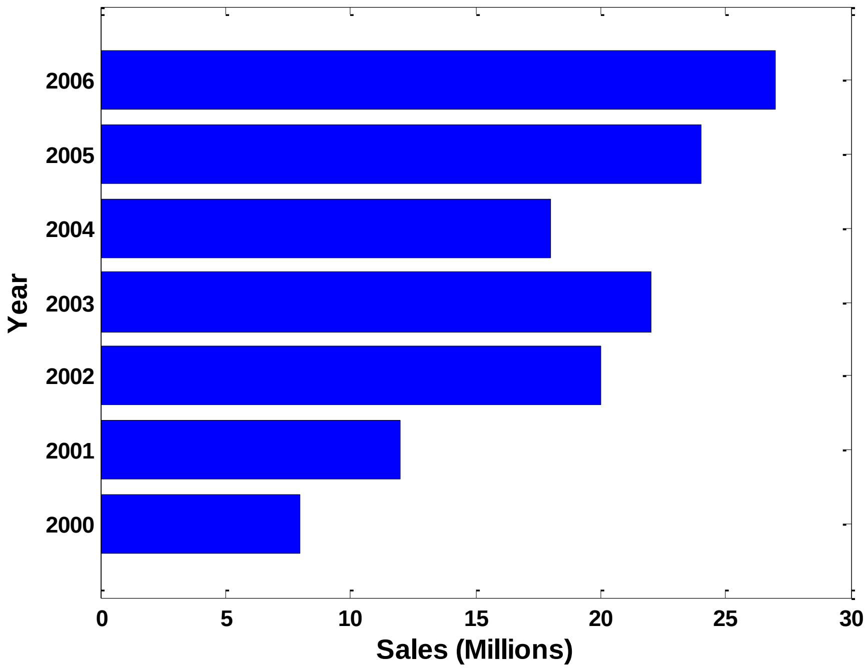
Special Graphs: Bar Charts

```
year  = 2000:2006;
sales = [8 12 20 22 18 24 27 ];
```

```
bar( year, sales,'r');
xlabel('Year');
ylabel('Sales (Millions)');
```

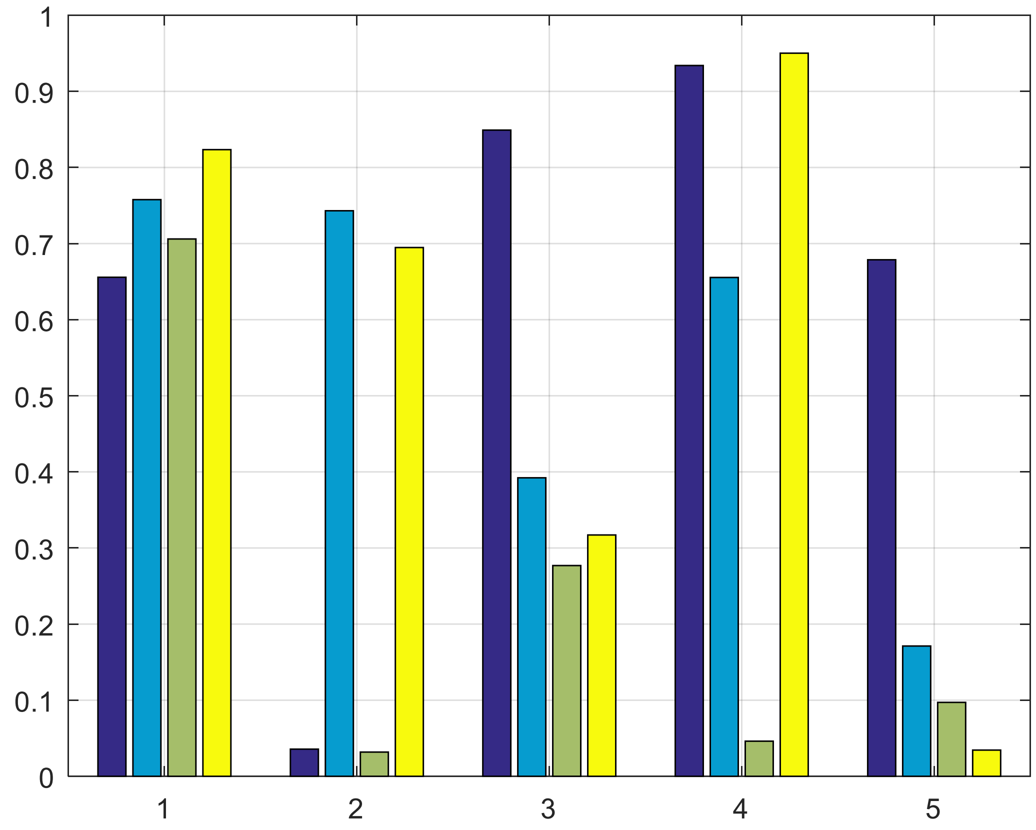
```
barh( year, sales,'b');
ylabel('Year');
xlabel('Sales (Millions)');
```





Multiple Bars

- Each column represents a bar chart.
- Different colors are assigned to different columns.



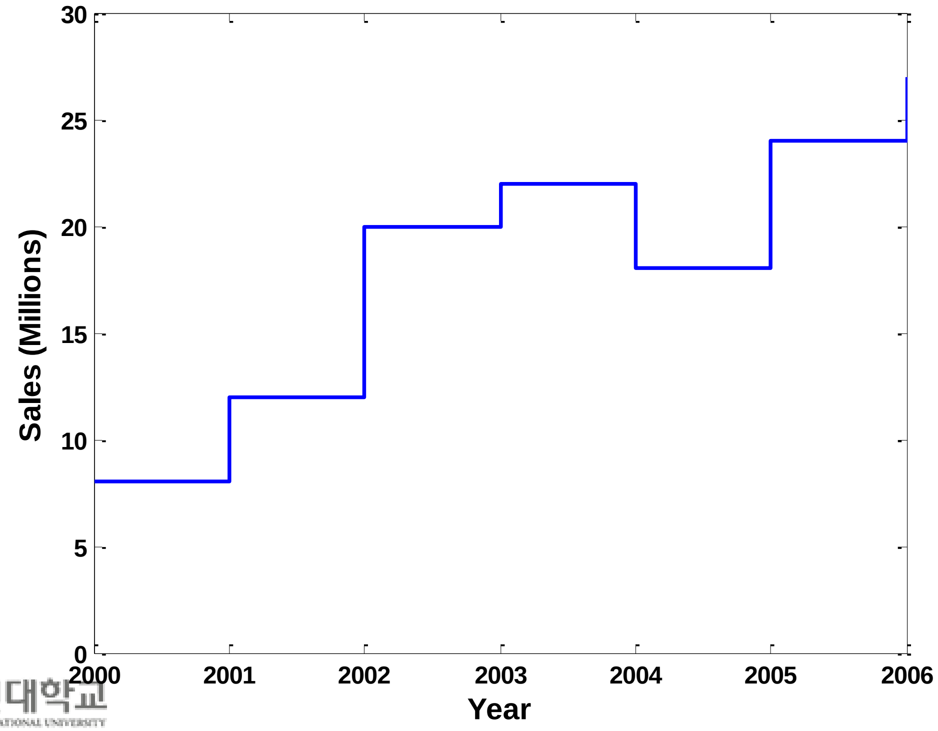

```
a=rand(5,4);
bar( a );
grid on;
```

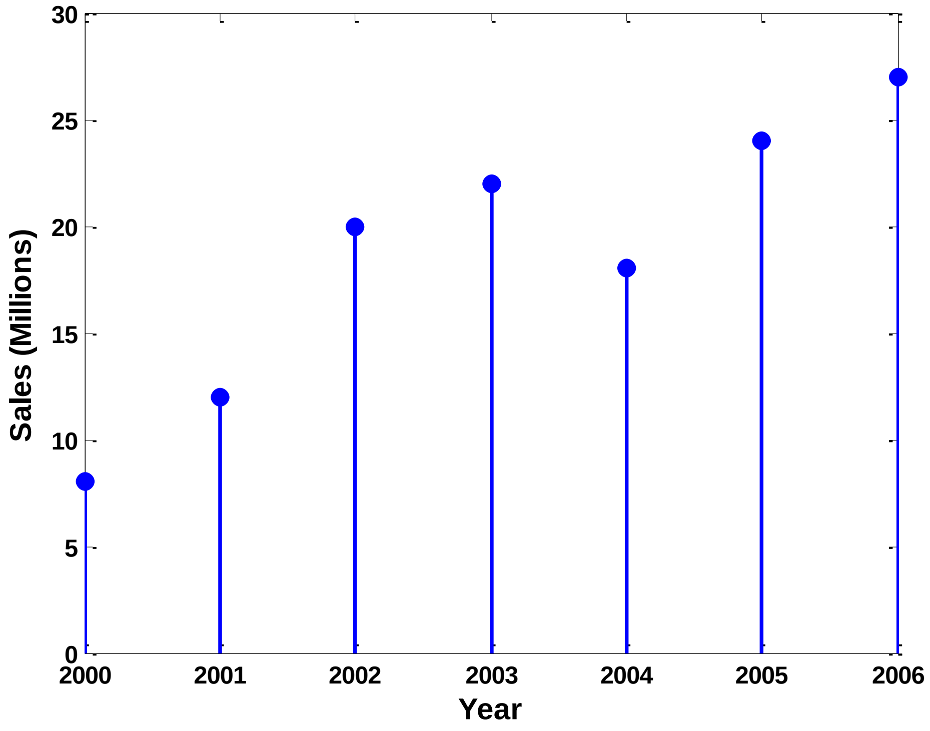
Special Graphs: Stairs & Stem

```
year  = 2000:2006;
sales = [8 12 20 22 18 24 27 ];
```

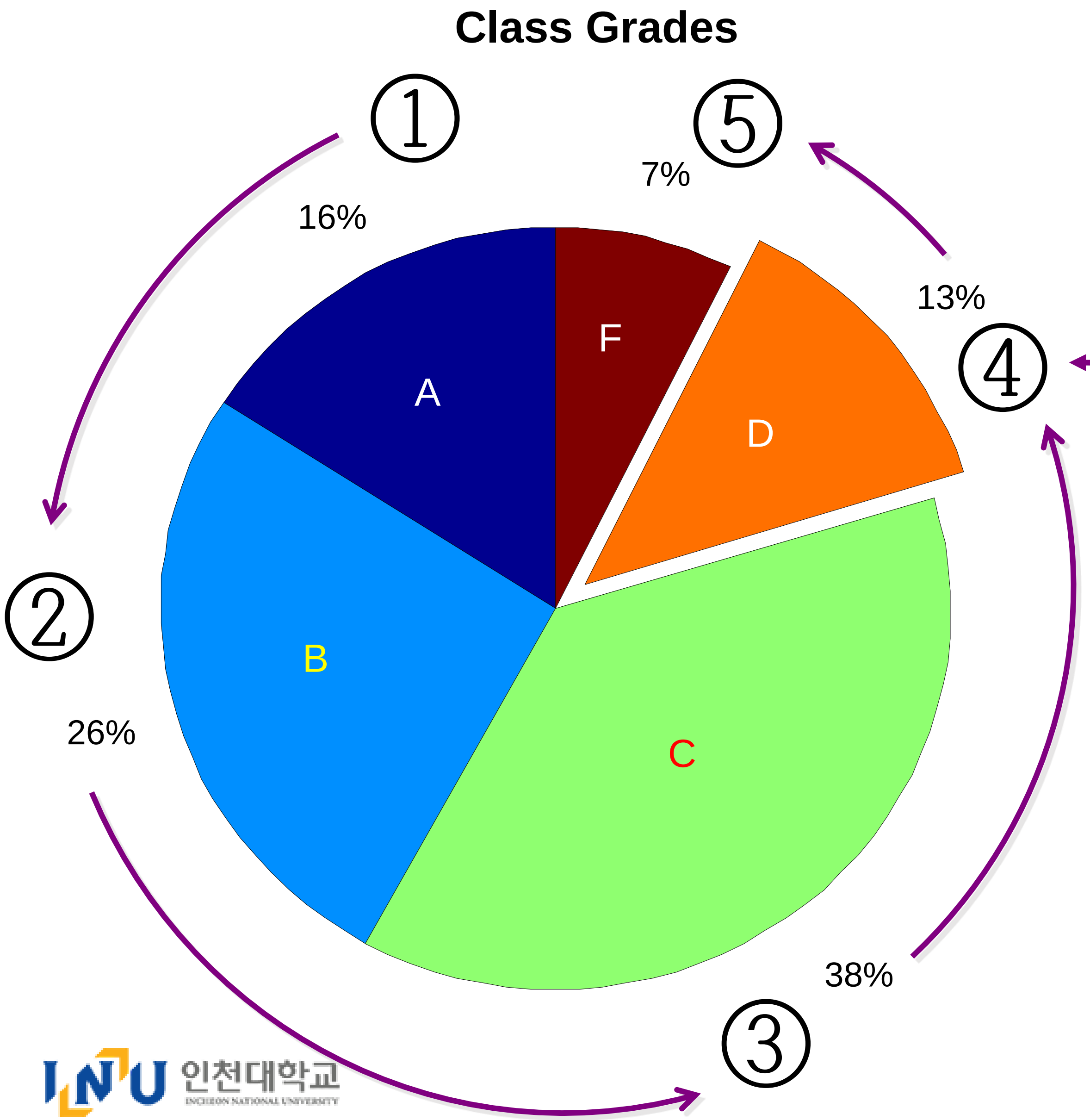
```
stairs( year, sales);
xlabel('Year');
ylabel('Sales (Millions)');
```

```
stem( year, sales,'filled');
xlabel('Year');
ylabel('Sales (Millions)');
```





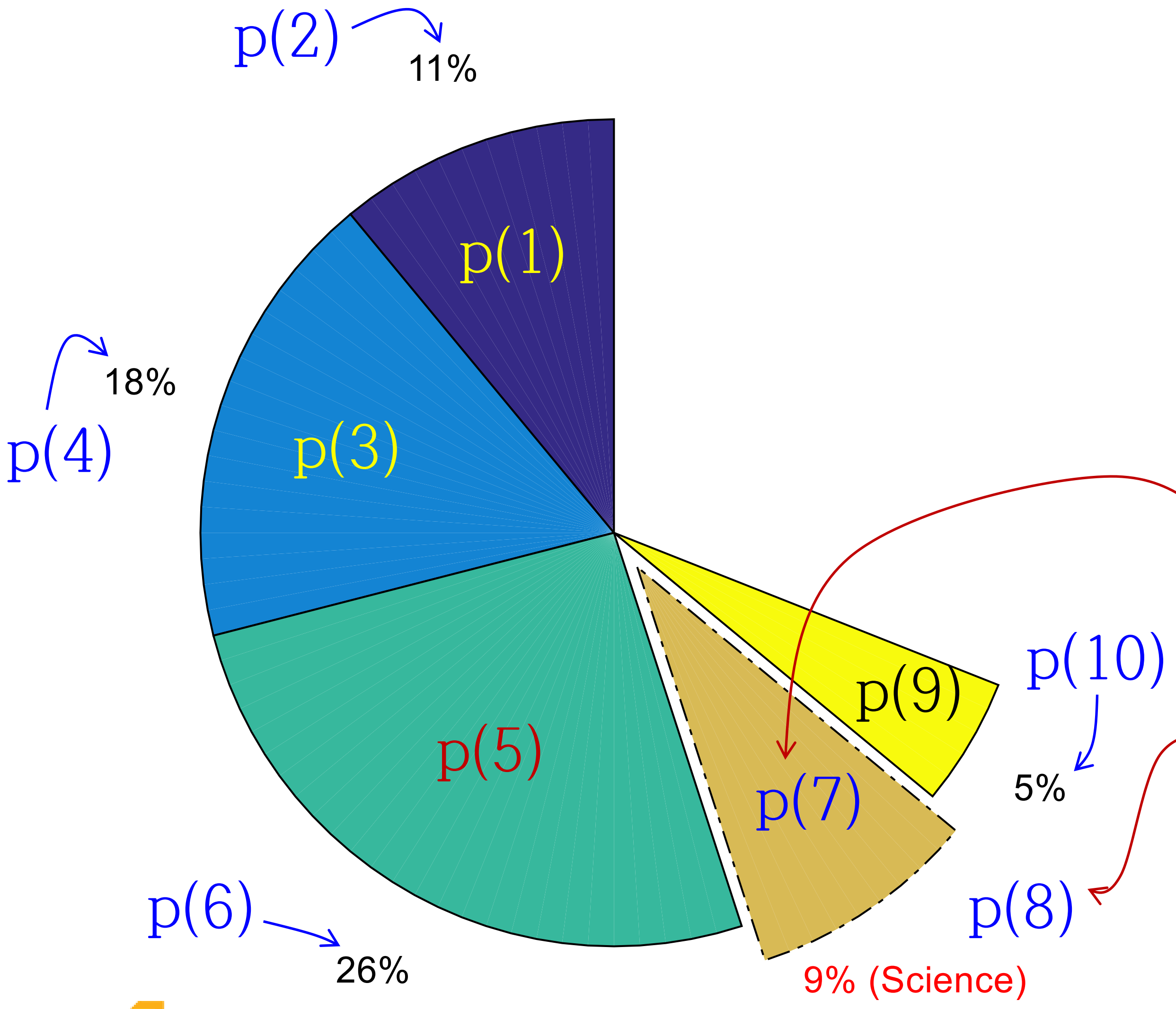
Pie Chart



- If the sum of values > 1, it display percentage.

```
grades = [ 11 18 26 9 5];
pie(grades,[ 0 0 0 1 0]);
title('Class Grades');
```

Pie Chart



- If the sum of values ≤ 1, it displays the values.

```
grades = [ 11 18 26 9 5]*0.01;
figure(2);
p = pie(grades,[ 0 0 0 1 0]);
p(7).LineStyle = '-.';
p(8).String = '9% (Science)';
p(8).Color = [1 0 0];
```

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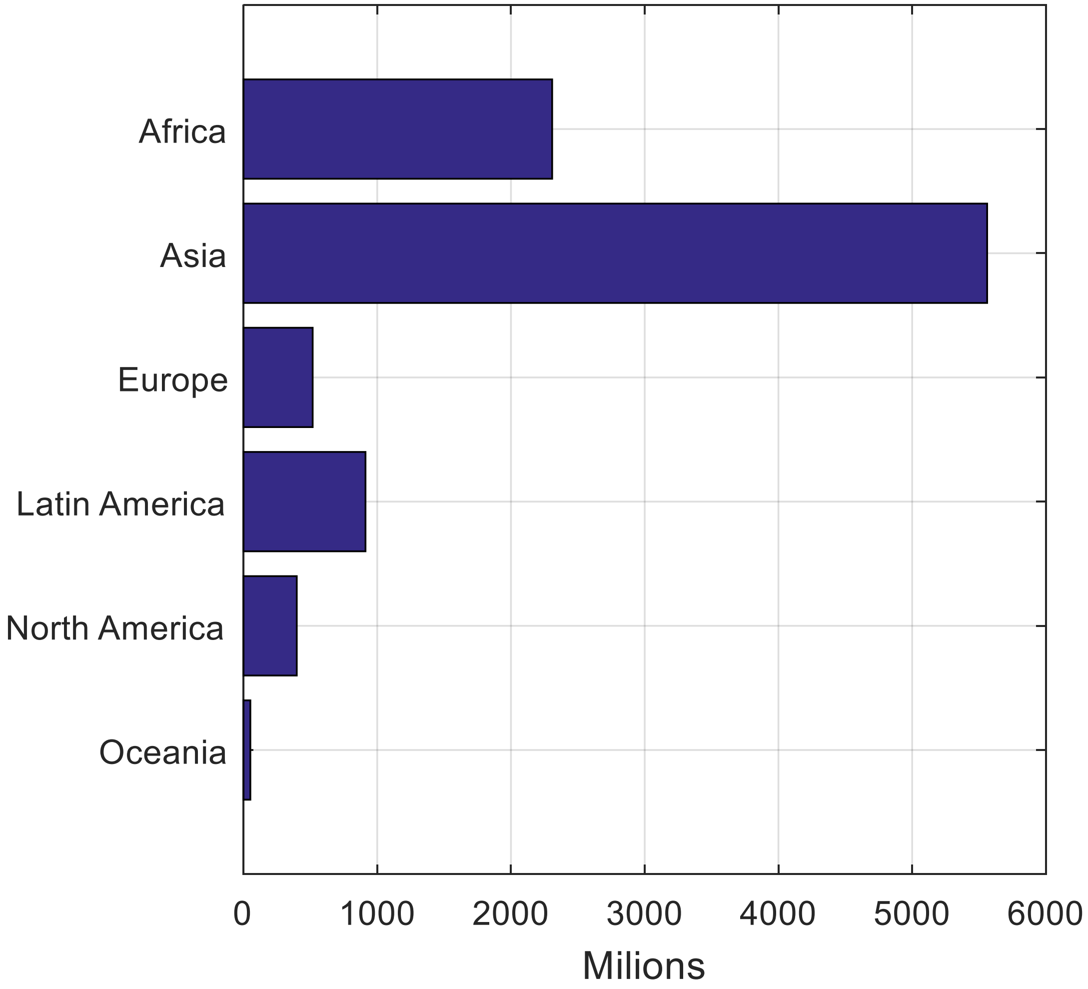
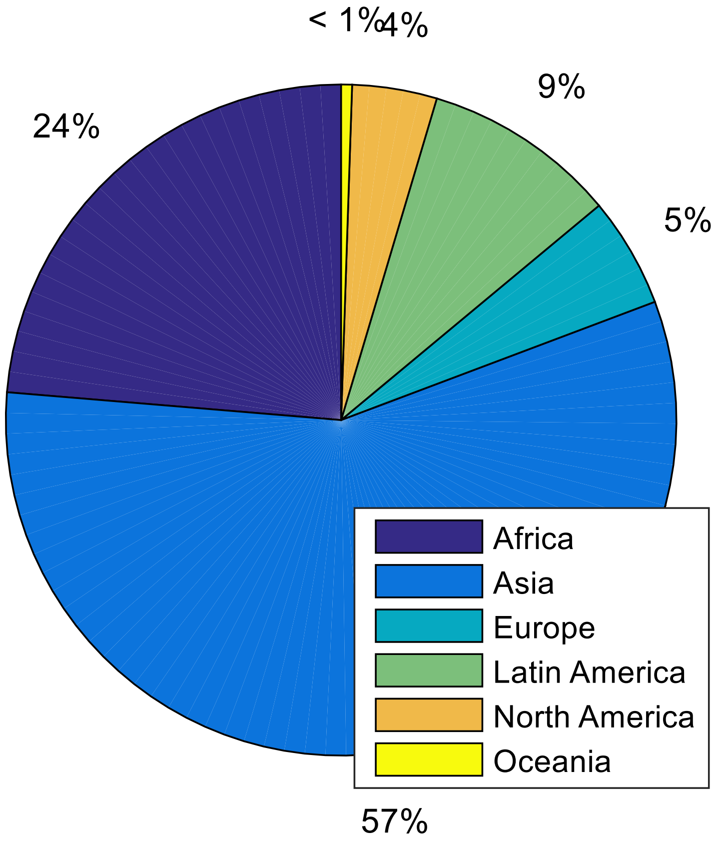
Example: World Pop. in Y2150

- Represent the predicted world population in year 2150 in a bar chart and a pie chart.
  - Get the raw data from Wikipedia
    - Visit http://en.wikipedia.org/wiki/World_population
  - Draw a bar chart and a pie chart based on the data.
    - Use subplot to place the two charts side by side.
  - Use sensible legend or tick label.

Sample Graph





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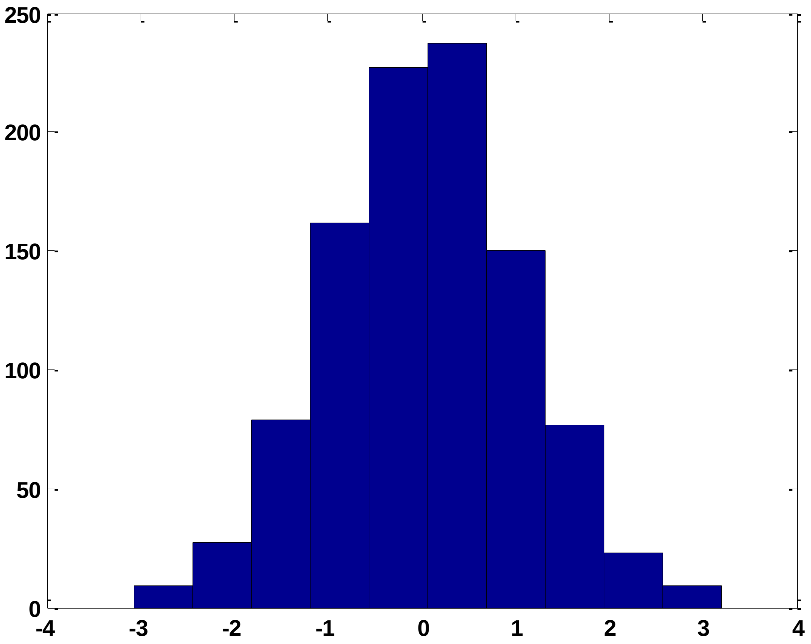
Sample Script

world_population.m

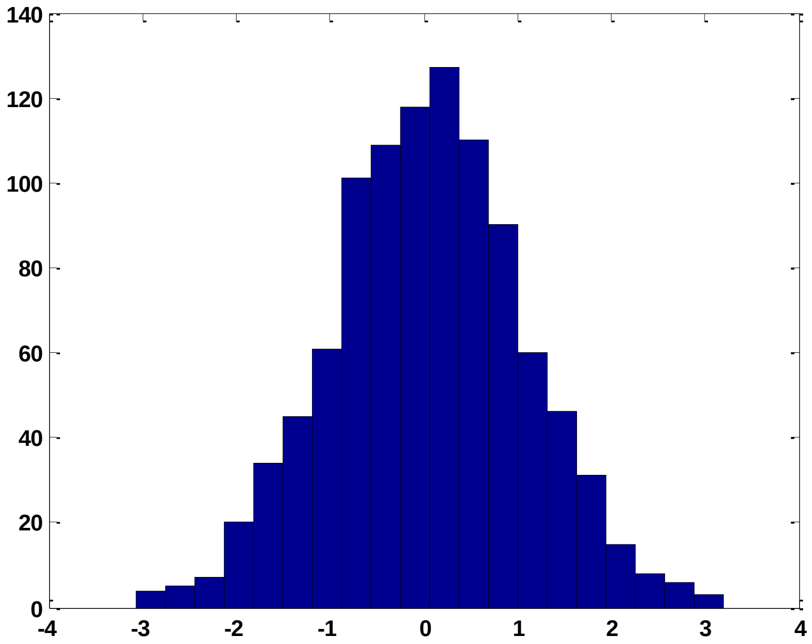
```
PopData = [ 2308, 5561, 517, 912, 398, 51 ];
figure('Position', [100, 400, 900, 400] );
subplot(1,2,1); barh(PopData); grid on;
ax = gca; ax.YTickLabel = {'Africa', 'Asia', 'Europe', 'Latin America', ...
    'North America', 'Oceania'};
ax.YDir = 'reverse';
xlabel('Milions');
subplot(1,2,2); pie(PopData);
legend( 'Africa', 'Asia', 'Europe', 'Latin America', 'North America', ...
    'Oceania', 'Location', 'SouthEast' );
```

Histogram (1/2)

- Number of occurrences in each bin.
- The default number of bins is 10.




```
s=randn(1,1000);
hist(s)
```




```
s=randn(1,1000);
hist(s, 20)
```

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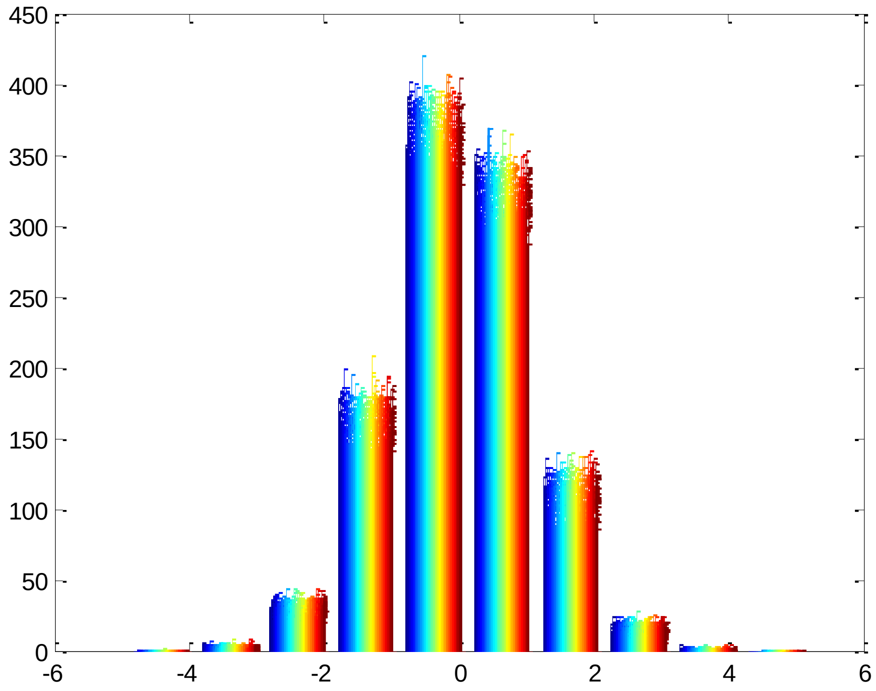
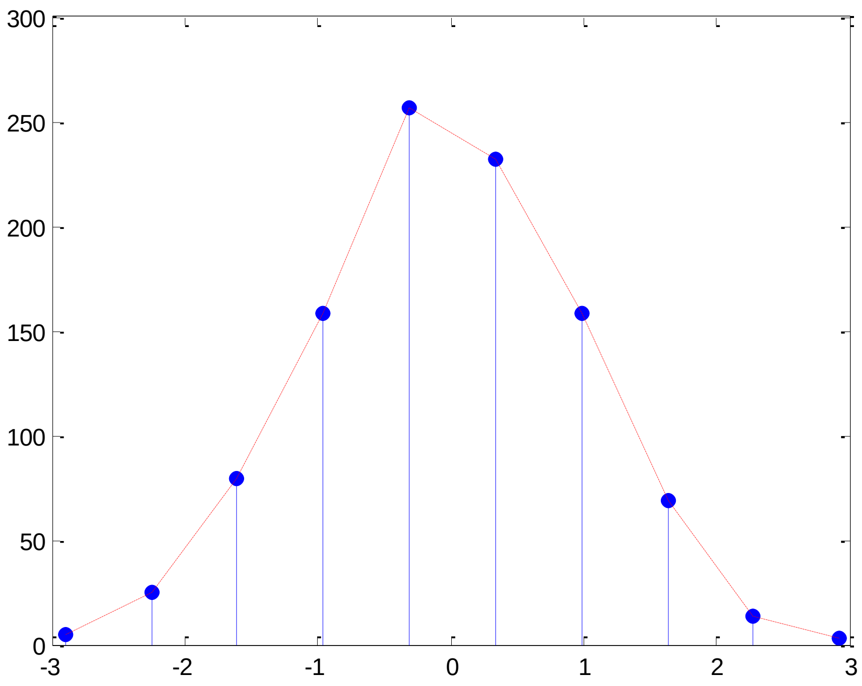
Histogram (2/2)

- Histogram of a Matrix
- Use of histogram data




```
s=randn(1000);
hist(s)
```




```
s=randn(1,1000);
[n x ] = hist(s);
stem(x,n,'filled'); hold on;
plot(x,n,'r-.');
```

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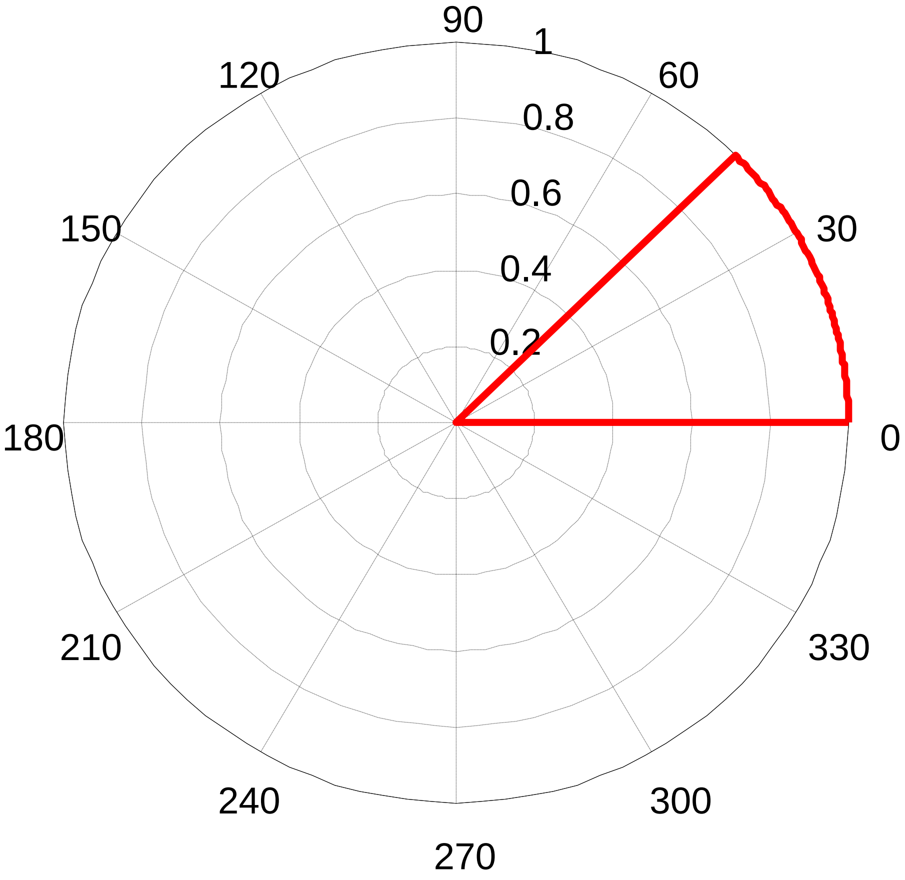
Polar Plot

$$\theta \qquad r$$

- **polar(theta, radius, 'line spec')**

polar_pie.m

```
t  = 0:0.01:pi/4;
th = [t 0 0 ];
r  = [ones(1,length(t)) 0 1 ];
h  = polar( th, r, 'r-');
set(h,'LineWidth',3);
```



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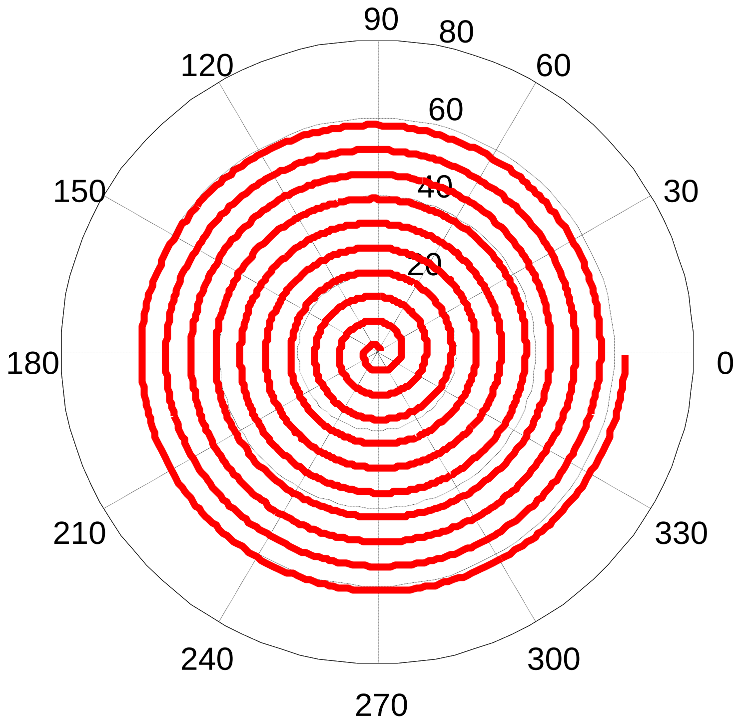
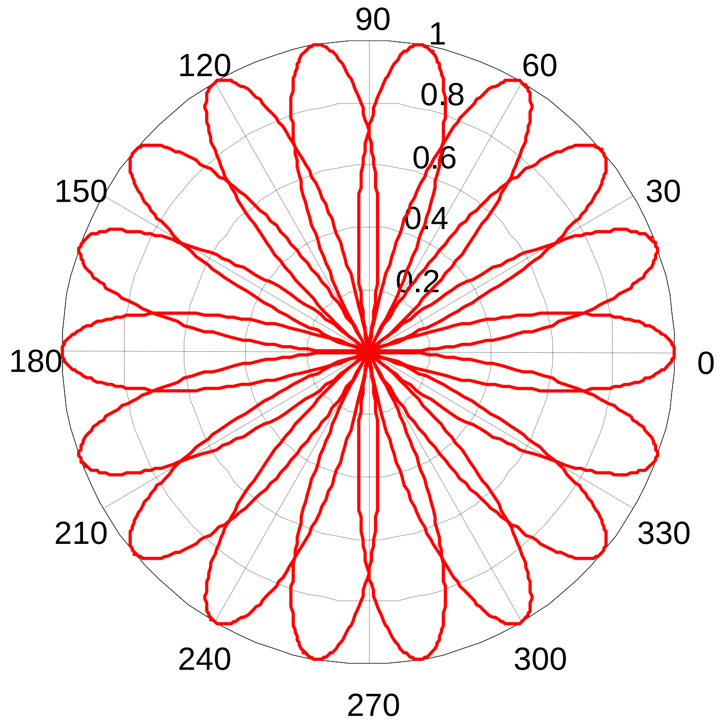
More Polar Plots



$$\theta = 0 \sim 20\pi$$
$$r = \theta$$



$$\theta = 0 \sim 4\pi$$
$$r = \sin(4.5\theta)$$

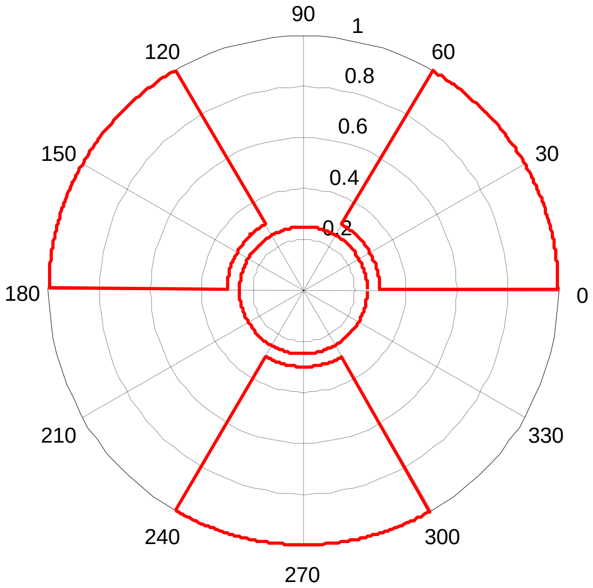
polar_spiral.m

```
th = 0:0.01:20*pi;
h = polar(th,th,'r-');
set(h, 'LineWidth',3);
```

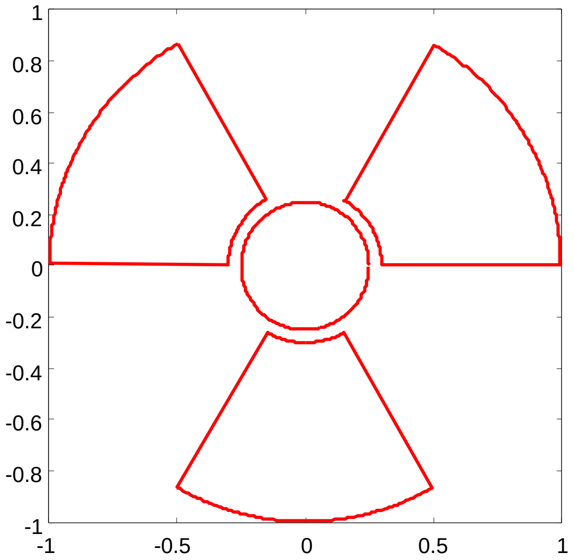
polar_petal.m

```
th = 0:0.01:4*pi;
r  = sin(4.5*th);
h = polar(th,r,'r-');
set(h, 'LineWidth',2);
```

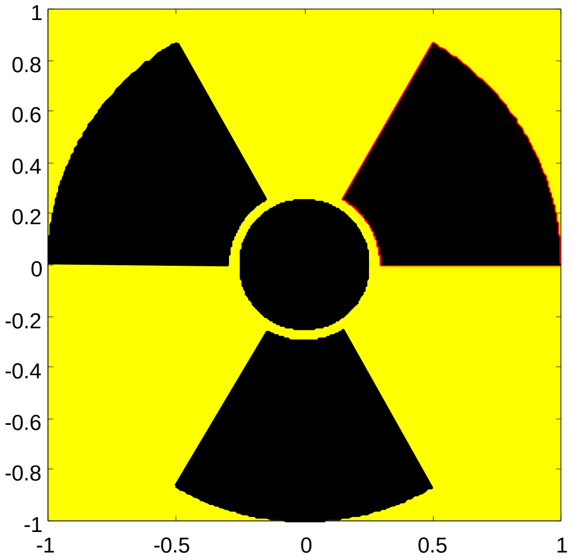
Polar / Plot / Patch



Polar



Plot



Patch

Script for Polar / Plot / Patch

- polar(θ , r) ←→ plot($r\cos\theta$, $r\sin\theta$)
- patch($r\cos\theta$, $r\sin\theta$, Color)

polar_patch_demo.m

```
% Polar, Plot and Patch demo
%% a wing
t1 = 0:0.01:pi/3; % counter-clockwise
tr = t1(end:-1:1); % reverse direction
nt = length(t1);
th = [t1 tr 0];
r1 = [ones(1,nt) 0.3*ones(1,nt) 1];
%% a circle
t2 = 0:0.01:2*pi;
r2 = ones(1,length(t2));

%% Polar
figure(1);
h1  = polar( th, r1, 'r-'); hold on;
h2  = polar( th+2/3*pi, r1, 'r-');
h3  = polar( th-2/3*pi, r1, 'r-');
h0  = polar( t2, 0.25*r2, 'r-');
set([h0 h1 h2 h3], 'LineWidth', 3);
hold off;
```

```
%% Plot
figure(2);
h1  = plot( r1.*cos(th), r1.*sin(th), 'r-'); hold on;
h2  = plot( r1.*cos(th+2/3*pi), r1.*sin(th+2/3*pi), 'r-');
h3  = plot( r1.*cos(th-2/3*pi), r1.*sin(th-2/3*pi), 'r-');
h0  = plot( 0.25*r2.*cos(t2), 0.25*r2.*sin(t2), 'r-');
set([h0 h1 h2 h3], 'LineWidth', 3);
axis square;
hold off;

%% Patch - filled polygons
figure(3);
h1  = patch( r1.*cos(th), r1.*sin(th), 'k'); hold on;
h2  = patch( r1.*cos(th+2/3*pi), r1.*sin(th+2/3*pi), 'k');
h3  = patch( r1.*cos(th-2/3*pi), r1.*sin(th-2/3*pi), 'k');
h0  = patch( 0.25*r2.*cos(t2), 0.25*r2.*sin(t2), 'k');
set(gca,'Color','yellow');
axis square;
hold off;
```

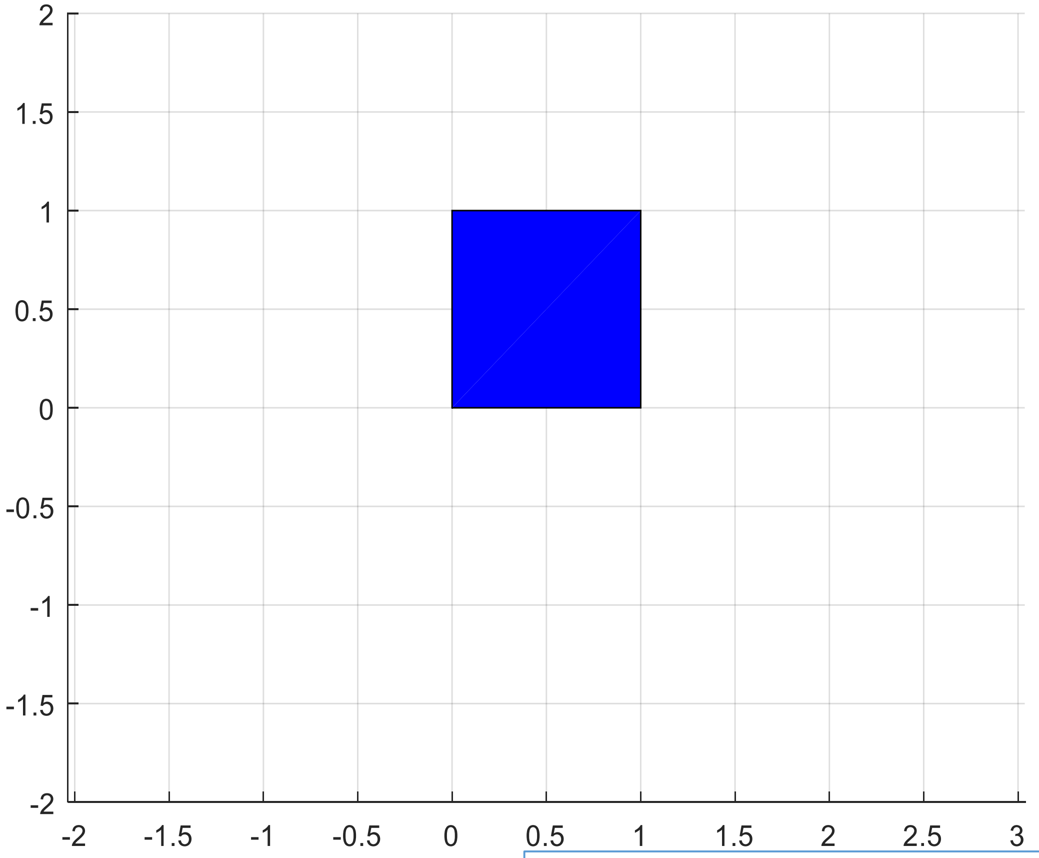
Basics of Patch

- Blue Square

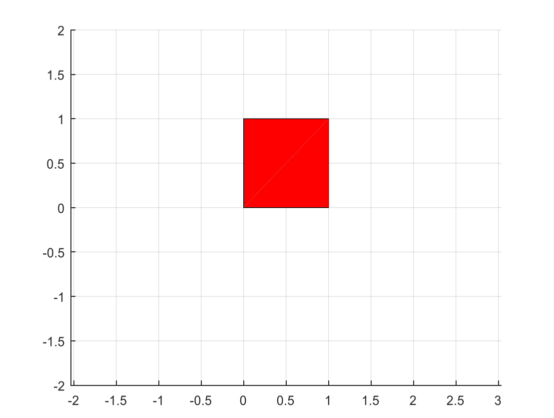
simple_patch.m

```
%% Simple Square patch
X = [0 1 1 0]';
Y = [0 0 1 1]';
figure(1); p = patch( X, Y, 'b' );
axis([-2 2 -2 2]); axis equal;
grid on;
p %#ok<*NOPTS>
```

```
p =

  Patch - 속성 있음:

    FaceColor: [0 0 1]
    FaceAlpha: 1
    EdgeColor: [0 0 0]
    LineStyle: '-'
        Faces: [1 2 3 4]
     Vertices: [4x2 double]

  모든 속성 표시
```




```
>> p.FaceColor = 'r';
```

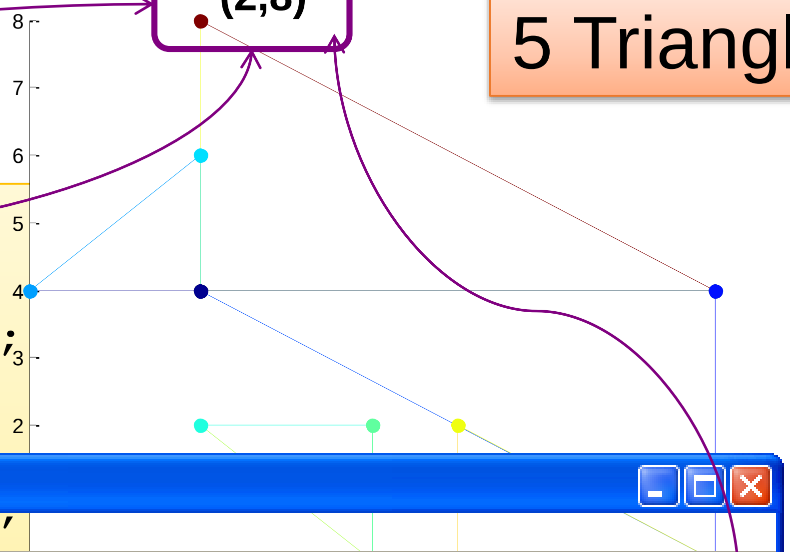


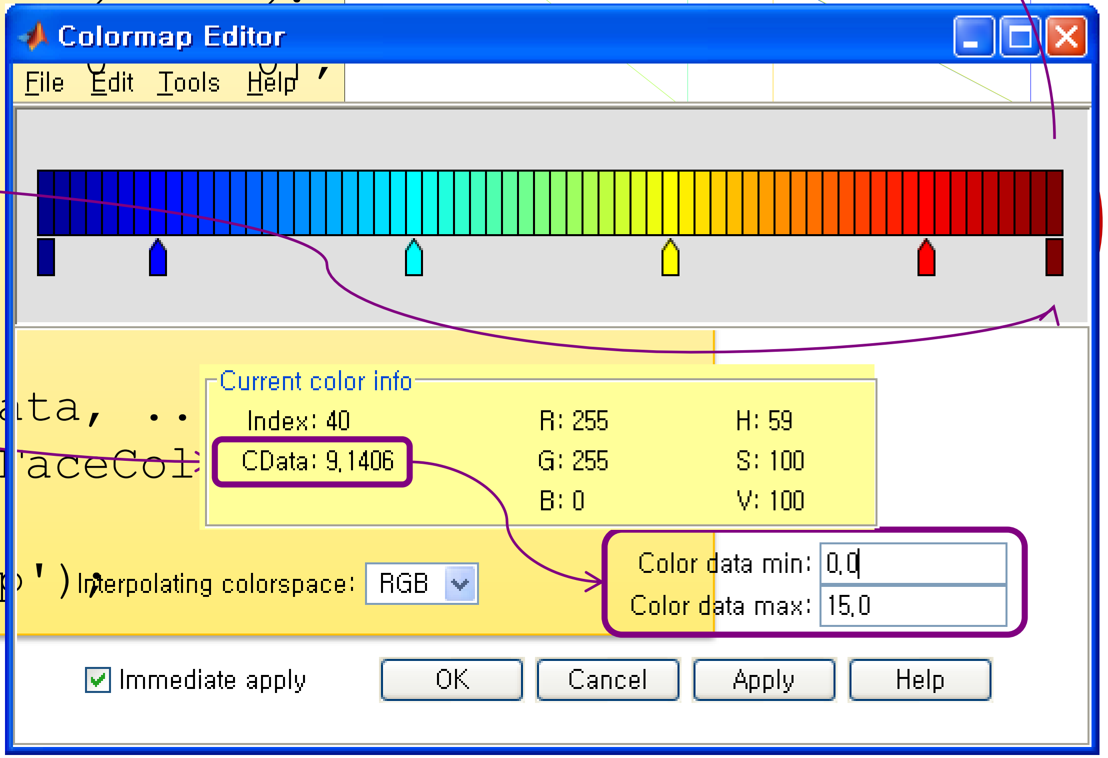
Coloring Patches

5 Triangles

patch_demo.m

```
xdata = [2    2    0    2    5;
         2    8    2    4    5;
         8    8    2    4    8];
ydata = [4    4    4    2    0;
         8    4    6    2    2;
         4    0    4    0    0];
cdata = [9    0    4
         15   2    5
         8    3    0
% colormapeditor
figure(1);
p = patch(xdata,ydata,cdata, ..
     'Marker','o','MarkerFaceCol
     'FaceColor','none');
set(p,'EdgeColor','interp');
```





colormapeditor

interp

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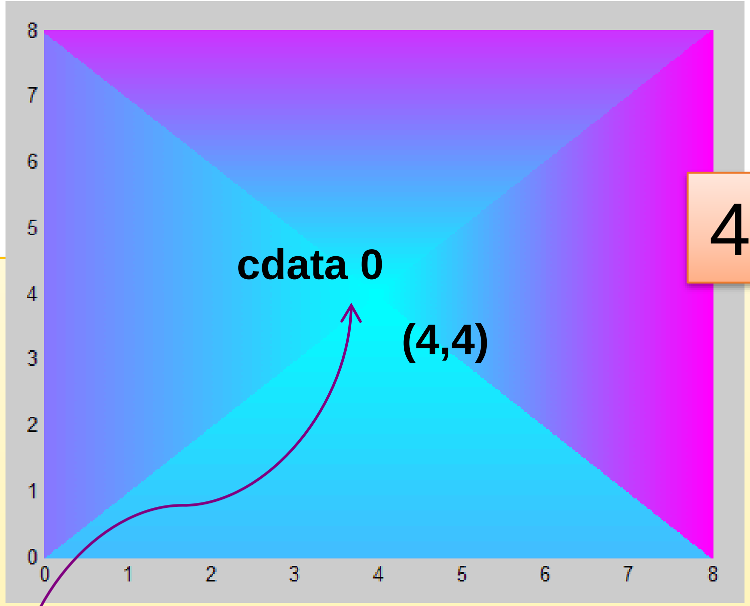
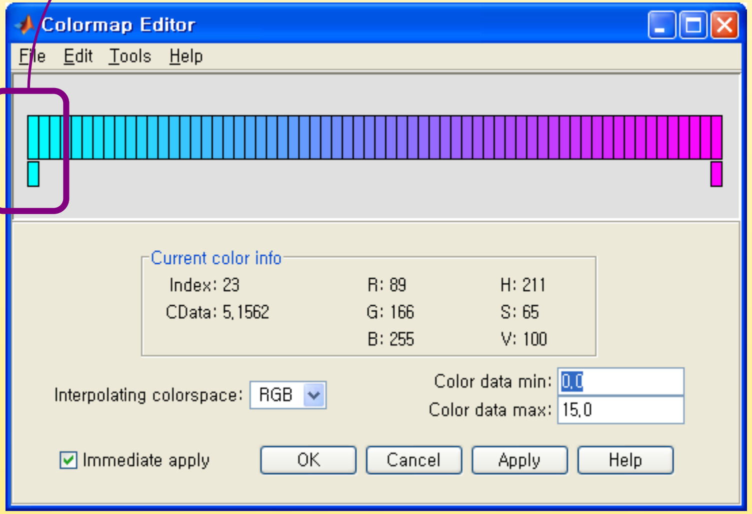
Patch Pyramid

patch_pyramid.m

```
xdata = [0      0      0      8;
         8      0      8      8;
         4      4      4      4];
ydata = [0      0      8      8;
         0      8      8      0;
         4      4      4      4];
cdata = [4      8      12     15;
         4      8      12     15;
         0      0      0      0];
% Select the current colomap
colormap('Cool');
figure(1);
p = patch(xdata,ydata,cdata,'FaceColor','interp');
set(p,'EdgeColor','interp');
```

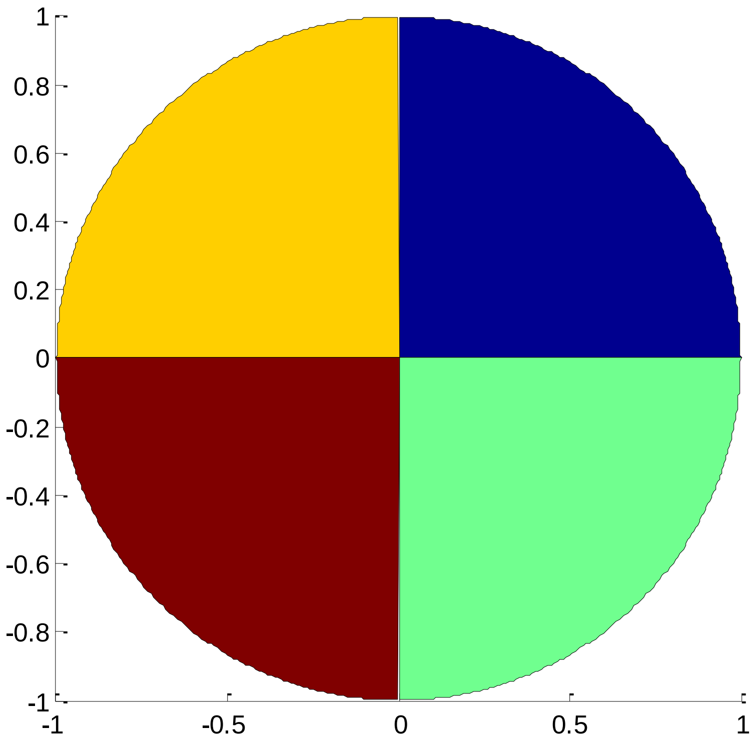


4 Triangles



Exercise: Color Ball

- Write a script for plotting the color ball below using patch.



Your Solution

- Script and Screenshot

patch_color_ball.m

```
% Color Ball
t0 = 0:0.01:pi/2;  t  = [ 0 t0 ];
N  = length(t);
r  = [ 0 ones(1,N-1) ];
x  = r .* cos(t);        y  = r .* sin(t);
u  = r .* cos(t+pi/2);   v  = r .* sin(t+pi/2);
X  = [x' u'   u'  x' ];
Y  = [y' v'  -v' -y' ];
I  = ones(N,1);

figure(1); colormap('colorcube');
set(gca,'CLim',[0 64]);
C  = I*[ 55 7 3 49];
colormap('colorcube');
p = patch(X, Y, C, 'FaceColor', 'flat');
axis square;
```

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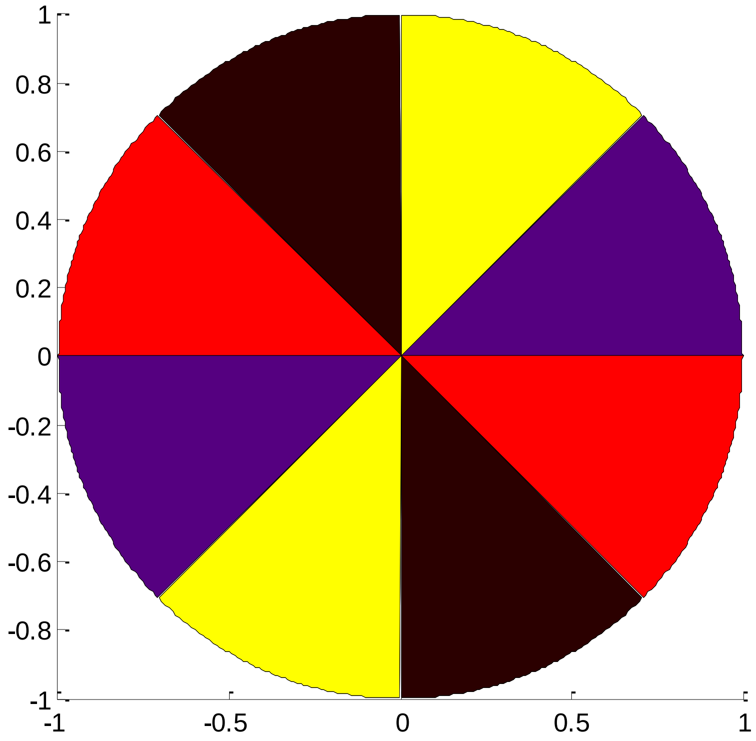
Exercise: Juggling Ball

- Write a script for plotting the color juggling ball below using patch.



Your Solution

- Script and Screenshot

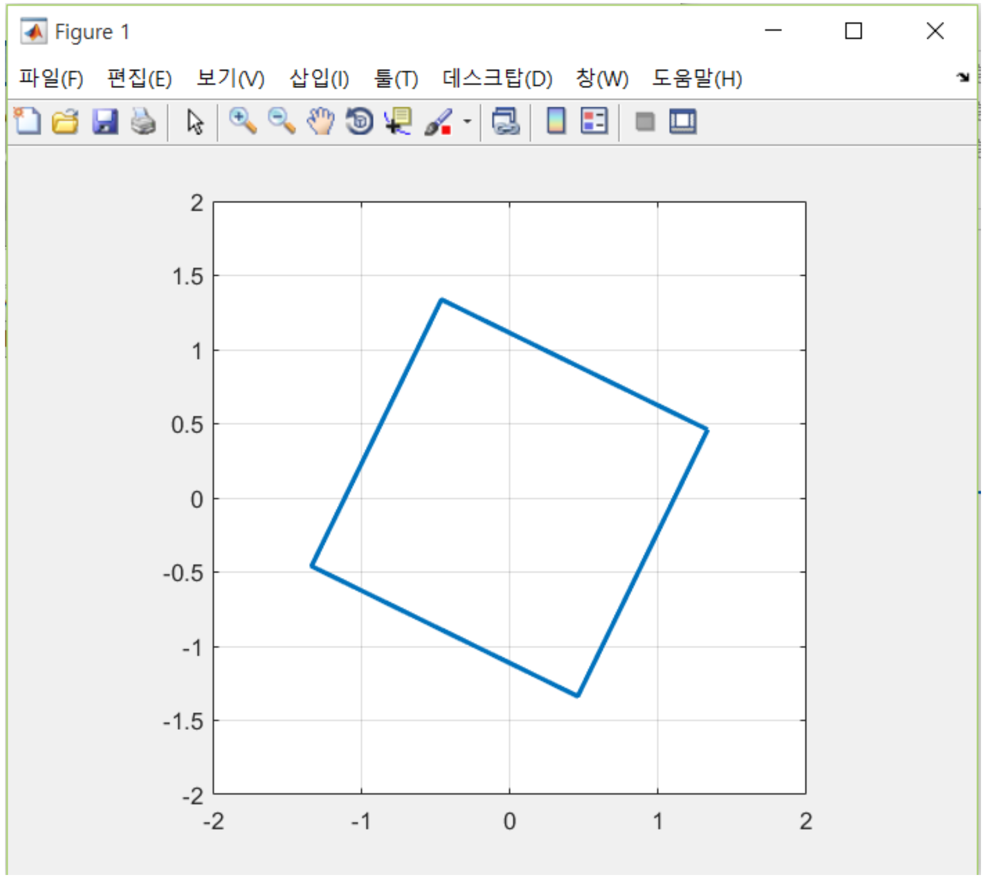
patch_jcolor_ball.m

Rotating Square

- Read https://en.wikipedia.org/wiki/Rotation_matrix
- Run the script below.

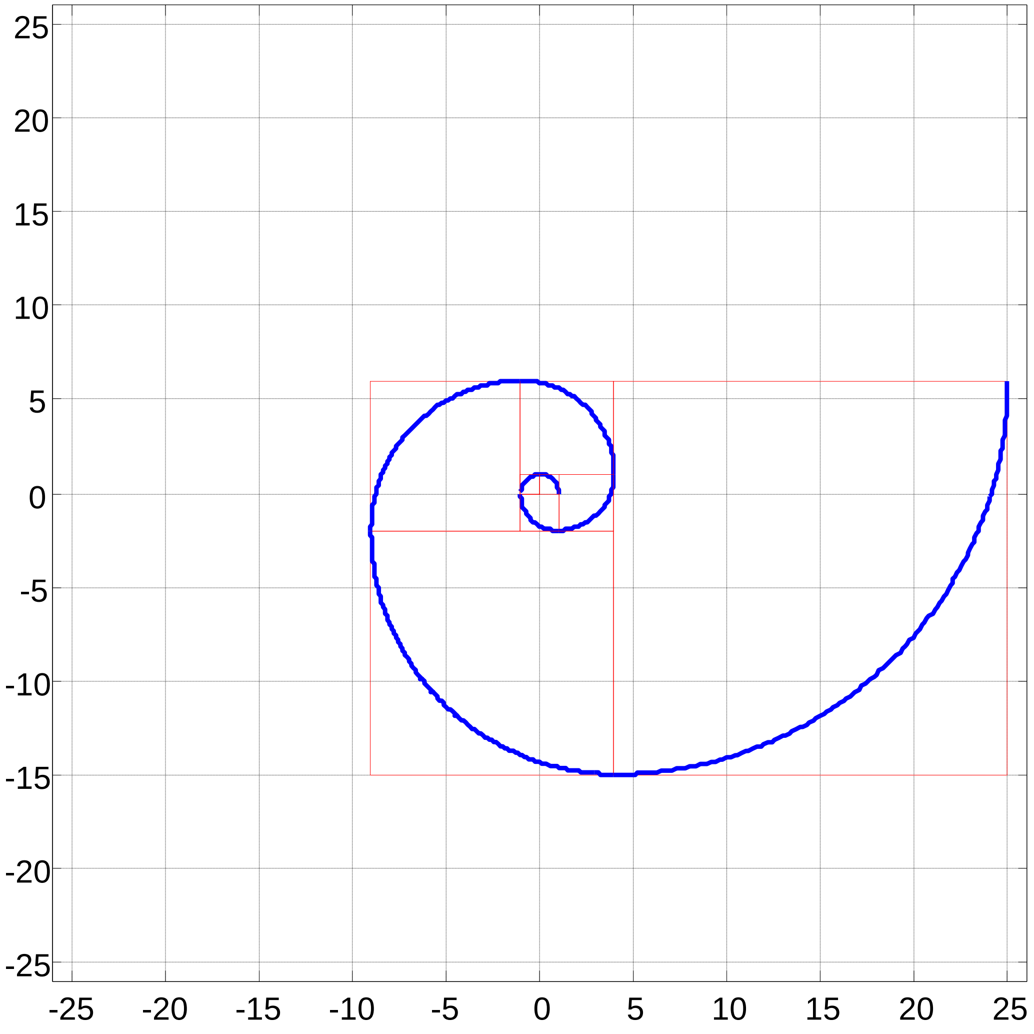
patch_jcolor_ball.m

```
% Rotating Square
x = [1 1 -1 -1 1];
y = [-1 1 1 -1 -1];
figure(1);
for t = 0:0.1:10*pi
    c = cos(t); s = sin(t);
    R = [c -s; s c ];
    P = R * [x; y];
    plot( P(1,:), P(2,:), 'LineWidth', 2 );
    axis([-2 2 -2 2]); axis square;
    grid on;
    pause(0.01);
end
```



Exercise: Fibonacci Plot

- Write a script for generating a Fibonacci plot.
  - Refer to Wikipedia for Fibonacci number.
  - Number of arcs N may be arbitrary.
  - Bonus for arbitrary starting direction and rotation control.



Your Solution

- Script and Screenshot

fibonacci_arcs.m

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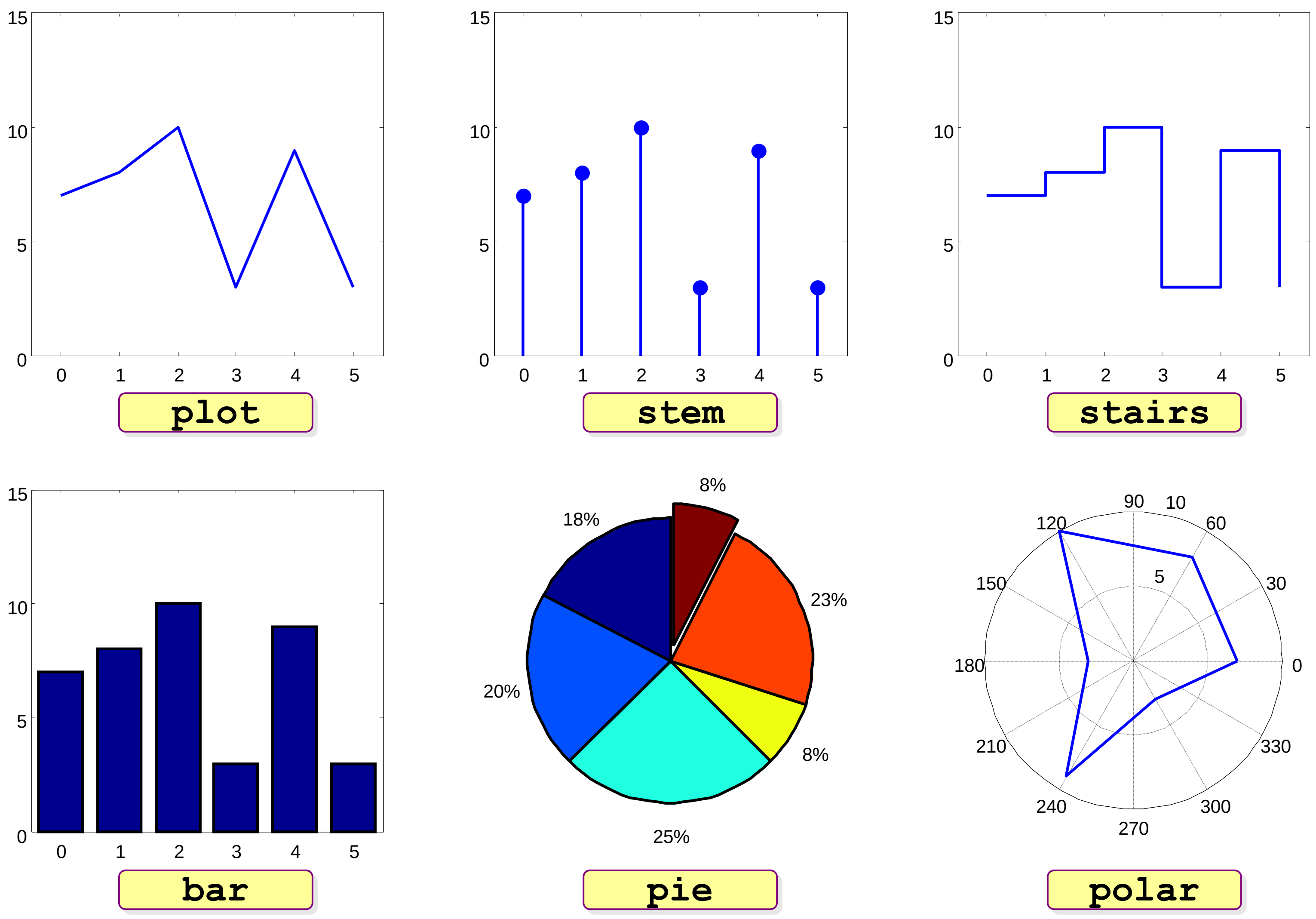
Subplot – Example



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Subplot - Script

sbuplots.m

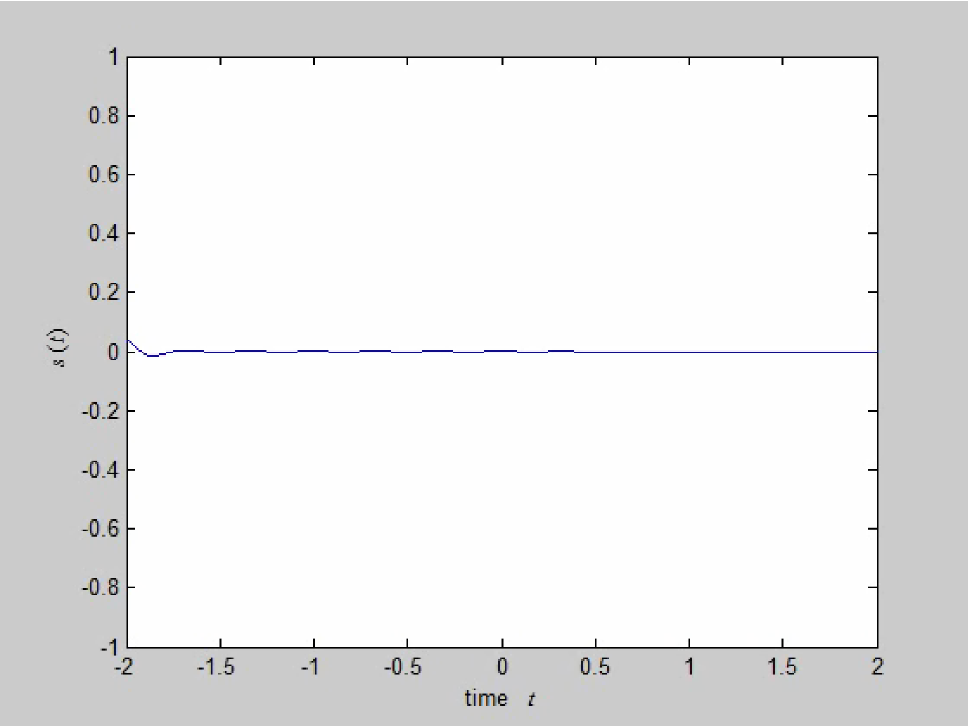
```
% Subplot Demo
y = floor(10*rand(1,6))+3;
x = [1:length(y)] - 1;

subplot(2,3,1); plot(x,y,'b-'); axis([-0.5 5.5 0 15]);
subplot(2,3,2); stem(x,y,'filled'); axis([-0.5 5.5 0 15]);
subplot(2,3,3); stairs(x,y,'b-'); axis([-0.5 5.5 0 15]);
subplot(2,3,4); bar(x,y,0.75); axis([-0.5 5.5 0 15]);
subplot(2,3,5); pie(y,[0 0 0 0 0 1]);
subplot(2,3,6); polar([x x(1)]*2*pi/6,[y y(1)],'b-');
```

Exercise: Wave-packet

- Plot the following moving graph using the following equation.

$$s(t) = \cos\left(6\pi(t-d)\right)\ \exp\left(-\pi(t-d)^2\right), d = -3 \sim 3$$

Play



for

pause

Your Solution

- Script and Screenshot

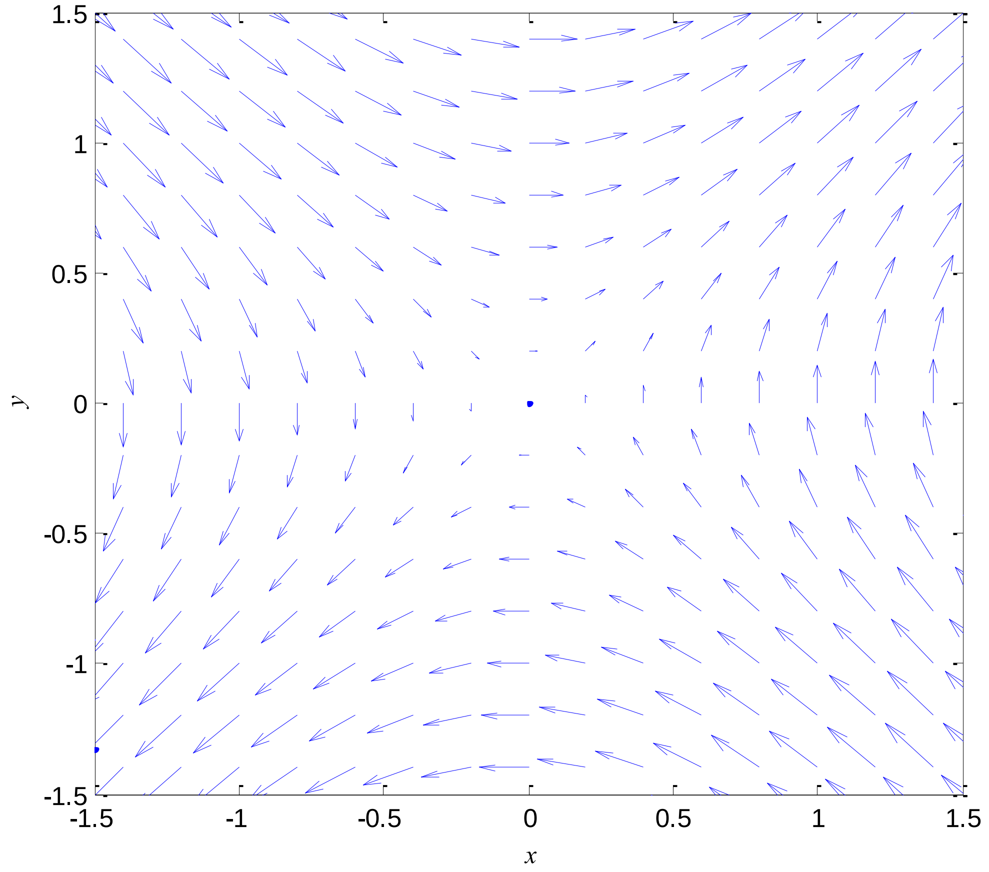
wavepacket.m

```
t = -5:0.0001:5;
y = cos(2*pi*3*t) .* exp( -pi*t.^2 );
figure(1); plot( t-3, y );
xlabel('time $t$', 'Interpreter', 'latex');
ylabel('$s(t)$', 'Interpreter', 'latex');
axis([-2 2 -1 1]);
d = -3:0.05:3;
szD = length(d);
for di = 1:szD
    plot(t+d(di), y );
    xlabel('time $t$', 'Interpreter', 'latex');
    ylabel('$s(t)$', 'Interpreter', 'latex');
    axis([-2 2 -1 1]);
    pause(0.05);
end
```

Exercise: Vector Field

- Plot a vector field corresponding to the following differential equation.

$$\frac{dy}{dx} = \frac{\sin(x)}{\sin(y)}$$



meshgrid

quiver

Sample Solution

- Script and Screenshot

vectorfield.m

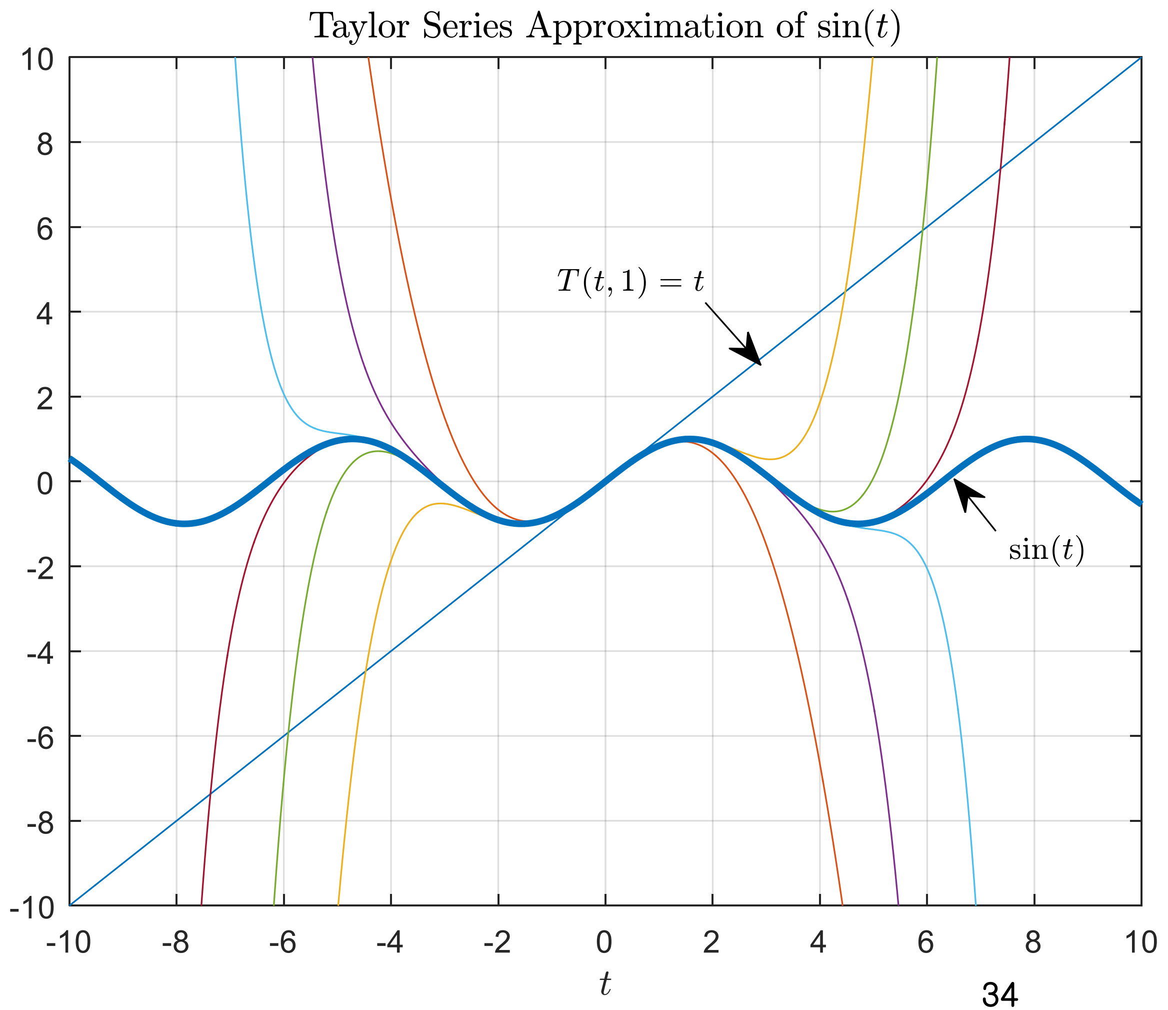
```
[X, Y] = meshgrid(-2:0.2:2);
Dx  = sin(Y);
Dy  = sin(X);
figure(1), quiver(X, Y, Dx, Dy );
R = 1.5;
axis([-1 1 -1 1]*R);
xlabel('$x$', 'Interpreter', 'latex');
ylabel('$y$', 'Interpreter', 'latex');
```

Exercise – Taylor Series

- The Taylor series expansions of $\sin(t)$ may be written as;

$$\sin(t) \cong T(t,N) = \sum_{n=1}^{N} (-1)^{n-1} \frac{t^{2n-1}}{(2n-1)!}$$

- Plot $T(t,N)$ along with $\sin(t)$ for $N = 1 \sim 7$.
- Add annotations and a title, as shown on the right graph.



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Sample Solution

- Script and Screenshot

Taylor_of_sin.m

```
k  = (1:2:13)';
nK = length(k);
s  = (-1).^(0:nK-1);
t  = -10:0.01:10;
nT = length(t);

X  = zeros(nK+1, nT);
x  = s(1) * t .^ k(1) / factorial(k(1));
X(1,:) = x;
for ki=2:nK
    x = s(ki) * t .^ k(ki) ...
        / factorial(k(ki));
    X(ki,:) = X(ki-1,:) + x;
end
X(nK+1,:) = sin(t);
```

```
f = figure(1);
h = plot( t, X' ); set( h(nK+1), 'LineWidth', 2 );
ylim([-10 10] ); grid on;
xlabel( '$t$', 'Interpreter', 'latex' );

title('Taylor Series Approximation of $\sin(t)$', ...
 'Interpreter', 'latex');

annotation(f, 'textarrow', ...
  [0.8 0.77], [0.47 0.52], ...
  'TextEdgeColor','none', ...
  'String',{'$\sin(t)$'}, 'Interpreter', 'latex');
annotation(f,'textarrow', ...
  [0.59 0.63], [0.69 0.63], ...
  'TextEdgeColor','none', ...
  'String',{'$T(t,1)=t$'}, 'Interpreter', 'latex');
```

Summary

- Recognize the following commands?

```
h = plot(x,y,'r-o');
set( h, 'LineWidth',2)
hold on
figure
figure(1)
set(gca, 'Color', 'yellow')
grid
axis square
title('KOSPI');
xlabel('{\it t}');
barh(X)
stem(t,y,'filled')
stairs(x,y)
polar(theta,rho)
box off
pie(data, [0 0 1 0])
patch(x,y,'k');
colormap('Cool')
legend('Theory','Data');
ezplot('cos(x)')
reshape(M,1,[])
repmat(N,2,1)
[s xbin] = hist(X)
```