

MATLAB
Fundamentals
2017
Parts 4, 5 & 6



These notes are derived from several sources (see below) including MathWorks documentation which can be found at <https://uk.mathworks.com/help/matlab/>

B.C. Lowe, An Introduction to Matlab

David F. Griffiths, Dundee University, An Introduction to Matlab,
<http://www.maths.dundee.ac.uk/software/MatlabNotes.pdf>

David Houcque, Northwestern University, Introduction To Matlab For Engineering Students,
<https://www.mccormick.northwestern.edu/documents/students/undergraduate/introduction-to-matlab.pdf>

Other Matlab Resources:

<https://ocw.mit.edu/resources/res-18-002-introduction-to-matlab-spring-2008/lecture-notes/>

Contents

4	Graph Plotting	4
4.1	Graphs from data	4
4.2	Graphs of Functions.	4
4.2.1	using <i>plot</i>	5
4.3	Copying graphs to a Word file.....	6
4.4	Hold	6
4.5	Multiplots and zooming	7
4.6	Improving the look	8
4.7	Subplot	10
4.8	Controlling axes.....	12
4.9	Tabulating functions and graph plotting.....	15
5	Solution of equations in one variable.....	18
6	Least Squares Linear Approximations	23

4 Graph Plotting

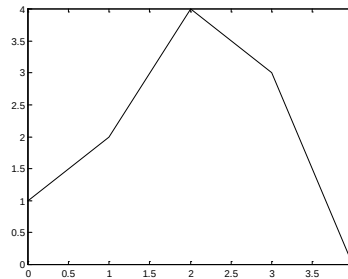
4.1 Graphs from data

We can plot graphs from lists of numbers (called vectors) of equal length.

For example:

```
» clear all  
» x=[0 1 2 3 4];  
» y=[1 2 4 3 0];  
» plot(x,y)
```

The plot command takes these to be the points (0, 1), (1, 2), (2, 4), (3, 3) and (4, 0), plots them and joins them with straight lines, resulting in the graph below.



4.2 Graphs of Functions.

Suppose we wish to plot the graph of $y = x^3 - 6x^2 + 9x$ from $x = 0$ to $x = 4$.

MATLAB does this by calculating the y values at a large number of equally spaced values of x , plotting these points and joining them up with straight lines (as for the data in Section 2.1). We can either use the *plot* command or the *fplot* command.

4.2.1 using *plot*

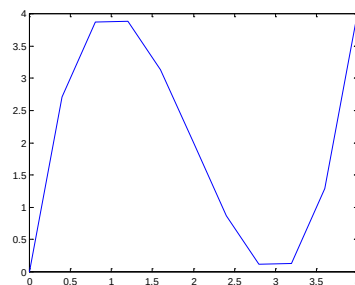
We specify the x values at which the function is to be evaluated and the function itself. Where necessary we must use the array multiplication and power operators `.*` and `.^` rather than `*` and `^`. (See Section 3 for an explanation of these).

If we use too few points the resulting graph is not smooth, as in the first example below. As a rule of thumb use at least 100 points.

We will use $n = 10$ points initially. The values of x are $h = \frac{4-0}{10} = \frac{4}{10} = 0.4$ apart. That

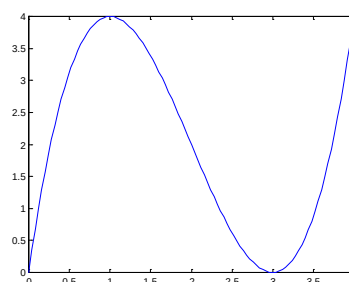
is, we will calculate $y = x^3 - 6x^2 + 9x$ at $x = 0, 0.4, 0.8, \dots, 3.6, 4$, plot the (x, y) points and join them with straight lines. This is achieved with

- » `n = 10; h = 4/n; x = 0:h:4;`
- » `% x=0:h:4 means x goes from 0 to 4 in steps of h = 0.4`
- » `plot(x, x.^3-6*x.^2+9*x)`
- » `% note the . That is, type x.^3 and x.^2, not x^3 and x^2`



It is clear that we need to have far more points to get a smooth curve. Change n to 100.

- » `n = 100; h = 4/n; x = 0:h:4; % now 100 points`
- » `plot(x, x.^3-6*x.^2+9*x)`



4.3 Copying graphs to a Word file

To copy the contents of a graphics window to a Word file:

1. open a Word document
2. in the graphics window click on Edit, then Copy Figure.
3. in the Word file put the cursor on the right page and then click on Paste in the Edit menu (or type Ctrl V). (To get a white, rather than grey, background use Edit Copy Options first).

4.4 Hold

Each time a *plot* command is used previous graphs are lost. This is not convenient if extra graphs need to be added later. To stop a window being cleared:

```
» n = 100;h = 4/n;x = 0:h:4;  
» plot(x, x.^3-6*x.^2+9*x),hold
```

Current plot held

```
» plot(x,sqrt(x))
```

These two, and subsequent, graphs are plotted in the same window. Disable the hold command with

```
» hold off
```

A window can be cleared with

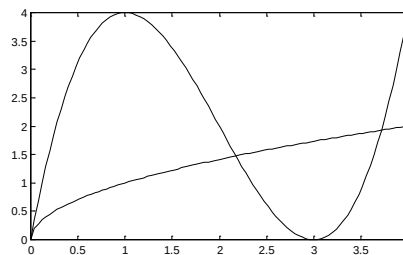
```
» clf
```

4.5 Multiplots and zooming

We will draw the graphs of $y = x^3 - 6x^2 + 9x$ and $y = \sqrt{x}$, and find their point of intersection closest to $x = 2$ correct to 2 decimal places (2D).

Plot both graphs together with the commands

```
» n=100;h=4/n;x=0:h:4;  
» plot(x, x.^3-6*x.^2+9*x), hold  
»                               % or use fplot('x^3-6*x^2+9*x',[0,4])  
» plot(x,sqrt(x))   % or fplot('sqrt(x)',[0,4])
```



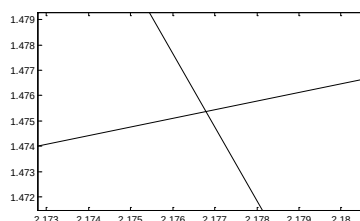
From the graphs, the curves intersect near $x = 2.2$, $y = 1.4$.

We can zoom in on this point with

```
» zoom
```

(When you have finished, the zoom facility can be turned off with **» zoom off**)

Use the mouse to move the arrow near the point of intersection and click the left mouse to zoom in by a factor of 2. Repeat until the graph shown below is obtained. (You can zoom out by a factor of 2 by clicking the right mouse.)



Looking at the scales on the axes, the x coordinate of the point of intersection lies between 2.176 and 2.177 and so is 2.18 correct to 2D. Similarly, the y coordinate is 1.48 to 2D. Hence $y = x^3 - 6x^2 + 9x$ and $y = \sqrt{x}$, intersect at (2.18,1.48) correct to 2D.

Alternative ways of zooming are

- (i) hold down the left mouse and drag to form a rectangle. Releasing the button causes the rectangle to enlarge and fill the window.
- (ii) on the graphing window toolbar click on the zoom icon (third from the right) and then click at the point of interest. Each click scales by a factor of 2.

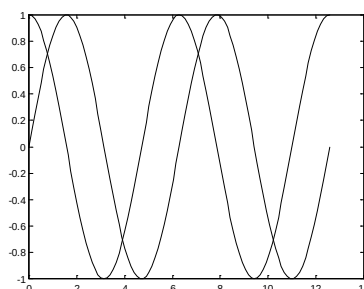
4.6 Improving the look

The presentation of graphs can be improved using different styles and colours for lines, adding a title to the graph, labeling the axes and using a legend to distinguish between graphs. Grids of dotted lines can also be added.

The use of these is illustrated in the following example.

We will plot $y = \sin x$ and $y = \cos x$ over two periods, from $x = 0$ to $x = 4\pi$.

```
» % define 100 points from 0 to 4pi
» n=100;h=4*pi/n;x=0:h:4*pi;
» % plot the basic curves
» plot(x,sin(x),x,cos(x))
```



The default is to plot solid lines. However, there is a third argument in the *plot* command to enable you to choose the line style and colour if you wish. If the sine and cosine graphs were to be printed, different styles would enable you to distinguish between them more easily.

The general format for the Plot command is

» **plot(x,y,'cs')**

where *c* is the colour and *s* the style. Some of the options available are:

colour <i>c</i>		style <i>s</i>	
blue	<i>b</i>	-	solid
cyan	<i>c</i>	--	dashed
green	<i>g</i>	.	point
black	<i>k</i>	:	dotted
magenta	<i>m</i>	+	plus
red	<i>r</i>	x	cross
yellow	<i>y</i>	o	circle

For example,

plot(x,2*x-1,'m-') plots $y = 2x - 1$ with magenta solid lines

plot(x,2*x-1,'bo') plots $y = 2x - 1$ with blue circles

plot(x,2*x-1,'k*-') plots $y = 2x - 1$ with black stars joined with solid lines

Plot the sine and cosine curves with

» **plot(x,sin(x),'r-',x,cos(x),'b+')**

» **% add a title**

```
» title('sine and cosine curves')
```

(The title will be whatever is enclosed in the quotes.)

```
» % label the axes
```

```
» xlabel('x axis'),ylabel('y axis')
```

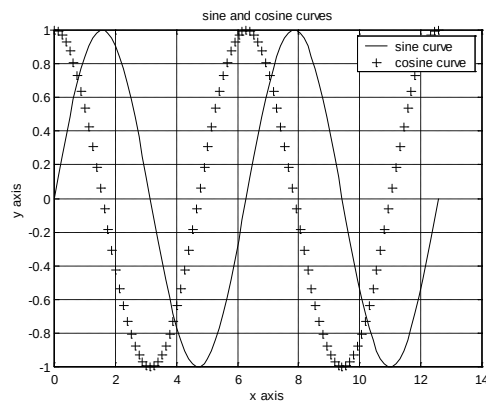
```
» % add a legend
```

```
» legend('sine curve','cosine curve')
```

```
» % add grids
```

```
» grid
```

The final graph should be similar to:



Note. An alternative way of doing all the above is to use the Insert menu in the graphing window.

It is also useful to draw the x and y axes. Do this by clicking on Insert in the toolbar, then Line. Position the cursor + at the origin, hold the left mouse down, move the cursor horizontally to the right hand side of the graph, and release to draw the x axis. You could repeat for the y axis (not necessary here).

4.7 Subplot

The graphics window can be split into a rectangular array of smaller windows into each of which one or more graphs can be plotted.

The windows are counted in rows from the top left. For example, if we wanted 3 rows of 2 windows, the first row would be windows 1, 2, the second row windows 3, 4 and the last

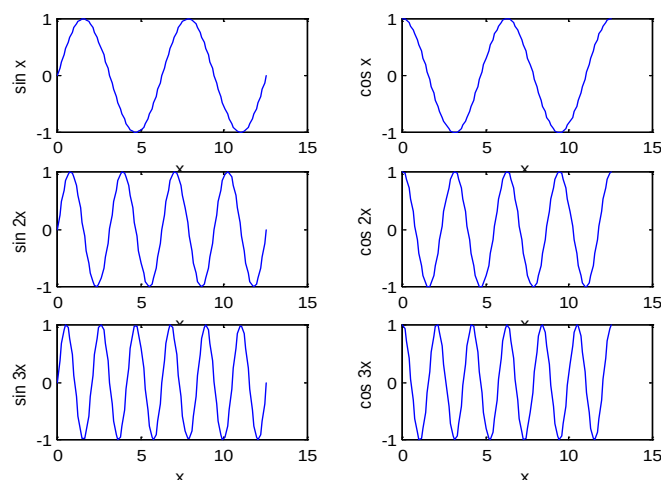
row windows 5, 6. The subplot command takes the form *subplot(abc)*, where *a* is the number of rows, *b* the number in each row and *c* the window number. Hence *subplot(325)* refers to window 5 of an array of 6 windows in 3 rows and 2 columns.

The following commands plot the graphs of $y = \sin x$, $y = \cos x$, $y = \sin 2x$, $y = \cos 2x$, $y = \sin 3x$, $y = \cos 3x$ from $x = 0$ to $x = 4\pi$.

```

» n=100;h=4*pi/n;x=0:h:4*pi;
» subplot(321),plot(x,sin(x))
»           xlabel('x'),ylabel('sin x')
» subplot(322),plot(x,cos(x))
»           xlabel('x'),ylabel('cos x')
» subplot(323),plot(x,sin(2*x))
»           xlabel('x'),ylabel('sin 2x')
» subplot(324),plot(x,cos(2*x))
»           xlabel('x'),ylabel('cos 2x')
» subplot(325),plot(x,sin(3*x))
»           xlabel('x'),ylabel('sin 3x')
» subplot(326),plot(x,cos(3*x))
»           xlabel('x'),ylabel('cos 3x')

```



4.8 Controlling axes

We can change the range of values of x and/or y shown in a graphics window.

The commands

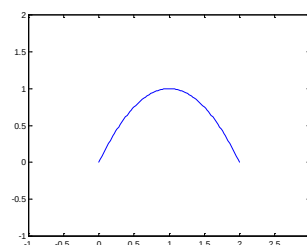
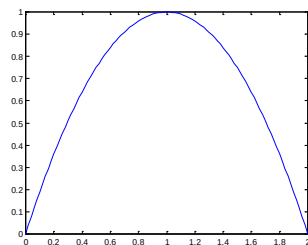
```
» clf;n=100;h=2/n;x=0:h:2;
```

```
» plot(x,2*x-x.^2)
```

produce the window below left. Adding the command

```
» axis([-1,3,-1,2])
```

results in the window below right.



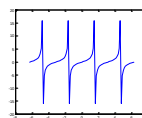
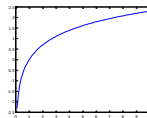
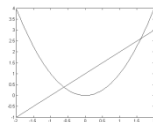
Type » **help axis** to see other options.

Exercise 2

1. Plot straight line segments for
- | x | 0 | 1 | 2 | 3 |
|-----|-----|-----|-----|-----|
| y | 0.8 | 3.2 | 4.9 | 7.1 |

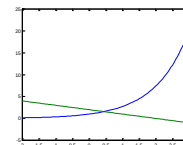
2. Plot, in separate windows, the graphs of

- (i) $x + 1$ and x^2 from $x = -2$ to $x = 2$
- (ii) $\ln x$ from $x = 0$ to $x = 10$
- (iii) $\tan x$ from $x = -2\pi$ to $x = 2\pi$.

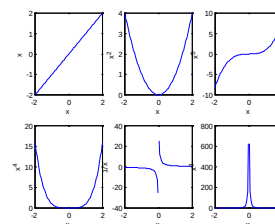


3. Plot, in the same window, e^x and $2 - x$.

Use zoom to show that the point of intersection, correct to 3D, is $(0.443, 1.557)$.



4. Use *subplot* to plot x , x^2 , x^3 , x^4 , $\frac{1}{x}$ and $\frac{1}{x^2}$ from $x = -3$ to $x = 3$.



5. Plot
- | x | 1 | 2 | 3 | 4 | 5 |
|-----|-----|-----|-----|-----|-----|
| y | 6.5 | 2.7 | 1.9 | 2.9 | 6.2 |

and show that $y = x^2 - 6x + 11$ is a good approximation.

6. Plot $y = x^3 - 6x^2 + 13$ and $y = 0$. Confirm that the equation $x^3 - 6x^2 + 13 = 0$ has 3 roots and that the largest root is 5.58, correct to 2D.

7. Plot, in the same window with different styles and colours, and a legend, the graphs of

1.5^x , 2^x , 3^x , 4^x and e^x . Show that e^x lies between 2^x and 3^x and very close to 2.7^x .

8. Show that the graphs of $\sin x + \cos x$, $\sqrt{2} \sin(x + \frac{\pi}{4})$ and $\sqrt{2} \cos(x - \frac{\pi}{4})$ are identical.

Find the smallest positive angle that satisfies the equation $\sin x + \cos x = 0.7$ and show that, to the nearest degree, this is 105° .

9. For the data in question 1, show that the line $y = 2x + 1$ lies reasonably close to the points.

10. The temperature y of a cup of coffee at time t was taken:

t (minutes)	0	5	10	20	30
y (degrees C)	100	74	56	36	27

Plot these points and show that $y = 20 + 80e^{-0.08t}$ is a good approximation to them.

4.9 Tabulating functions and graph plotting

To tabulate $y = 4x - 2$ for values of x from -2 to 4 , calculate the x values as a column vector and then the corresponding y values.

```
» x=[-2:4]';y=4*x-2
```

```
y =
```

```
-10
```

```
-6
```

```
-2
```

```
2
```

```
6
```

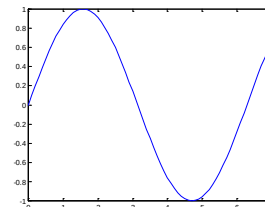
```
10
```

```
14
```

To draw the graph of $y = \sin x$ from $x = 0$ to $x = 7$ we first need to calculate y at a large number of values of x (see Section 2.2). If we want to have an increment of 0.1 there will be 70 x and 70 y values. There is no need to print these so use a semi-colon:

```
» x=[0:0.1:7]';y=sin(x);
```

```
» plot(x,y)
```



Suppose that we wish to obtain a table of values of $y = xe^x$ for $x = 0, 0.25, 0.5, \dots, 1$.

To find y we must multiply each element of the vector x by the corresponding element of the vector e^x .

x	$\times$	e^x	$=$	xe^x
0	$\times$	1	$=$	0
0.25	$\times$	1.2840	$=$	0.3210
0.5	$\times$	1.6487	$=$	0.8244
0.75	$\times$	2.1170	$=$	1.5878
1	$\times$	2.7183	$=$	2.7183

In MATLAB we must use array multiplication (not matrix multiplication).

```
» x=[0:0.25:1]';
```

```
» y=x.*exp(x)
```

```
y =
```

```
0
```

```
0.3210
```

```
0.8244
```

```
1.5878
```

```
2.7183
```

To plot of $y = x^3 - 6x^2 + 9x$ and $y = \sqrt{x}$ from $x = 0$ to $x = 4$ we need array power to obtain x^3 and x^2 .

```
» x=[0:0.1:4];
```

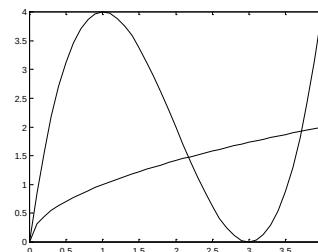
```
» y1=x.^3-6*x.^2+9*x;
```

```
» y2=sqrt(x);
```

```
» plot(x,y1),hold,plot(x,y2)
```

Current plot held

These graphs were also produced later.



Exercise 3

1. Tabulate $y = x + 1 - \cos x$ for values of x from 0 to 4 in steps of 0.5.
2. Plot the graphs of
 - (i) $y = x \cos x$ from $x = 0$ to $x = 100$
 - (ii) $y = e^{-x} \sin 10x$ from $x = 0$ to $x = 5$.

5 Solution of equations in one variable

In this section we will see how MATLAB solves equations in one unknown, which is usually called x . Examples of such equations are

$$\begin{array}{lll} (1) & 2x - 5 = 7 & (2) \quad x^2 - 3x + 2 = 0 \quad (3) \quad 3x^2 = 1 - 5x \\ (4) & x + \frac{1}{x} = 3 & (5) \quad \sin t = 2 - t \quad (6) \quad y = 3\ln(5x - 1) \end{array}$$

The command we will use is *solve*.

Algebraic or symbolic calculations are carried out using the Symbolic Maths Toolbox. We must first declare all variables that will be used as symbolic variables using the command *syms*.

The equation must be written in the form $f(x) = 0$. Of the equations above, (2) is already in this form but (1) and (3) must be written $2x - 5 - 7 = 0$ and $3x^2 + 5x - 1 = 0$ respectively. Similarly for the others.

Example 1

We will solve the equations (1), (2) and (3) above.

```
>> syms x                % defines x as a symbolic variable
>> solve(2*x-5-7)        % notice no " =0 "
ans =
6
>> solve(x^2-3*x+2)
ans =
```

```
[ 1]
[ 2]
>> solve(3*x^2+5*x-1)
ans =
[ -5/6+1/6*37^(1/2)]
[ -5/6-1/6*37^(1/2)]
```

So the equation $2x - 5 = 7$ has solution $x = 6$

$x^2 - 3x + 2 = 0$ has solutions $x = 1$ and $x = 2$

$3x^2 + 5x - 1 = 0$ has solutions $x = \frac{-5 \pm \sqrt{37}}{6}$.

The solution to the last equation is given exactly, but we can use the command *double* to put it in decimal form.

```
>> double(ans)
ans =
0.1805
-1.8471
```

The results are given as the elements of a vector. If we want to refer to the solutions individually in further work we can do so. To call the roots x_1 and x_2 :

```
ans =
0.1805
-1.8471
>> x1=ans(1), x2=ans(2)
x1 =
0.1805
x2 =
-1.8471
```

Example 2

In Section 2.2 we solved, graphically, the equation $x^3 - 6x^2 + 9x = \sqrt{x}$. We can now do it with *solve*.

```
>> solve(x^3-6*x^2+9*x-sqrt(x))  
ans =  
[ .12554518059198278430819923790695e-1]  
[ 2.1767162463141172673883633905468]  
[ 3.7200502387885013371644022991649]  
[ 0]
```

MATLAB has given us all four answers correct to 32 significant figures. The one we found previously was the second of these and rounds to 2.18 correct to 2D, as before.

Warning: Matlab version 2016 and onwards will not reproduce the above result. To overcome this use the command `vpa ( )` as follows:-

```
>> vpa(x^3-6*x^2+9*x-x^(1/2))  
ans =  
9.0*x - 6.0*x^2 - 1.0*x^(1/2) + x^3  
>> solve(ans)  
ans =  
  
0  
  
0.012554518059198278430819923790695  
2.1767162463141172673883633905468  
3.720050238788501337164402299165
```

Example 3

This example illustrates how MATLAB can solve an equation symbolically.

The solution of $x^2 + bx + 3 = 0$ is $x = \frac{-b \pm \sqrt{b^2 - 12}}{2}$. In MATLAB:

```
>> syms x b      % space between x and b
```

```
>> solve(x^2+b*x+3)
```

```
ans =
```

```
[ -1/2*b+1/2*(b^2-12)^(1/2)]
```

```
[ -1/2*b-1/2*(b^2-12)^(1/2)]
```

Example 4

Solve the equations $x + \frac{1}{x} = 3$ and $\sin t = 2 - t$.

```
>> solve(x+1/x-3)
```

```
ans =
```

```
[ 3/2+1/2*5^(1/2)]
```

```
[ 3/2-1/2*5^(1/2)]
```

```
>> double(ans)
```

```
ans =
```

```
2.6180
```

```
0.3820
```

```
>> syms t
```

```
>> double(solve(sin(t)-2+t)) % commands can be nested
```

```
ans =
```

```
1.1061
```

The solutions of $x + \frac{1}{x} = 3$ are $x = 2.6180, 0.3820$.

The solution of $\sin t = 2 - t$ is $t = 1.1061$.

Example 5

This example illustrates how we can solve for one variable in terms of another (rearrange an equation).

Rearrange the equations $y = 3x - 9$, $y = 2\ln(5x - 4)$ and $y = e^{3x} + 1$ as $x = \dots$

```
>> syms x1 x2 x3 y
>> x1=solve(y-3*x1+9), x2=solve(y-2*log(5*x2-4)),
>> x3=solve(y-exp(3*x3)-1)

x1 =
1/3*y+3
x=2
1/5*exp(1/2*y)+4/5
x=3
1/3*log(y-1)
```

Exercise 4

1. Solve the following equations.

$$\begin{array}{lll} \text{(i)} & 1 + 5x = 2x + 16 & \text{(ii)} \quad x^2 - 5x + 6 = 0 \quad \text{(iii)} \quad 2x^2 - 7x + 2 = 0 \quad \text{(iv)} \\ & e^{x^2-4} = 100 & \text{(v)} \quad \sin x = 1 - x \quad \text{(vi)} \quad e^x = 8 - 3x \end{array}$$

2. Solve the following equations in terms of a .

$$\text{(i)} \quad x^3 + 4ax^2 + x = 0 \quad \text{(ii)} \quad \sin(ax) = 0.5$$

3. Rearrange the following equations for $x = \dots$

$$\begin{array}{ll} \text{(i)} & y = 2\cos\left(x + \frac{\pi}{2}\right) \quad \text{(ii)} \quad y = \tan^{-1}(3x - 1) \\ \text{(iii)} & y = 20 + 80e^{-0.02x} \quad \text{(iv)} \quad y = 2x^2 + x^4 \end{array}$$

4. (i) Show that the sum of the two roots of the equation $x^2 = x + 1$ is 1.

(ii) Show that the product of the three roots of the equation $x^3 - 6x^2 + 13 = 0$ is

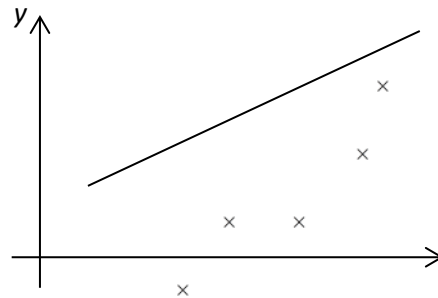
6 Least Squares Linear Approximations

Given a set of experimental (x, y) values, we want to find the best straight line that approximates the data.

That is find m and c so that the line $y = mx + c$ fits the points as well as possible.

The technique used to find m and c is called Least Squares.

Example 1



Find the least squares straight line approximation to

x	0.5	1.3	2.5	3.8
y	1.8	4.1	4.6	7.9

1. input the x and y values as row vectors

```
>> x=[0.5 1.3 2.5 3.8];
```

```
>> y=[1.8 4.1 4.6 7.9];
```

2. Use the command *polyfit* to find m and c . The command below finds m and c as the elements of a row vector p .

```
>> p=polyfit(x,y,1)
```

$p =$

```
1.6845    1.1890
```

so the equation of the line is $y = 1.6845x + 1.1890$.

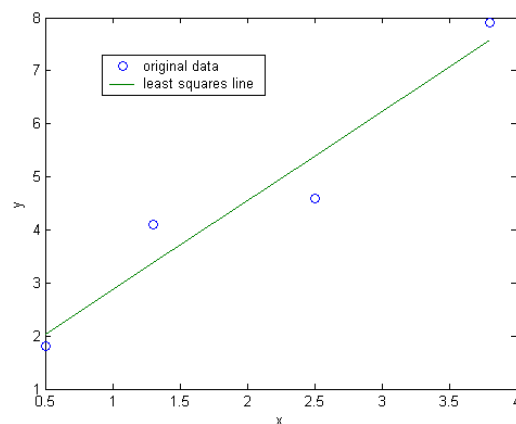
3. Use *polyval* to calculate the *y* values according to the least squares line (called *yfit*) and draw the graphs of the original points and the line.

```
>> yfit=polyval(p,x)
```

```
yfit =
```

```
2.0312    3.3788    5.4001    7.5899
```

```
>> plot(x,y,'o',x,yfit)
```



```
>> % use Insert menu for labels and legend
```

4. We can use the line to estimate *y* at different values of *x*.

```
>> y1=polyval(p,2)    % finds y at x=2
```

```
y1 =
```

```
4.5579
```

```
>> y2=polyval(p,3.2)    % finds y at x=3.2
```

```
y2 =
```

```
6.5792
```

so $y(2) \approx 4.5579$ and $y(3.2) \approx 6.5792$.

5. We can compare the actual and computed values of *y*:

```
>> diff=y-yfit
```

```
diff =
```

-0.2312 0.7212 -0.8001 0.3101

6. We can use the line to estimate x for a given y value.

```
>> syms x
```

```
>> solve(1.6845*x+1.1890-6) % to find x when y=6
```

```
ans =
```

```
9622/3369
```

```
>> double(ans)
```

```
ans =
```

```
2.8560
```

so when $y = 6$, $x = 2.8560$.

If the equation connecting x and y is not linear, it must first be converted to straight line form. The next example illustrates this.

Example 2

The temperature θ °C at time t minutes of a cup of coffee above room temperature is given by the formula $\theta = ae^{bt}$. θ was measured at different times t .

t	0	5	10	20	30
θ	80	50	30	10	5

Find a and b using least squares.

Take logs to convert $\theta = ae^{bt}$ to straight line form.

Then $\ln \theta = \ln a + \ln(e^{bt}) = \ln a + bt = bt + \ln a$ and so the graph of $\ln \theta$ against t will be a straight line.

Comparing $\ln \theta = bt + \ln a$ with $y = mx + c$ we need $y = \ln \theta$ and $x = t$.

The gradient of the least squares line is $m = b$ and the intercept $c = \ln a \Rightarrow a = e^c$.

```

>> % input given data and prepare new x y data
>> % original data
>> t=[0 5 10 20 30];
>> theta=[80 50 30 10 5];

>> % new data
>> x=t % no change in t needed
x =
    0    5   10   20   30
>> y=log(theta)
y =
    4.3820    3.9120    3.4012    2.3026    1.6094

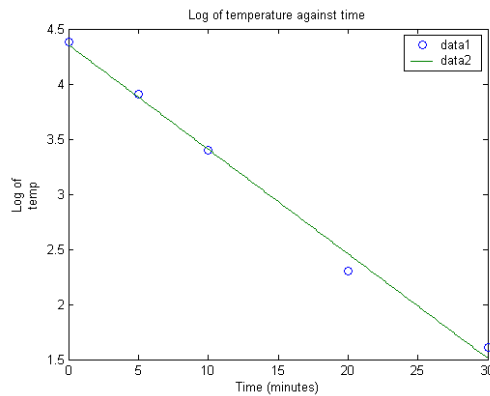
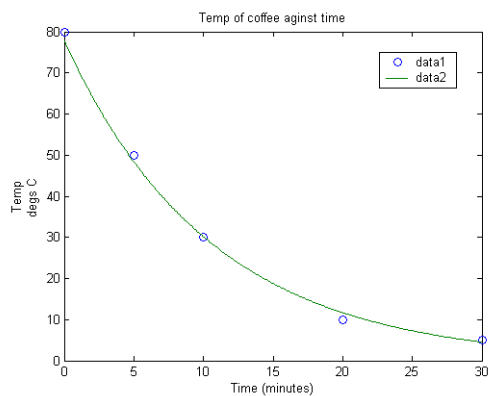
>> % find least squares line
>> p=polyfit(x,y,1)
p =
   -0.0948    4.3539
>> % p=[p(1) p(2)]=[c m]

>> % find a and b
>> b=p(1),a=exp(p(2))
b =
   -0.0948
a =
    77.7839

```

Rounding to 2S, the equation is $\theta = 78e^{-0.095t}$.

```
>> % plot data and theta against t
>> % to get smooth curve define t1 (300 points)
>> t1=0:0.1:30;
>> plot(t,theta,'o',t1,a*exp(b*t1))
>> % see left graph below
>> % plot straight line forms of data and curve
>> plot(t,log(theta),'o',t1,p(1)*t1+p(2))
>> % see right hand graph below
```



Exercise 5

- The table gives the speed v of a car at time t .

t	1	2	3	4	5
v	33	38	42	46	49

v and t are related by the equation $v = at + b$, where a and b are constants.

- Input the data and use *polyfit* to find the best fit values of a and b .

$$[v = 29.6 + 4t]$$

- (ii) Use *polyval* to find the estimated values of v .
- (iii) Draw a graph showing the data and the least squares straight line.

2. The table gives the distance s traveled by the car in question 1 in terms of the time t taken.

t	1	2	3	4	5
s	32	67	107	150	198

s and t are related by the equation $s = at + bt^2$, where a and b are constants.

- (i) Input the data and plot s against t . You will not get a straight line as $s = at + bt^2$ is a parabola.
- (ii) Divide by t to convert the equation to straight line form.

Then $\frac{s}{t} = a + bt$. This is of the form $y = mx + c$.

- (iii) Find the transformed data using $x = t$ and $y = \frac{s}{t}$ (remember to use array division, that is type $s./t$) and use *polyfit* to find a and b .
 $[s = 29.89t + 1.92t^2]$
- (iv) Use *polyval* to find the estimated values of y and s (*yfit* and *sfit*) and plot
 - (a) the straight line forms of data and curve.
 - (b) the actual data and fitted parabola.

3. The surface area s of rust on a metal plate at time t was measured.

t	2	3	4	5	6	7	8
s	2.34	2.75	3.16	3.63	4.16	4.79	5.62

s and t are related by $s = ae^{bt}$. Estimate a and b and draw suitable graphs of the data and approximation.