9. Other Operations on Vectors

MATLAB has a large number of built-in functions. You will only become familiar with them by using them.

Try to make the vector **v** in command window and use the functions below.

v=[23 0 3 16 -8 13]

length(v) number of elements in v.

6

size(v) size of matrix v (raw, column).

1 6

find(v) finds indices of non-zero elements.

1 3 4 5 6

find(v==0) finds indices of elements equal to zero.

2

find(v==16) finds indices of elements equal to 16.

4

find(v>7) finds indices of elements greater than 7.

1 4 6

v(find(v>7)) finds the values of elements greater than 7.

23 16 13

sum(v) sum of elements

47

max(v) maximum element.

23

min(v) minimum element.

-8

mean(v) mean of elements.

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7.8333

sort(v) sorts elements from minimum to maximum value.

-8 0 3 13 16 23

all(v) equal to 1 if all elements nonzero, 0 if any element nonzero.

0

abs(v) vector with absolute value of all element

23 0 3 16 8 13

Exercise 1:

Write a program to calculate average density, conductivity and specific heat for water in the range of temperatures from 0 to 50 C . Knowing that this parameters for water are a function of temperature such as the following equations.

The Density

$\rho = 1200.92 - 1.0056\ T_K{}^o + 0.001084 * (T_K{}^o)^2$

The condactivity

$K = 0.34 + 9.278 * 10^{-4}\ .T_K{}^o$

The Specific heat

$C_P = 0.015539\ (T_K{}^o - 308.2)^2 + 4180.9$

Note: take 11 point of temperatures

Solution:

```
T=[0:5:50]+273;
p= 1200.92 - 1.0056*T+ 0.001084 * T.^2;
Kc = 0.34 + 9.278 * 10^-4 *T;
Cp = 0.015539*(T - 308.2).^2 + 4180.9;
Average_density=mean(p)
Average_conductivity=mean(Kc)
Average_specificheat=mean(Cp)
```

Gives the results

```
Averagedensity =
   997.7857
Averageconductivity =
   0.6165
Averagespecificheat =
   4.1864e+003
```

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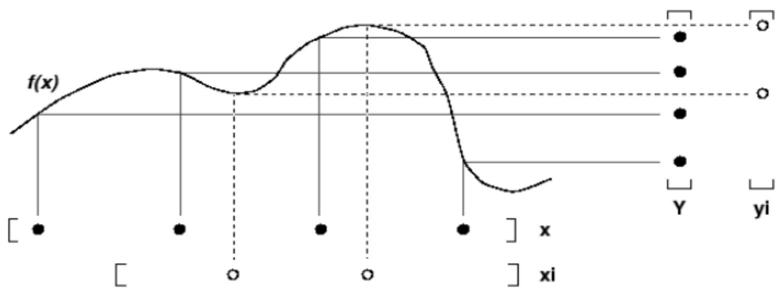
10. Polynomial Interpolation

The command interp1 interpolates between data points. It finds values at intermediate points, of a one-dimensional function that underlies the data. This function is shown below, along with the relationship between vectors x, y, xi, and yi.



Interpolation is the same operation as table lookup. Described in table lookup terms, the table is [x,y] and interp1 looks up the elements of xi in x, and, based upon their locations, returns values yi interpolated within the elements of y. Syntax yi = interp1(x,y,xi) where xi may be single element or a vector of elements.

Exercise 2:

The vapor pressures of 1-chlorotetradecane at several temperatures are tabulated here.

T (^oC)	98.5	131.8	148.2	166.2	199.8	215.5
P*(mmHg)	1	5	10	20	60	100

Calculate the value of vapor pressure corresponding to 150 ^oC?

Solution:

T= [98.5 131.8 148.2 166.2 199.8 215.5];

P= [1 5 10 20 60 100];

Pi=interp1 (T, P, 150)

The result will be:

Pi=

11.0000

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Exercise 3:

The heat capacity of a gas is tabulated at a series of temperatures:

T (°C)	20	50	80	110	140	170	200	230
Cpj/mol.°C	28.95	29.13	29.30	29.48	29.65	29.82	29.99	30.16

Calculate the values of heat capacity corresponding to 30, 70, 100 and 210 °C.

Solution:

T= [20 50 80 110 140 170 200 230];

P= [28.95 29.13 29.30 29.48 29.65 29.82 29.99 30.16];

Pv=interp1 (T, P, [30 70 100 210])

The results will be

Pv =

29.0100 29.2433 29.4200 30.0467

11.Polynomials in Matlab

The equation $p(x) = a_n x^n + a_{n-1} x^{n-1} + \cdot\cdot\cdot + a_1 x + a_0$ is called a polynomial in x. The terms of this polynomial are arranged in descending powers of x while the ai's are called the coefficients of the polynomial and are usually real or complex numbers. The degree of the polynomial is n (the highest available power of x).

In Matlab, a polynomial is represented by a vector. To create a polynomial in Matlab, simply enter each coefficient of the polynomial into the vector in descending order (from highest-order to lowest order). Let's say you have the following polynomial:

$y=x^4+3x^3-15x^2-2x+9$

To enter this polynomial into Matlab, just enter it as a vector in the following manner:

y = [1 3 -15 -2 9]

Also to represent the polynomial $y=2x^3 + 2x^2 + 4x + 1$.

y = [2 2 4 1];

Matlab can interpret a vector of length n+1 as an n^{th} order polynomial. Thus, if your polynomial is missing any coefficients, you must enter zeros in the appropriate place in the vector. For example, $p(x) = x^6-2x^4-x^3+2x^2+5x-8$ is a polynomial that is arranged in descending powers of x. The coefficients of the polynomial are 1, 0, −2, −1, 2, 5, and −8. In this case, there is an understood term of x^5. However, Matlab doesn't "understand" that a term is missing unless you explicitly tell it so.

For other example, the polynomial $y=x^4+1$ would be represented in Matlab as:

y = [1 0 0 0 1]

12. Roots

To calculate the roots of a polynomial, enter the coefficients in an array in descending order. Be sure to include zeroes where appropriate.

For example to find the roots of the polynomial y= x4 + 6x3 + 7x2 - 6x - 8 = 0 type the command:

```
p = [ 1 6 7 -6 -8 ];
r = roots(p)
```

yields

```
r =
        -4.0000
        -2.0000
        -1.0000
         1.0000
```

Note: The coefficients could be entered directly in the roots command. The same answer as above would be obtained using the following expression.

```
r = roots([ 1 6 7 -6 -8 ])
r =
  -4.0000
   1.0000
  -2.0000
  -1.0000
```

For example finding the roots of $y=x^4+3x^3-15x^2-2x+9=0$ would be as easy as entering the following command;

```
r=roots([1 3 -15 -2 9])
r =
  -5.5745
   2.5836
  -0.7951
   0.7860
```

13. PolyVal

You can use polyval and the fitted polynomial p to predict the y value of the data you've fitted for some other x values. The syntax for determining the value of a polynomial $y=x^4 + 6x^3 + 7x^2 - 6x - 8$ at any point is as follows.

```
p = [ 1 6 7 -6 -8 ];
y=polyval(p,3
y=

      280
```

Where p is the vector containing the polynomial coefficients, (see above). Similarly, the coefficients can be entered directly in the polyval command.

```
y = polyval([1 6 7 -6 8],3)
y =

      280
```

The polynomial value at multiple points (vector) can be found.

```
z = [ 3 5 7];
```

y=polyval(p,z

y =

2801512 4752

14. Polyfit

To determining the coefficients of a polynomial that is the best fit of a given data you can use **polyfit** command. The command is **polyfit(x, y, n),** where x, y are the data vectors and 'n' is the order of the polynomial for which the least-squares fit is desired.

Exercise 4:

Fit x, y vectors to 3 rd order polynomial

x = [1.0 1.3 2.4 3.7 3.8 5.1];

y = [-6.3 -8.7 -5.2 9.5 9.8 43.9];

coeff = polyfit(x,y,3)

coeff =

0.3124 1.5982 -7.3925 -1.4759

After determining the polynomial coefficients, the **polyval** command can be used to predict the values of the dependent variable at each value of the independent variable.

ypred = polyval(coeff,x)

ypred =

-6.9579 -7.6990 -5.6943 8.8733 10.6506 43.8273

Its clear that there is a deviation between the actual y points and predicted y points because that the polynomial is best fit to this actual points.

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Exercise 5:

Fit the following data describing the accumulation of species A over time to a second order polynomial, then by using this polynomial, predict the accumulation at 15 hours.

Time (hr)	1	3	5	7	8	10
Mass A acc.	9	55	141	267	345	531

Solution: First, input the data into vectors, let:

a = [9, 55, 141, 267, 345, 531];

time = [1, 3, 5, 7, 8, 10];

Now fit the data using polyfit

coeff = polyfit(time,a,2)

coeff =

5.0000 3.0000 1.0000

So, Mass A = $5*(time)^2 + 3 * (time) + 1$

Therefore to calculate the mass A at 15 hours

MApred = polyval(coeff,15)

MApred =

1.1710e+003

Exercise 6:

Fit the following vapor pressure vs temperature data in fourth order polynomial. Then calculate the vapor pressure when T=100 ^{O}C.

Temp (C)	-36.7	-19.6	-11.5	-2.6	7.6	15.4	26.1	42.2	60.6	80.1
Pre. (kPa)	1	5	10	20	40	60	100	200	400	760

Solution:

vp = [1, 5, 10, 20, 40, 60, 100, 200, 400, 760];

T = [-36.7, -19.6, -11.5, -2.6, 7.6, 15.4, 26.1, 42.2, 60.6, 80.1];

p=polyfit(T,vp,4)

pre= polyval(p,100)

the results will be:

p =

0.0000 0.0004 0.0360 1.6062 24.6788

pre =

1.3552e+003

Exercise 7:

The calculated experimental values for the heat capacity of ammonia are:

T (C)	Cp (cal /g.mol C)
0	8.371
18	8.472
25	8.514
100	9.035
200	9.824
300	10.606
400	11.347
500	12.045

1. Fit the data for the following function

$$Cp = a + bT + CT^2 + DT^3$$

Where T is in C

2. Then calculate amount of heat Q required to increase the temperature of 150 mol/hr of ammonia vapor from 0 C to 200 C if you know that:

$$Q = n \int_{Tin}^{Tout} Cp\,dt$$

Solution:

```
T=[0,18,25,100,200,300,400,500]
Cp=[8.371, 8.472, 8.514, 9.035, 9.824, 10.606, 11.347, 12.045]
P=polyfit(T,Cp,3)
n=150;
syms t
Cpf=P(4)+P(3)*t+P(2)*t^2+P(1)*t^3;
Q= n*int(Cpf, 0,200)
  2.7180e+005
```