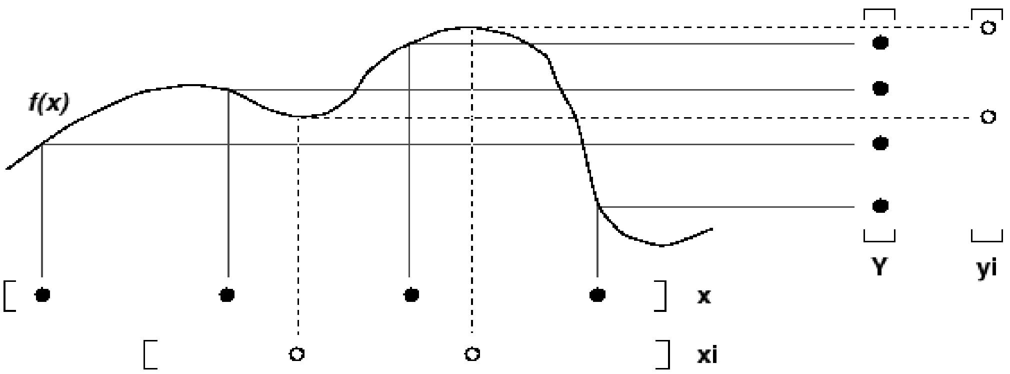
Interpolation

1. One-Dimensional 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 1:

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
```

Exercise 2:

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];
CP= [28.95 29.13 29.30 29.48 29.65 29.82 29.99 30.16];
Xi=[30 70 100 210];
CPi=interp1 (T, CP,Xi)
```

The results will be

```
Pv =
 29.0100   29.2433   29.4200   30.0467
```

Exercise 3:

Chemical engineer, as well as most other engineers, uses thermodynamics extensively in their work. The following polynomial can be used to relate specific heat of dry air, C_p KJ/(Kg K), to temperature (K):

C_p= 0.994 +1.617×10^{-4}T+9.7215×$10^{-8}$$T^2$ – 9.5838 × 10^{-11} T^3 + 1.9520 × 10^{-14} T^4

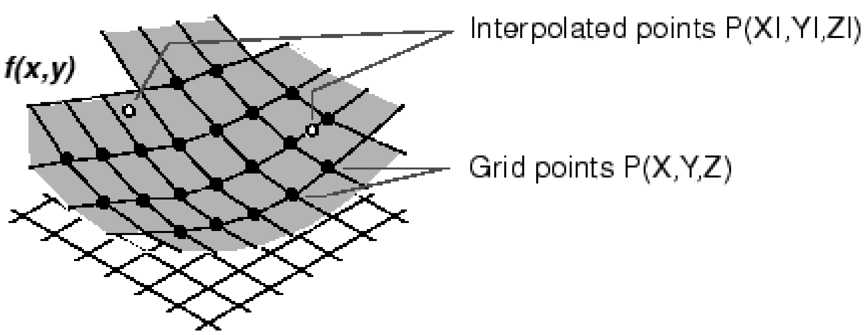
Determine the temperature that corresponds to a specific heat of 1.2 KJ/(Kg K).

Solution:

```
T=10:10:10000;
Cp=0.99403+1.617e-4*T+9.7215e-8*T.^2-9.5838e-11*T.^3+1.9520e-14*T.^4;
Ti=interp1(Cp,T,1.2)
```

2.Two-Dimensional Interpolation

The **interp2** command performs two-dimensional interpolation between data points. It finds values of a two-dimensional function underlying the data at intermediate points>



Its most general form is:

```
Zi = interp2(X, Y, Z, Xi, Yi)
Zvector = interp2(X, Y, Z, Xvector, Yvector)
```

Note: the number of elements of the X vector and Z matrix rows must be the same, while the number of elements of the Y vector and Z matrix columns must be the same.

Exercise 4:

Calculate the values of z corresponding to (x,y)=(1.3, 1.5) and (1.5,2.3) from data as following:

x=1, 2

y= 1, 2, 3

z = 10 20

40 50

70 80

Solution

```
x = [1 2];
y = [1 2 3];
z = [10 20; 40 50; 70 80];
z1 = interp2(x,y,z,1.3,1.5)
```

The results will be

```
z1 =
   28
```

To interpolate a vector of x, y points repeat the same code with small change:

```
z12 = interp2(x,y,z,[1.3,1.5],[1.5,2.3])
z12 =
   28   54
```

Practice Problems

1) Given the following experimental data:

Flow rate (q, m3/s)	1	2	3	4	5	6
Temperature (T, ^oC)	2.2	7.8	13.9	27.8	41.2	62.1

Find the temperature for q = 2.5, 3.5, 4.5;

2) The volume V of liquid in a spherical tank of radius r is related to the depth h of the liquid by $V = \frac{\pi h^2 (3r-h)}{3}$ determine h given r=1 m and V=0.5 m^3.

3) A liquid mixture of benzene and toluene is in equilibrium with its vapor in closed system. At what temperature would the vapor phase composition of both benzene and toluene 50% at equilibrium, given that the pressure in closed container is 1.4 atm?

$$P^o_{benzene} = \exp\left(10.4 - \frac{3740}{T + 5.8}\right)$$

$$P^o_{Toluene} = \exp\left(9.0 - \frac{3500}{T+10}\right)$$ Where: P^o in atm and T in K.

4) The friction factor f depends on the Reynolds number Re for turbulent flow in smooth pipe according to the following relationship.

$$\frac{1}{\sqrt{f}} = -0.40 + \sqrt{3}\ln(\text{Re}\sqrt{f})$$

Write required code to compute **f** for Re = 25200, using ***interp1*** command.

5) Use **interp2** to calculate the enthalpy, internal energy and specific volume of superheated steam when pressure is 2 bar ant temperature is 120 ^{o}C.

P(bar) ($T_{sat.}$ °C)		Sat'd Water	Sat'd Steam	Temperature (°C)→ 50	75	100	150	200	250	300	350
0.0	$\hat{H}$	—	—	2595	2642	2689	2784	2880	2978	3077	3177
(—)	$\hat{U}$	—	—	2446	2481	2517	2589	2662	2736	2812	2890
	$\hat{V}$	—	—	—	—	—	—	—	—	—	—
0.1	$\hat{H}$	191.8	2584.8	2593	2640	2688	2783	2880	2977	3077	3177
(45.8)	$\hat{U}$	191.8	2438.0	2444	2480	2516	2588	2661	2736	2812	2890
	$\hat{V}$	0.00101	14.7	14.8	16.0	17.2	19.5	21.8	24.2	26.5	28.7
0.5	$\hat{H}$	340.6	2646.0	209.3	313.9	2683	2780	2878	2979	3076	3177
(81.3)	$\hat{U}$	340.6	2484.0	209.2	313.9	2512	2586	2660	2735	2811	2889
	$\hat{V}$	0.00103	3.24	0.00101	0.00103	3.41	3.89	4.35	4.83	5.29	5.75
1.0	$\hat{H}$	417.5	2675.4	209.3	314.0	2676	2776	2875	2975	3074	3176
(99.6)	$\hat{U}$	417.5	2506.1	209.2	313.9	2507	2583	2658	2734	2811	2889
	$\hat{V}$	0.00104	1.69	0.00101	0.00103	1.69	1.94	2.17	2.40	2.64	2.87
5.0	$\hat{H}$	640.1	2747.5	209.7	314.3	419.4	632.2	2855	2961	3065	3168
(151.8)	$\hat{U}$	639.6	2560.2	209.2	313.8	418.8	631.6	2643	2724	2803	2883
	$\hat{V}$	0.00109	0.375	0.00101	0.00103	0.00104	0.00109	0.425	0.474	0.522	0.571
10	$\hat{H}$	762.6	2776.2	210.1	314.7	419.7	632.5	2827	2943	3052	3159
(179.9)	$\hat{U}$	761.5	2582	209.1	313.7	418.7	631.4	2621	2710	2794	2876
	$\hat{V}$	0.00113	0.194	0.00101	0.00103	0.00104	0.00109	0.206	0.233	0.258	0.282