# Question 1 :
# Synthesis of 4 bar Mechanism using Freudenstein's Equation

**X** is Matrix of Inputs for Precision Points

**Y** is Matrix of Outputs of Precision Points

**Phi** is Input Angle Matrix

**Shi** is Output Angle Matrix

**K** is Freudenstein Equation's Constant

**L** is Length Matrix of the Mechanism with L1 as known Quantity

```
clear
% Constants
del_x = 2;
del_y = 4;
del_phi = deg2rad(45);
del_shi = deg2rad(90);
R_phi = del_phi/del_x;
R_shi = del_shi/del_y;

pp =3; % Number of Precision Points
```

## Chebyshev Spacing

```
xo =0;
X = zeros(1,3);
for  j = 1:3

    diff_j = (del_x/2)*(1 - cos( (pi*(2*j - 1))/(2*pp) ) );
    xj = xo + diff_j;
    X(1,j) = xj;
    xo = xj;
end

Y = zeros(1,3);
for j = 1:3
    Y(1,j) = X(1,j)^2;
end

% Initial Condition
phi1 = deg2rad(10) ;
shi1= deg2rad(20)  ;

phi = [phi1 0 0];
shi = [shi1 0 0];
```

```
for j = 2:3
     phi(1,j) = R_phi*(X(1,j)-X(1,j-1)) + phi(1,j-1);
     shi(1,j) = R_shi*(Y(1,j)-Y(1,j-1)) + shi(1,j-1);
end
```

## Freudenstein's Equation

```
S = sym('K',[1,3]);
C = ones(3,3);
for j=1:3
    C(1,j) = cos(phi(j));
    C(2,j) = -cos(shi(j));
end

D = zeros(3,1);
for j = 1:3
    D(j,1) = cos(phi(1,j) - shi(1,j));
end

EQn = (S*C)' == D;
[s1 , s2 , s3] = solve(EQn,S);
K1 = vpa(s1);K2 = vpa(s2) ; K3 = vpa(s3);
K = [K1 K2 K3];
```

### Synthesis of Mechanism

Lengths calculated for L1 as 10 and 20 units

```
l1 = 5;
l2 = l1./K2;
l4 = l1./K1;
l3 = sqrt(-(2.*l2.*l4.*K3) + l2.^2 + l4.^2 + l1.^2);
L = [l1 l2 l3 l4]'
```

L =

$$\begin{pmatrix} 5 \\ -0.80265894803527656728127542215377 \\ 4.5993204555168615241153581596362 \\ -0.41480004001362929237831392492186 \end{pmatrix}$$

### Plot of Mechanism

```
OA = [ 0 ; 0 ];
OB = [l1 ;0];
B = OB + [l2*cos(phi(1)) ; l2*sin(phi(1))];
A = B + [l3*cos(phi(2)) ; l3*sin(phi(2))];

line([OA(1) OB(1)],[OA(2) OB(2)]);
hold on
line([OB(1) B(1)] , [OB(2) B(2)]);
line([B(1) A(1)],[B(2) A(2)]);
line([A(1) OA(1)],[A(2) OA(2)]);
hold off
```

```
grid on
title(' Plot / Drawing of Mechanism')
```