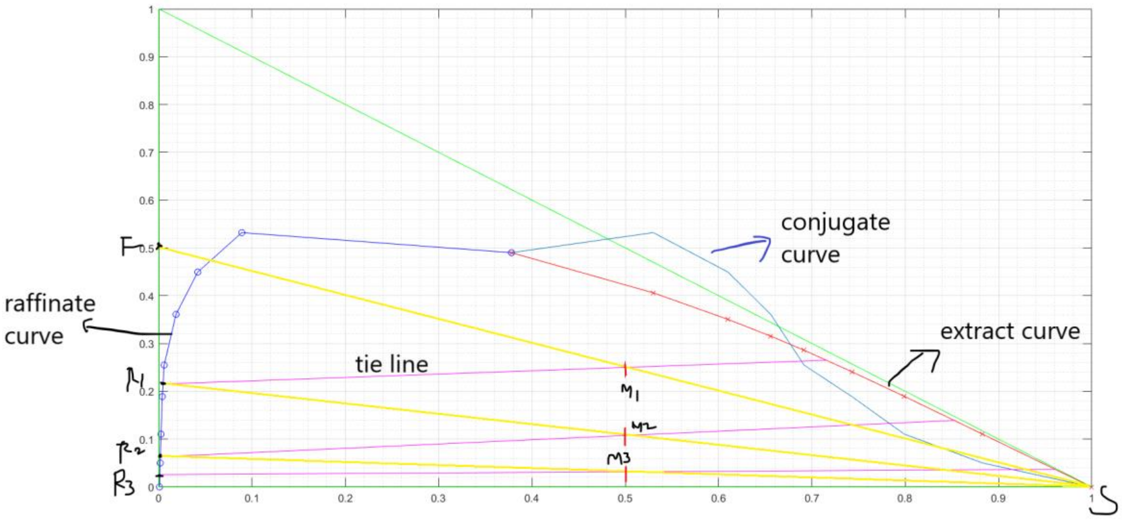
Question 1

Stepping process

X coordinate- composition of **chlorobenzene**

Y coordinate- composition of **Pyridine**



Code

```
clear; close all;
%% Equilibrium Data
a_e = [0,11.05,18.95,24.1,28.6,31.55,35.05,40.6,49]*0.01;
c_e = 0.01*[0.05 0.67 1.15 1.62 2.25 2.87 3.95 6.4 13.2];
s_e = 0.01*[99.95 88.28 79.9 74.28 69.15 65.58 61 53 37.8];
a_r = 0.01*[0 5.02 11.05 18.9 25.5 36.1 44.95 53.2 49];
s_r = 0.01*[0.08 0.16 0.24 0.38 0.58 1.85 4.18 8.9 37.8];
c_r = 0.01*[99.92 94.82 88.71 80.72 73.92 62.05 50.87 37.9 13.2];
plot(s_e,a_e,'red',s_r,a_r,'blue',s_e,a_e,'rx',s_r,a_r,'bo');
hold on;
plot([0,1],[0,0],'green',[0,0],[0,1],'green',[1,0],[0,1],'green');
% %Plotting the tie lines
% for i = 1:9
%     plot([s_r(i),s_e(i)],[a_r(i),a_e(i)],'m');
% end
grid on;grid minor;
rx = spline(a_r(1:8),s_r(1:8));
ey = spline(s_e(1:8),a_e(1:8));
%% conjugate curve
cc_y = spline(s_e,a_r);
plot(s_e,a_r);
cc_x = spline(a_r(1:8),s_e(1:8));
%% Feed data
mF1 = 2000;
yF1 = 0.5;
yS = 0;
```

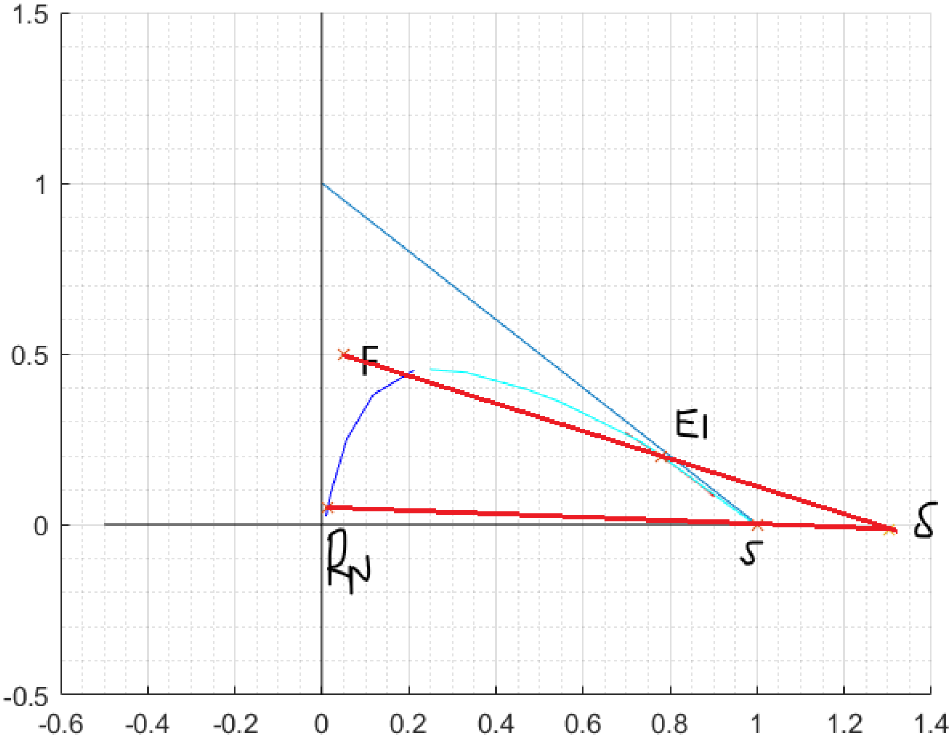
```matlab
S1 = mF1;
%% Mixing point 1
yM = yF1/2;
xM = 0.5;%Always
plot(xM,yM,'+');
sol = fsolve(@(x) cctie(x,xM,yM,rx,ey,cc_y),0.6);
[xR1,yR1,xE1,yE1] = endpts(sol,rx,ey,cc_y);
plot([xR1,xE1],[yR1,yE1],'m',0,yF1,'x');
%% Stage 2
yM2  = yR1/2;
plot(xM,yM2,'r+');
sol2 = fsolve(@(x) cctie(x,xM,yM2,rx,ey,cc_y),0.7);
[xR2,yR2,xE2,yE2] = endpts(sol2,rx,ey,cc_y);
plot([xR2,xE2],[yR2,yE2],'m');
%% Stage 3
yM3  = yR2/2;
plot(xM,yM3,'r+');
sol2 = fsolve(@(x) cctie(x,xM,yM3,rx,ey,cc_y),0.7);
[xR3,yR3,xE3,yE3] = endpts(sol2,rx,ey,cc_y);
plot([xR3,xE3],[yR3,yE3],'m');
% %% Stage 4
% yM3  = yR3/2;
% plot(xM,yM3,'r+');
% sol2 = fsolve(@(x) cctie(x,xM,yM3,rx,ey,cc_y),0.7);
% [xR3,yR3,xE3,yE3] = endpts(sol2,rx,ey,cc_y);
% plot([xR3,xE3],[yR3,yE3],'m');
%% mass balance
raff_m = zeros(1,3)+mF1;
R = mF1;
y_E = [yE1 yE2 yE3];
y_R = [yF1 yR1 yR2 yR3];
for i = 1:2
    R = R*(2*y_E(i)-y_R(i))/(y_E(i)-y_R(i+1));
    raff_m(i+1) = R;
end
%% Function to get end pts of tie line given pt on cc
function [xR,yR,xE,yE] = endpts(x,rx,ey,cc_y)
    xE = x;
    yR = ppval(cc_y,x);
    xR = ppval(rx,yR);
    yE = ppval(ey,xE);
end
%% function to return slope difference given point on cc and mid pt
function val = cctie(x,xM,yM,rx,ey,cc_y)
    xE = x;
    yR = ppval(cc_y,x);
    xR = ppval(rx,yR);
    yE = ppval(ey,xE);
    val = (yE-yR)*(xE-xM) - (yE-yM)*(xE-xR);
end
```

Question 2

Determining Delta point.

X coordinate- composition of **water**

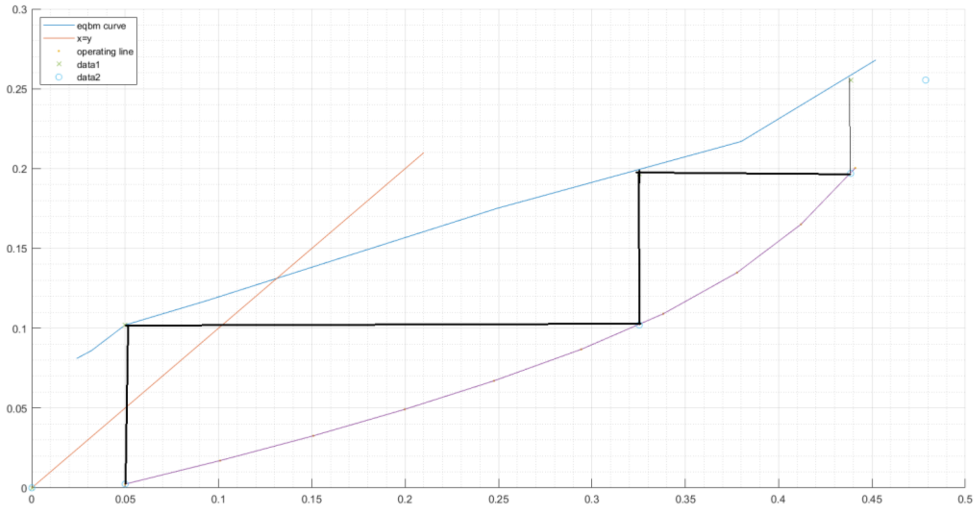
Y coordinate- composition of **alcohol**



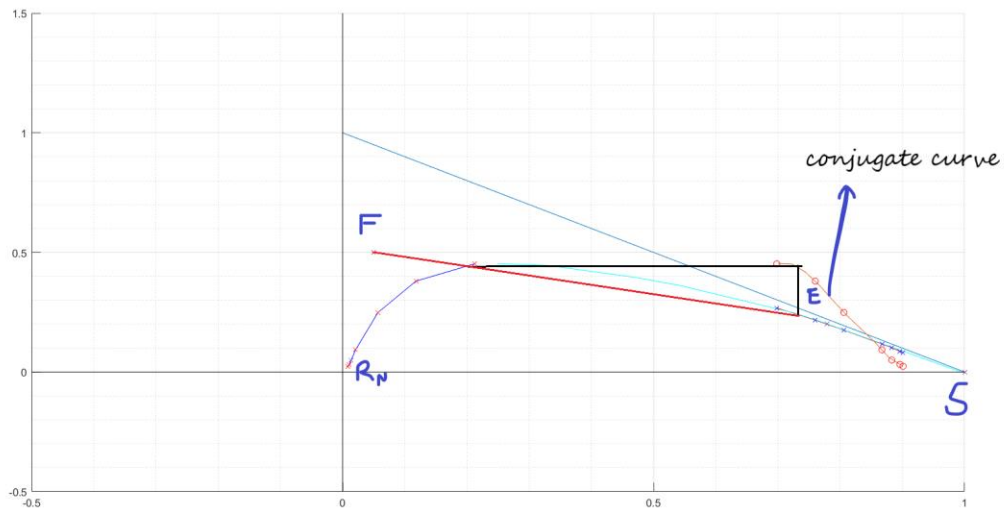
Drawing stages after projecting the right angled diagram to xy.

X coordinate- composition of alcohol in raffinate

Y coordinate- composition of alcohol in extract



Determining the maximum extract limit



Code

```
% Ether-Carrier, Alcohol-A, Water-Solvent
clear; close all;
%% Equilibrium data
ar = 0.01*[2.4 3.2 5 9.3 24.9 38 45.2];
sr = 0.01*[0.9 1.1 1.4 2.1 5.7 11.8 21.2];
raff = spline(ar,sr);
r = spline(sr,ar);
ae = 0.01*[8.1 8.6 10.2 11.7 17.5 21.7 26.8];
se = 0.01*[90.1 89.6 88.3 86.7 80.6 76 69.8];
```

```
ext = spline(ae,se);
e = spline(se,ae);
%additional points
a_add = 0.01*[45.37 44.55 39.57 36.23 24.74 21.33 0 0];
s_add = 0.01*[24.93 33 47.01 54.11 72.52 76.61 99.4 0.5];
hold on;
plot(sr,ar,'b',se,ae,'r',s_add,a_add,'c');
%Completing the triangle
plot(linspace(0,1,5),1-linspace(0,1,5));
%Plotting the axes
plot(zeros(1,2),linspace(-0.5,1.5,2),'k');
plot(linspace(-0.5,1,2),zeros(1,2),'k');
plot(sr,ar,'rx',se,ae,'bx');
grid on; grid minor;
%% conjugate curve
curve = spline(se,ar);
plot(linspace(0.7,0.9,10),ppval(curve,linspace(0.7,0.9,10)),se,ar,'r
o');
%% Given Feed Data
yF =0.5;
xF = 0.05;
yRN = 0.05;
xRN = ppval(raff,yRN);
yE1 = 0.2;
xE1 = ppval(ext,yE1);
plot([xF,xE1,xRN,1],[yF,yE1,yRN,0],'x');
%% Finding Del point
RS = polyfit([xRN,1],[yRN,0],1);
FE = polyfit([xE1,xF],[yE1,yF],1);
fun = @(x)(polyval(RS,x)-polyval(FE,x));
delx = fsolve(fun,0);
dely = polyval(RS,delx);
%% Drawing lines from the del point
%no. of lines
n = 10;
m = linspace(FE(1),RS(1),n);
line = @(y)(delx + 1./m.*(y-dely));
raff_int = @(y)(line(y)-ppval(raff,y));
% ext_int = @(y)(line(y)-ppval(ext,y));
xA = fsolve(raff_int,zeros(1,n)+1);
xB = line(xA);
line1 = @(x)(m.*(x-delx)+dely);
% raff_int = @(x)(line(x)-ppval(r,x));
[p,s] = polyfit(se,ae,4);
ext_int = @(x)(line1(x)-polyval(p,x));
yB = fsolve(ext_int,zeros(1,n)+1);
yA = line1(yB);
plot([xF,xE1,xRN,1],[yF,yE1,yRN,0],'x');
% % Resizing since only 7 points were properly obtained
% yB = yB(1:7);
% yA = yA(1:7);
% xA = xA(1:7);
% xB = xB(1:7);
figure();
hold on;
plot(sr,ar,'b',se,ae,'r',s_add,a_add,'c');
```

```
plot(delx,dely,'x');
%Completing the triangle
plot(linspace(0,1,5),1-linspace(0,1,5));
%Plotting the axes
plot(zeros(1,2),linspace(-0.5,1.5,2),'k');
plot(linspace(-0.5,1,2),zeros(1,2),'k');
grid on; grid minor;
plot(xB,xA,'rx',yB,yA,'bx');%,linspace(0.7,1,10),polyval(p,linspace(
0.7,1,10)),'k');
%% Equilibrium projection
xeqbm = ar;
yeqbm = ae;
figure();
hold on;
plot(xeqbm,yeqbm,[0.21,0],[0.21,0],xA,yA,'.',xA,yA);
grid on; grid minor;
legend('eqbm curve','x=y','operating line','Location','northwest');
%% Stepping
i = 1;
xy = spline(yeqbm,xeqbm);
OL = spline(xA,yA);
xcoords = zeros(1,7);
ycoords = zeros(1,7);
xcoords2 = zeros(1,8);
ycoords2 = zeros(1,8);
x0 = 0.05;
y0 = spline(xA,yA,x0);
yx = spline(xeqbm,yeqbm);
LO = spline(yA,xA);
xcoords2(1)= x0;
ycoords2(1) = y0;
while y0 < 0.2
    y0 = ppval(yx,x0);
    xcoords(i) = x0;
    ycoords(i)=y0;
    x0 = ppval(LO,y0);
    xcoords2(i+1) = x0;
    ycoords2(i+1) = y0;
    i = i + 1;
end
plot(xcoords,ycoords,'x',xcoords2,ycoords2,'o');
```