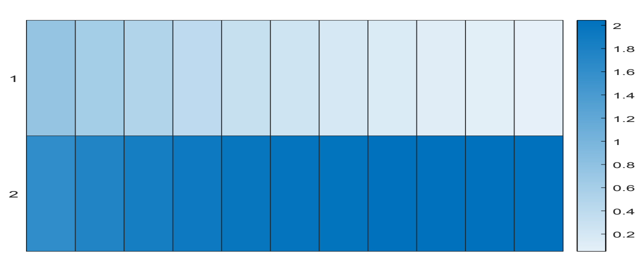
9.9 (***Number of stages for countercurrent leaching***)[3] A slurry of a seaweed is to be leached with hot water to recover a valuable protein. The slurry (48.1% solids, 49% water and 2.9% protein) enters a countercurrent leaching battery at a rate of 400 kg/h. Hot water enters at the other end at a rate of 500 kg/h. The underflow leaving the unit may have a maximum of 0.2% protein. Calculate the number of ideal contact stages required. The following 'equilibrium data' generated by laboratory tests (Chopey: *Chem. Engg. Calculations*, McGraw-Hill, 1994) may be used.

Extract (overflow) concentration, mass fraction			*Slurry (underflow) concentration, mass fraction*		
Water	*Protein*	*Solids*	*Water*	*Protein*	*Solids*
0.952	0.046	0.002	0.542	0.026	0.432
0.967	0.032	0.001	0.564	0.019	0.417
0.979	0.021	0.00	0.586	0.013	0.401
0.989	0.011	0.00	0.5954	0.0066	0.398
0.994	0.006	0.00	0.5994	0.0036	0.397
0.998	0.002	0.00	0.6028	0.0012	0.396

Plot the solid-liquid Equilibrium data in Ponchon Savarit diagram (plot Xc vs z and Yc vs Z). Suppose you use 400 kg of feed and 30**0 kg of solvent** for the above countercurrent leaching.

Countercurrent operation in *Ponchon Savarit Diagram:*

1. Locate S and F point, mention who is the underflow and who is the overflow. Calculate the concentration of the solute in mixture x_m from the material balance and locate the M point.
2. Draw the FM line and the tie lines.
3. Steps for drawing delta point.
   (a) locate point F and locate Ln.(b) Join F and S and locate M.(c) Join Ln and M and extend it to meet the overflow line at V1.
   (d) Find the slope for Ln S and FV1. LnS and FV1 are joined and extended to meet delta point.
   (e) Get the tie line through V1 to find L1 to get ZL1 and Xc1, ZV1 and Yc1. Store these variables in an array so that a heatmap can be drawn to check the solute/solid level in overflow and underflow.
   (g) Calculate the number of stages required for performing the separation. And plot the heatmap showing the solute level (C) and solid (A) in underflow and overflow. [color heatmap can be presented as follows using heatmap function].
   4. Do you think we can calculate stage number for solvent less than 300 kg? [given that the equilibrium condition from the tie line can only be interpolated, but not extrapolated].



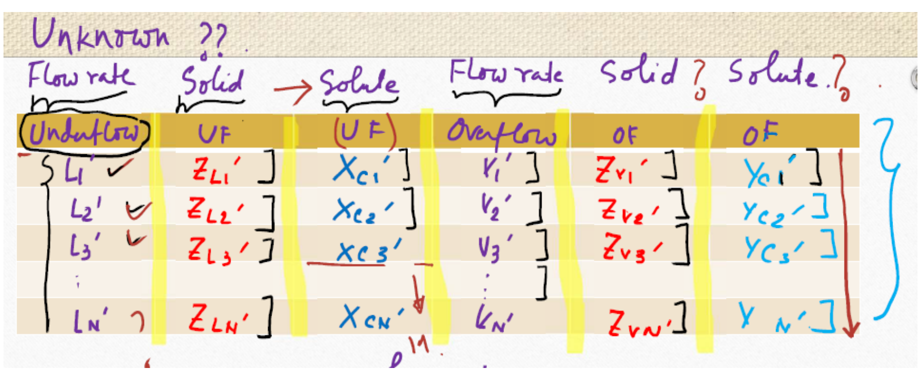
```
wA = [0.002 0.001 0.0 0.0 0.0 0.0];
wB = [0.952 0.967 0.979 0.989 0.994 0.998];
wC = [0.046 0.032 0.021 0.011 0.006 0.002];
wA_dash = [0.432 0.417 0.401 0.398 0.397 0.396];
wB_dash = [0.524 0.564 0.586 0.5954 0.5994 0.6028];
wC_dash = [0.026 0.019 0.013 0.0066 0.0036 0.0012];

for i = 1:length(wA)
    xc(i) = (wC_dash(i))/(wC_dash(i)+wB_dash(i));
    Z(i) = (wA(i))/(wB(i)+wC(i));
    yc(i) = (wC(i))/(wC(i)+wB(i));
    z(i) = (wA_dash(i))/(wB_dash(i)+wC_dash(i));
end

%DETERMINING MIXTURE POINT

M = F_dash+S_dash;
zM = (((F_dash*zF)+(S_dash*zS))/M);
xM = (((F_dash*xCF)+(S_dash*yCS))/M);

a4 = plot([xCF yCS],[zF, zS],'-or');
text(xCF, zF, 'Fdash');
text(yCS, zS, 'Sdash');
Wb = 0.6017;
Wa = 1 - (Wb+Wc);
Wc = 0.002;
xCN = Wc/(Wc+Wb);
zN = polyval(p1, xCN);
```



Calculation of delta point:

```
syms x y;

[delta_x, delta_y] =
```

```
double(delta_x);
double(delta_y);
```