**Problem 1a**

**The PDF attached shows process details.**

**Problem 1b**

**The Matlab code is attached**

%% Problem 1b

clear all; close all; clc;

% assume k1=k2=k3=k4=k,for first consideration, let k=k1=0.1

% gamma1\*R\_T/V2=5;

% gamma3\*X\_T/V4=10;

% V1/V2=(gamma1\*R\_T/V2)\*thetaB;

% V3/V4=(gamma3\*X\_T/V4)\*xstar;

% Assume k\_D=0.05

k\_D=0.05;k1=0.1;

for i=1:100

thetaB(i)=1/(1+k\_D(i));

xstar(i)=((5.\*thetaB(i).\*k1+k1+1-5.\*thetaB(i))-sqrt((5.\*thetaB(i)-5.\*thetaB(i).\*k1-k1-1).^2-4.\*(1-5.\*thetaB(i)).\*(5.\*thetaB(i).\*k1)))./(2.\*(1-5.\*thetaB(i)));

% xstar=((1+k1+V1/V2\*k2-V1/V2)+-sqrt((V1/V2-V1/V2\*k2-k1-1)^2-4\*(1-V1/V2)\*(V1/V2\*k2)))/(2\*(1-V1/V2));

ystar(i)=((1+k1+10.\*xstar(i).\*k1-10.\*xstar(i))-sqrt((10.\*xstar(i)-10.\*xstar(i).\*k1-k1-1).^2-4.\*(1-10.\*xstar(i)).\*(10.\*xstar(i).\*k1)))./(2.\*(1-10.\*xstar(i)));

% ystar=(1+k3+V3/V4\*k4-V3/V4)+sqrt((V3/V4-V3/V4\*k4-k3-1)^2-4\*(1-V3/V4)\*(V3/V4\*k4))/(2\*(1-V3/V4))

k\_D(i+1)=k\_D(i)+0.05;

end

kd=k\_D(1:length(k\_D)-1);

% plot figure at k=0.1

figure (1)

plot(1./kd,thetaB,1./kd,xstar,1./kd,ystar);

legend('thetaB','xstar','ystar');

xlabel('1/k\_D');

title('PS 1b for k=0.1');

% assume k1=k2=k3=k4=k,for first consideration, let k=k2=10

k2=10;

k\_D=0.05;

for i=1:100

thetaB2(i)=1/(1+k\_D(i));

xstar2(i)=((5.\*thetaB2(i).\*k2+k2+1-5.\*thetaB2(i))-sqrt((5.\*thetaB2(i)-5.\*thetaB2(i).\*k2-k2-1).^2-4.\*(1-5.\*thetaB2(i)).\*(5.\*thetaB2(i).\*k2)))./(2.\*(1-5.\*thetaB2(i)));

% xstar=((1+k1+V1/V2\*k2-V1/V2)-sqrt((V1/V2-V1/V2\*k2-k1-1)^2-4\*(1-V1/V2)\*(V1/V2\*k2)))/(2\*(1-V1/V2));

ystar2(i)=((1+k2+10.\*xstar2(i).\*k2-10.\*xstar2(i))-sqrt((10.\*xstar2(i)-10.\*xstar2(i).\*k2-k2-1).^2-4.\*(1-10.\*xstar2(i)).\*(10.\*xstar2(i).\*k2)))./(2.\*(1-10.\*xstar2(i)));

% ystar=(1+k3+V3/V4\*k4-V3/V4)+sqrt((V3/V4-V3/V4\*k4-k3-1)^2-4\*(1-V3/V4)\*(V3/V4\*k4))/(2\*(1-V3/V4))

k\_D(i+1)=k\_D(i)+0.05;

end

kd=k\_D(1:length(k\_D)-1);

% plot figure at k=10

figure (2)

plot(1./kd,thetaB2,1./kd,xstar2,1./kd,ystar2);

legend('thetaB','xstar','ystar');

xlabel('1/k\_D');

title('PS 1b for k=10');





**Problem 1c**

**The Excel attached shows the process details. The Hill coef. used for 1/kd vs thetaB, xstar, ystar are the following: for k=0.1, n=1 3.35 7.08; c1/2=2.22 0.483 0.245; for k=10, n=1 1.03 1.057; c1/2=1 0.174 0.02;**

**Problem 1d**

**The Matlab code is attached**

%% Problem 1d

% consider 1/KD=0.1 at k1=0.1

KD=1/0.1; k1=0.1;

thetaB1d=1/(1+KD);

xstar1d=((5.\*thetaB1d.\*k1+k1+1-5.\*thetaB1d)-((5.\*thetaB1d-5.\*thetaB1d.\*k1-k1-1).^2-4.\*(1-5.\*thetaB1d).\*(5.\*thetaB1d.\*k1)).^(0.5))./(2.\*(1-5.\*thetaB1d));

ystar1d=((1+k1+10.\*xstar1d.\*k1-10.\*xstar1d)-((10.\*xstar1d-10.\*xstar1d.\*k1-k1-1).^2-4.\*(1-10.\*xstar1d).\*(10.\*xstar1d.\*k1)).^(0.5))./(2.\*(1-10.\*xstar1d));

% consider 1/KD=0.15 at k1=0.1

KD2=1/0.15;

thetaB1d2=1/(1+KD2);

xstar1d2=((5.\*thetaB1d2.\*k1+k1+1-5.\*thetaB1d2)-((5.\*thetaB1d2-5.\*thetaB1d2.\*k1-k1-1).^2-4.\*(1-5.\*thetaB1d2).\*(5.\*thetaB1d2.\*k1)).^(0.5))./(2.\*(1-5.\*thetaB1d2));

ystar1d2=((1+k1+10.\*xstar1d2.\*k1-10.\*xstar1d2)-((10.\*xstar1d2-10.\*xstar1d2.\*k1-k1-1).^2-4.\*(1-10.\*xstar1d2).\*(10.\*xstar1d2.\*k1)).^(0.5))./(2.\*(1-10.\*xstar1d2));

% percentage change of thetaB, xstar, and ystar for k=0.1 respectivly:

thetaB\_ch=abs((thetaB1d-thetaB1d2)./thetaB1d).\*100

xstar\_ch=abs((xstar1d-xstar1d2)./xstar1d).\*100

ystar\_ch=abs((ystar1d-ystar1d2)./ystar1d).\*100

% consider 1/KD=0.1 at k1=10

KD=1/0.1; k2=10;

thetaB1d=1/(1+KD);

xstar1d=((5.\*thetaB1d.\*k2+k2+1-5.\*thetaB1d)-((5.\*thetaB1d-5.\*thetaB1d.\*k2-k2-1).^2-4.\*(1-5.\*thetaB1d).\*(5.\*thetaB1d.\*k2)).^(0.5))./(2.\*(1-5.\*thetaB1d));

ystar1d=((1+k2+10.\*xstar1d.\*k2-10.\*xstar1d)-((10.\*xstar1d-10.\*xstar1d.\*k2-k2-1).^2-4.\*(1-10.\*xstar1d).\*(10.\*xstar1d.\*k2)).^(0.5))./(2.\*(1-10.\*xstar1d));

% consider 1/KD=0.15 at k1=10

KD2=1/0.15;

thetaB1d2=1/(1+KD2);

xstar1d2=((5.\*thetaB1d2.\*k2+k2+1-5.\*thetaB1d2)-((5.\*thetaB1d2-5.\*thetaB1d2.\*k2-k2-1).^2-4.\*(1-5.\*thetaB1d2).\*(5.\*thetaB1d2.\*k2)).^(0.5))./(2.\*(1-5.\*thetaB1d2));

ystar1d2=((1+k2+10.\*xstar1d2.\*k2-10.\*xstar1d2)-((10.\*xstar1d2-10.\*xstar1d2.\*k2-k2-1).^2-4.\*(1-10.\*xstar1d2).\*(10.\*xstar1d2.\*k2)).^(0.5))./(2.\*(1-10.\*xstar1d2));

% percentage change of thetaB, xstar, and ystar for k=10 respectivly:

thetaB\_ch2=abs((thetaB1d-thetaB1d2)./thetaB1d).\*100

xstar\_ch2=abs((xstar1d-xstar1d2)./xstar1d).\*100

ystar\_ch2=abs((ystar1d-ystar1d2)./ystar1d).\*100

**command window**

thetaB\_ch =

43.4783

xstar\_ch =

101.8261

ystar\_ch =

402.5798

thetaB\_ch2 =

43.4783

xstar\_ch2 =

27.9659

ystar\_ch2 =

5.6566

**Problem 1e**

**According to the solutions shown in problem 1d, we can see the importance of tuning. For k=0.1, when the input has a small change, the outputs of xstar and ystar have a big change. For k=10, when the input has a small change, the outputs of xstar and ystar does not change very much comparing to the results of k=0.1. Therefore, it is very important to define the parameters that can fit model well. For this problem, if we want to get sensitive results, we can use k=0.1; if we want the output that has less variation as input varies, we can use k=10.**