Problem 1

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Part 1

```
clc
clear all
load A1.dat
b1=zeros(size(A1,1),1);
b1(10) = -100;

A2=A1(:,1:end-1);
b2=b1;
b2(4)=140;
rank_A2 = rank(A2)
det_A2=det(A2*A2')
x2=A2\b2
```

```
rank_A2 =

    21


det_A2 =

  145.0525


x2 =

  100.0000
  -39.8743
  -35.3352
  144.4134
  120.7388
  109.7067
  114.2458
  117.7374
    0.0000
  147.1788
   -4.3017
   13.1564
   13.1564
   19.7905
```

```
  -12.9190
   19.7905
         0
  -69.8324
  298.8422
    9.8953
  147.1788
  -69.8324
```

Part 2

```
A3=A1(:,1:end-2);
b3=b1;
b3(3)=30;
b3(4)=140;
rank_A3=rank(A3)
det_A3=det(A3)
x3=inv(A3)*b3
```

```
rank_A3 =

    21


det_A3 =

    4.0000


x3 =

  100.0000
   17.1300
   15.1800
   80.9200
   91.0906
   95.8300
   93.8800
   92.3800
         0
   51.1400
   30.4400
   22.9400
   22.9400
   20.0900
    5.5500
   20.0900
  142.9600
   30.0000
  186.1294
   81.5250
```

```
   51.1400
```

Part 3

```
A4=A1(:,1:end-4);
b4=b1;
b4(3)=30;
b4(4)=140;
b4(15)=-47;
b4(5)=60;
rank_A4=rank(A4)
det_A4=det(A4'*A4)
x4 = inv(A4'*A4)*A4'*b4
x4check = A4\b4


rank_A4 =

    19


det_A4 =

   4.5938e+03


x4 =

   98.8159
   18.8044
   15.5664
   76.7735
   86.0188
   89.6873
   88.1682
   87.1232
   -0.5349
   64.2274
   20.4214
   11.7321
   14.5210
   12.9835
   -1.9858
   11.2645
   89.6115
   31.6000
   59.2233


x4check =

   98.8159
```

```
   18.8044
   15.5664
   76.7735
   86.0188
   89.6873
   88.1682
   87.1232
   -0.5349
   64.2274
   20.4214
   11.7321
   14.5210
   12.9835
   -1.9858
   11.2645
   89.6115
   31.6000
   59.2233
```

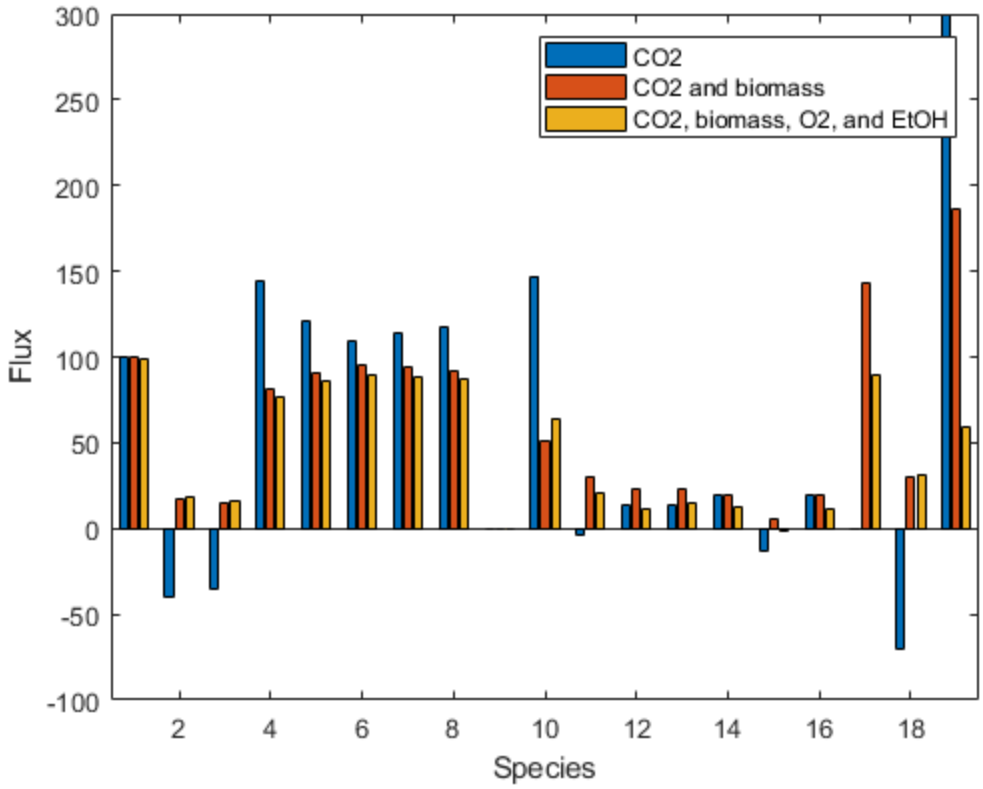
Part 4 Plots

```
figure (2)
bar([x2(1:19) x3(1:19) x4(1:19)])
xlabel('Species')
ylabel('Flux')
legend('CO2','CO2 and biomass','CO2, biomass, O2, and EtOH')
norm(x2(1:19)-x3(1:19))
norm(x2(1:19)-x4(1:19))
norm(x3(1:19)-x4(1:19))
```

```
ans =

  256.9697
```

```
ans =

  311.9377
```

```
ans =

  140.5441
```



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Problem 2

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Problem 2.1

```
%  F(1)= P -(x1*Gamma1*Psat1 + x2*Gamma2*Psat2);
%  F(2)= x1+x2-1;
%  F(3)= log(Gamma1)- Alpha/(1 +((Alpha*x1)/(Beta*x2)))^2;
%  F(4)= log(Gamma2)- Beta/(1 +((Beta*x2)/(Alpha*x1)))^2;
```

Problem 2.2

```
% In nonlinear_sys
% function F = nonlinear_sys(X,P)
%  x1=X(1); x2=X(2); Gamma1=X(3); Gamma2=X(4);

%  Parameters
%  Alpha = 1.89;
%  Beta = 1.66;

%  Psat1 = 229.47; % mm Hg
%  Psat2 = 23.69; % mm Hg


%  Enter your system of nonlinear functions below
%  F(1)= P -(x1*Gamma1*Psat1 + x2*Gamma2*Psat2);
%  F(2)= x1+x2-1;
%  F(3)= log(Gamma1)- Alpha/(1 +((Alpha*x1)/(Beta*x2)))^2;
%  F(4)= log(Gamma2)- Beta/(1 +((Beta*x2)/(Alpha*x1)))^2;

% end
```

Problem 2.3

```
clc
clear all
x0 = [1 2 3 4];
P = 180; %mm Hg
x= fsolve(@(X) nonlinear_sys(X,P), x0);
x1=x(1)
```

```
x2=x(2)
Gamma1=x(3)
Gamma2=x(4)
Psat1 = 229.47; % mm Hg
Psat2 = 23.69; % mm Hg
y1 = x1*Gamma1*Psat1/P
y2 = x2*Gamma2*Psat2/P
```

```
Equation solved.

fsolve completed because the vector of function values is near zero
as measured by the default value of the function tolerance, and
the problem appears regular as measured by the gradient.
```

```
x1 =

    0.2864
```

```
x2 =

    0.7136
```

```
Gamma1 =

    2.4360
```

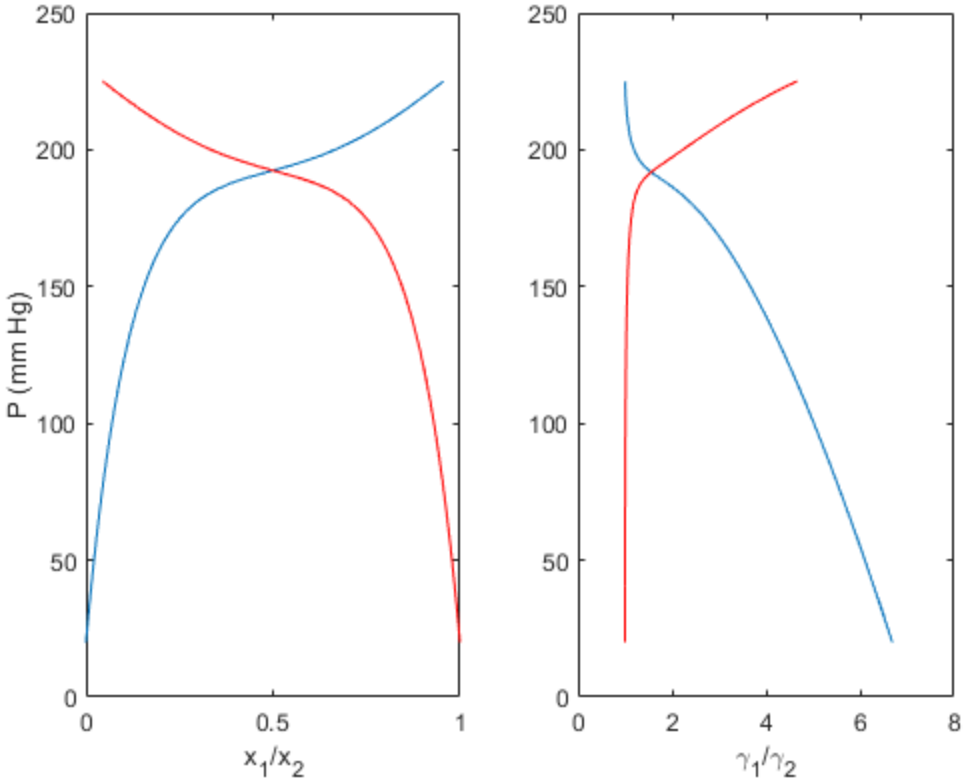
```
Gamma2 =

    1.1774
```

```
y1 =

    0.8894
```

```
y2 =

    0.1106
```

Problem 2.4

```
pArray = linspace(20,225);
VLE_plot(pArray);
```



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