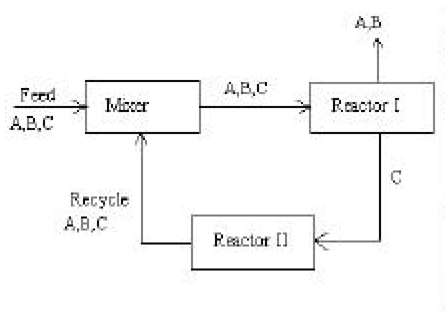
To be handed in no later than 9:21 a.m., Wednesday, July 7

The chemical plant shown below consists of a mixer, where the feed stream and one recycle stream are mixed, and two reactors.



There are three components in the system, A, B, and C. The feed consists of 40 kilograms/hour of A, 20 kg/hr of B, and 40 kg/hr of C. Reactor I separates the incoming mixture of A, B, and C into two parts. The ”top” fraction consists solely of A and B and is the final product of the plant. The amount of A in the product is 25% of the mass of the total stream (A+B+C) entering Reactor I, and the amount of B in the final product is 20% of this reactor input stream. The ”bottom” fraction of the Reactor I output consists entirely of C, and is, of course, 55% of the mass of the input stream. Reactor II converts the C that enters it into 10% A, 20% B and the rest C. This output is recycled back into the mixer.

Write nine equations in nine variables that describe the system. [The nine variables are the mass per hour of: A,B, and C in the stream leaving the mixer, the A and B leaving the top of Reactor I, the C leaving the bottom of Reactor I, and the A,B, and C leaving Reactor II.] Solve the system of equations using Gauss elimination with no pivoting. Do not use a canned program to do this, but use one of your own making. Then solve the system using an available canned program, *e.g.*, **Matlab**, and compute the difference between the two solutions. I would like to see your code.

My solution

Let's name the variables. The rates of A, B, and C leaving the mixer will be called A_m, B_m, and C_m. Let A_I, B_I, and C_I be the rates of A, B, and C leaving Reactor I, and let the rates leaving Reactor II be A_{II}, B_{II}, and C_{II}. We then have the equations:

$$A_I = 0.25(A_m + B_m + C_m)$$

$$B_I = 0.20(A_m + B_m + C_m)$$

$$C_I = 0.55(A_m + B_m + C_m)$$

$$A_{II} = 0.10C_I$$

$$B_{II} = 0.20C_I$$

$$C_{II} = 0.70C_I$$

$$A_m = A_{II} + 40$$

$$B_m = B_{II} + 20$$

$$C_m = C_{II} + 40$$

In matrix-vector form:

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & -0.25 & -0.25 & -0.25 \\ 0 & 1 & 0 & 0 & 0 & 0 & -0.20 & -0.20 & -0.20 \\ 0 & 0 & 1 & 0 & 0 & 0 & -0.55 & -0.55 & -0.55 \\ 0 & 0 & -0.10 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -0.20 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & -0.70 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} A_I \\ B_I \\ C_I \\ A_{II} \\ B_{II} \\ C_{II} \\ A_m \\ B_m \\ C_m \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 40 \\ 20 \\ 40 \end{bmatrix}$$

Here is my **Matlab** code for Gauss elimination, no pivoting:

```
function x=solve(a)
    b=utriang(a);
    n=length(a);
    j=n-2;
    x(n-1)=b(n-1,n)/b(n-1,n-1);
      while j>=1
        r=b(j,n); k= j+1;
          while k<=n-1
            r=r-b(j,k).*x(k);
            k=k+1;
        end
    x(j)=r/b(j,j);
    j=j-1;
   end

function b=utriang(a)
   b=a;
   n=length(a);
   j=1;
     while j<=n-2
       b(j:n-1,j:n)=reduce(b(j:n-1,j:n));
```

```
        j=j+1;
      end

function c =reduce(a)
   a=pivot(a);
   n=length(a);
   j=2;
     while j<=n-1
        mult = a(j,1)/a(1,1);
       a(j,1:n)=a(j,1:n)-mult.*a(1,1:n);
       j=j+1;
    end
c=a;

function b=pivot(a)
    j=1;n=length(a);
      while abs(a(j,1))<=0
        j=j+1;
      end
  q=a(1,1:n);a(1,1:n)=a(j,1:n);
  a(j,1:n)=q;
 b=a;
```

Now, here is my solution:

```
» solve(A)'
ans =
 55.5556
 44.4444
 122.2222
 12.2222
 24.4444
 85.5556
 52.2222
 44.4444
 125.5556
```

Now let’s see what **Matlab** says:

» **B\c**
ans =

55.5556
44.4444
122.2222
12.2222
24.4444
85.5556
52.2222
44.4444
125.5556

Looks just the same! Let's see what the difference is:

» **solve(A)'-B\c**
ans =
1.0e-013 *
0.0711
0.0711
0.1421
0
0
0
0
0
0

About as close to zero as you can get!