Topics for Today:

- Questions from last lectures?
- Web page being updated. Syllabus is last piece to be added.
- Course Expectations
  - “Three for one rule…” at least 9 hrs/wk!
  - Check web page for reading assignments
  - Print out lecture info and read before coming to class.
  - Pre-Req Material: Text books by Glover and/or Stevenson.
- Comments on Homework #1
  - “Vectors” can be row vector or column vector – pay attention when entering into MatLab.
  - Linked lists — "in situ" dynamic changes
- Today - System Data & Parameters:
  - Line Data
  - Generator Data
  - Transformer Data
Row Vectors: $B = [1 \ 2 \ 3 \ 4]$

Column Vectors: $B = [1; 2; 3; 4]$

$B = \begin{bmatrix} 1 \\ 2 \\ 3 \\ 4 \end{bmatrix}$
Linked Lists:

Fill: Change a zero value (unstored) to a non-zero value.

Strategy: Store in open position in storage vector (don't shift!)
- Modify links for that row.

Elimination: Change non-zero value to zero.
- Change storage value to zero.
- Collapse links (modify) to skip over that position.

Always - Keep list of open locations
OPEN POSITIONS -

IOPEN: Pointer to first open location at bottom of list.

For open positions within list:

NOPEN = No. of "gaps" in list vector.

\[
\begin{array}{c|c|c}
    \text{IOPEN} & 1 & 2 \\
    \hline
    1 & 10 & 12 \\
    2 & 7 & \\
    3 & & \\
    4 & & \\
\end{array}
\]

EX: \( \text{NOPEN} = 3 \) use \( \text{MOPEN}(3) \)

If NOPEN = 0
Then go to

OBJECT: USE TOP OF STORAGE VECTOR.
Inverting $[A]$:
- Sparse $[B_{bus}]$ inverts to be a full $[Z_{bus}]$.
- Extra storage
- Very inefficient: too many floating point operations.

Better; in situ
- Gauss Elim.
- Gauss-Jordan

Also called
- LU Factorization $\iff$ Mainstay Method.

Triangularization $\implies$ Print & study paper!
Example of "in situ" algorithm.

Gauss Elimination

\[
[A] [x] = [B]
\]

\[
\begin{bmatrix}
1 & 1 & 1 & -1 \\
1 & -1 & -1 & 1 \\
2 & 1 & -1 & 2 \\
3 & 1 & 2 & -1
\end{bmatrix}
\begin{bmatrix}
x_1 \\
x_2 \\
x_3 \\
x_4
\end{bmatrix}
=
\begin{bmatrix}
2 \\
0 \\
9 \\
7
\end{bmatrix}
\]

Soln. method: does row operations on \([A]\) & \([B]\) values in place. Avoids computation & storage overhead of inverting \([A]\).
Back to Gauss Elimination

\[
\text{STEP Row} \quad \begin{bmatrix}
1 & 1 & 1 & -1 & 2 \\
1 & -1 & -1 & 1 & 0 \\
2 & 0 & -1 & 2 & 9 \\
3 & 0 & 2 & -1 & 7 \\
\end{bmatrix}
\]

Normalize to main diagonal & eliminate column positions below main diagonal.
Solve for x4 first, then back substitute.
\[ B_1 = A_1^{1/2} \]
\[ B_2 = A_2 - B_1 \]
\[ B_3 = A_3 - 2B_1 \]
\[ B_4 = A_4 - 3B_1 \]

\[
\begin{bmatrix}
1 & 1 & 1 & -1 & \text{2} \\
0 & -2 & -2 & 2 & -2 \\
0 & -1 & -3 & 4 & 5 \\
0 & -2 & -1 & 2 & \text{1}
\end{bmatrix}
\]

\[
C_1 \]
\[ C_2 = B_2/(-2) \]
\[ C_3 = B_3 + C_2 \]
\[ C_4 = B_4 + 2C_2 \]

\[
\begin{bmatrix}
1 & 1 & 1 & -1 & \text{2} \\
0 & 1 & 1 & -1 & \text{1} \\
0 & 0 & -2 & 3 & 6 \\
0 & 0 & 0 & 0 & 3
\end{bmatrix}
\]
D1
D2
D3 = C3/(-2)
D4 = C4 - D3

\[
\begin{bmatrix}
1 & 1 & 1 & -1 & 2 \\
0 & 1 & 1 & -1 & 1 \\
0 & 0 & 1 & -\frac{3}{2} & -3 \\
0 & 0 & 0 & \frac{3}{2} & 6
\end{bmatrix}
\]

\[
\begin{bmatrix}
1 & 1 & 1 & -1 & 2 \\
0 & 1 & 1 & -1 & 1 \\
0 & 0 & 1 & -\frac{3}{2} & -3 \\
0 & 0 & 0 & 1 & 4
\end{bmatrix}
\]

\(X_4 = 4\)
\(X_3 - \frac{3}{2}X_4 = -3\)
\(X_3 - \frac{3}{2}(4) = -3\)
\(X_3 = 3\)

Gauss Elim. is Complete.

Back Substitution

\(X_2 + X_3 - X_4 = 1\)
\(X_2 + 3 - 4 = 1\)
\(X_2 = 2\)
\(X_1 = 1\)

\[
X = \begin{bmatrix}
1 \\
2 \\
3 \\
4
\end{bmatrix}
\]
Gauss Jordan: Similar to Gauss, but also eliminates upper diagonal:

If Gauss-Jordan was used:

More calcs reg'd in elimination but no back-substitution is required.
System Data & System Parameters

( GOAL: Build [Ybus] from system data.)

(See web page - Standard Data Cases)

- Data File Formats
  - CDF
  - PTI
  - PECO

Line Data:

Example from Stevenson:

<table>
<thead>
<tr>
<th>Line, bus to</th>
<th>Length</th>
<th>R</th>
<th>X per unit</th>
<th>X per unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>bus</td>
<td>km</td>
<td>Ω</td>
<td>Ω</td>
<td>Mvar</td>
</tr>
<tr>
<td>1-2</td>
<td>64.4</td>
<td>8</td>
<td>32</td>
<td>0.042</td>
</tr>
<tr>
<td>1-3</td>
<td>48.3</td>
<td>6</td>
<td>24</td>
<td>0.031</td>
</tr>
<tr>
<td>2-3</td>
<td>48.3</td>
<td>6</td>
<td>24</td>
<td>0.031</td>
</tr>
<tr>
<td>3-4</td>
<td>128.7</td>
<td>80</td>
<td>16</td>
<td>0.084</td>
</tr>
<tr>
<td>3-5</td>
<td>80.5</td>
<td>50</td>
<td>10</td>
<td>0.053</td>
</tr>
<tr>
<td>4-5</td>
<td>96.5</td>
<td>60</td>
<td>12</td>
<td>0.063</td>
</tr>
</tbody>
</table>

† At 138 kV.

R  jX

\[ \frac{c}{2} \]

C represents the "LINE CHARGING MVAR"

HALF-LINE or FULL-LINE?