Topics for Today:

- Introductions: course syllabus (being updated)
- Startup
  - Book
  - Software: Matlab, (Cyme, Aspen may be used for benchmarking)
- Access to EERC 134 (SGOC - Smart Grid Operations Center)
- May be useful to buy 3-ring binder
- Use grid paper or white paper for homework submissions.
- Quick Review of Mesh and NODE equations
- Matrix formulations
- Possible Solution Methods
- Buy book, scan through Chapters 1 and 2 for Wed
- Matlab tutorials for beginners, posted on EE5200 web page.
- Pre-Req review notes and video, posted on EE5200 web page
"BIG DATA"

Traditional
- Data Structures
- Algorithms
- Applications

New
- Servers
- Dynamic Flow of data
- Dist Process Algorithms

Matlab
- Cyne
- Aspen
Mesh 1: \[ V_1 = Z_1 \bar{I}_1 + Z_2 (\bar{I}_1 - \bar{I}_2) \]

Mesh 2: \[ 0 = Z_2 (\bar{I}_2 - \bar{I}_1) + Z_3 (\bar{I}_2 - \bar{I}_3) + Z_4 (\bar{I}_2 - \bar{I}_3) \]

Mesh 3: \[ -V_3 = Z_4 (\bar{I}_3 - \bar{I}_2) + Z_5 (\bar{I}_3) \]
In Matrix Form:

\[
\begin{bmatrix}
  Z_1 + Z_2 & -Z_2 & 0 \\
  -Z_2 & Z_2 + Z_3 + Z_4 & -Z_4 \\
  0 & -Z_4 & Z_4 + Z_5 \\
\end{bmatrix}
\begin{bmatrix}
  \vec{I}_1 \\
  \vec{I}_2 \\
  \vec{I}_3 \\
\end{bmatrix}
= \begin{bmatrix}
  \vec{V}_1 \\
  0 \\
  \vec{V}_2 \\
\end{bmatrix}
\]

\[Z_{\text{Loop or Mesh}} = Z_{\text{Mesh}}\]

\[Z_{NN} = \sum Z_s \text{ around mesh } N \quad (\text{Self-impedance of mesh})\]

\[Z_{NK} = -\sum Z_s \text{ that are mutual to meshes } N \neq K,\]

\(\vec{I}_s\) are mesh currents - not much use in power system analysis.

\(\vec{V}_s\) usually node voltages, but at inner node of Gen.
Node Eqns.

KCL: \[ \sum I_{s\text{(in)}} = 0 \]

Node 1:
\[ 2 + (V_2 - V_1) + (V_3 - V_1) + (-V_1) = 0 \]

Node 2:
\[ 8 + (V_1 - V_2) + (V_3 - V_2) + (-V_2) = 0 \]

Node 3:
\[ 0 + (V_2 - V_3) + (V_1 - V_3) + (-V_3) = 0 \]
In Matrix Form:

\[
\begin{bmatrix}
8 & -2 & -5 \\
-2 & 9 & -4 \\
-5 & -4 & 15
\end{bmatrix}
\begin{bmatrix}
y_1 \\
y_2 \\
y_3
\end{bmatrix}
=
\begin{bmatrix}
2 \\
8 \\
0
\end{bmatrix}
\]

Nodal Admittance Matrix

Node Voltages

Injected Currents

\[[Y_n] \text{ or } [Y_{bus}]\]

\[y_{nn} = +\sum \text{ Admittances } \text{ "landing" on node } N\]

\[y_{nk} = -\sum \text{ Admittances } \text{ "spanning" between nodes } N \& K.\]

Typical System: Lots of zeroes in off-diagonal elements

Exploit this by not store zero values.

Use Sparse Matrix methods
Key Points:

\[
\begin{align*}
[Z\text{ MESH}]^{-1} &= [Y\text{ MESH}] \\
[Y\text{ BUS}]^{-1} &= [Z\text{ BUS}]
\end{align*}
\]

SPARSE \hspace{2cm} \text{FULL}

From previous example:

\[
[Y\text{ BUS}][V\text{ BUS}] = [I_{INJ}]
\]

\text{KNOWN} \hspace{2cm} \text{Knowns (Generators)}
\uparrow \hspace{2cm} \text{UNKNOWN}

How to solve?

- Brute force
- Gauss Elimination
- en situa methods
- Gauss-Jordan
- LU Factorization & preferred for large systems
Review -

Passive Voltage Drop Sign Convention
- Motors
- Loads (Impedances)

Active Sign Convention
- Generators (Sources)
Observations on topology of $[Y_{bus}]$

- Main diagonal is non-zero
- Most off-diagonal terms are zero
  (Sparse systems) most $yk = 0$
- Can $[Y_{bus}]$ always be inverted?
  (i.e. nonsingular). Singular matrices will produce "divide by zero overflow" and crash program.

Answer: Make sure you have at least one branch to ground/reference!

**Ex:**

```
\begin{align*}
V_1 & \quad 2.5 \quad 5.5 \quad 4.5 \quad 2.5 \\
V_2 & \quad 5.5 \\
V_3 & \quad 4.5 \\
\end{align*}
```
\[ \begin{bmatrix} +7 & -2 & -5 \\ -2 & +6 & -4 \\ -5 & -4 & +9 \end{bmatrix} \]

Problem to look for:
If \( 2 \) of terms in a row is zero, then you're probably dealing with a singular matrix!

**TRY TO INVERT WITH MATLAB!**

- Symmetry about main diagonal

\[ \begin{bmatrix} \text{ynk} \\ \text{ykn} \end{bmatrix} \]

If no dependent sources, or phase-shifting xfmrs, then it will be symmetric.