# Debugging

- ***AUTOSPC***
- AUTOSPC(NONZERO)=YES
  - Reduces printed table
  - Prints translational DOF that should not be auto-spc
    - All MSC Nastran elements have translational K
- How does this automatic SPC thing work?
  - First a review of FEM equations

# Debugging

- ***Basic FEM equation***

$$\{F\} = [K]\{u\}$$

- **Solve for displacements**

$$\{u\} = \{F\} / [K]$$

- **Calculate strains**

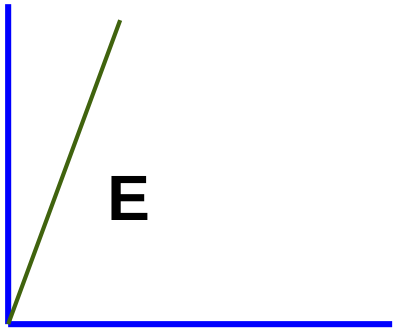
$$\{e\} = [B]\{u\}$$

- **Calculate stresses**

$$\{\sigma\} = E[B]\{u\}$$

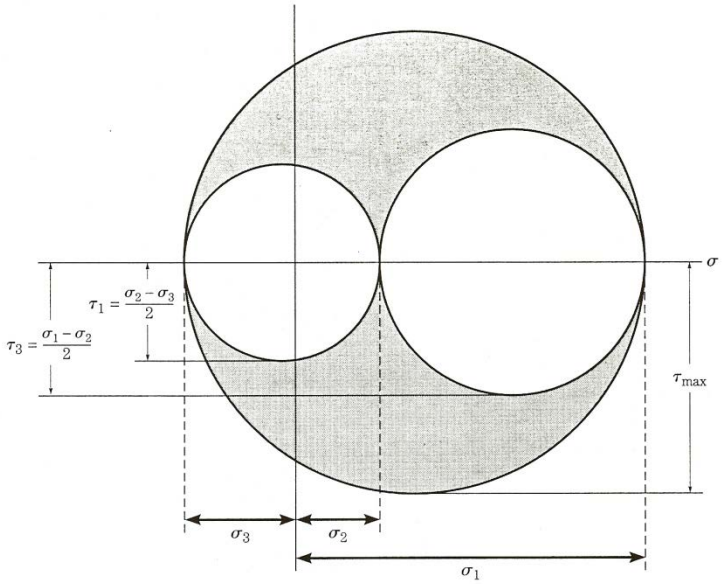
- **Stress is linearly related to stiffness**

$$\{\sigma\} = E[B]\{F\} / [K] = const / [K]$$



# Debugging

- ***Principal stresses in 3D***




**Standard 3 root algebraic equation for principal stress**

$$\sigma^3 - I_1\sigma^2 + I_2\sigma - I_3 = 0$$

**Stress and stiffness have a linear relation**

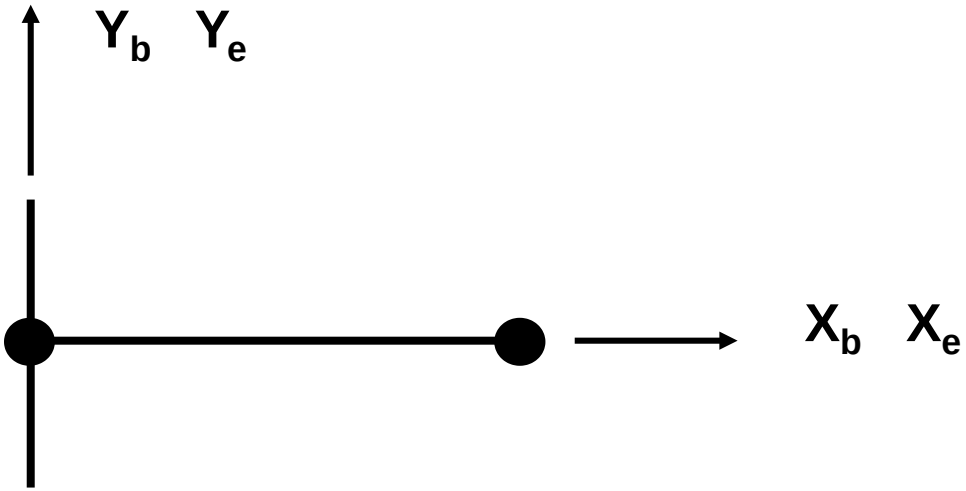
$$\{\sigma\} = const / [K]$$

**Standard 3 root algebraic equation for principal stiffness**

$$K^3 - I_1K^2 + I_2K - I_3 = 0$$

# Debugging

- ***AUTOSPC example***




**Element coordinate system and grid systems coincide**

**L=10.0**
**A = 1.0**
**$I_1$ = 0.1**
**$I_2$ = 0.1**
**J = 0.0**

**Torsion stiffness will be 0.0**

# Debugging

- ***AUTOSPC example***

**The system [K] matrix is:**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1000000 | | | | | | -1000000 | | | | | |
| 2 | | 12000 | | | | 60000 | | -12000 | | | | 60000 |
| 3 | | | 12000 | | -60000 | | | | -12000 | | -60000 | |
| 4 | | | | | | | | | | | | |
| 5 | | | -60000 | | 400000 | | | | 60000 | | 200000 | |
| 6 | | 60000 | | | | 400000 | | -60000 | | | | 200000 |
| 7 | -1000000 | | | | | | 1000000 | | | | | |
| 8 | | -12000 | | | | -60000 | | 12000 | | | | -60000 |
| 9 | | | -12000 | | 60000 | | | | 12000 | | 60000 | |
| 10 | | | | | | | | | | | | |
| 11 | | | -60000 | | 200000 | | | | 60000 | | 400000 | |
| 12 | | 60000 | | | | 200000 | | -60000 | | | | 400000 |

**GPSP is the DMAP module that performs the AUTOSPC function**

# Debugging

- ***AUTOSPC example***

**General equation for finding the roots of a 3x3 matrix:**

$$K_R^3 - (k_{11}+k_{22}+k_{33})K_R^2 + (k_{11}k_{22}+k_{11}k_{33}+k_{22}k_{33}-k_{12}^2-k_{23}^2-k_{31}^2)K_R - (k_{11}k_{22}k_{33}+2k_{12}k_{23}k_{31}-k_{11}k_{23}^2-k_{22}k_{31}^2-k_{33}k_{12}^2)=0.0$$

**The first 3x3:**

| | | |
|---|---|---|
| 1000000 | | |
| | 12000 | |
| | | 12000 |

**No off diagonal terms**

**Has roots:**
**1000000**
**12000**
**12000**

# Debugging

- ***AUTOSPC example***

**GPSP takes these three roots and applies the following logic:**

**1) MAX K = MAX( 1000000, 12000, 12000) = 1000000**

**2) DOF 1: 1000000/MAX K = 1.0**

**2a) is 1.0 < 1.0e-07?**

**No: leave DOF 1 in the 'g' set**
**Yes: put DOF 1 in the 's' set**

**3) Repeat for DOF 2 and DOF 3**

**The next 3x3 is for the rotational DOF and one of the roots is 0.0. Therefore GPSP will put DOF 4 in the 's' set**

# Debugging

- ***AUTOSPC example***
- **The ratio check ‘normalizes’ the values**
- **The numerical threshold then becomes unit independent**
- **PARAM, EPZERO defines the threshold**
- **Default is 1.0e-07 and unchanged for 20 plus years**