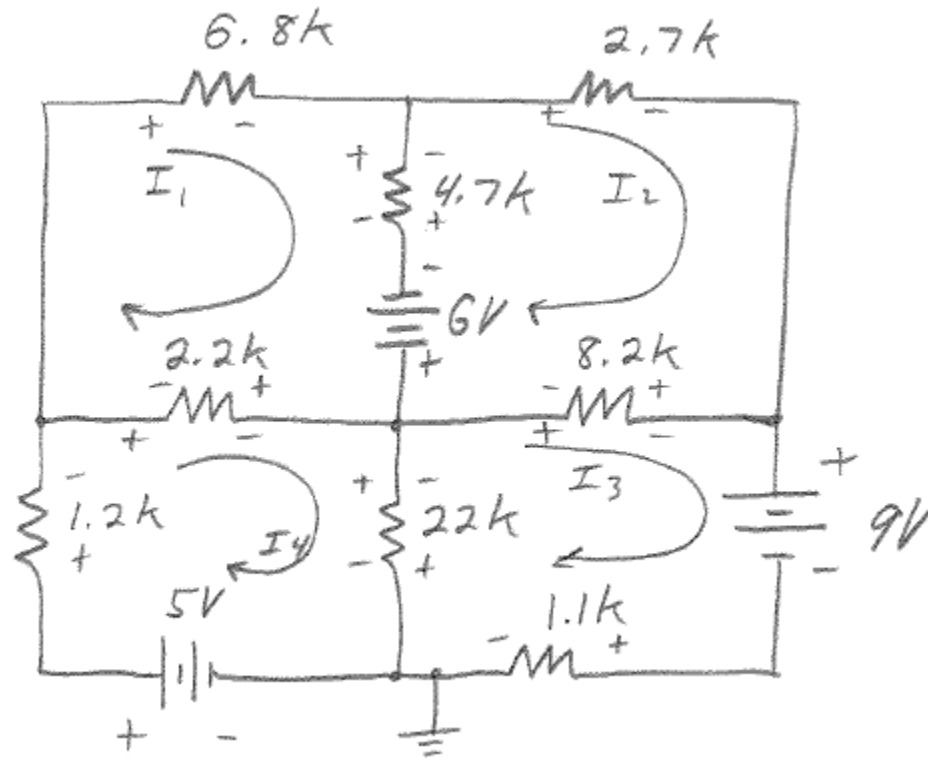# *E*lectrical
*E*ngineering
*T*echnology

Mesh Analysis Breakout (4x4 system)

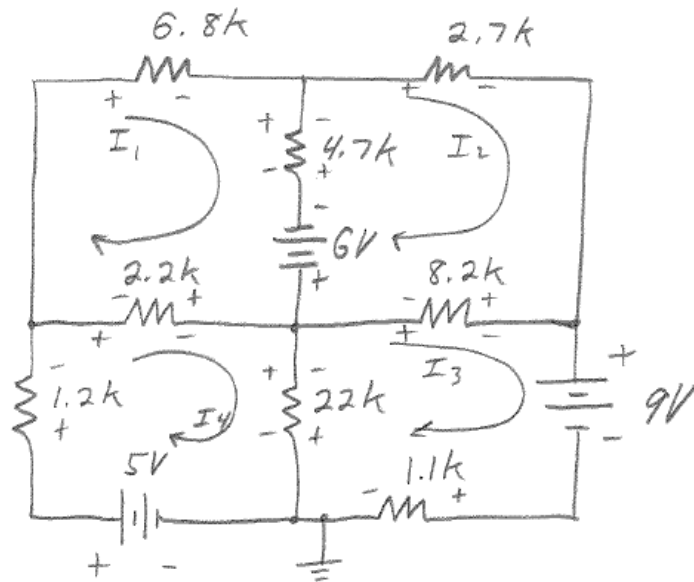**Fall 2018 (2181)**

Breakout Problem #1

Find:
-        The loop (MESH) currents as drawn

Breakout Problem #1

I_1 loop : $-6.8kI_1 - 4.7k I_1 + 4.7k I_2 + 6 - 2.2k I_1 + 2.2k I_4 = 0$

$$-13.7k I_1 + 4.7k I_2 + 0 I_3 + 2.2k I_4 = -6 \qquad (1)$$

I_2 loop : $-6 - 4.7k I_2 + 4.7k I_1 - 2.7k I_2 - 8.2k I_2 + 8.2k I_3 = 0$

$$4.7k I_1 - 15.6k I_2 + 8.2k I_3 + 0 I_4 = 6 \qquad (2)$$

I_3 loop : $-22k I_3 + 22k I_4 - 8.2k I_3 + 8.2k I_2 - 9 - 1.1k I_3 = 0$

$$0 I_1 + 8.2k I_2 - 31.3k I_3 + 22k I_4 = 9 \qquad (3)$$

I_4 loop : $-1.2k I_4 - 2.2k I_4 + 2.2k I_1 - 22k I_4 + 22k I_3 + 5 = 0$

$$2.2k I_1 + 0 I_2 + 22k I_3 - 25.4k I_4 = -5 \qquad (4)$$

Breakout Problem #1

$$-13.7k\,I_1 + 4.7k\,I_2 + 0\,I_3 + 2.2k\,I_4 = -6 \qquad (1)$$

$$4.7k\,I_1 - 15.6k\,I_2 + 8.2k\,I_3 + 0\,I_4 = 6 \qquad (2)$$

$$0\,I_1 + 8.2k\,I_2 - 31.3k\,I_3 + 22k\,I_4 = 9 \qquad (3)$$

$$2.2k\,I_1 + 0\,I_2 + 22k\,I_3 - 25.4k\,I_4 = -5 \qquad (4)$$

SOLVING YIELDS:

$$I_1 = 32.11\,\mu A$$
$$I_2 =$$
$$I_3 =$$
$$I_4 =$$

Your AC Circuits calculator will handle this with ease

But how using the Sharp EL-516?

Method of Determinants (Appendix B and your calculator manual)

Breakout Problem #1

EXPANDING FROM APPENDIX B TO SOLVE A 4x4

$$a_1 w + b_1 x + c_1 y + d_1 z = e_1$$
$$a_2 w + b_2 x + c_2 y + d_2 z = e_2$$
$$a_3 w + b_3 x + c_3 y + d_3 z = e_3$$
$$a_4 w + b_4 x + c_4 y + d_4 z = e_4$$

VARIABLES

$$w, x, y, z$$

WHERE

$$D = \begin{vmatrix} a_1 & b_1 & c_1 & d_1 \\ a_2 & b_2 & c_2 & d_2 \\ a_3 & b_3 & c_3 & d_3 \\ a_4 & b_4 & c_4 & d_4 \end{vmatrix}$$

$$w = \frac{\begin{vmatrix} e_1 & b_1 & c_1 & d_1 \\ e_2 & b_2 & c_2 & d_2 \\ e_3 & b_3 & c_3 & d_3 \\ e_4 & b_4 & c_4 & d_4 \end{vmatrix}}{D}$$

- Column **1** is the vector e1, e2, e3, e4
- The remaining columns are the variable coefficients from the system of equations

$$x = \frac{\begin{vmatrix} a_1 & e_1 & c_1 & d_1 \\ a_2 & e_2 & c_2 & d_2 \\ a_3 & e_3 & c_3 & d_3 \\ a_4 & e_4 & c_4 & d_4 \end{vmatrix}}{D}$$

- Column **2** is the vector e1, e2, e3, e4
- The remaining columns are the variable coefficients from the system of equations

And so on for variables y and z…

Breakout Problem #1

$$-13.7k\,I_1 + 4.7h\,I_2 + 0\,I_3 + 2.2h\,I_4 = -6 \qquad (1)$$

$$4.7k\,I_1 - 15.6k\,I_2 + 8.2k\,I_3 + 0\,I_4 = 6 \qquad (2)$$

$$0\,I_1 + 8.2k\,I_2 - 31.3k\,I_3 + 22k\,I_4 = 9 \qquad (3)$$

$$2.2k\,I_1 + 0\,I_2 + 22k\,I_3 - 25.4k\,I_4 = -5 \qquad (4)$$

WHERE

$$D = \begin{vmatrix} a_1 & b_1 & c_1 & d_1 \\ a_2 & b_2 & c_2 & d_2 \\ a_3 & b_3 & c_3 & d_3 \\ a_4 & b_4 & c_4 & d_4 \end{vmatrix}$$

Becomes ->

$$D = \begin{vmatrix} -13,700 & 4700 & 0 & 2,200 \\ 4700 & -15,600 & 8200 & 0 \\ 0 & 8,200 & -31,300 & 22,000 \\ 2200 & 0 & 22,000 & -25,400 \end{vmatrix}$$

$$w = \frac{\begin{vmatrix} e_1 & b_1 & c_1 & d_1 \\ e_2 & b_2 & c_2 & d_2 \\ e_3 & b_3 & c_3 & d_3 \\ e_4 & b_4 & c_4 & d_4 \end{vmatrix}}{D}$$

Becomes ->

$$I_1 = \frac{\begin{vmatrix} -6 & 4700 & 0 & 2,200 \\ 6 & -15,600 & 8200 & 0 \\ 9 & 8,200 & -31,300 & 22,000 \\ -5 & 0 & 22,000 & -25,400 \end{vmatrix}}{D}$$

Breakout Problem #1

Solving D on the EL-516T:

$$D = \begin{vmatrix} -13,700 & 4700 & 0 & 2,200 \\ 4700 & -15,600 & 8200 & 0 \\ 0 & 8,200 & -31,300 & 22,000 \\ 2200 & 0 & 22,000 & -25,400 \end{vmatrix}$$

MODE 5   (MATRIX)

MATH 1   (EDIT)

4 4   (4x4)

ENTER

    ENTER COEFFICIENTS

ON/C

MATH 3 0   (STORES IN A)

ON/C

MATH 4 (DET)

MATH 0 0   (RECALLS A)   ENTER

Yields: D = 30.4341E15

- See the posted Sharp EL-516 manual and accompanying examples for previous versions of the EL-516

Following the same procedure for the numerator of:

$$I_1 = \frac{\begin{vmatrix} -6 & 4700 & 0 & 2,200 \\ 6 & -15,600 & 8200 & 0 \\ 9 & 8,200 & -31,300 & 22,000 \\ -5 & 0 & 22,000 & -25,400 \end{vmatrix}}{D}$$

Yields:

$$I_1 = \frac{977.2880E9}{30.4341E15}$$

Or **I₁ = 32.11 uA**

- Find I_2, I_3 and I_4 using the same method… i.e. I_2 is variable x and so on
- Find I_2, I_3 and I_4 by substituting I_1 into the original equations and solving the remaining 3x3 system