KIRCHHOFF VOLTAGE LAW

ONE OF THE FUNDAMENTAL CONSERVATION LAWS IN ELECTRICAL ENGINERING

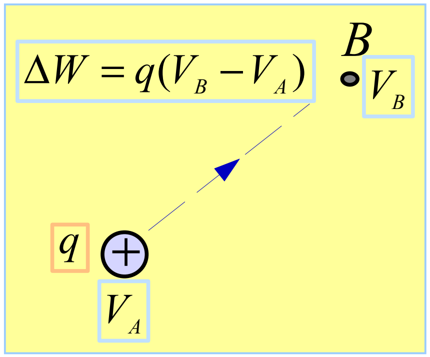
THIS IS A CONSERVATION OF ENERGY PRINCIPLE
"ENERGY CANNOT BE CREATE NOR DESTROYED"

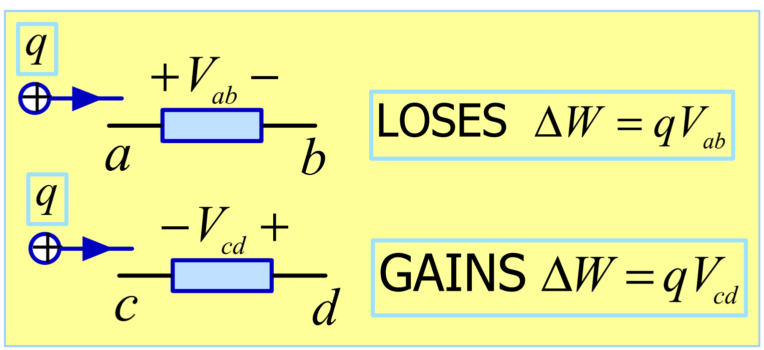
GEAUX

KIRCHHOFF VOLTAGE LAW (KVL)

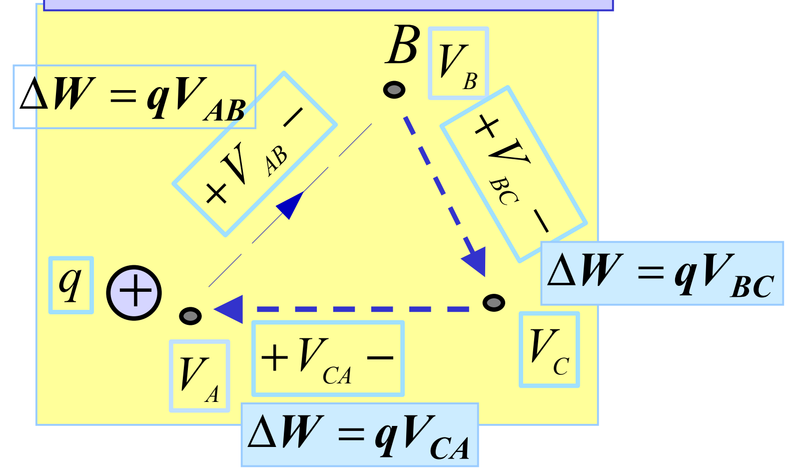
KVL IS A CONSERVATION OF ENERGY PRINCIPLE

A POSITIVE CHARGE GAINS ENERGY AS IT MOVES TO A POINT WITH HIGHER VOLTAGE AND RELEASES ENERGY IF IT MOVES TO A POINT WITH LOWER VOLTAGE





A "THOUGHT EXPERIMENT"

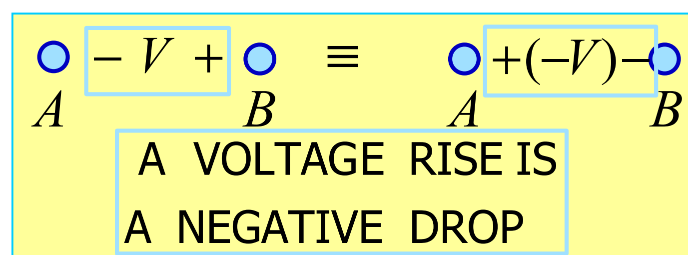


IF THE CHARGE COMES BACK TO THE SAME INITIAL POINT THE NET ENERGY GAIN MUST BE ZERO (Conservative network)

OTHERWISE THE CHARGE COULD END UP WITH INFINITE ENERGY, OR SUPPLY AN INFINITE AMOUNT OF ENERGY

$$q(V_{AB} + V_{BC} + V_{CD}) = 0$$

KVL: THE ALGEBRAIC SUM OF VOLTAGE DROPS AROUND ANY LOOP MUST BE ZERO



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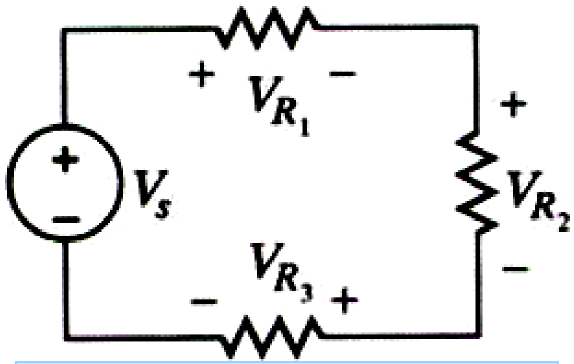
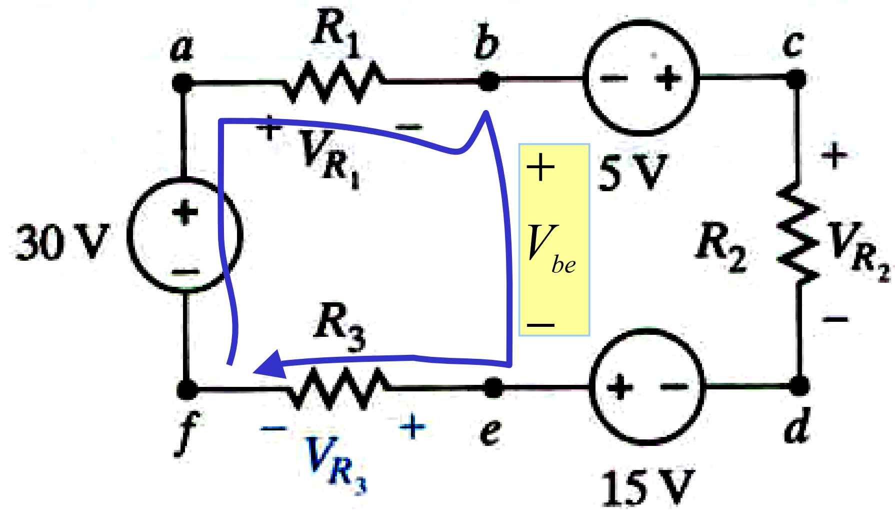
D2.4 Write the KVL equation for the following loop, traveling clockwise:



$$-V_S + V_{R_1} + V_{R_2} + V_{R_3} = 0$$

PROBLEM SOLVING TIP: KVL IS USEFUL TO DETERMINE A VOLTAGE - FIND A LOOP INCLUDING THE UNKNOWN VOLTAGE

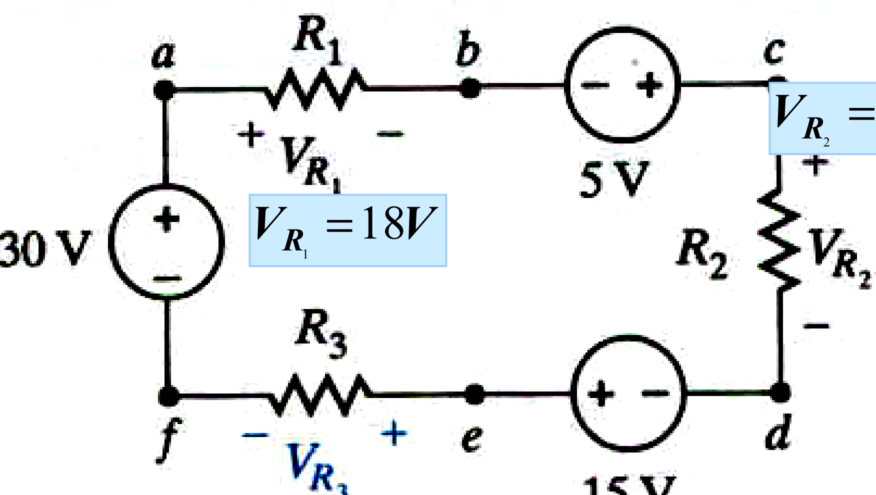
THE LOOP DOES NOT HAVE TO BE PHYSICAL



EXAMPLE: V_{R1}, V_{R3} ARE KNOWN

DETERMINE THE VOLTAGE V_{be}

$$V_{R_1} + V_{be} + V_{R_3} - 30[V] = 0$$



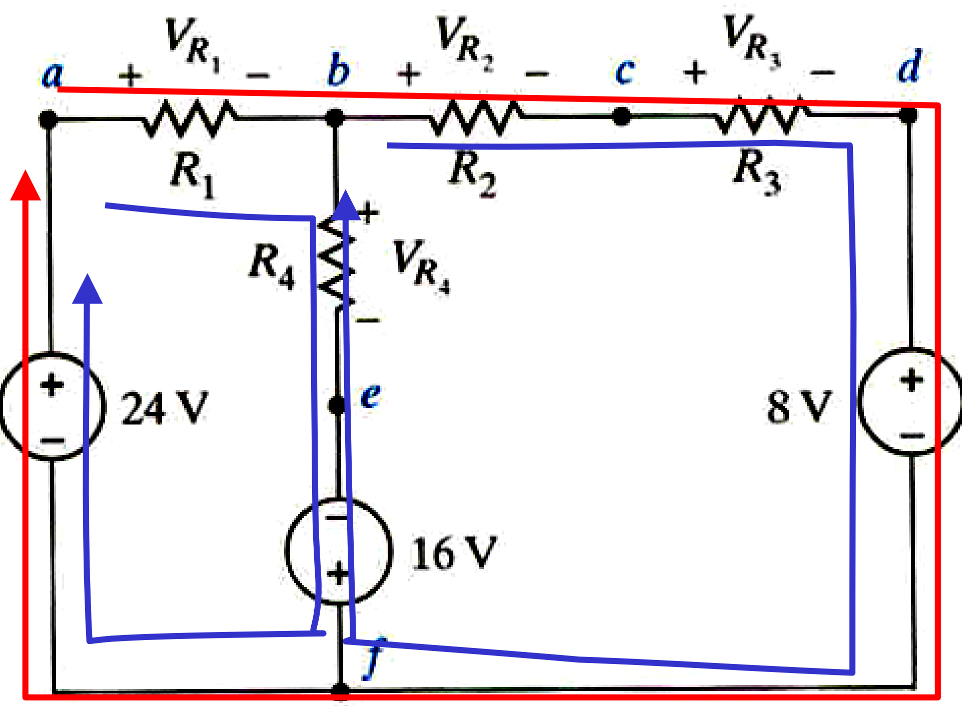
$V_{R_2} = 12V$

$V_{R_1} = 18V$

LOOP *abcdefa*

$$+V_{R_1} - 5 + V_{R_2} - 15 + V_{R_3} - 30 = 0$$

BACKGROUND: WHEN DISCUSSING KCL WE SAW THAT NOT ALL POSSIBLE KCL EQUATIONS ARE INDEPENDENT. WE SHALL SEE THAT THE SAME SITUATION ARISES WHEN USING KVL



$$V_{R_1} + V_{R_4} - 16 - 24 = 0$$

$$V_{R_2} + V_{R_3} + 8 + 16 - V_{R_4} = 0$$

$$V_{R_1} + V_{R_2} + V_{R_3} + 8 - 24 = 0$$

THE THIRD EQUATION IS THE SUM OF THE OTHER TWO!!

A SNEAK PREVIEW ON THE NUMBER OF LINEARLY INDEPENDENT EQUATIONS

IN THE CIRCUIT DEFINE

N NUMBER OF NODES

B NUMBER OF BRANCHES

$N-1$ LINEARLY INDEPENDENT KCL EQUATIONS

$B-(N-1)$ LINEARLY INDEPENDENT KVL EQUATIONS

EXAMPLE: FOR THE CIRCUIT SHOWN WE HAVE N = 6, B = 7.
HENCE THERE ARE ONLY TWO INDEPENDENT KVL EQUATIONS

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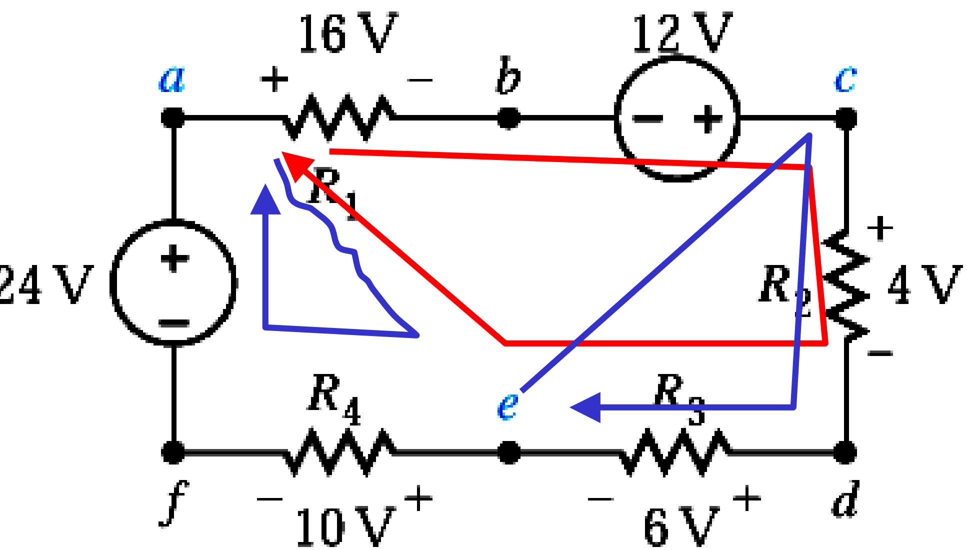
FIND THE VOLTAGES V_{ae}, V_{ec}



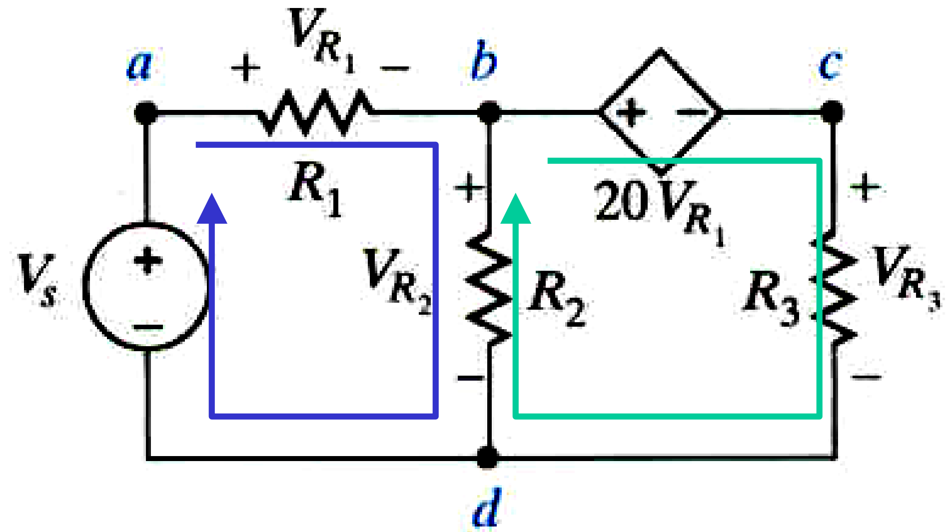
$$V_{ae} + 10 - 24 = 0$$

$$16 - 12 + 4 + 6 - V_{ae} = 0$$

GIVEN THE CHOICE USE THE SIMPLEST LOOP

$$4 + 6 + V_{ec} = 0$$

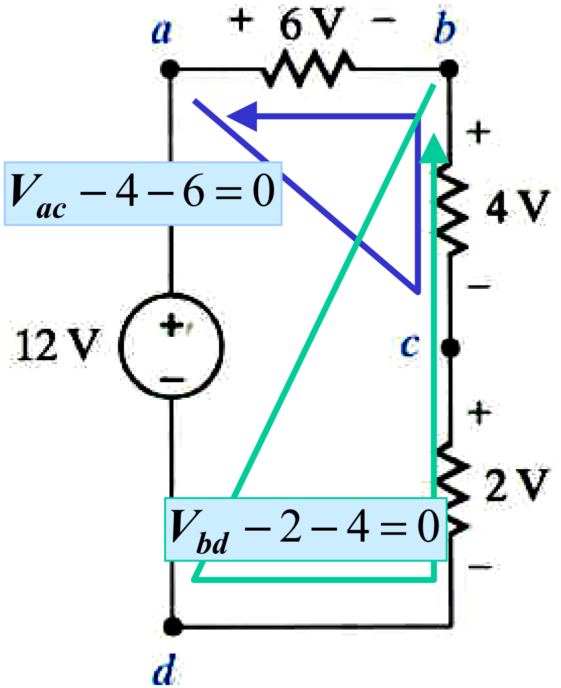
DEPENDENT SOURCES ARE HANDLED WITH THE SAME EASE



$$V_{R_1} + V_{R_2} - V_S = 0$$

$$20V_{R_1} + V_{R_3} - V_{R_2} = 0$$

GEAUX



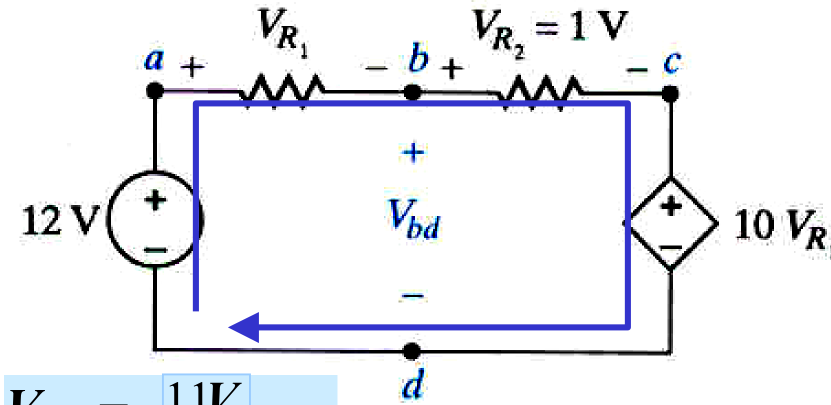
$V_{ac} - 4 - 6 = 0$

$V_{bd} - 2 - 4 = 0$

$V_{ad} =$ ______

$V_{ac} =$ $10V$

$V_{bd} =$ $6V$



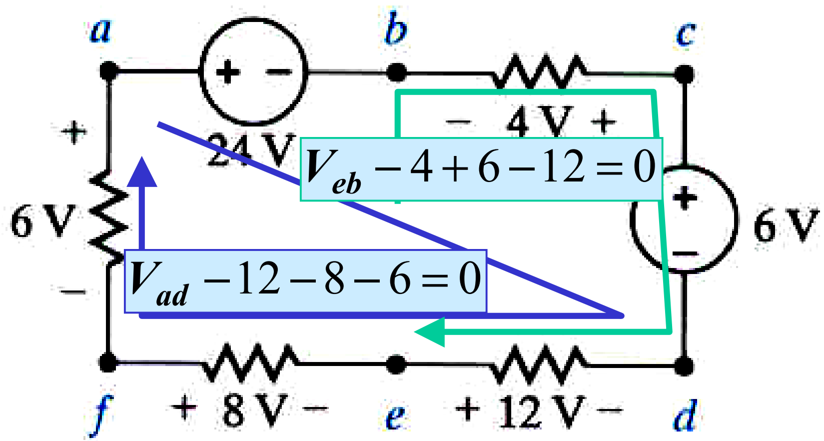
$V_{bd} =$ $11V$

MUST FIND V_{R_1} FIRST

$-12 + V_{R_1} + 1 + 10V_{R_1} = 0 \Rightarrow V_{R_1} = 1V$

DEPENDENT SOURCES ARE NOT REALLY DIFFICULT TO ANALYZE

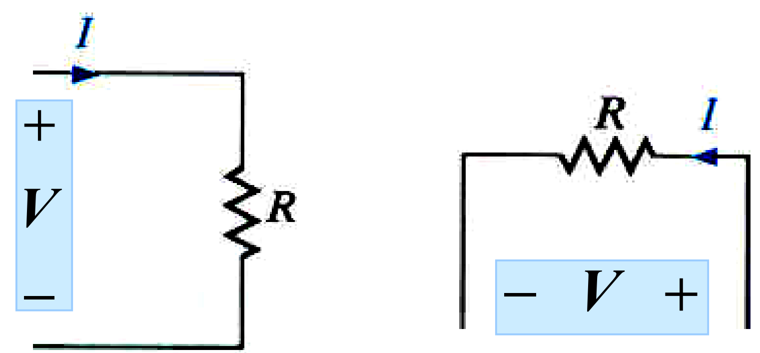
REMINDER: IN A RESISTOR THE VOLTAGE AND CURRENT DIRECTIONS MUST SATISFY THE PASSIVE SIGN CONVENTION



$V_{eb} - 4 + 6 - 12 = 0$

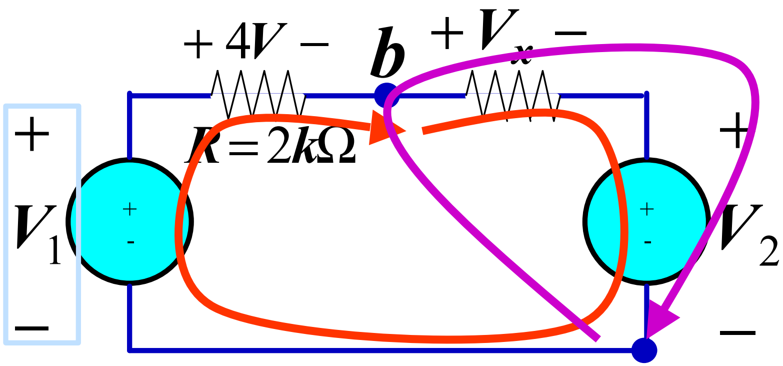
$V_{ad} - 12 - 8 - 6 = 0$

$V_{ad} =$ ______, $V_{eb} =$ ______



GEAUX

SAMPLE PROBLEM



$V_1 = 12V, V_2 = 4V$

DETERMINE

V_x = **4V**

V_{ab} = **-8V**

Power disipated on the 2k resistor

P_{2k} =

Remember past topics

We need to find a closed path where only one voltage is unknown

$$FOR\ V_X$$

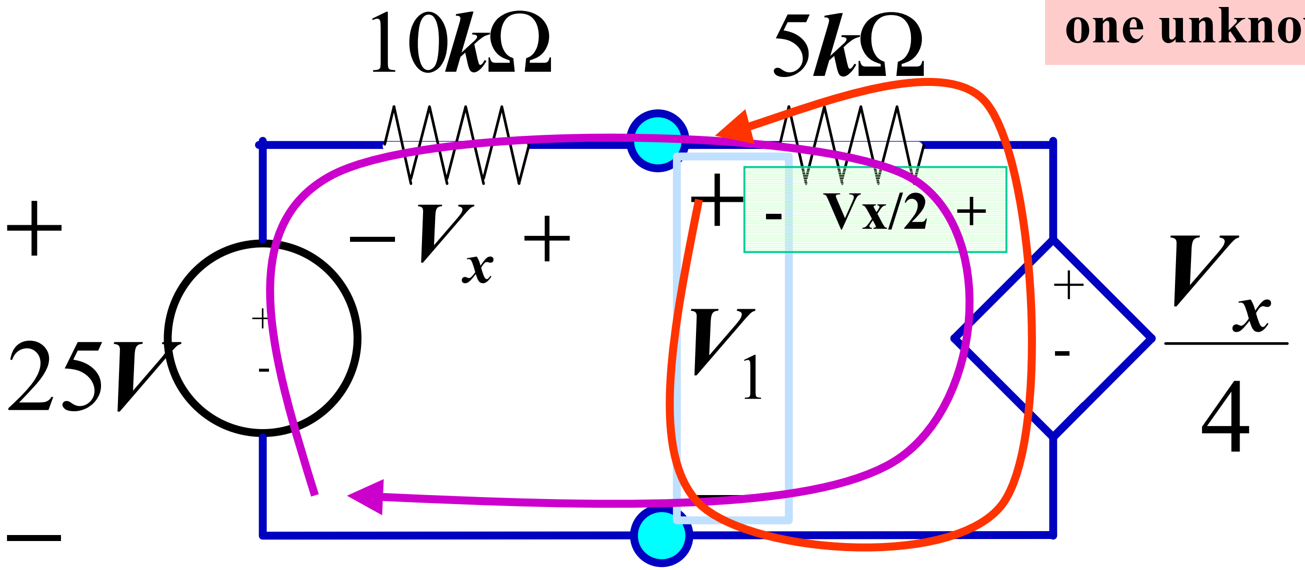
$$V_X + V_2 - V_1 + 4 = 0$$

$$V_X + 4 - 12 + 4 = 0$$

$$V_X + V_2 + V_{ab} = 0$$

$$V_{ab} = -V_X - V_2$$

GEAUX



There are no loops with only one unknown!!!

The current through the 5k and 10k resistors is the same. Hence the voltage drop across the 5k is one half of the drop across the 10k!!!

$$-25[V] - V_X - \frac{V_X}{2} + \frac{V_X}{4} = 0$$

$$V_X = -20[V]$$

$$V_1 - \frac{V_X}{4} + \frac{V_X}{2} = 0$$

$$V_1 = -\frac{V_X}{4} = 5[V]$$