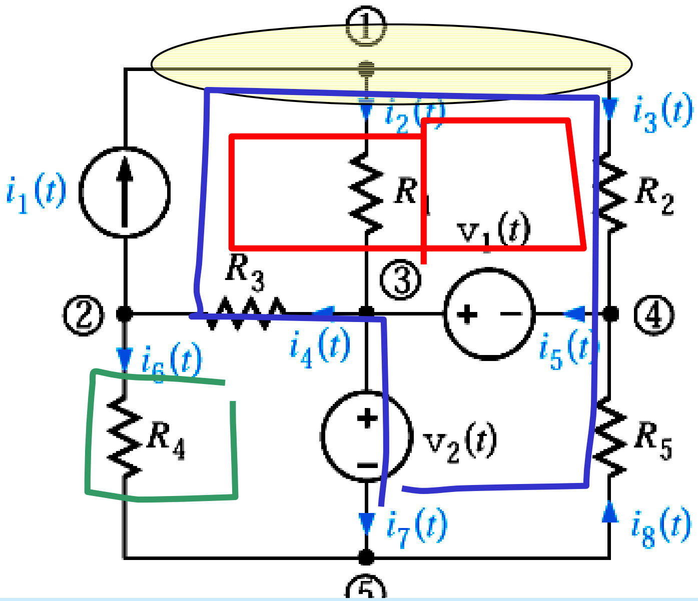
KIRCHHOFF CURRENT LAW

ONE OF THE FUNDAMENTAL CONSERVATION PRINCIPLES IN ELECTRICAL ENGINEERING

“CHARGE CANNOT BE CREATED NOR DESTROYED”

GEAUX

NODES, BRANCHES, LOOPS



NODE: point where two, or more, elements are joined (e.g., big node 1)

LOOP: A closed path that never goes twice over a node (e.g., the blue line)

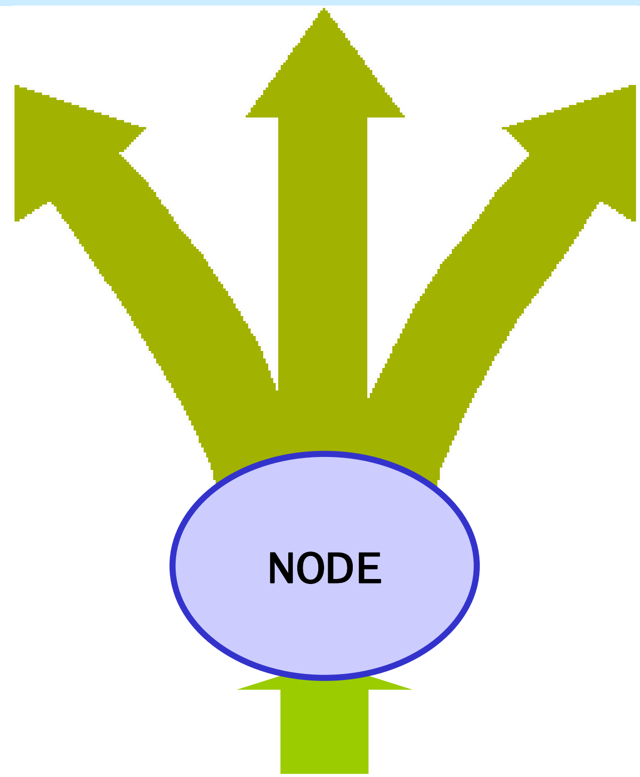
The red path is NOT a loop

BRANCH: Component connected between two nodes (e.g., component R4)

A NODE CONNECTS SEVERAL COMPONENTS. BUT IT DOES NOT HOLD ANY CHARGE.

TOTAL CURRENT FLOWING INTO THE NODE MUST BE EQUAL TO TOTAL CURRENT OUT OF THE NODE

(A CONSERVATION OF CHARGE PRINCIPLE)



GEAUX

KIRCHHOFF CURRENT LAW (KCL)

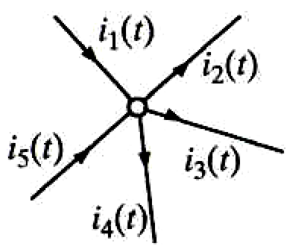
SUM OF CURRENTS FLOWING INTO A NODE IS EQUAL TO SUM OF CURRENTS FLOWING OUT OF THE NODE

A current flowing into a node is equivalent to the negative flowing out of the node

ALGEBRAIC SUM OF CURRENT (FLOWING) OUT OF A NODE IS ZERO

ALGEBRAIC SUM OF CURRENTS FLOWING INTO A NODE IS ZERO

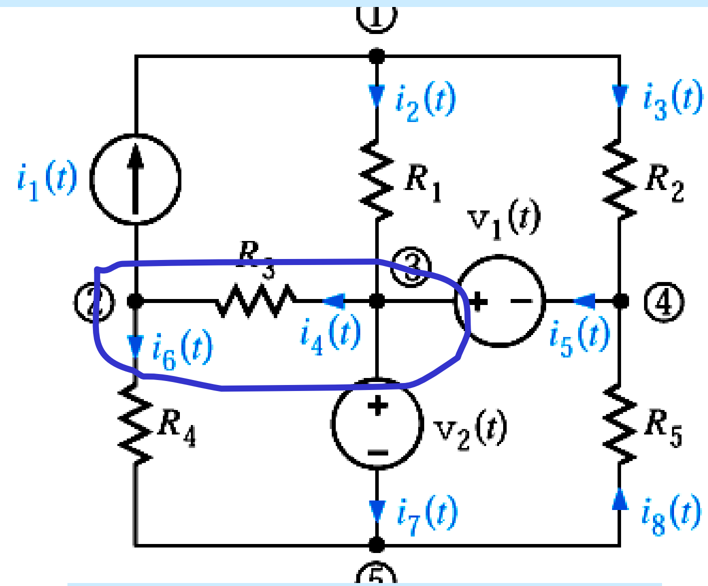
D2.3 Write the KCL equation for the following node:



$$i_1(t) - i_2(t) - i_3(t) - i_4(t) + i_5(t) = 0$$

A GENERALIZED NODE IS ANY PART OF A CIRCUIT WHERE THERE IS NO ACCUMULATION OF CHARGE

... OR WE CAN MAKE SUPERNODES BY AGGREGATING NODES



Leaving 2: $i_1 + i_6 - i_4 = 0$

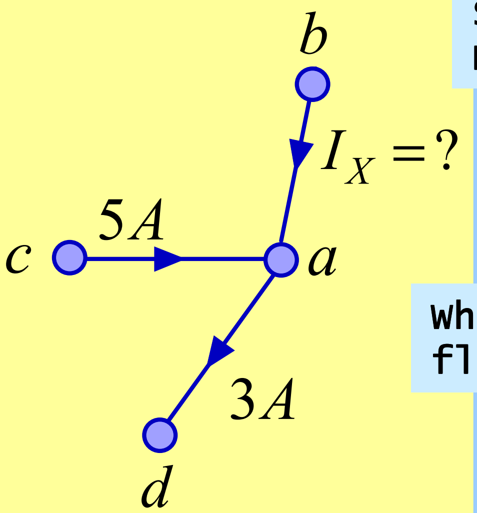
Leaving 3: $-i_2 + i_4 - i_5 + i_7 = 0$

Adding 2 & 3: $i_1 - i_2 - i_5 + i_6 + i_7 = 0$

INTERPRETATION: SUM OF CURRENTS LEAVING NODES 2&3 IS ZERO

VISUALIZATION: WE CAN ENCLOSE NODES 2&3 INSIDE A SURFACE THAT IS VIEWED AS A GENERALIZED NODE (OR SUPERNODE)

PROBLEM SOLVING HINT: KCL CAN BE USED TO FIND A MISSING CURRENT

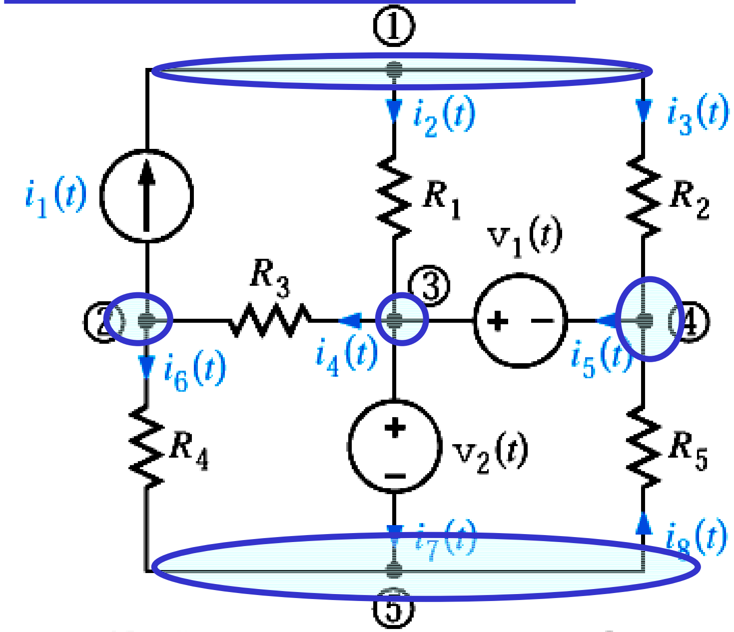


SUM OF CURRENTS INTO NODE IS ZERO

$$5A + I_X + (-3A) = 0$$
$$I_X = -2A$$

Which way are charges flowing on branch a-b?

WRITE ALL KCL EQUATIONS



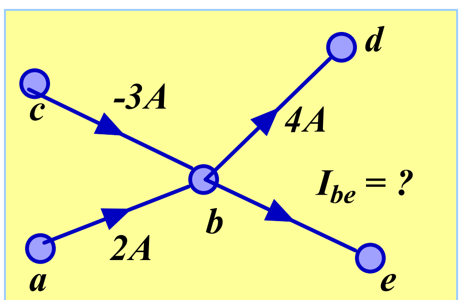
$$-i_1(t) + i_2(t) + i_3(t) = 0$$
$$i_1(t) - i_4(t) + i_6(t) = 0$$
$$-i_2(t) + i_4(t) - i_5(t) + i_7(t) = 0$$
$$-i_3(t) + i_5(t) - i_8(t) = 0$$
$$-i_6(t) - i_7(t) + i_8(t) = 0$$

THE FIFTH EQUATION IS THE SUM OF THE FIRST FOUR... IT IS REDUNDANT!!!

...AND PRACTICE NOTATION CONVENTION AT THE SAME TIME...

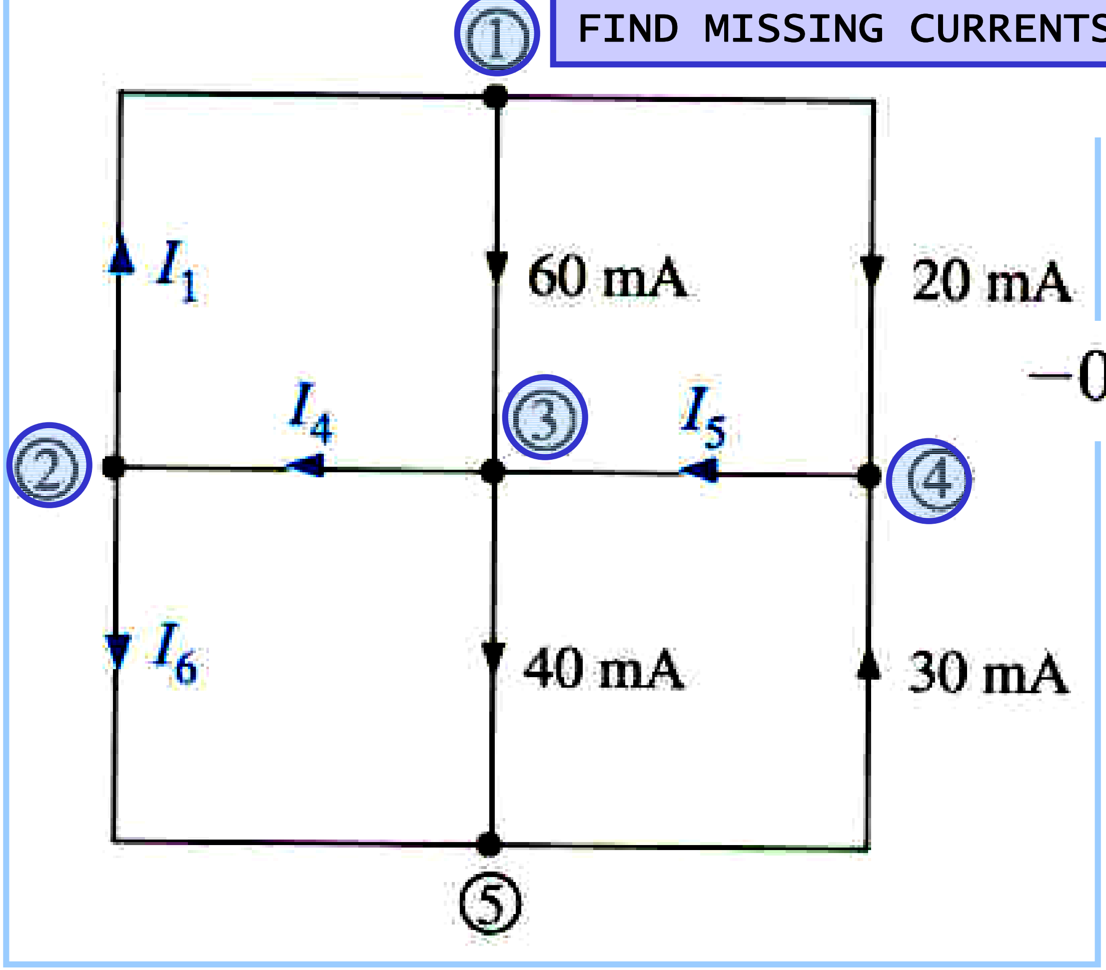
$I_{ab} = 2A,$
$I_{cb} = -3A$
$I_{bd} = 4A$
$I_{be} = ?$

NODES: *a,b,c,d,e*
BRANCHES: *a-b,c-b,d-b,e-b*



$$I_{be} + 4A + [-(-3A)] + (-2A) = 0$$

FIND MISSING CURRENTS



$$-I_1 + 0.06 + 0.02 = 0$$

$$I_1 - I_4 + I_6 = 0$$

$$-0.06 + I_4 - I_5 + 0.04 = 0$$

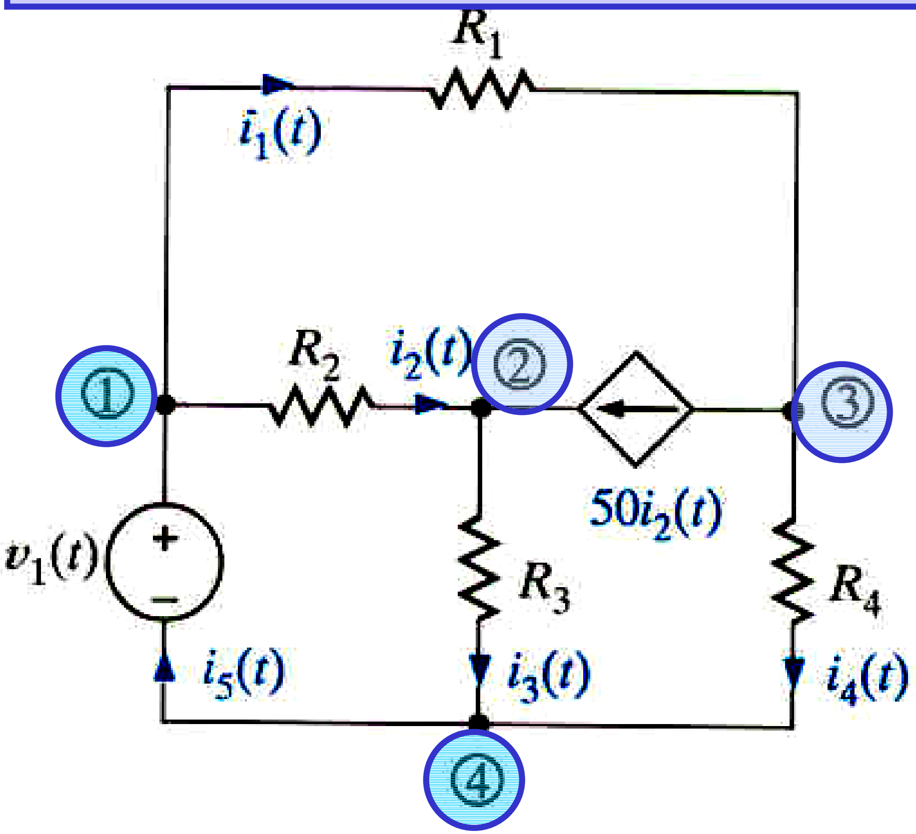
$$-0.02 + I_5 - 0.03 = 0$$

KCL DEPENDS ONLY ON THE INTERCONNECTION.
THE TYPE OF COMPONENT IS IRRELEVANT

KCL DEPENDS ONLY ON THE TOPOLOGY OF THE CIRCUIT

GEAUX

WRITE KCL EQUATIONS FOR THIS CIRCUIT



$$i_1(t) + i_2(t) - i_5(t) = 0$$

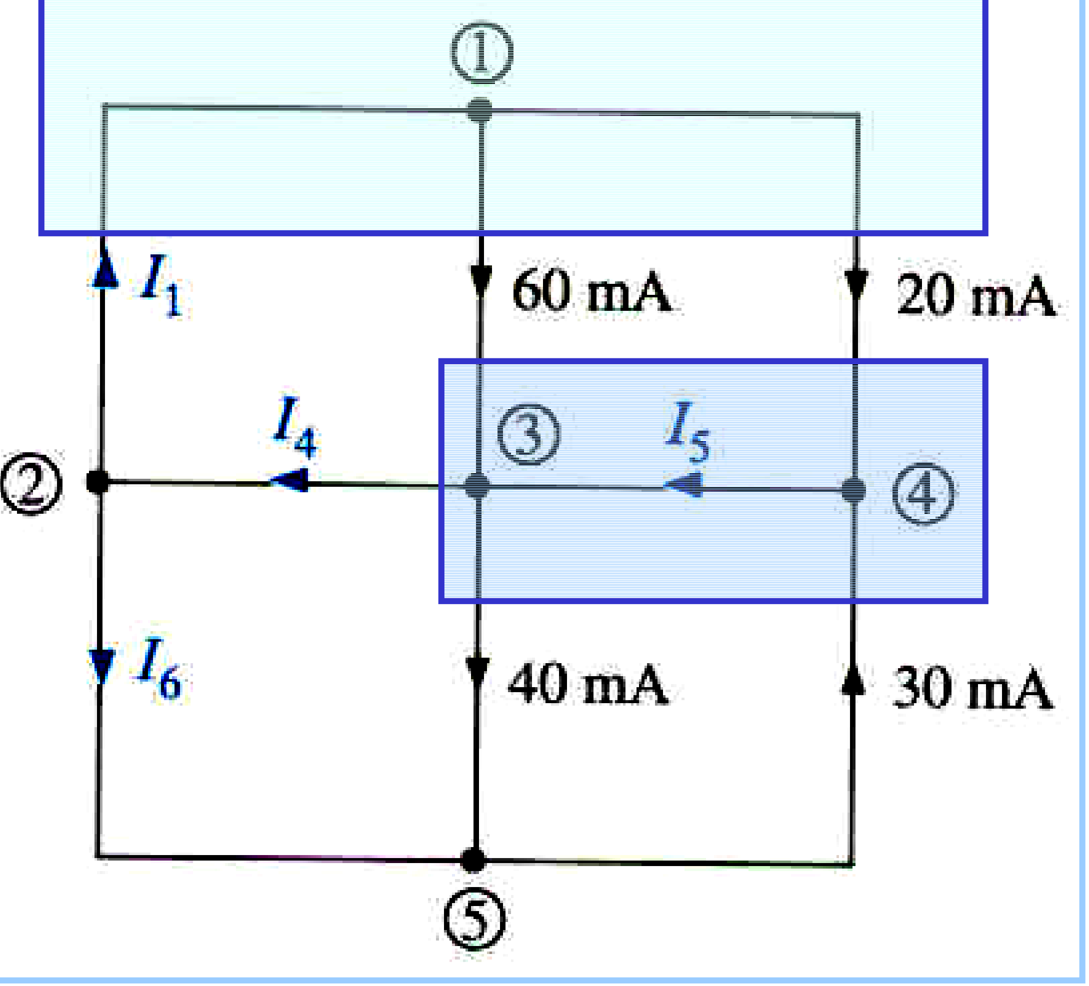
$$-i_2(t) + i_3(t) - 50i_2(t) = 0$$

$$-i_1(t) + 50i_2(t) + i_4(t) = 0$$

$$i_5(t) - i_3(t) - i_4(t) = 0$$

- THE LAST EQUATION IS AGAIN LINEARLY DEPENDENT OF THE PREVIOUS THREE
- THE PRESENCE OF A DEPENDENT SOURCE DOES NOT AFFECT APPLICATION OF KCL KCL DEPENDS ONLY ON THE TOPOLOGY

GEAUX



Here we illustrate the use of a more general idea of node. The shaded surface encloses a section of the circuit and can be considered as a BIG node

SUM OF CURRENTS LEAVING BIG NODE = 0

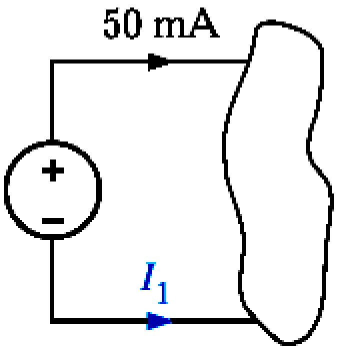
$$I_4 + 40mA - 30mA - 20mA - 60mA = 0$$

$$I_4 = 70mA$$

THE CURRENT I5 BECOMES INTERNAL TO THE NODE AND IT IS NOT NEEDED!!!

GEAUX

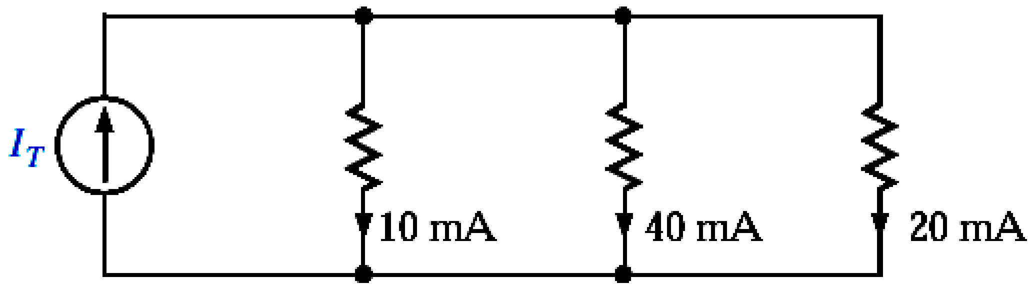
Find I_1



(a)

$$I_1 = -50mA$$

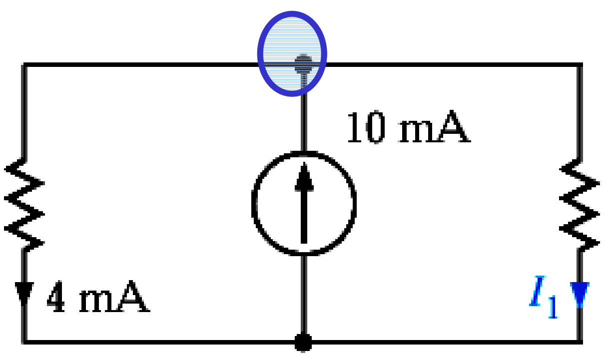
Find I_T



(b)

$$I_T = 10mA + 40mA + 20mA$$

Find I_1



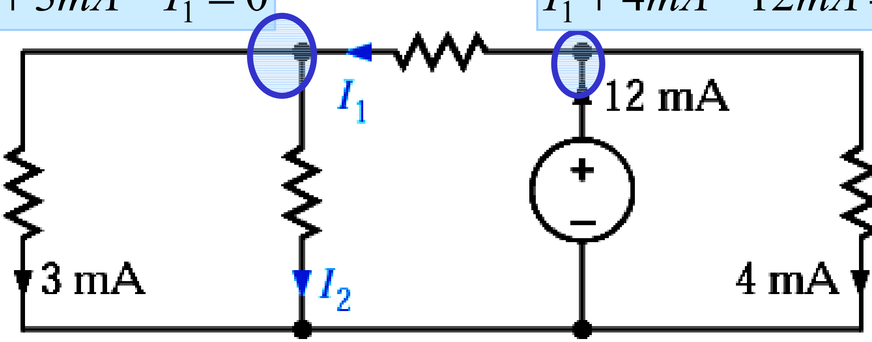
$$10mA - 4mA - I_1 = 0$$

(a)

Find I_1 and I_2

$$I_2 + 3mA - I_1 = 0$$

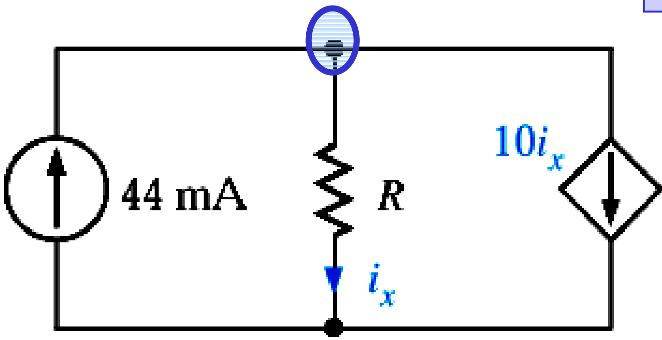
$$I_1 + 4mA - 12mA = 0$$



(b)

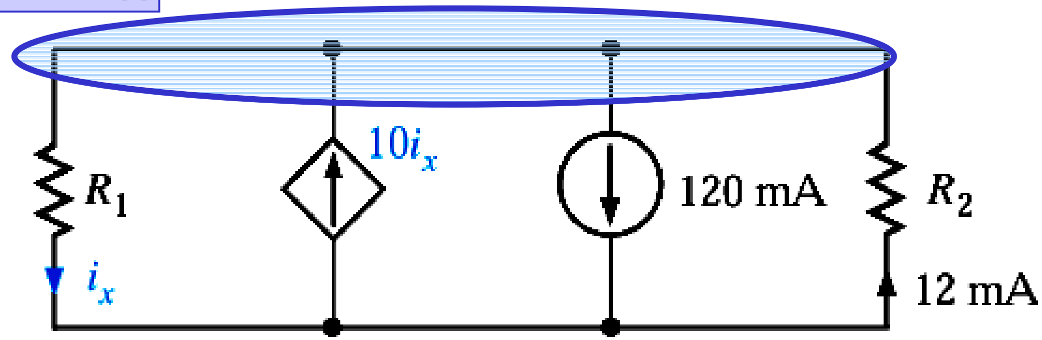
GEAUX

Find i_x



(a)

$$10i_x + i_x - 44mA = 0$$
$$i_x = 4mA$$

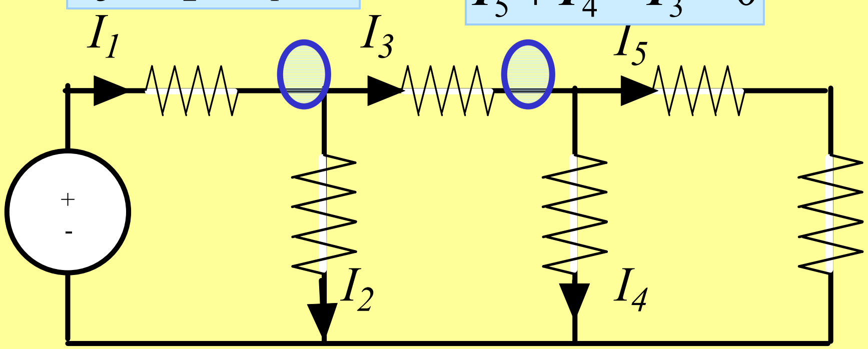


(b)

$$i_x - 10i_x + 120mA - 12mA = 0$$

$$I_3 + I_2 - I_1 = 0$$

$$I_5 + I_4 - I_3 = 0$$



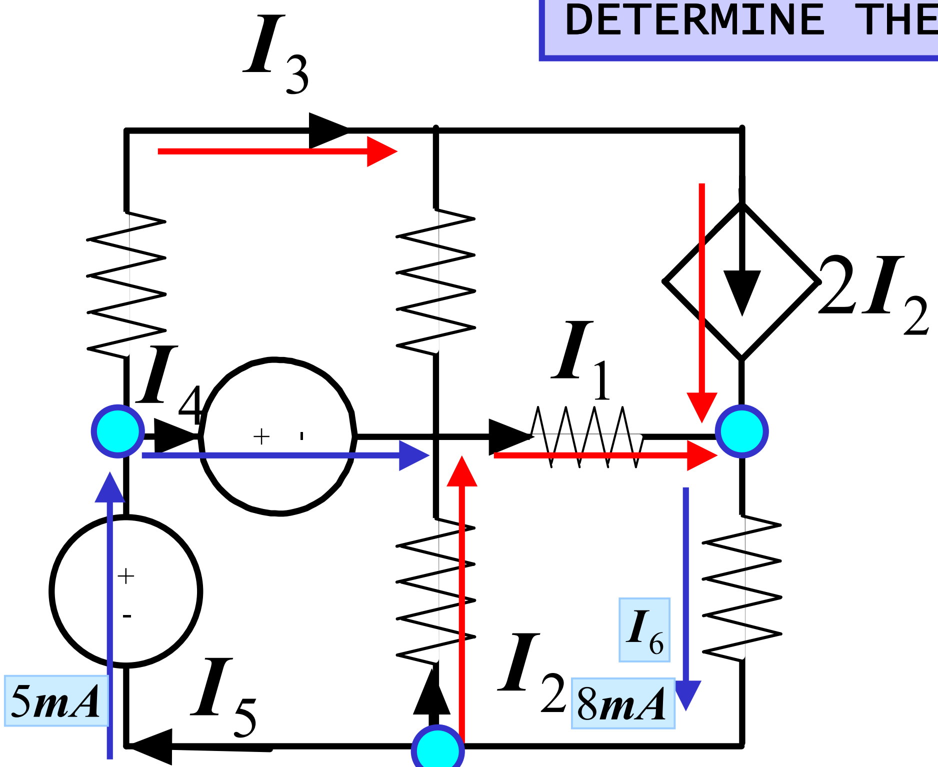
I_1 = $14mA$

I_5 = $5mA$

$I_2 = 6mA$, $I_3 = 8mA$, $I_4 = 4mA$

GEAUX

DETERMINE THE CURRENTS INDICATED



$$I_4 = 2mA$$

$$I_5 = 5mA$$

$$I_1 = 2mA,\ I_2 = 3mA,\ I_3 = 5mA$$

$$I_6 - I_1 - 2I_2 = 0 \Rightarrow I_6 = 8mA$$

$$I_5 + I_2 - I_6 = 0$$

$$I_4 + I_3 - I_5 = 0$$

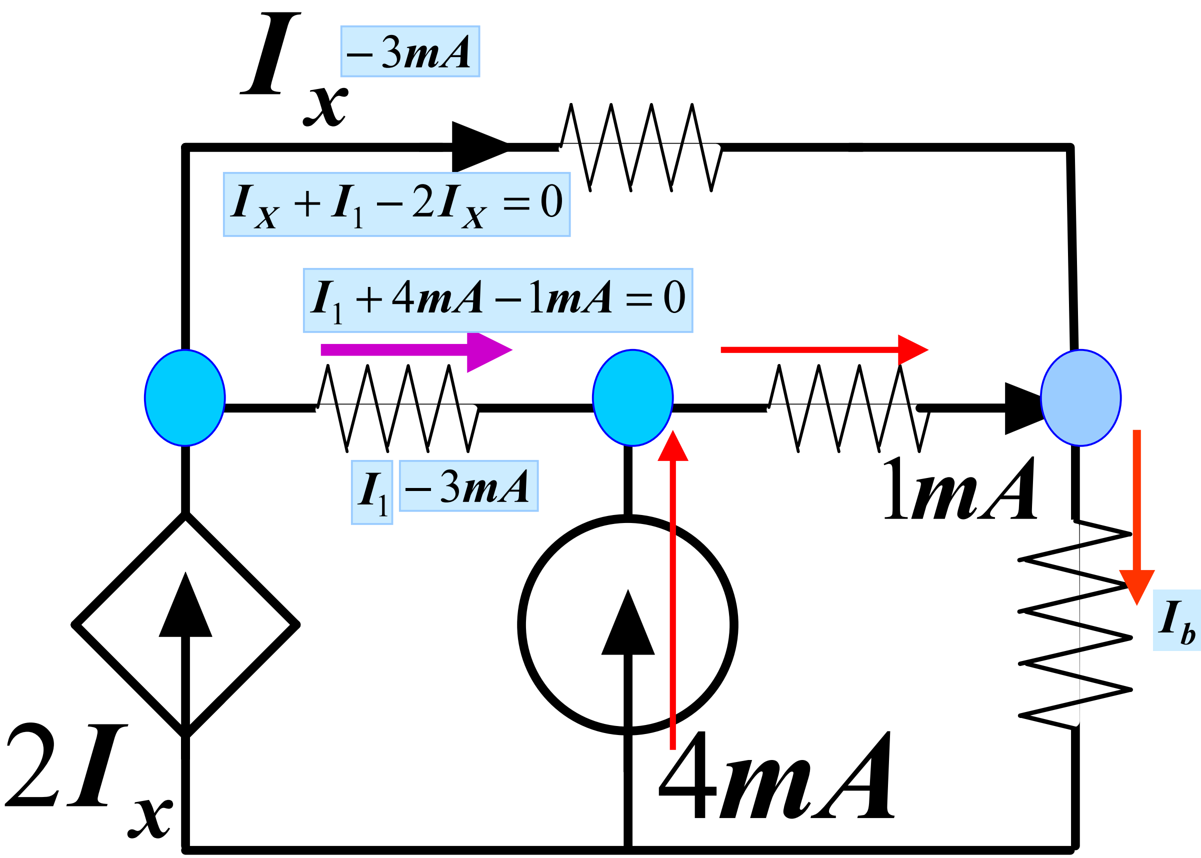
THE PLAN

MARK ALL THE KNOWN CURRENTS

FIND NODES WHERE ALL BUT ONE CURRENT ARE KNOWN

GEAUX

FIND I_x



VERIFICATION

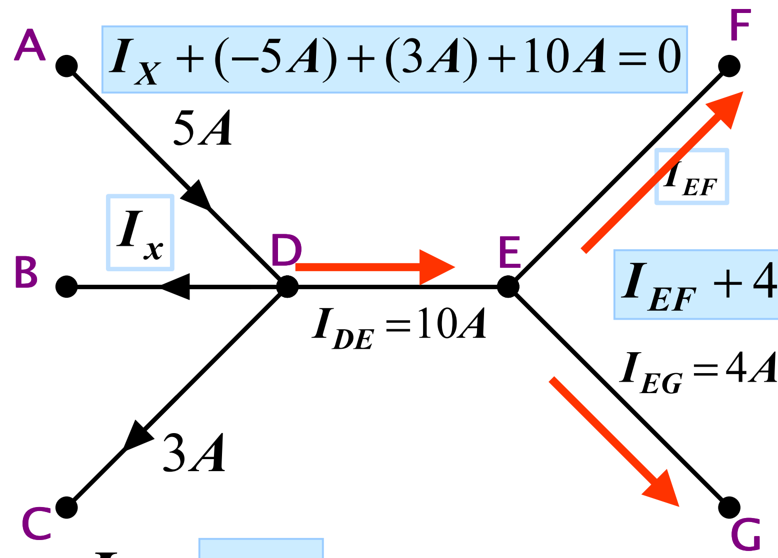
$I_b = 1mA + I_X = -2mA$

$2I_X + 4mA = I_b$

This question tests KCL and convention to denote currents

Use sum of currents leaving node = 0

$$I_X + (-5A) + (3A) + 10A = 0$$



$$I_{EF} + 4A - 10A = 0$$

$I_x =$ **-8A**

On BD current flows from **B** to **D**

$I_{EF} =$ **6A**

On EF current flows from **E** to **F**