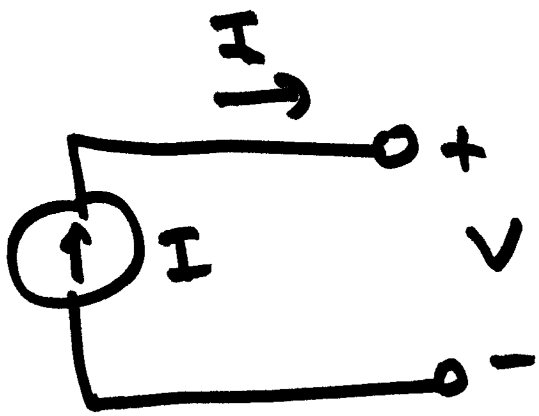
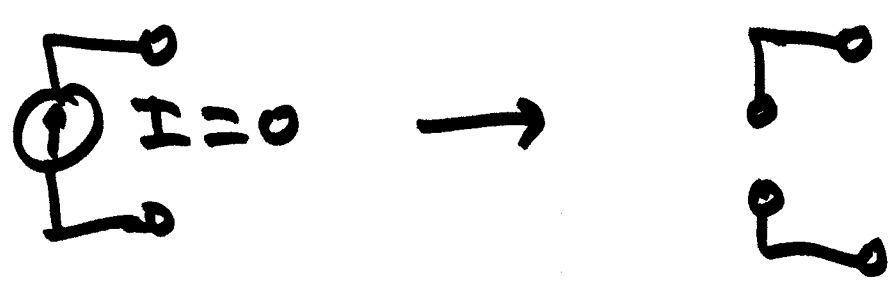
1/23/02

Ideal current source



$$R_{eq} = \frac{\Delta V}{\Delta I}, \quad \Delta I = 0$$

$$\Rightarrow R_{eq} \to \infty$$



Summary

set sources to zero

1) voltage $\longrightarrow$ short circuit 

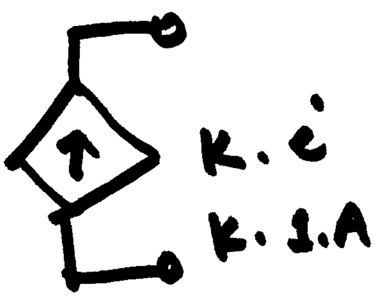
2) current $\longrightarrow$ open circuit 

Independent VS. Dependent Sources

A) Independent:. voltage or current is fixed, set by the source

B) Dependent:. Voltage or current is not fixed, but it depends on something (another Parameter)

Symbol notation



Dependent current source

Super Position

(Theorem, Principle)

Linear function

$y = f(x)$

$x \rightarrow$ variable

$f(\cdot) \rightarrow$ function

$y \rightarrow$ result of x

$x_1, x_2 \rightarrow$ two different inputs

$y_1 = f(x_1)$

$y_2 = f(x_2)$

$x_1 + x_2$

$y_3 = f(x_1 + x_2)$

Example

$x_1 = 10^\circ$

$x_2 = 20^\circ$

$f(\cdot) = \sin(\cdot)$

$y_1 = \sin(10^\circ)$

$y_2 = \sin(20^\circ)$

$y_3 = \sin(10+20) = \sin(30^\circ)$

$y_3 \neq y_1 + y_2$

If function <u>is</u> Linear then $y_3 = y_1 + y_2$

Example $y = \int x \, dx$

$$y_1 = \int x_1 \, dx$$

$$y_2 = \int x_2 \, dx$$

$$y_3 = \int (x_1 + x_2) \, dx$$

$$= \underbrace{\int x_1 \, dx}_{y_1} + \underbrace{\int x_2 \, dx}_{y_2}$$

$\Rightarrow y_3 = y_1 + y_2$

Definition of a Linear function

Linear if:- a) $f(x_1 + x_2) = f(x_1) + f(x_2)$

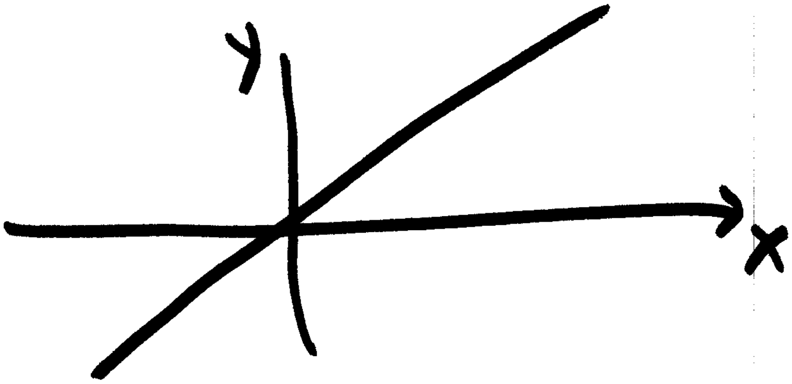
and b) $f(Kx) = K f(x)$

K = constant

or $f(K_1 x_1 + K_2 x_2) = K_1 f(x_1) + K_2 f(x_2)$

Simple test

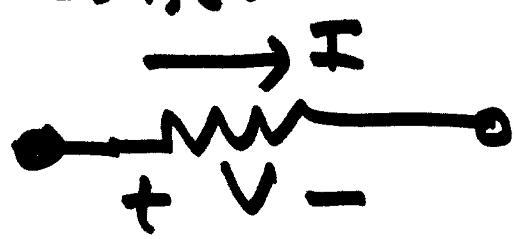
$y = f(x)$



Linear if plot of y vs. x is a straight line passing through the origin

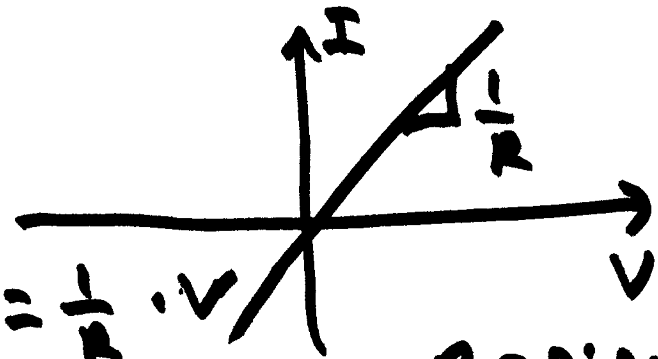
Example:.

Resistor

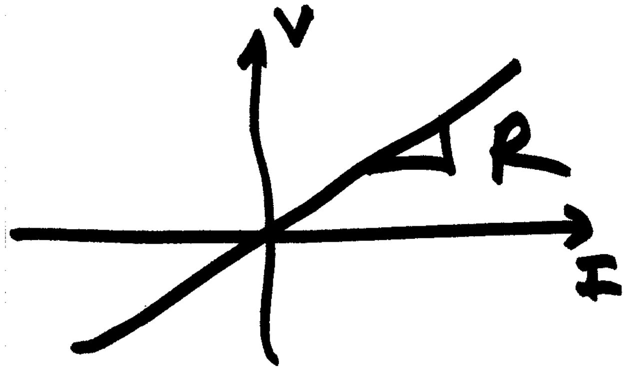


Let

$y = I$
$x = V$



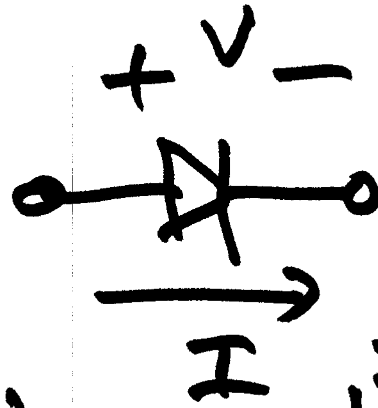
$I = \frac{1}{R} \cdot V$



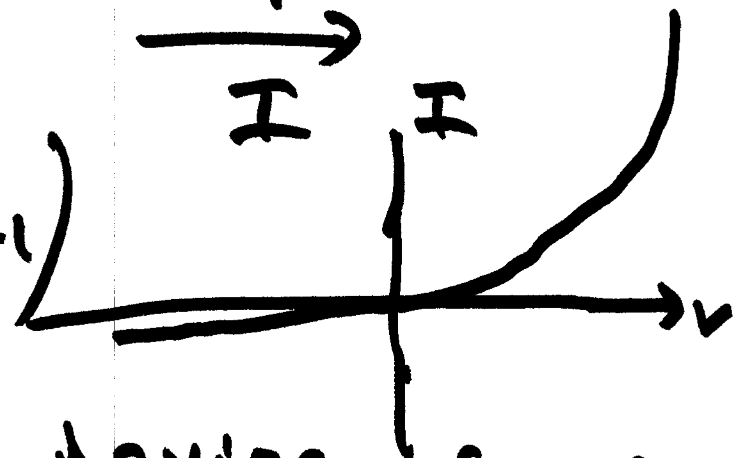
Resistor is a Linear component

Example 2

A diode



$$I = I_0\left(e^{V/V_T} - 1\right)$$



Non Linear device (component)

Circuits.

a) if a circuit is made up of Linear components then the circuit is called Linear.

b) if a circuit contains at least one non-Linear component, then the circuit is non Linear

So, In a Linear function

$y_1 = f(x_1)$

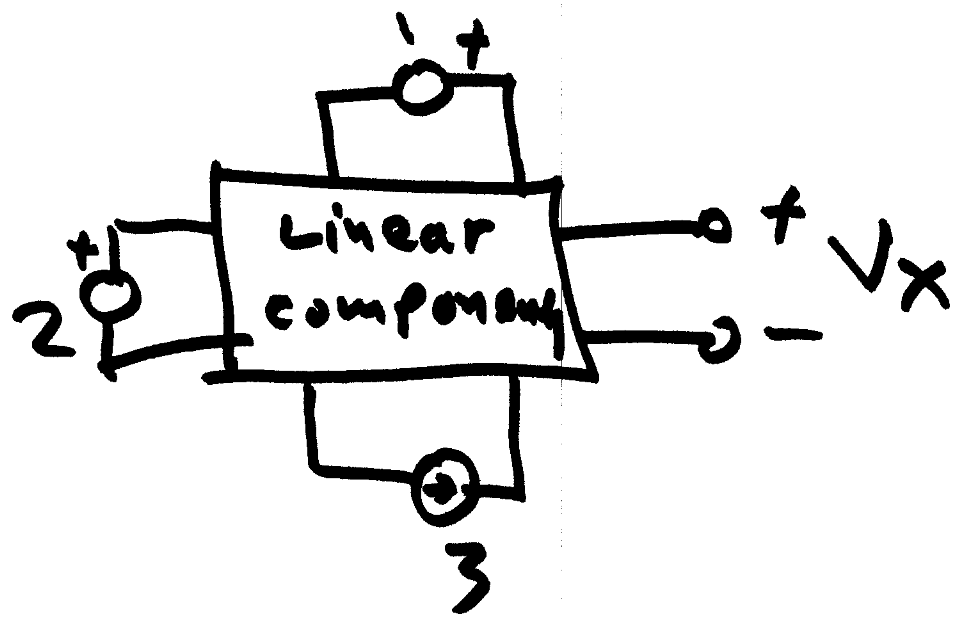
$y_2 = f(x_2)$

then $f(x_1 + x_2) = f(x_1) + f(x_2)$

$= y_1 + y_2$

superposition capitalized

in circuits



V_{x_1} voltage Due to Source 1

V_{x_2} " " " " 2

V_{x_3} " " " " 3

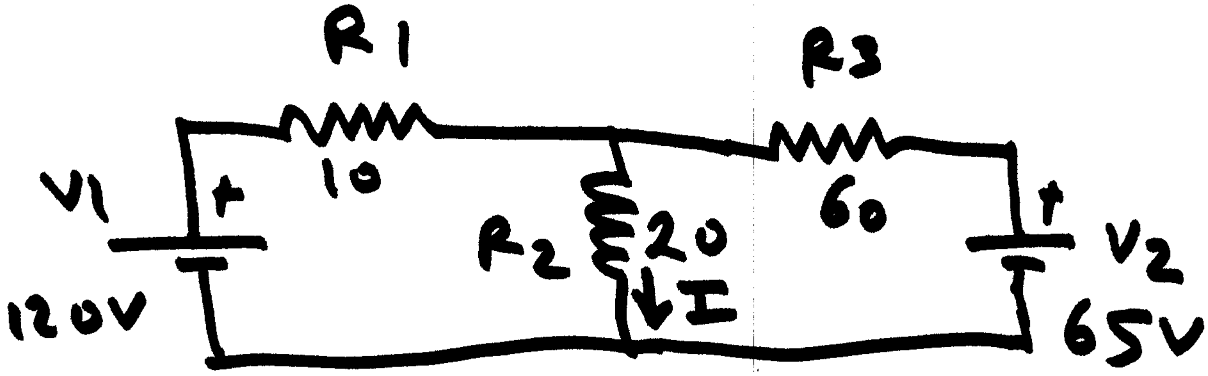
$\Rightarrow V_x = V_{x_1} + V_{x_2} + V_{x_3}$

Superposition theorem

1) Assume linear circuit
2) Multiple Sources (Inputs)
3) Compute an unknown (voltage or current) result of inputs.

Theorem The result of all inputs applied together, is equal to the summation or individual result of each input applied individually, with the rest set to zero

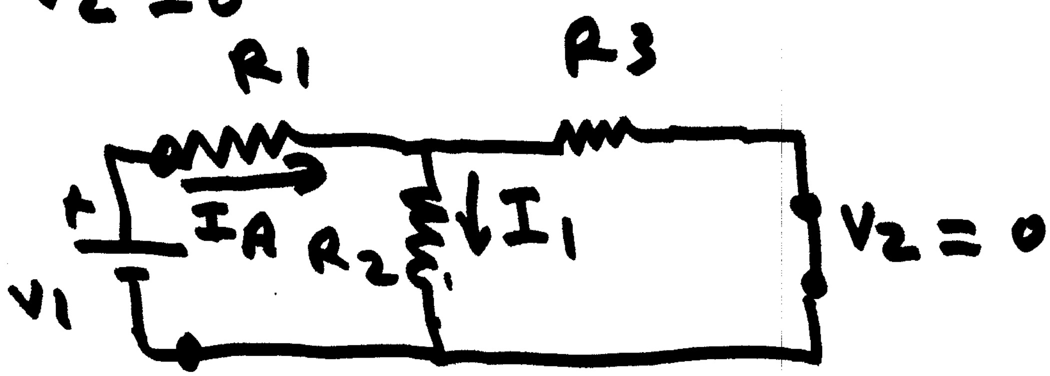
Example 1



Find current I

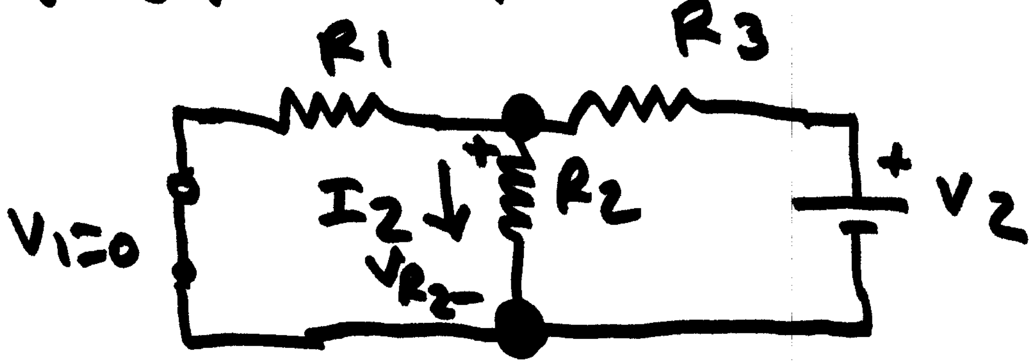
use super position

First set
$V_2 = 0$



$$I = I_1 + I_2$$

Then set $V_1 = 0$



Compute I_1: use current divider

$$I_1 = I_A \frac{R_3}{R_2+R_3}$$

$$I_A = \frac{V_1}{R_{eq}} \qquad R_{eq} = R_1 + (R_2 \| R_3)$$

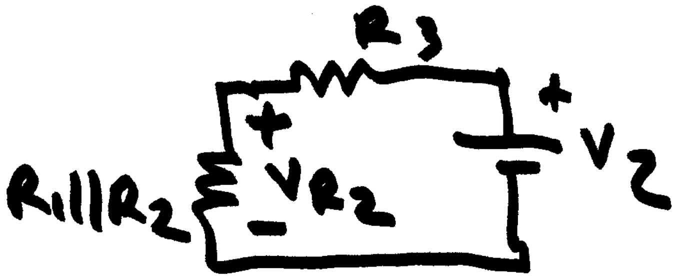
$$R_{eq} = 10 + (20 \| 60) = 10 + \frac{1200}{80} = 25\Omega$$

$$I_A = \frac{120V}{25\Omega} =$$

$$I_1 = \frac{120}{25} \frac{60}{80} = 3.6A$$

$$\boxed{I_1 = 3.6A}$$

Find I_2 use voltage divider



$$V_{R2} = V_2 \frac{R_1 \| R_2}{R_1 \| R_2 + R_3}$$

$$V_{R2} = 65 \frac{6.66}{6.66+60} = 6.5V$$

$$\Rightarrow I_2 = \frac{V_{R2}}{R_2} = \frac{6.5V}{20} = 0.325 A$$

$$I_1 = 3.6A, \quad I_2 = 0.325A$$

$\Rightarrow$ superposition

$$I = 3.6 + 0.325 = \underline{\underline{3.925 A}}$$

Note: Superposition doe not apply to power calculation because $P = V \cdot I$ is not a linear function

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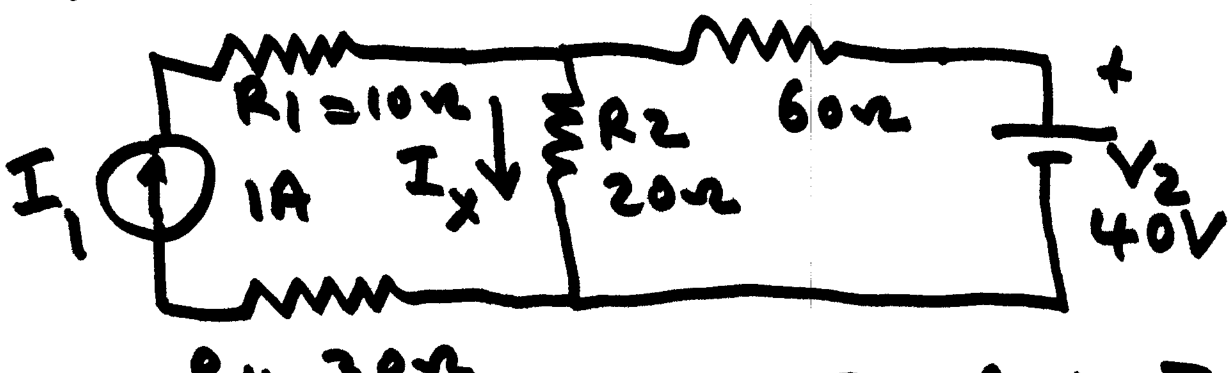
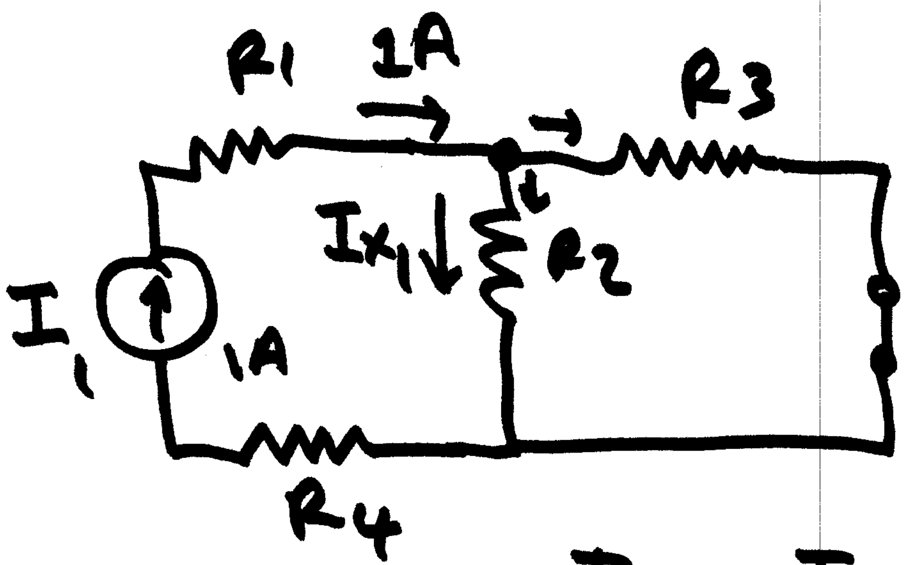
Example 2



Compute Ix

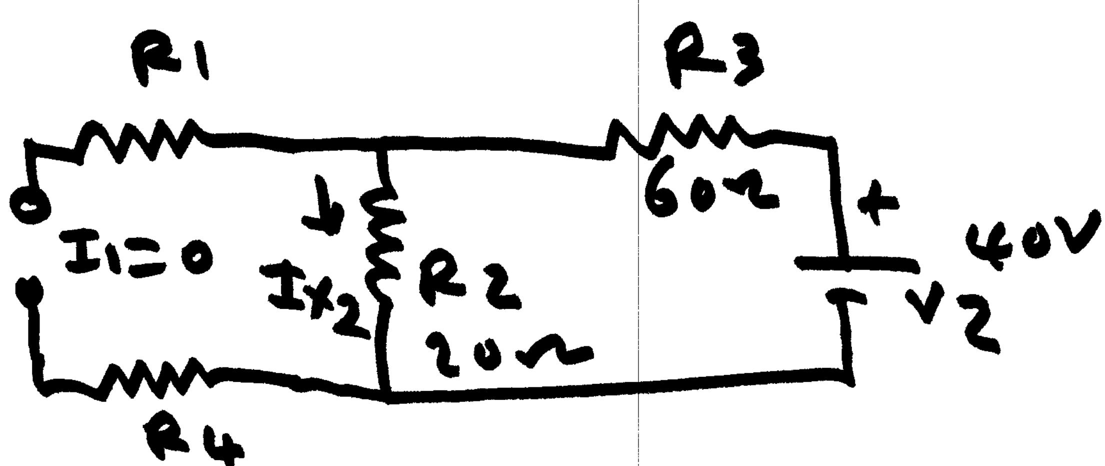
Frist consider the current source



$$I_{x_1} = I_1 \frac{R_3}{R_2 + R_3}$$

$$= 1A \frac{60}{80} = \frac{3}{4} A$$

Next consider V2



$$I_{x_2} = \frac{V2}{Req} = \frac{40V}{80\Omega} = \frac{1}{2} A$$

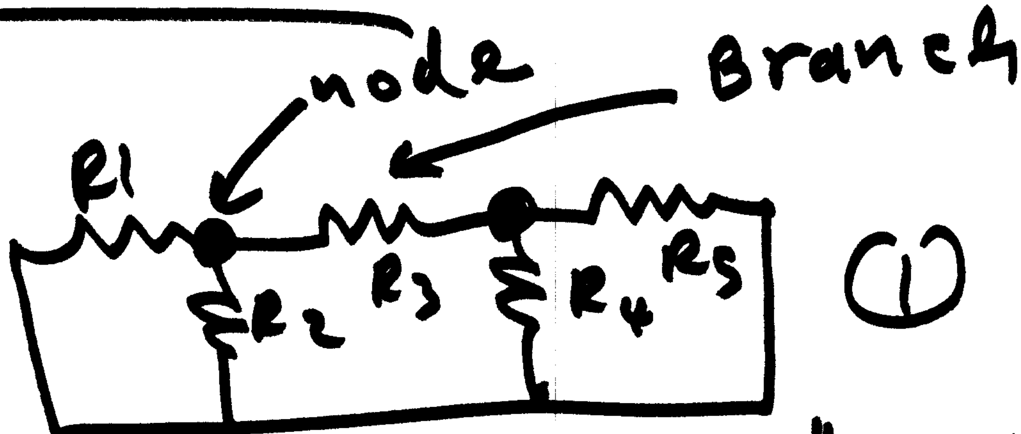
$\Rightarrow I_x = I_{x1} + I_{x2} = \frac{3}{4} + \frac{1}{2} = \underline{\underline{1.25\,A}}$

If the polarity of 40V source is reversed

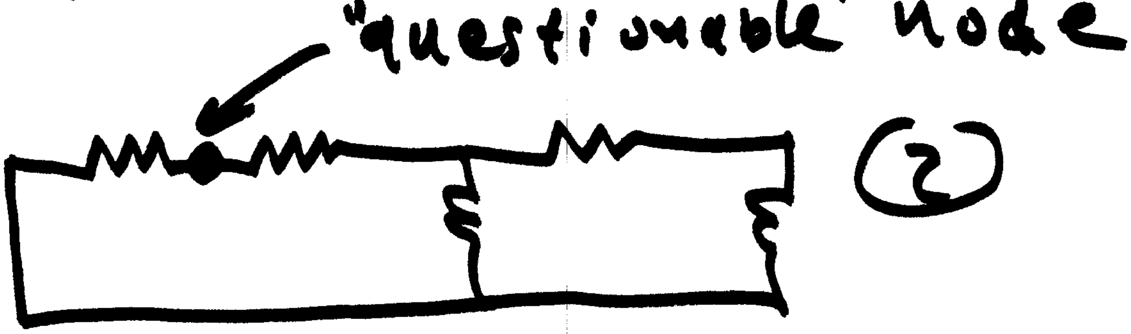
$\Rightarrow \quad I_{x2} = -\frac{1}{2}A$

$\Rightarrow \quad I_x = \frac{3}{4} - \frac{1}{2} = \underline{\underline{0.25\,A}}$

Definitions

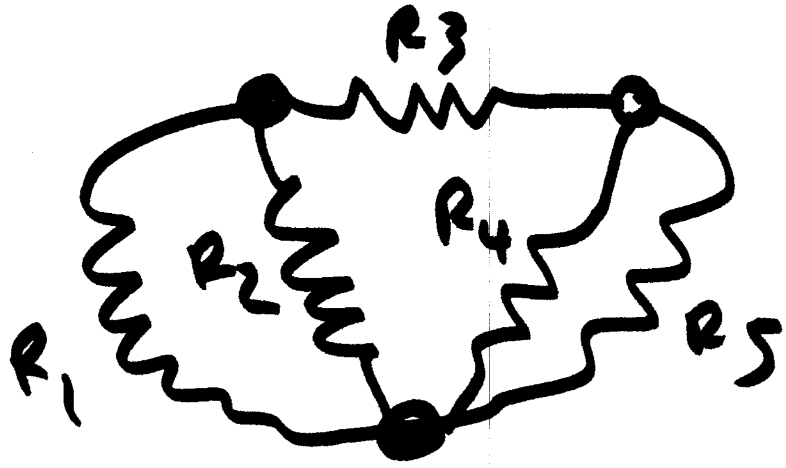


(1)



(2)

Re-draw #1



3 nodes