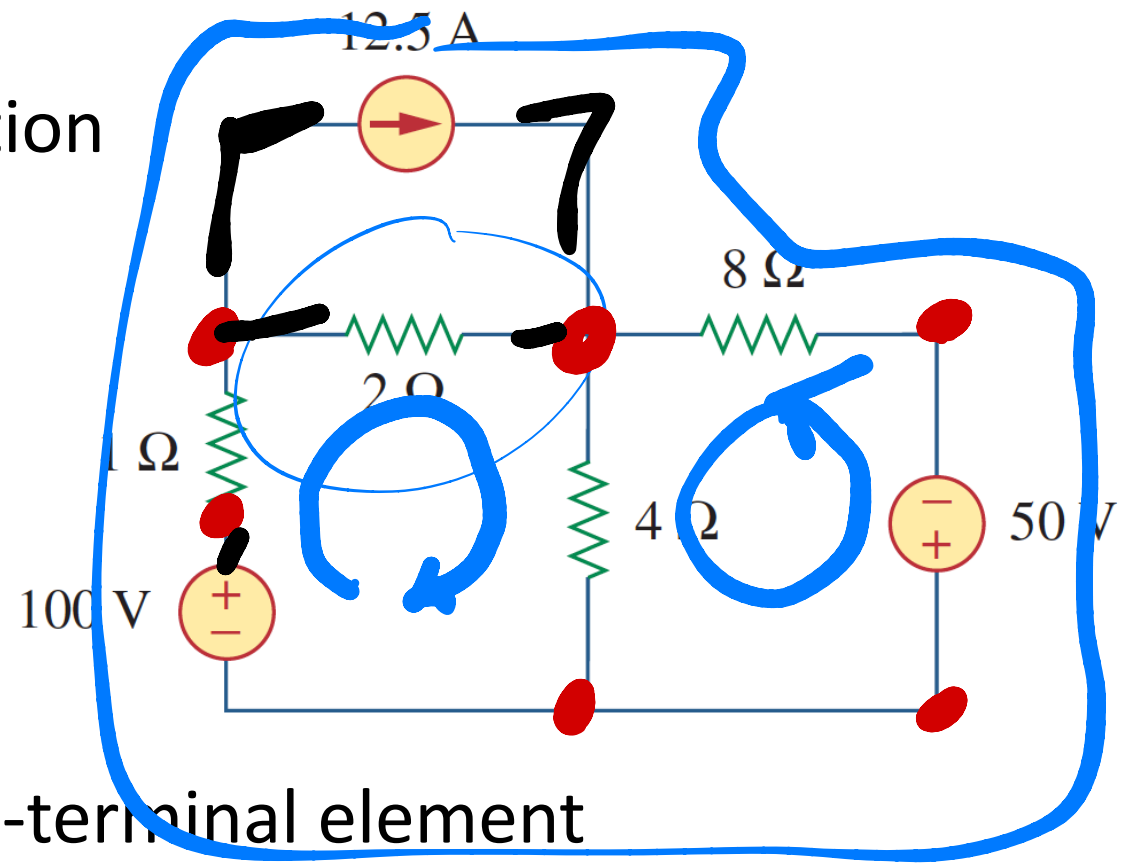
Basics – 3

circuits; Kirchhoff

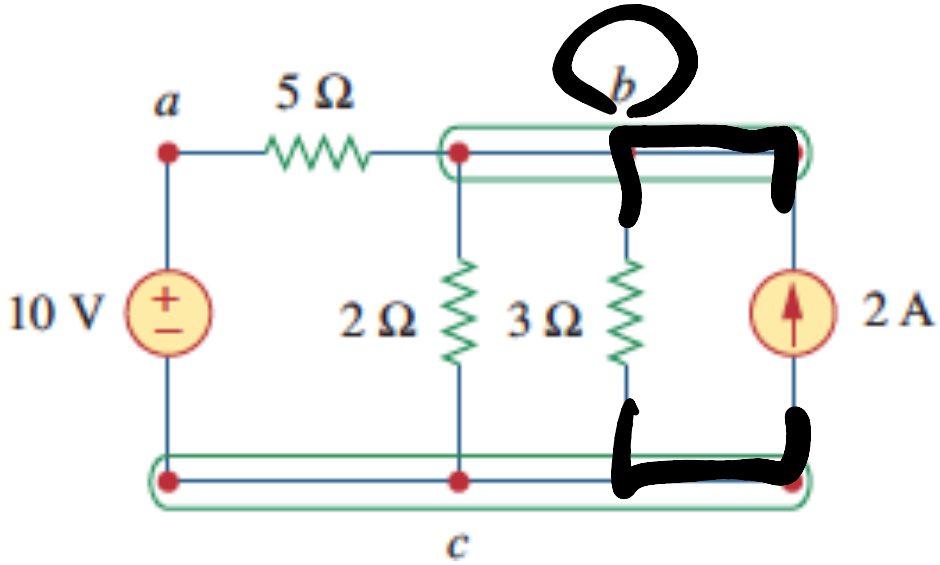
Circuit Concepts

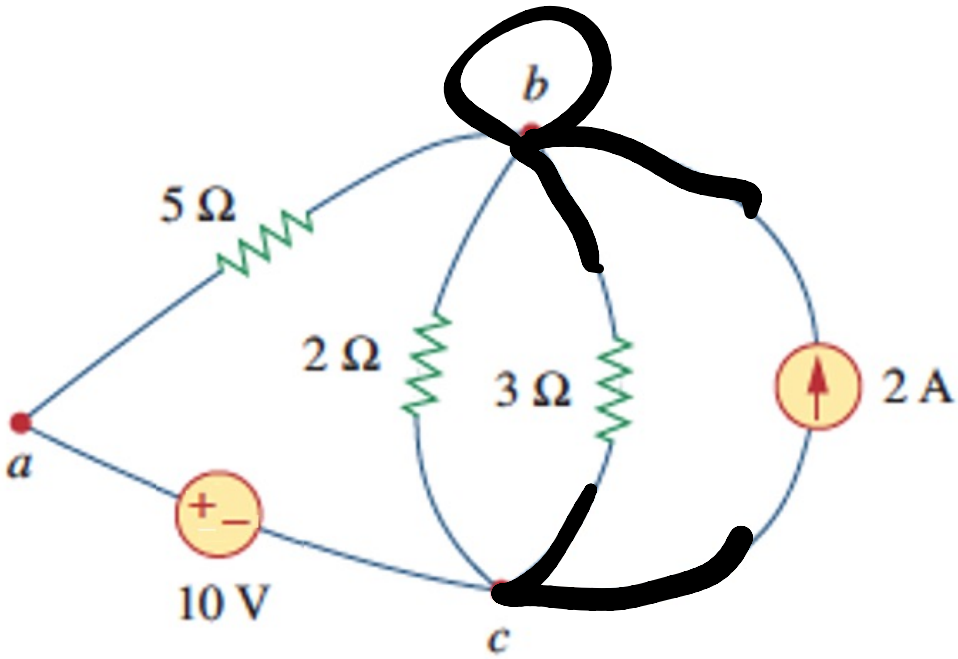
- Circuit = interconnection of multiple devices



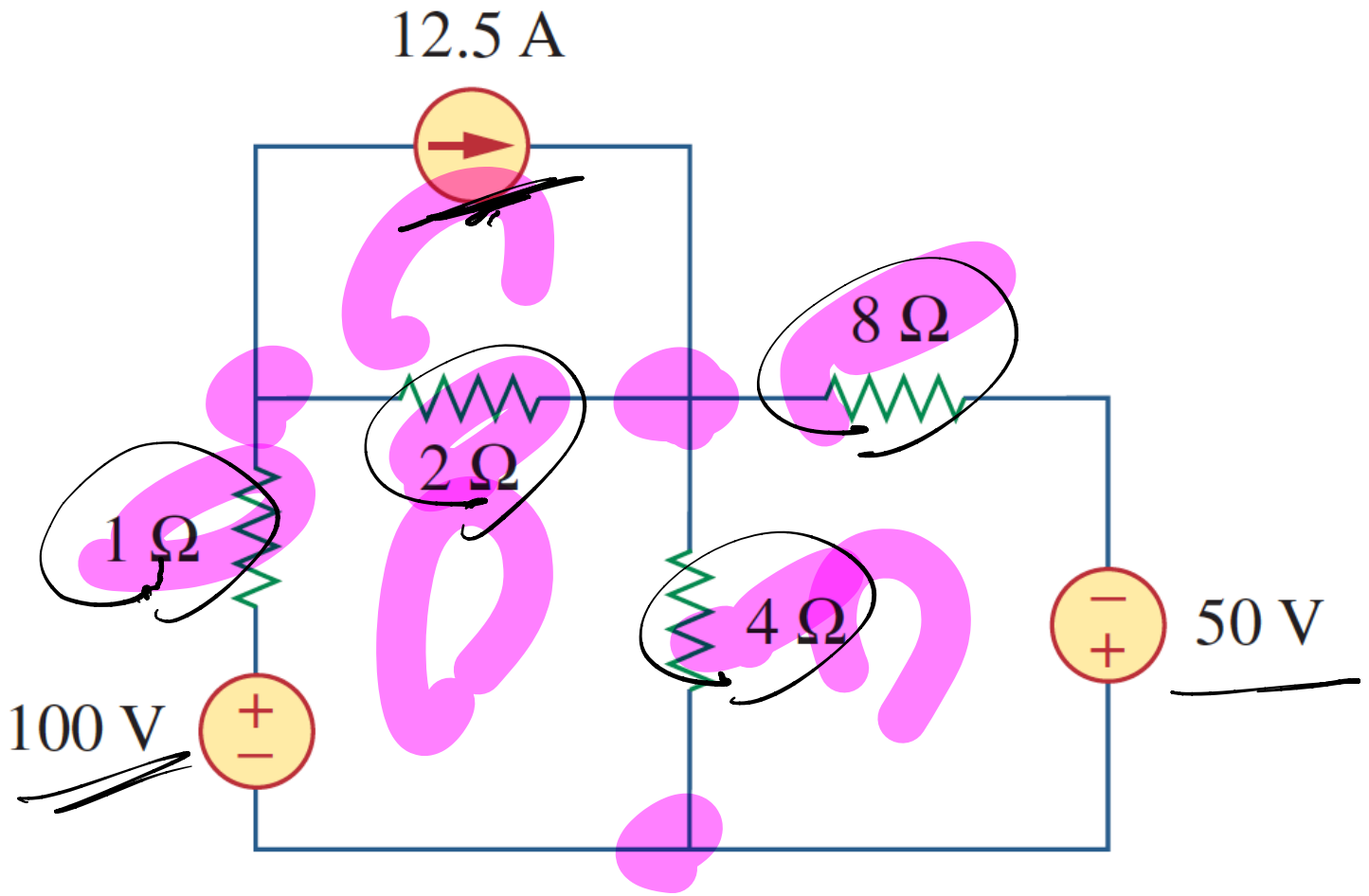
- Definitions:
  - Branch – a single 2-terminal element
  - Node – point where (≥2) branches connect
  - Loop – closed path around the circuit

Wires are like elastic bands



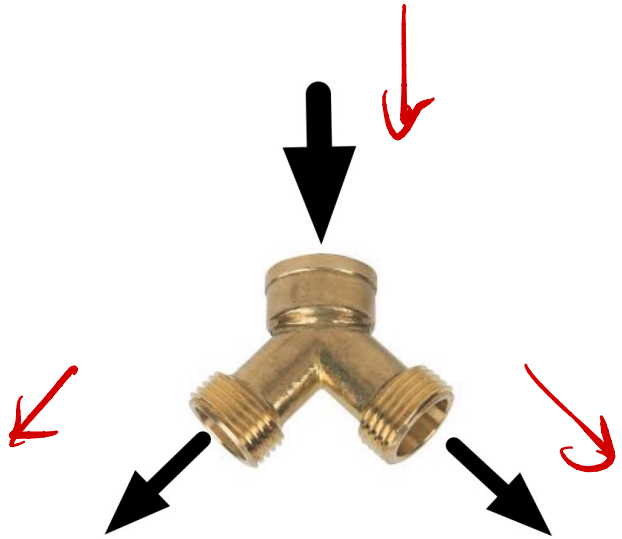


Voltage/Current Labelling

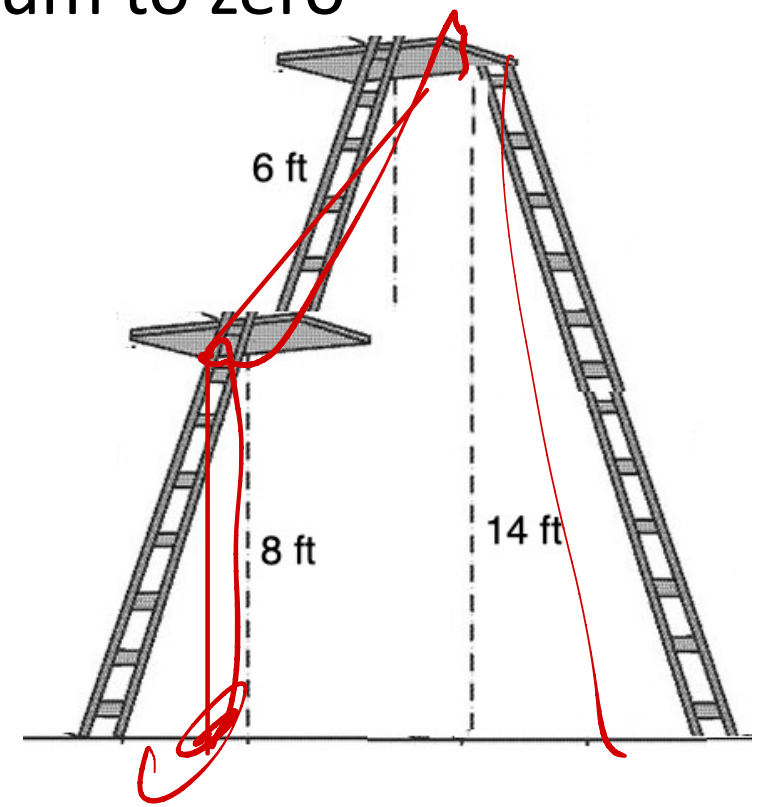


Kirchhoff's Laws

- Current Law (KCL) – conservation of current at a node – currents into a node sum to zero



- Voltage Law (KVL) – voltages changes around a closed path sum to zero

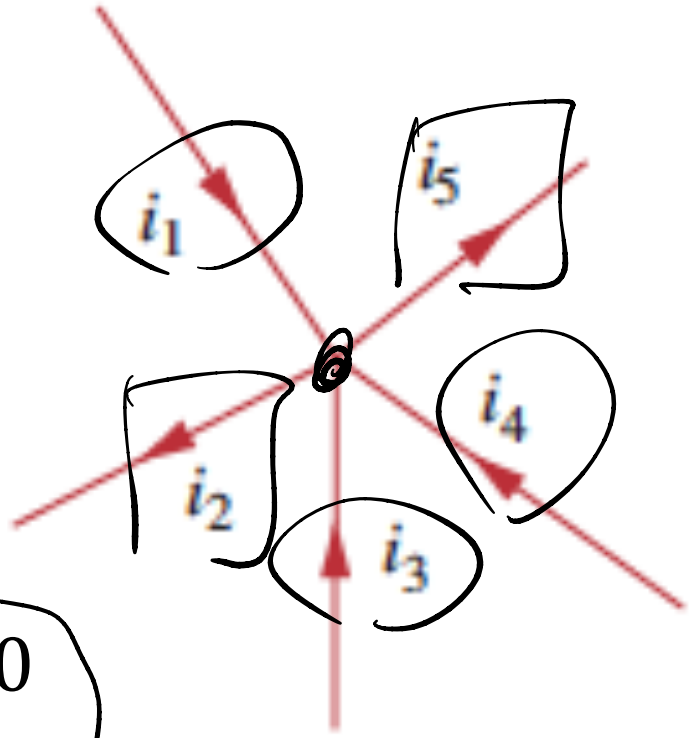


KCL

$$i_1 + i_3 + i_4 = i_2 + i_5$$

or

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



- Sum of currents in = sum of currents out

  or

- Sum of currents (in or out) equals 0

2.13 For the circuit in Fig. 2.77, use KCL to find the branch currents I_1 to I_4.

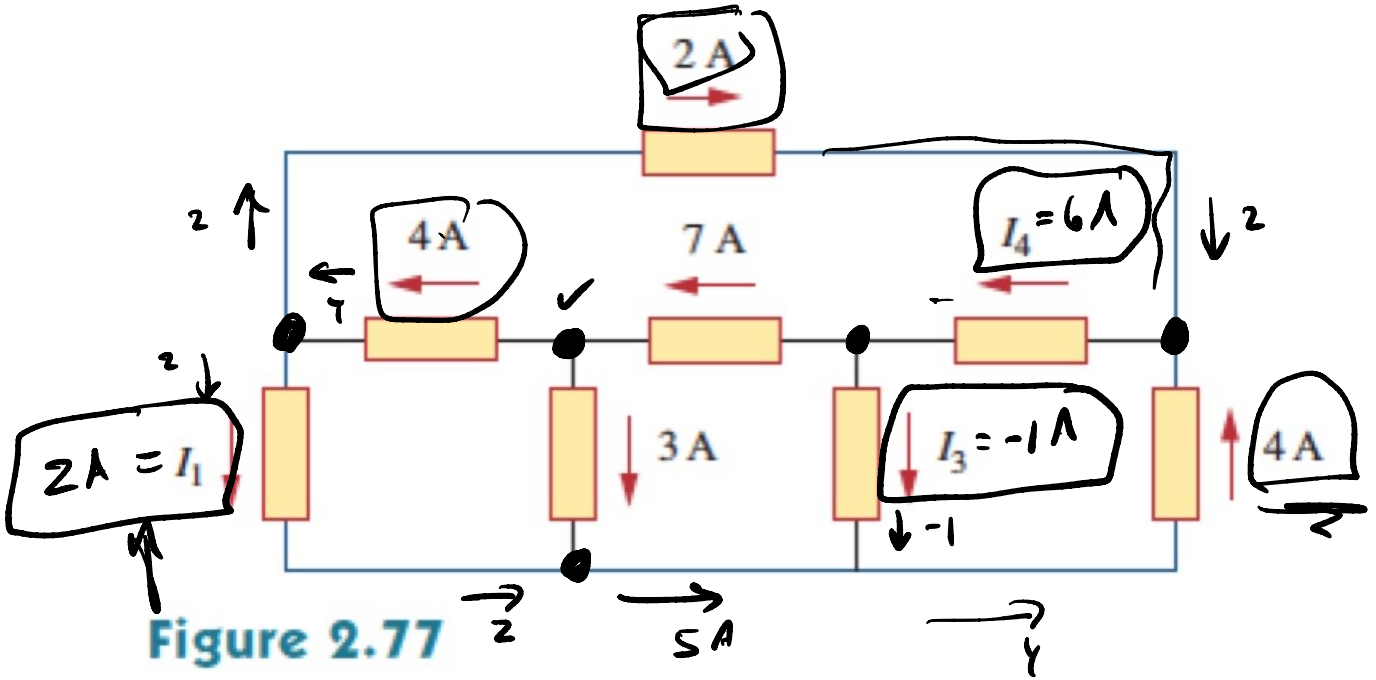


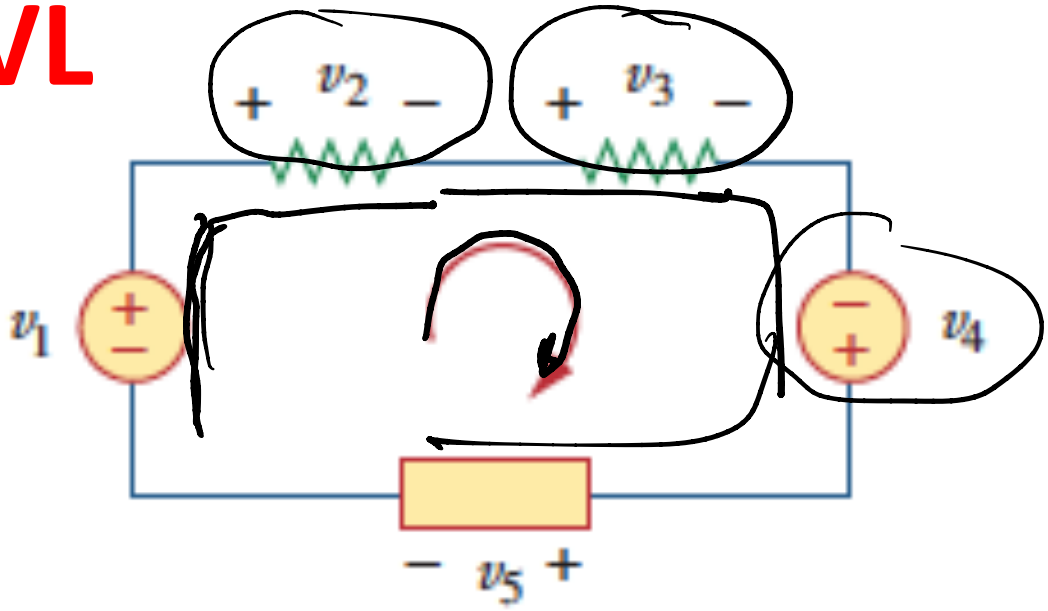
Figure 2.77

KVL

$$v_2 + v_3 + v_5 = v_1 + v_4$$

or

$$(-v_1) + v_2 + v_3 + (-v_4) + v_5 = 0$$



- Sum of voltages gains = sum of voltages drops

  or

- Sum of voltages (up or down) equals 0

2.14 Given the circuit in Fig. 2.78, use KVL to find the branch voltages V_1 to V_4.

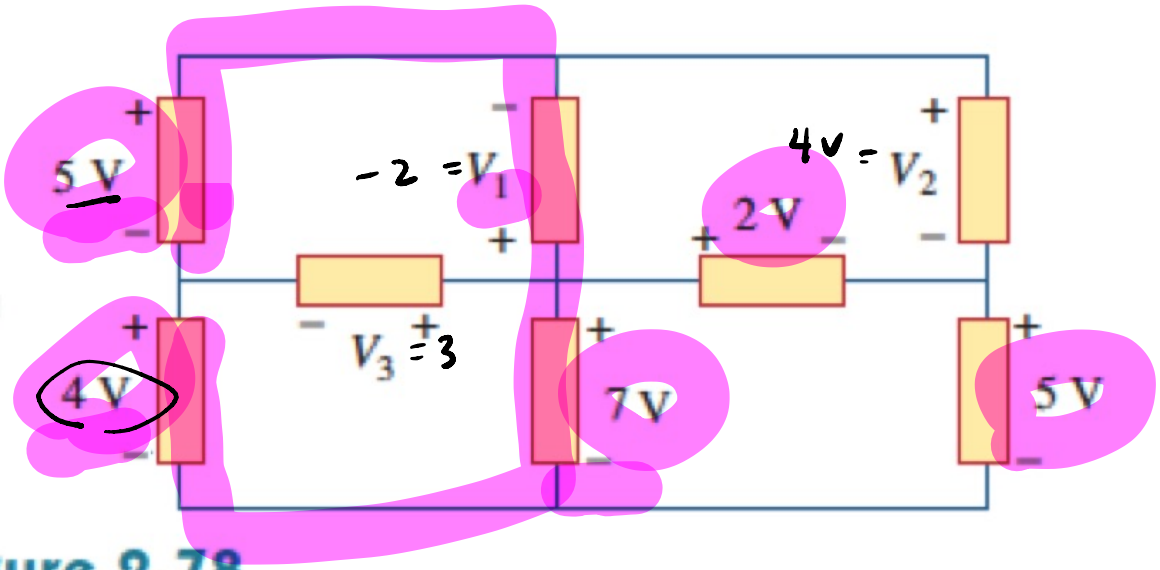
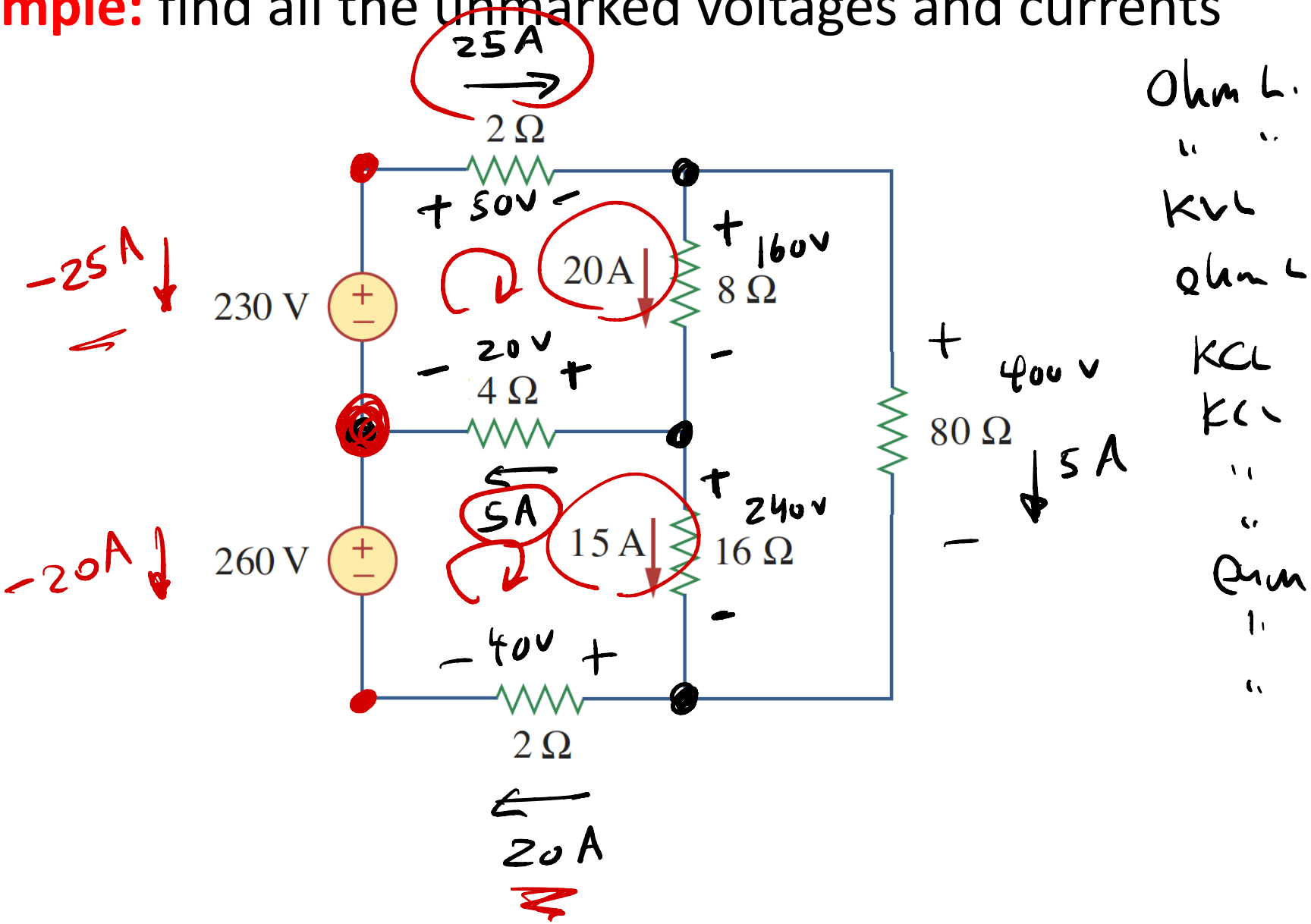


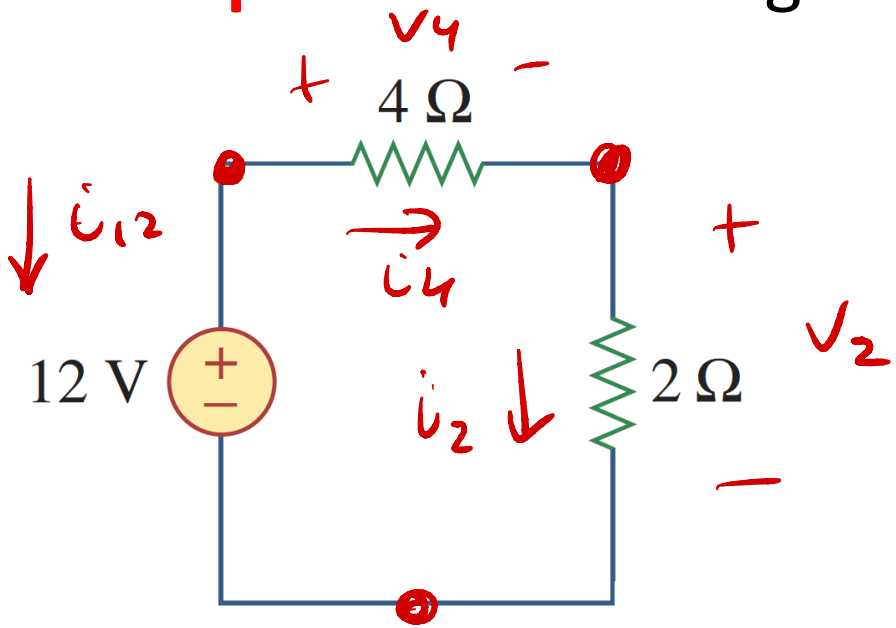
Figure 2.78

$$\frac{-(-2)}{2} - \frac{V_2}{4} + \frac{2}{2} = 0$$

Example: find all the unmarked voltages and currents



Example: find all voltages and currents



Ohm's: $V_4 = 4\, i_4$

$V_2 = 2\, i_2$

KVL: $12 - V_4 - V_2 = 0$

KCL: $i_{12} + i_4 = 0$

$i_2 - i_4 = 0$

$-i_2 - i_{12} = 0$

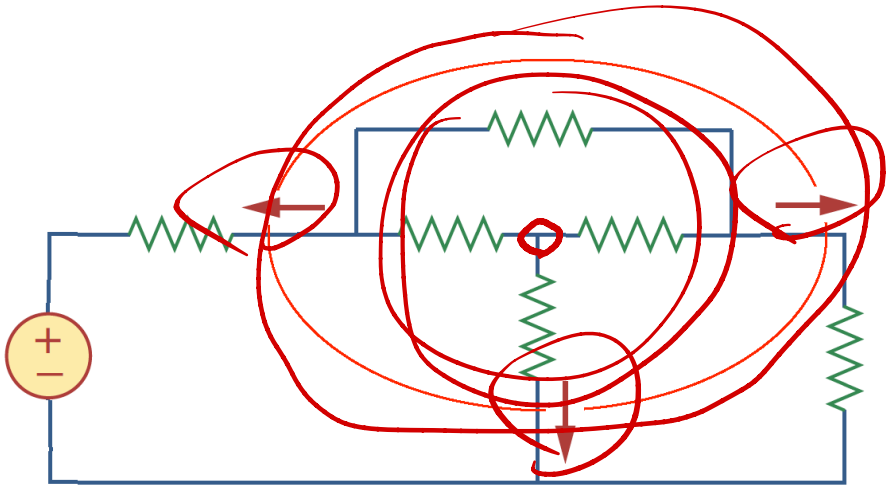
$i_2 = i_4 = 2\,A$

$v_4 = 8v$ $\qquad i_{12} = -2\,A$

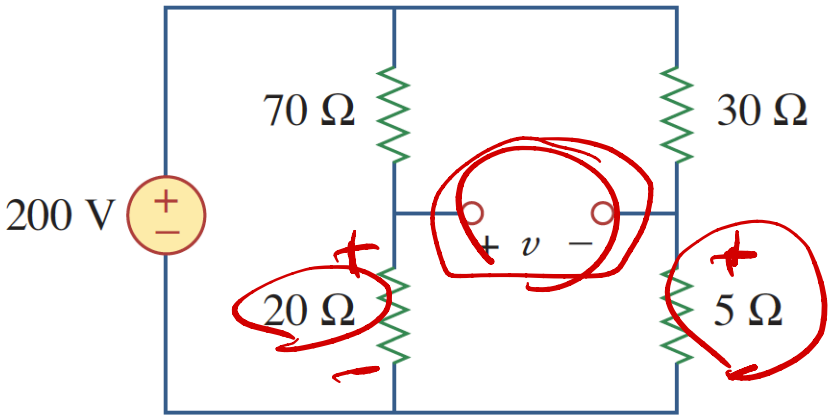
$v_2 = 4V$

More Generally

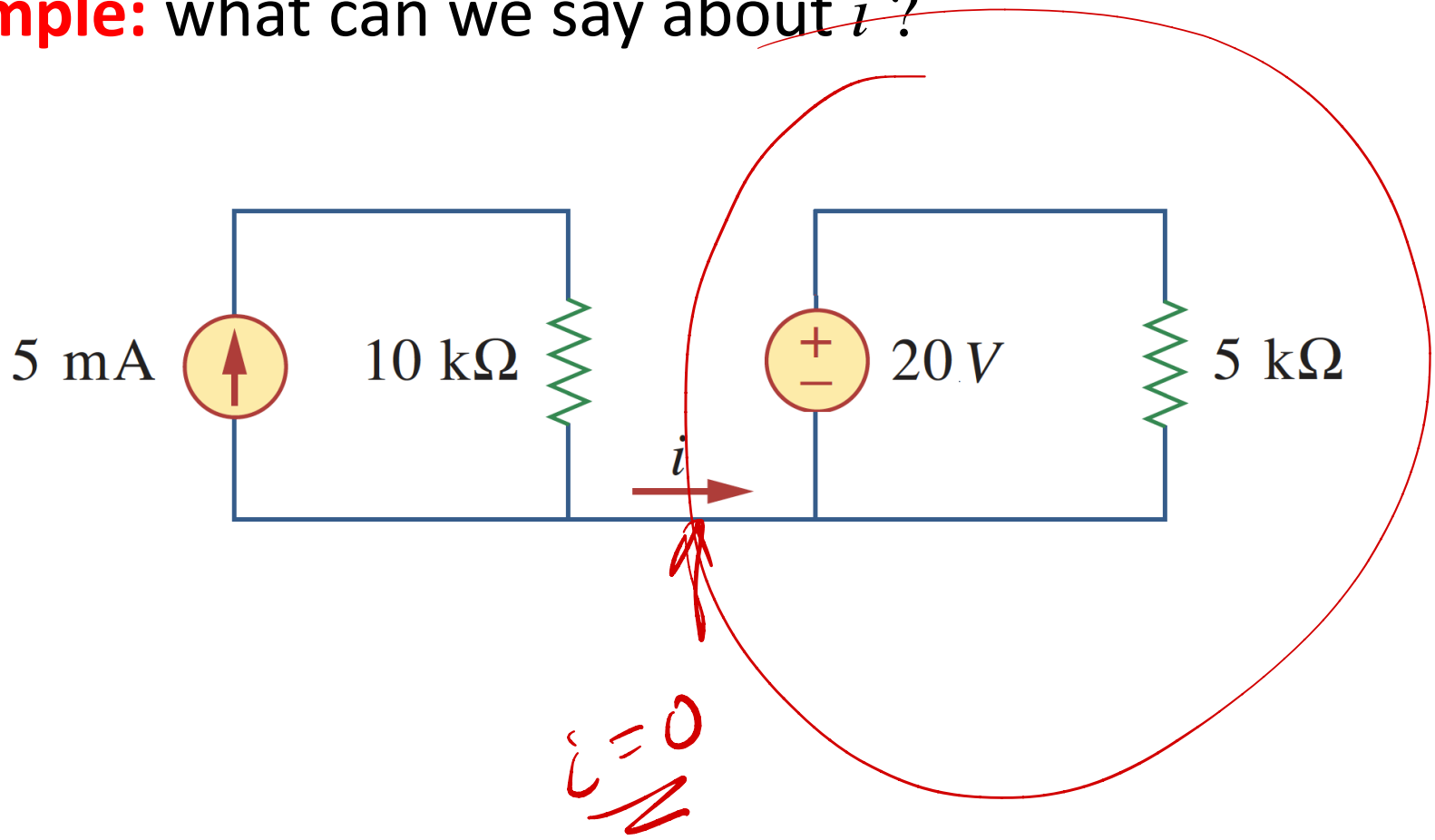
- KCL on cutsets



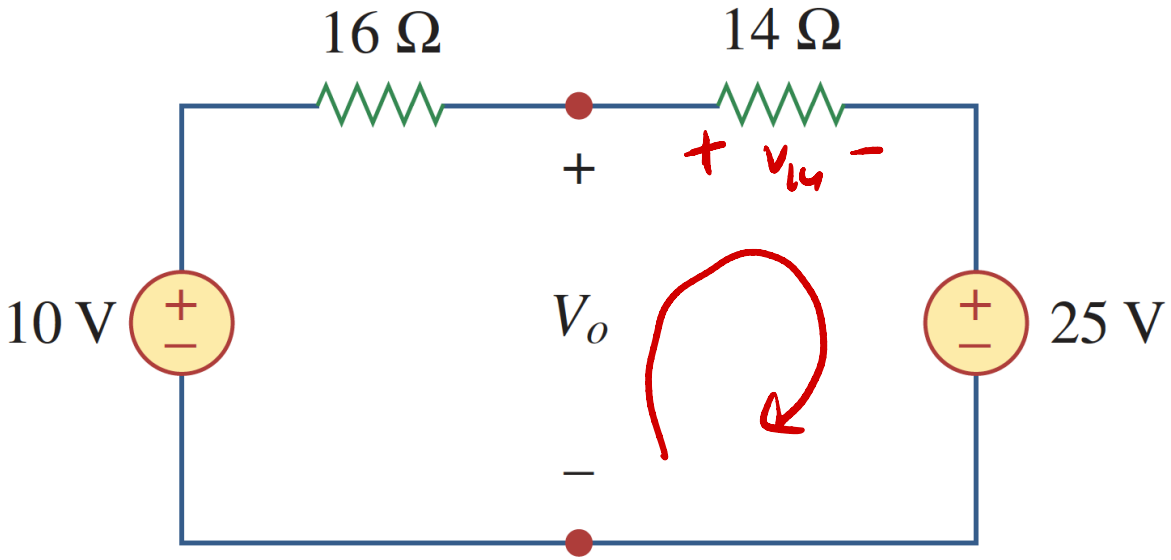
- KVL across gaps



Example: what can we say about i ?



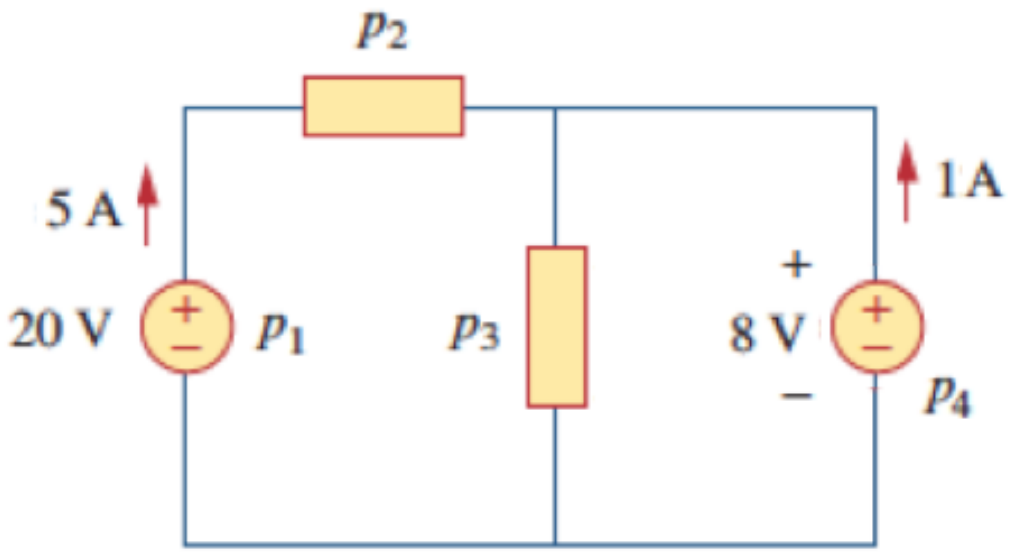
Example: what can we say about V_o ?



$V_o = V_{14} + 25$

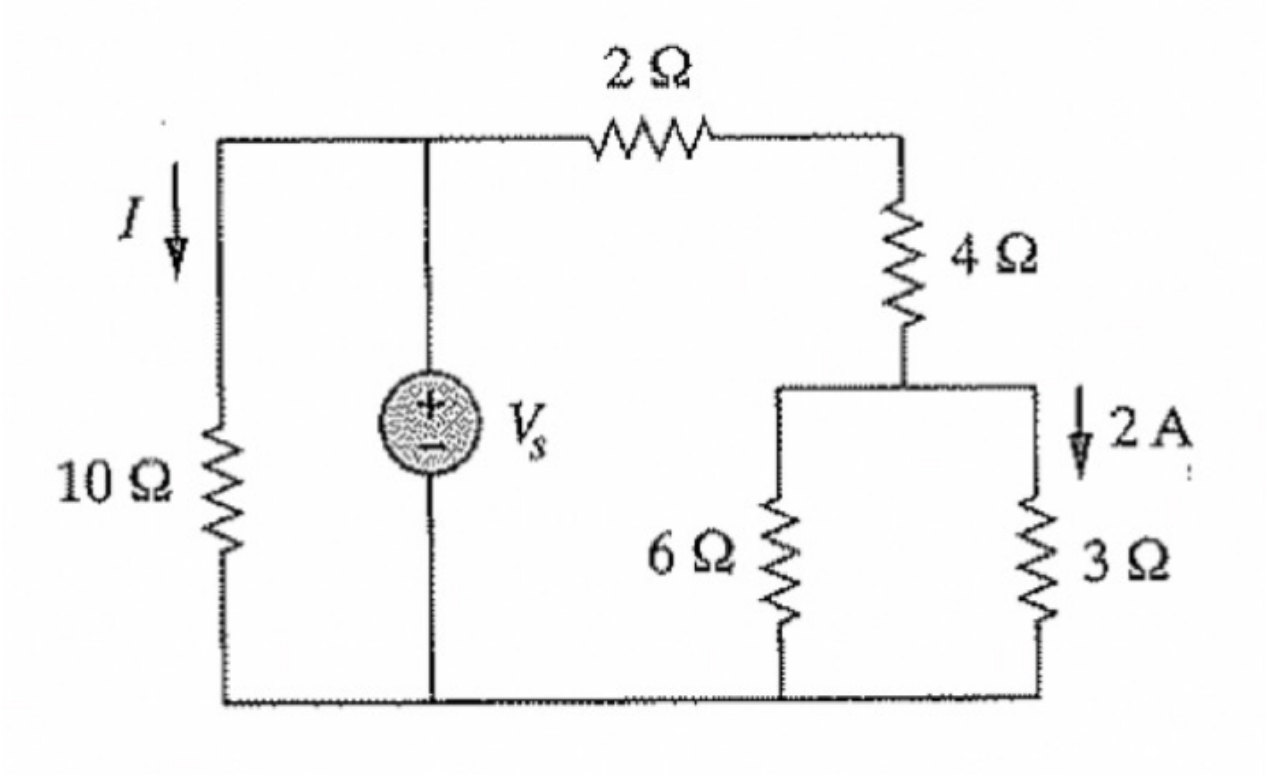
Practice problem: compute the powers, check conservation of power

$p_1 = -100\ W$
$p_2 = 60\ W$
$p_3 = 48\ W$
$p_4 = -8\ W$



$24\ V, 2.4\ A$

Practice problem: given the marked 2 A current, find V_s and I



Practice problem: if $v = 4$ V, find the power of the current source

$-14\ W$