Unit - II
2.7 Thevenin's Theorem

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Online Circuit Simulator

https://www.circuitlab.com/editor/#

https://www.falstad.com/circuit/

Syllabus

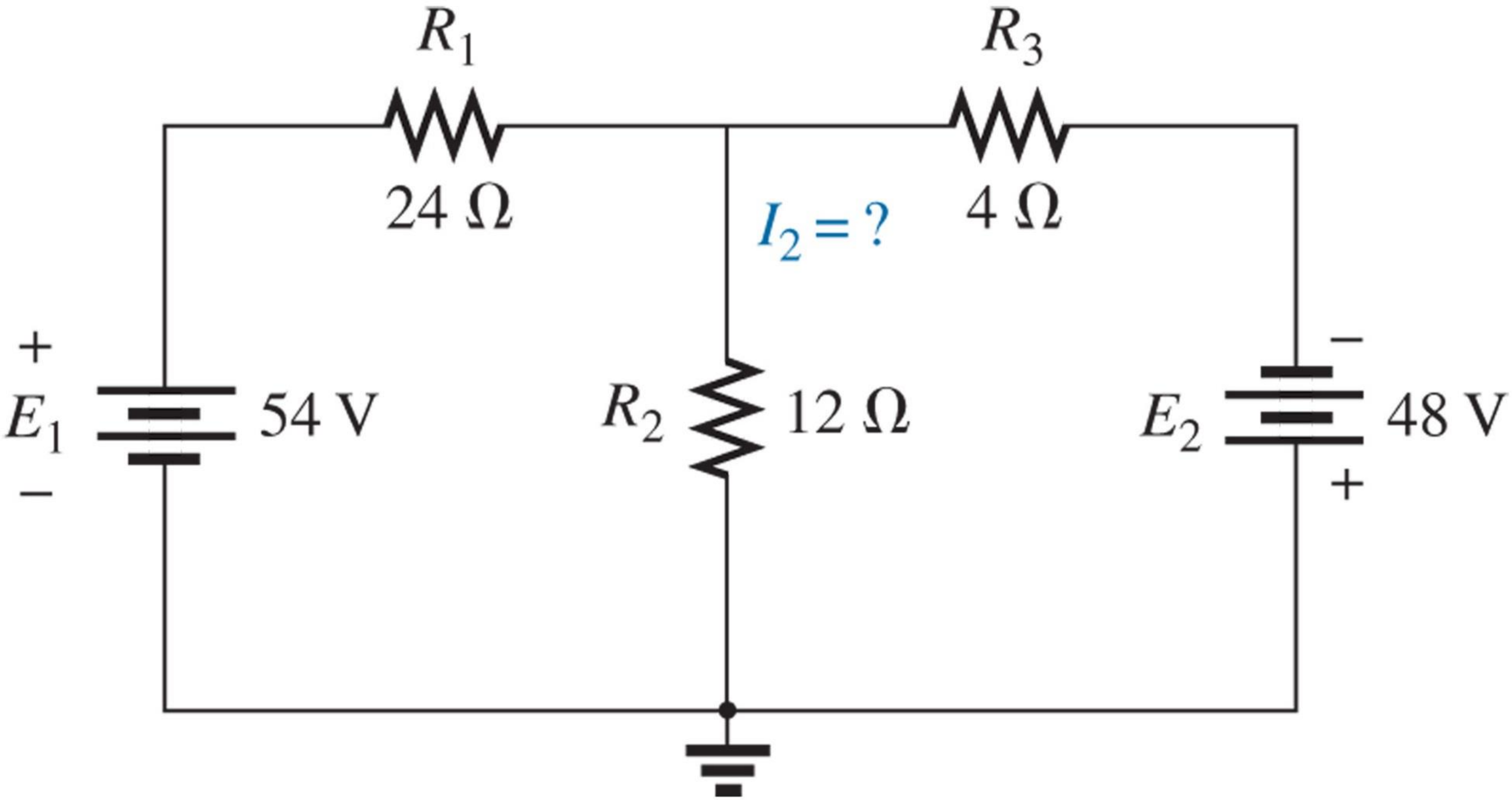
UNIT – II **14 Periods**

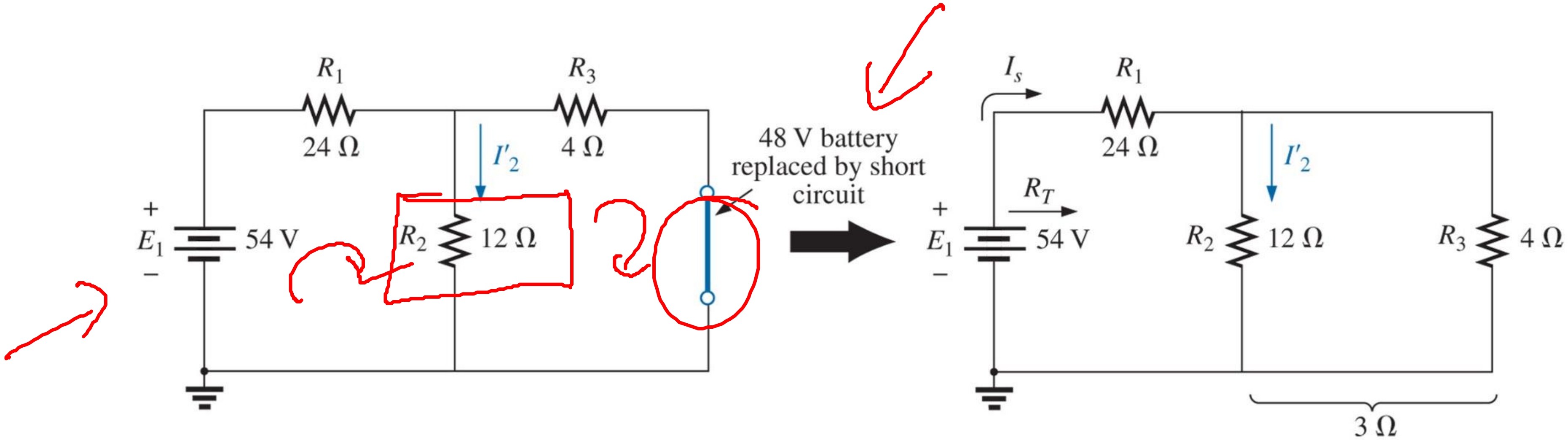
DC Circuit Analysis: Voltage source and current sources, ideal and practical, Kirchhoff's laws and applications to network solutions using mesh analysis, - Simplifications of networks using series- parallel, Star/Delta transformation, DC circuits-Current-voltage relations of electric network by mathematical equations to analyse the network (Superposition theorem, Thevenin's theorem, Maximum Power Transfer theorem), Transient analysis of R-L, R-C and R-L-C Circuits.

AC Steady-state Analysis: AC waveform definitions - Form factor - Peak factor - study of R-L - R-C -RLC series circuit - R-L-C parallel circuit - phasor representation in polar and rectangular form - concept of impedance - admittance - active - reactive - apparent and complex power - power factor, Resonance in R-L-C circuits - 3 phase balanced AC Circuits

Example

- Determine the current in the 12 Ω resistor



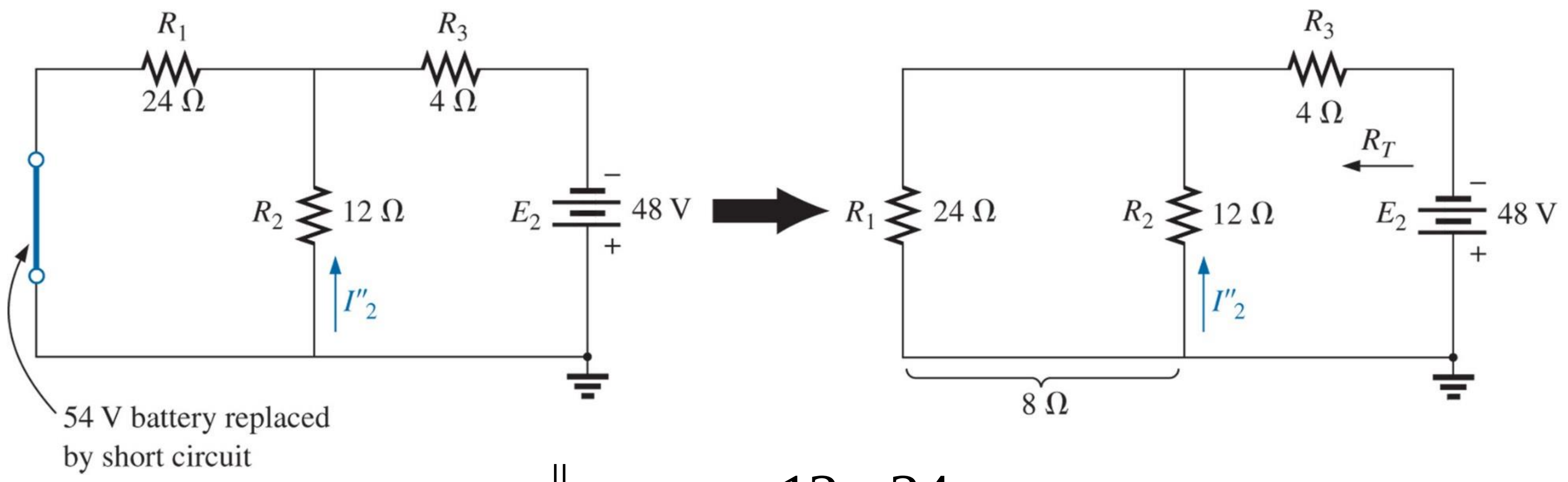


$$R_T = R_1 + R_2 \| R_3 = 24 + \frac{12 \times 4}{12 + 4} = 24 + 3 = 27\Omega$$

$$I_s = \frac{E_1}{R_T} = \frac{54}{27} = 2A$$

Used current devider rule to determine I'_2

$$I'_2 = \left(\frac{R_3}{R_3 + R_2} \right) I_s = \frac{4}{4+12} \times 2 = 0.5A$$



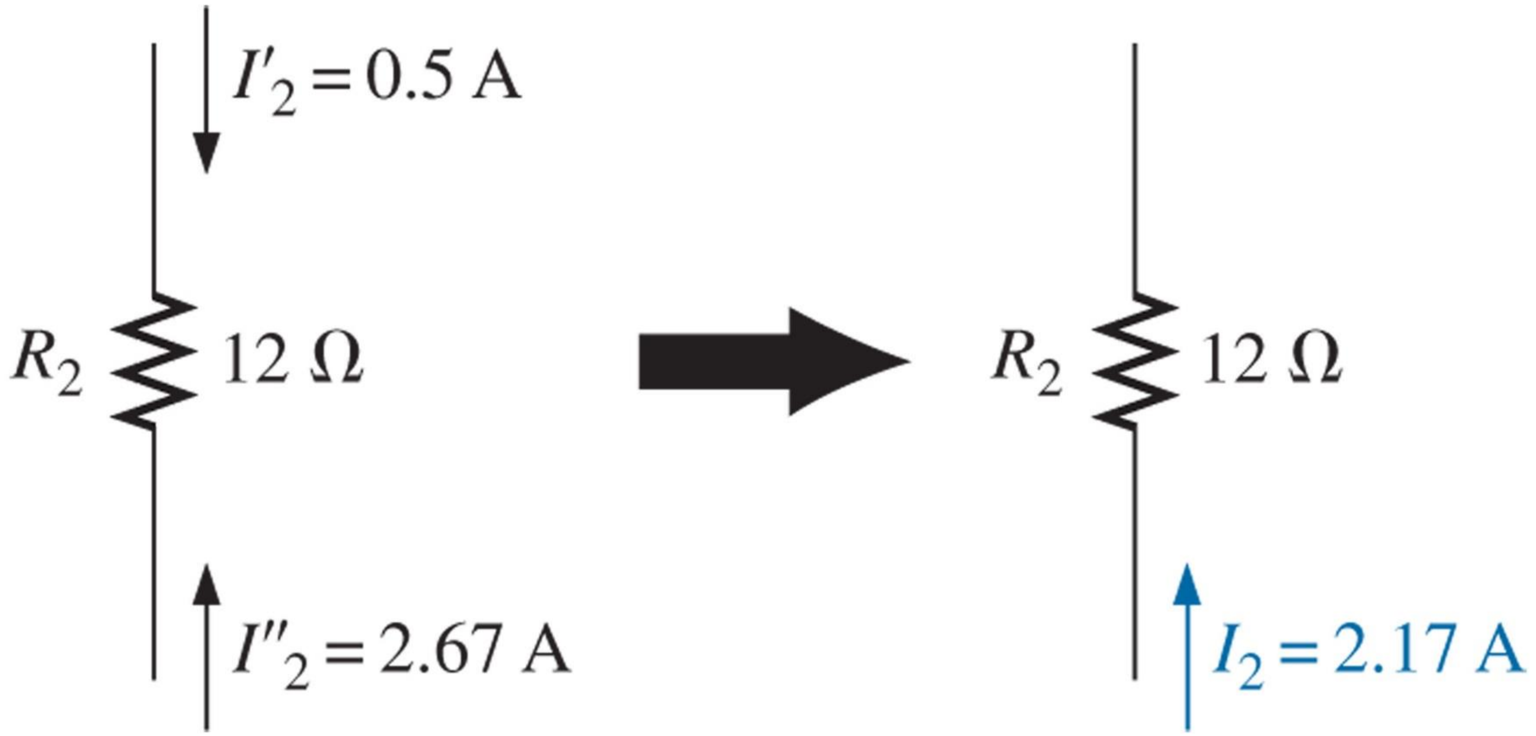
$$R_T = R_3 + R_2 \| R_1 = 4 + \frac{12 \times 24}{12 + 24} = 4 + 8 = 12\Omega$$

$$I_s = \frac{E_1}{R_T} = \frac{48}{12} = 4A$$

Used current devider rule to determine I''_2

$$I''_2 = \left(\frac{R_1}{R_1 + R_2} \right) I_s = \frac{24}{24 + 12} \times 4 = 2.677\,A$$

To determine current I_2 for the network:



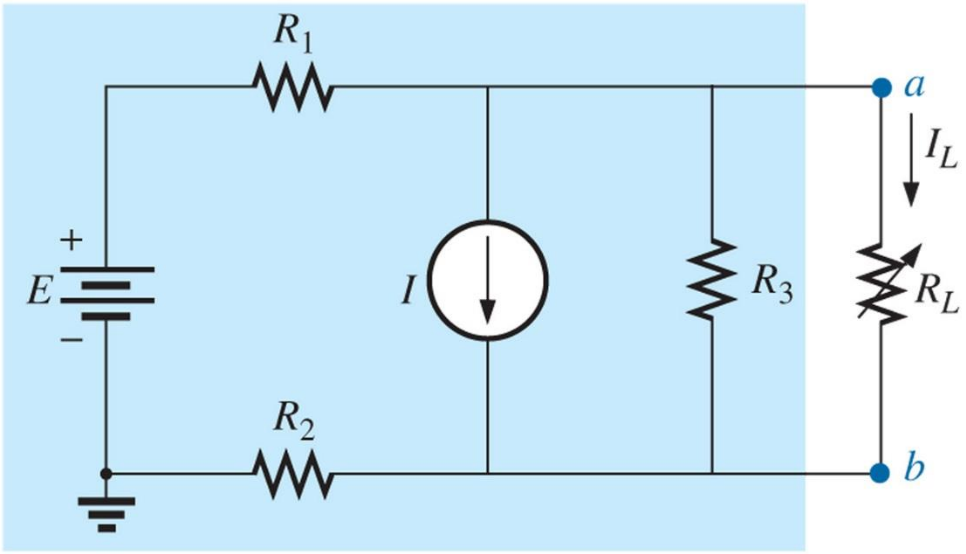
The net current therefore is the difference of the two and in the direction of the larger current:

$$I_2 = I''_2 - I'_2 = 2.667 - 0.5 = 2.167\,A$$

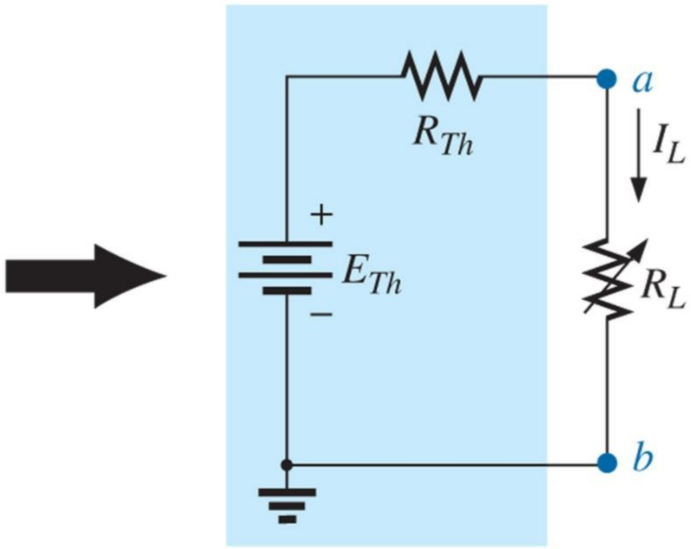
Thevenin's Theorem

Thevenin's Theorem state that,

An active network having two terminals A and B can be replaced by a constant-voltage source having an e.m.f E and internal resistance r. The value of E is equal to the open-circuit potential difference between A and B with the load disconnected and the source of e.m.f replaced by their internal resistance.

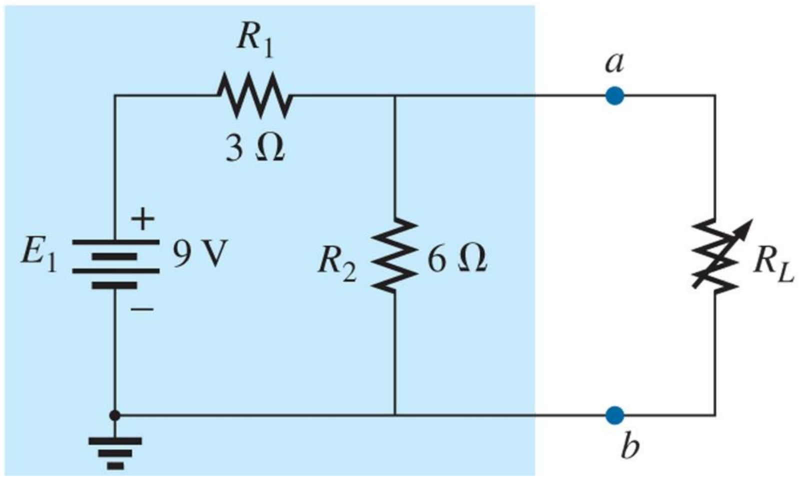


(a)

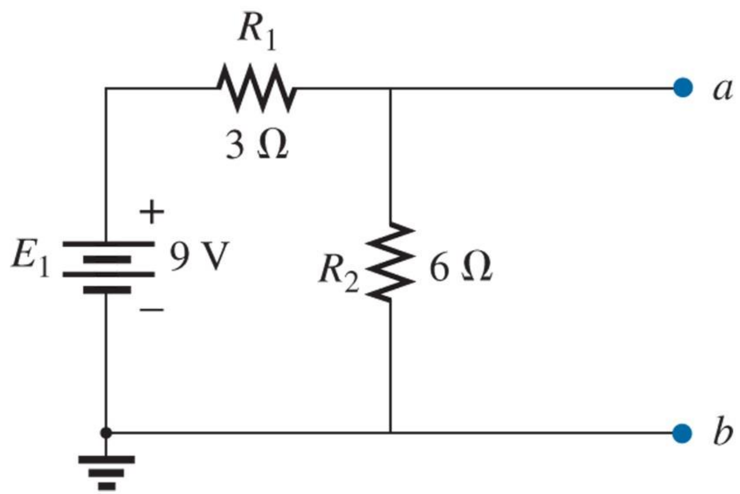


(b)

Thevenin's Theorem Procedure



Original



Step 1 and 2

Step 1: Remove the load resistor R_L.

Step 2 : Mark the terminal as a and b. We have an open circuit across terminal a and b.

Thevenin's Theorem Procedure

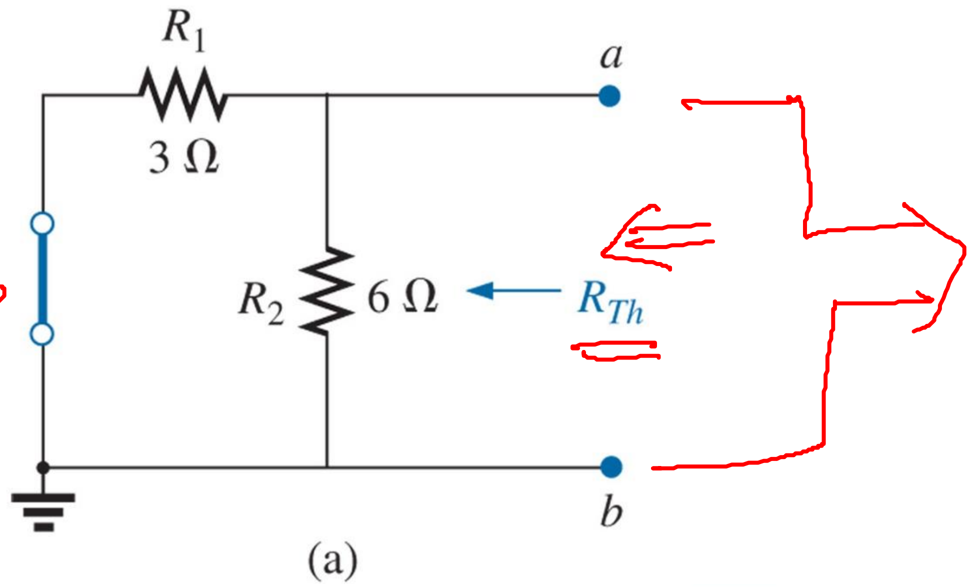
- Step 3:
  - Replace the voltage source with a short-circuit equivalent.
  - Calculate the R_{TH}

Turn off all Sources

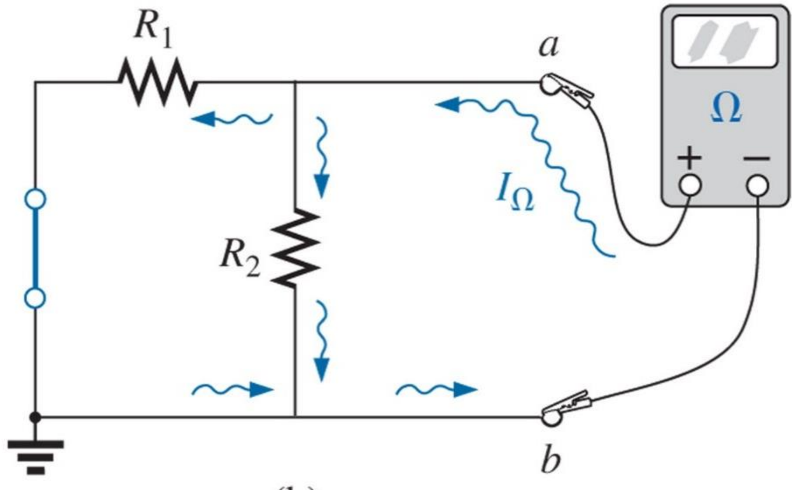
V → short circuit

I → open circuit

$$R_{TH} = R_1 \| R_2 = \frac{3\times 6}{3+6} = 2\Omega$$

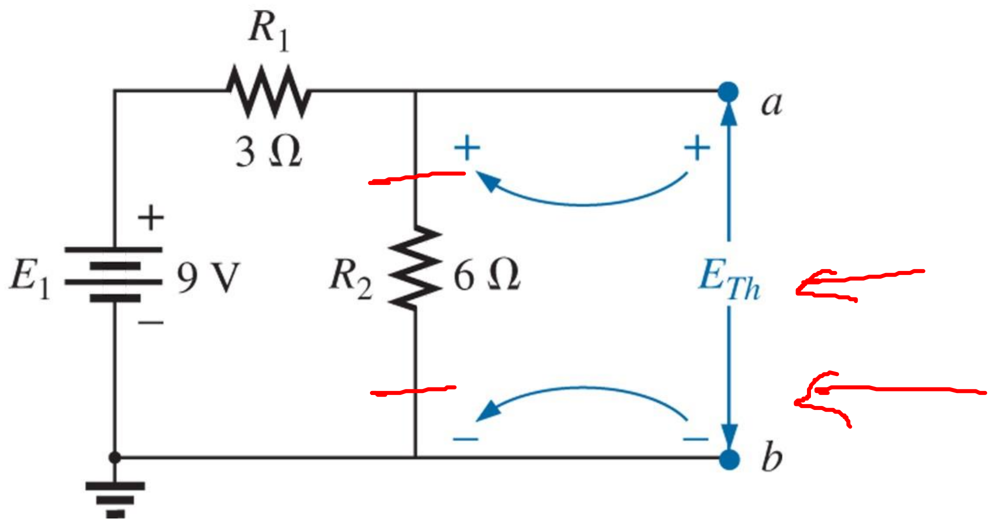


(a)



(b)

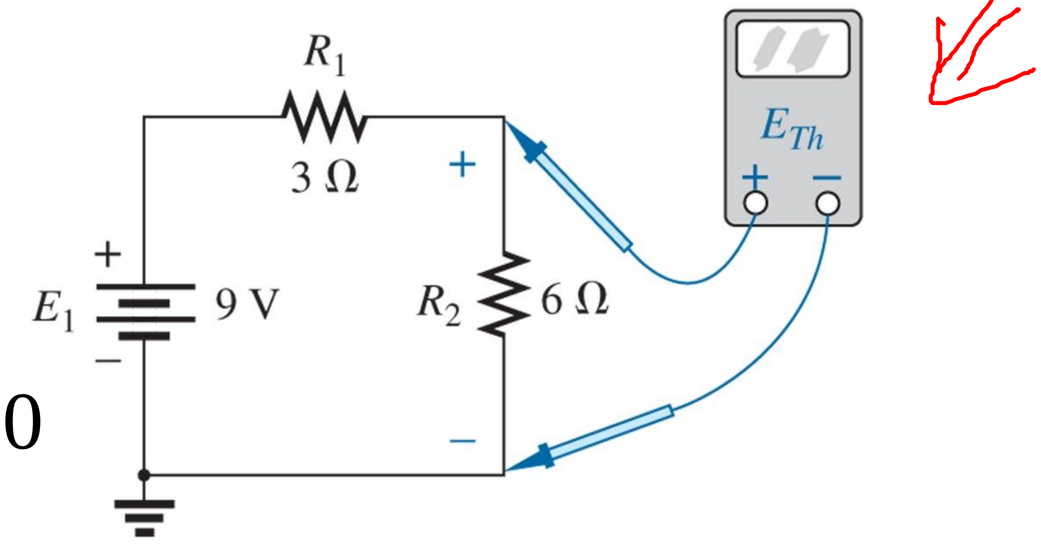
- Step 4:
  - Put back the voltage source. Apply voltage devider rule to find VTH



$$E_{Th} = \frac{R_2}{R_2 + R_1} \times E = \frac{6 \times 9}{6+3} = \frac{54}{9} = 6V$$

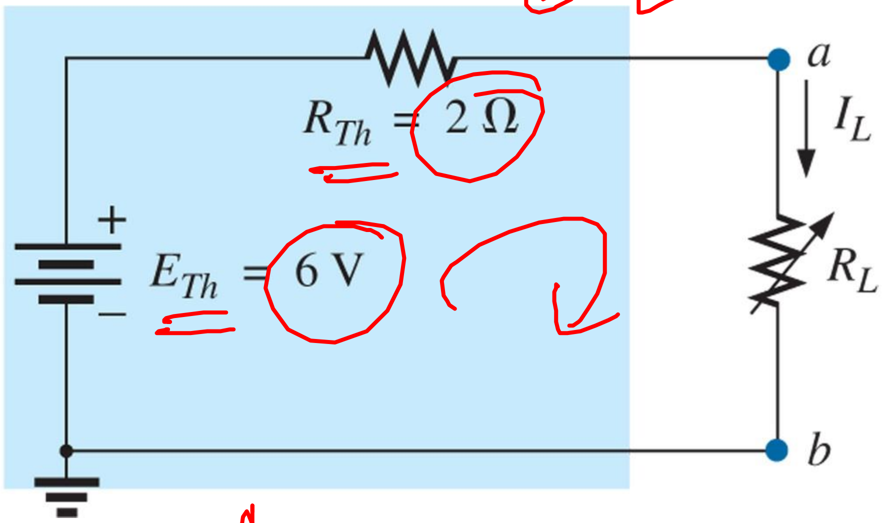
- Or using Mesh current analysis:

Loop 1	Loop2
$9 - 3I - 6I = 0$	$-E_{Th} + 6I = 0$
$9 - 9I = 0$	$-E_{Th} + 6(1V) = 0$
$9 = 9I$	$E_{Th} = 6V$
$I = 1A$	



Thevenin’s Theorem Procedure

- Step 5:
  - Draw the Thevenin equivalent circuit.
  - Placed the R_L. Across terminal a and b.
- Addition:
  - If require to measure current I_L,

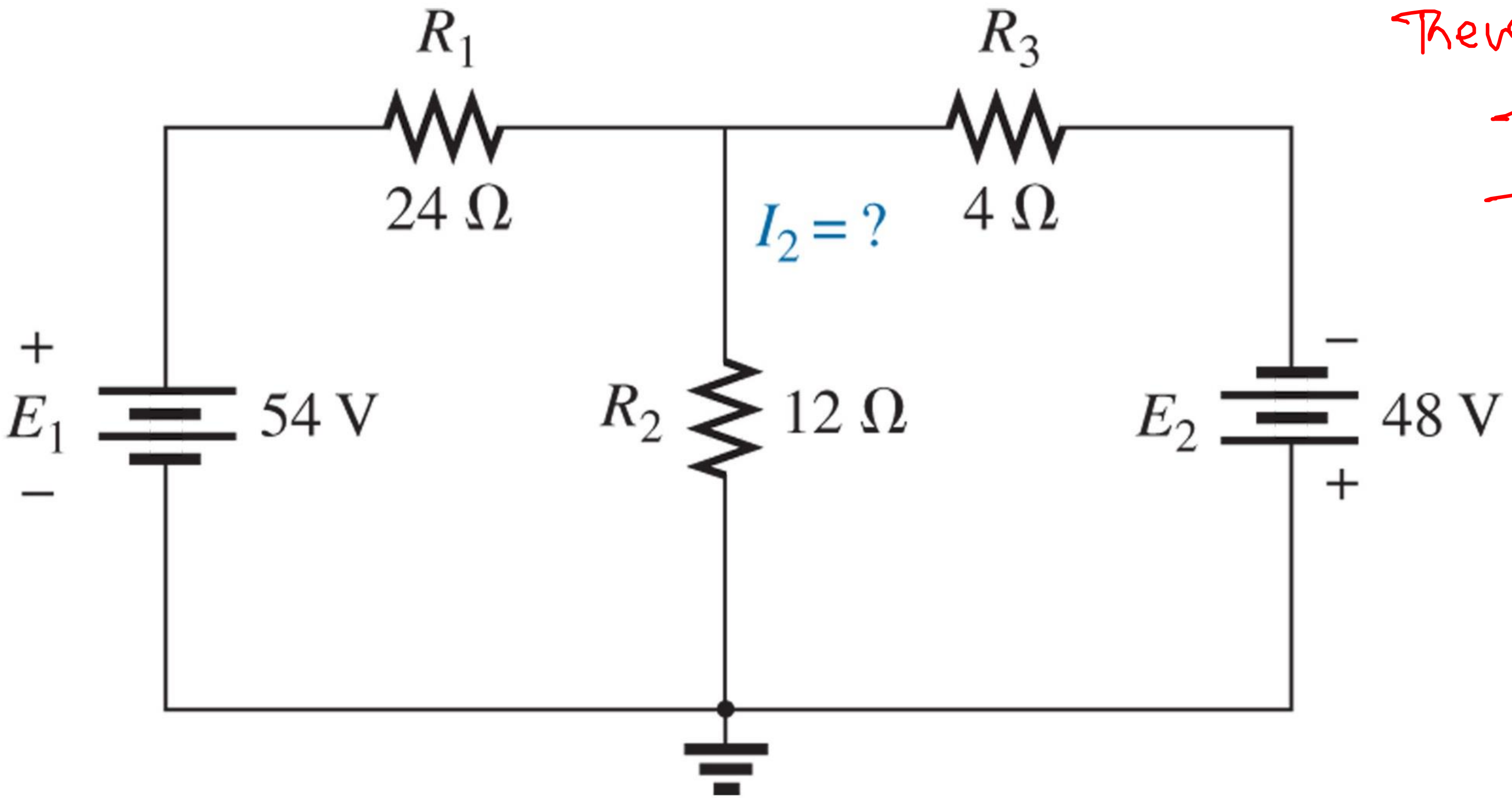


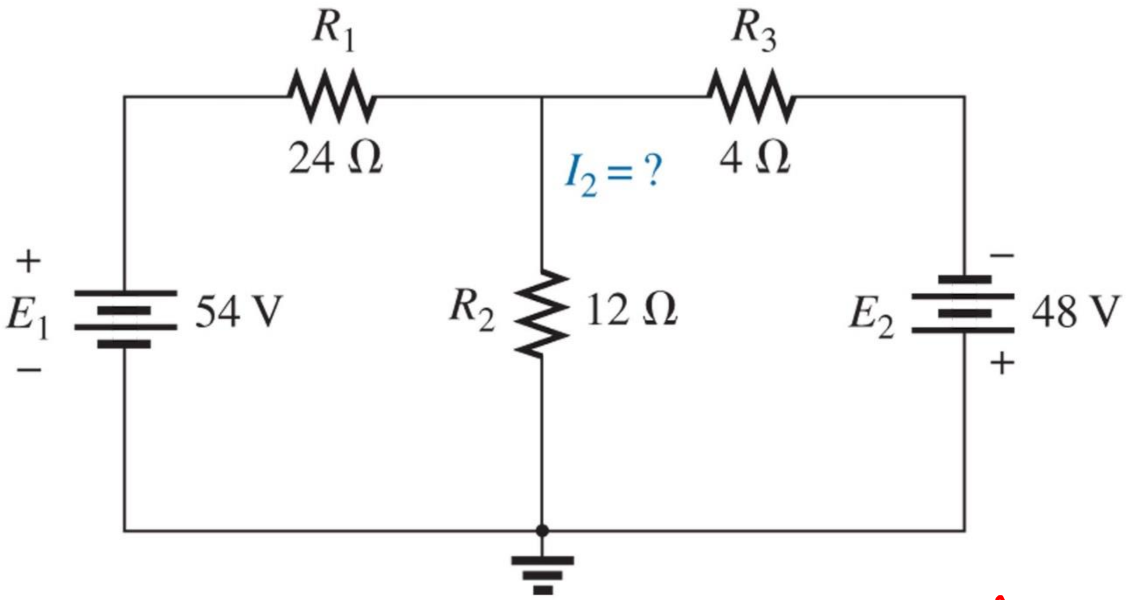
$$I_L = \frac{V_{Th}}{R_{Th} + R_L}$$

Example 4

- Determine the current in the 12 Ω resistor

using Thevenin's theorem

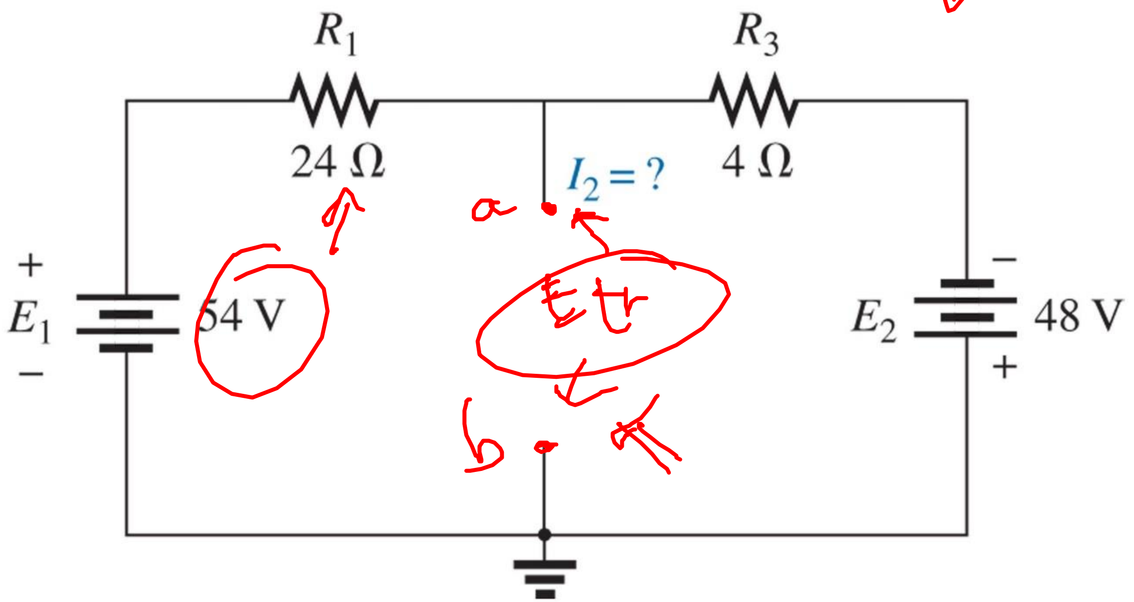


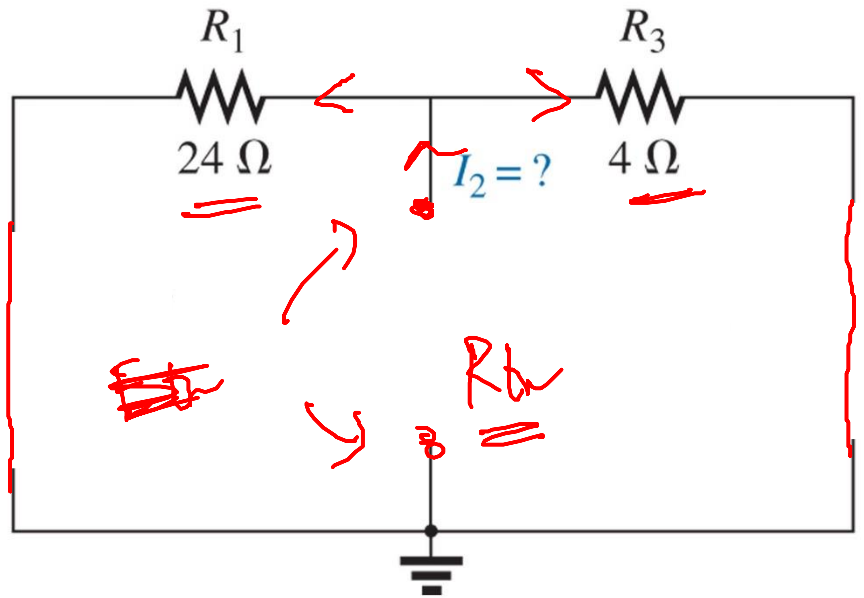


① Remove load resistance

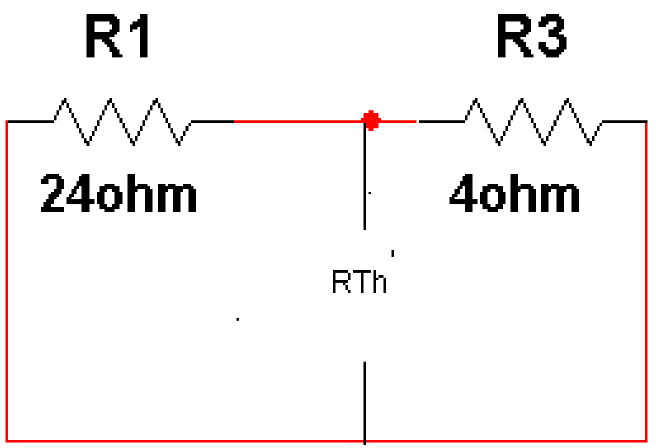
② $R_{th} \longrightarrow$

$$R_{th} = \frac{24 \times 4}{24+4} = 3.42\ \Omega$$





$$R_{TH} = R_1 \| R_3 = \frac{24 \times 4}{24+4} = 3.42\Omega$$

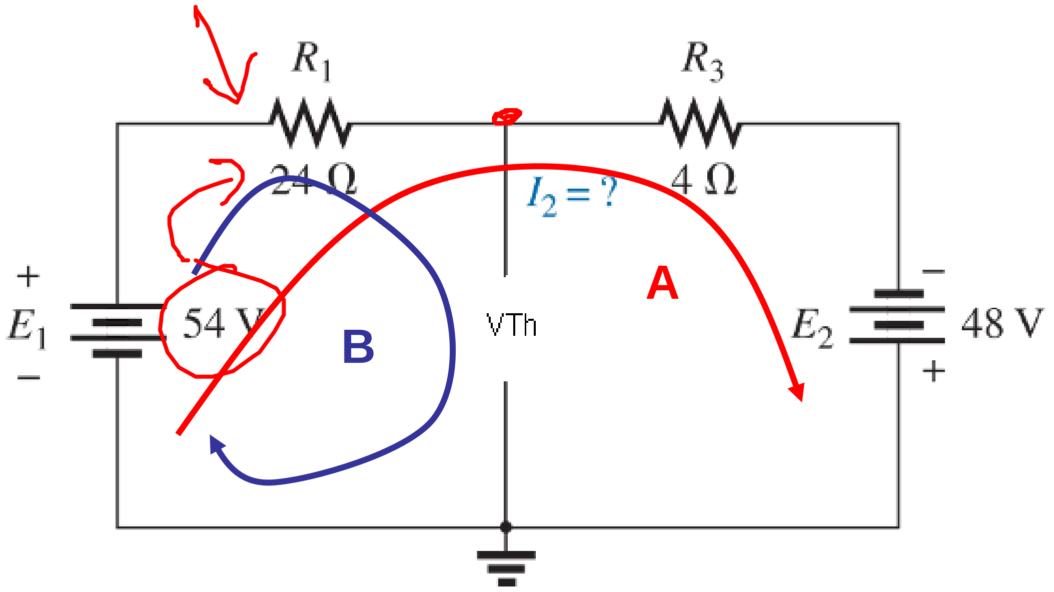


Apply KVL to Loop A

$$54 - 24I - 4I + 48 = 0$$

$$102 - 28I = 0$$

$$I = \frac{102}{28} = 3.643A$$



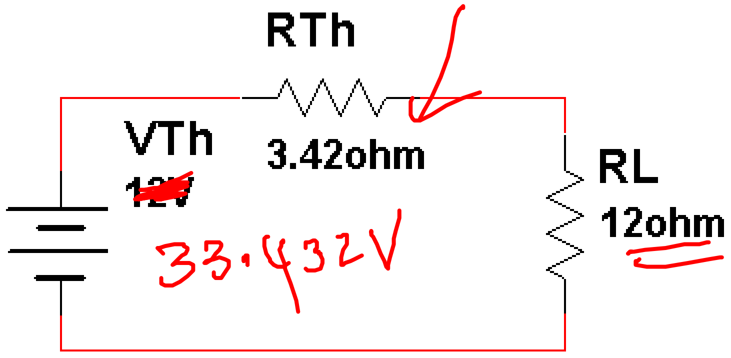
Apply KVL to Loop B

$$54 - 24I + V_{Th} = 0$$

$$V_{Th} = -54 + 24(3.643)$$

$$V_{Th} = 33.432V$$

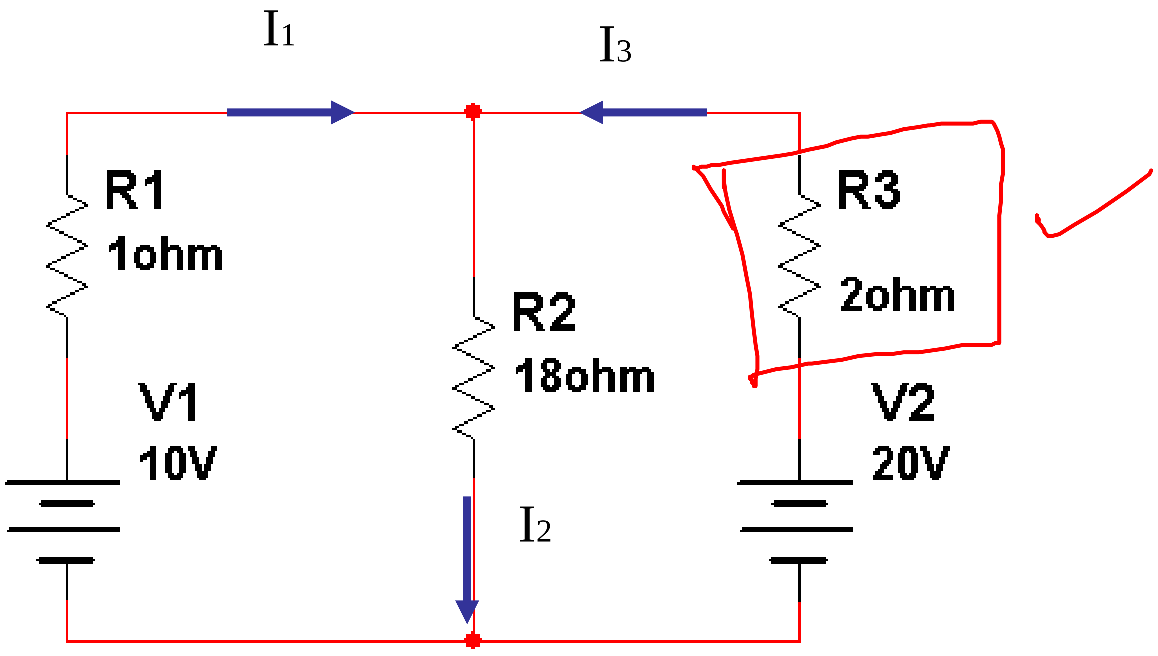
- The Thevenin equivalent circuit



- Current across 12 Ω resistor is:

$$I_{12\Omega} = \frac{33.432V}{3.42 + 12} = 2.168A$$

Practice Problem



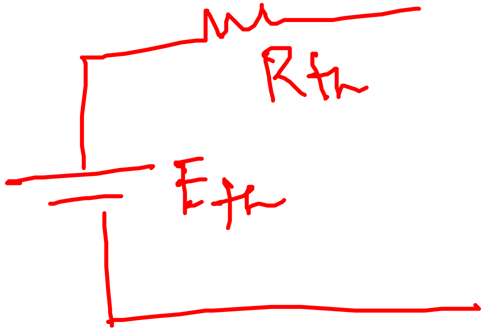
Find the current through 2 ohm resistor using Thevenin's theorem

Summary

Thevenin's theorem

↳ Steps → Remove load

- ↳ Rth → Turn off Sources
  - ↳ V → SC
  - ↳ I → OC
- ↳ Vth →
- ↳ Load current



Exercise