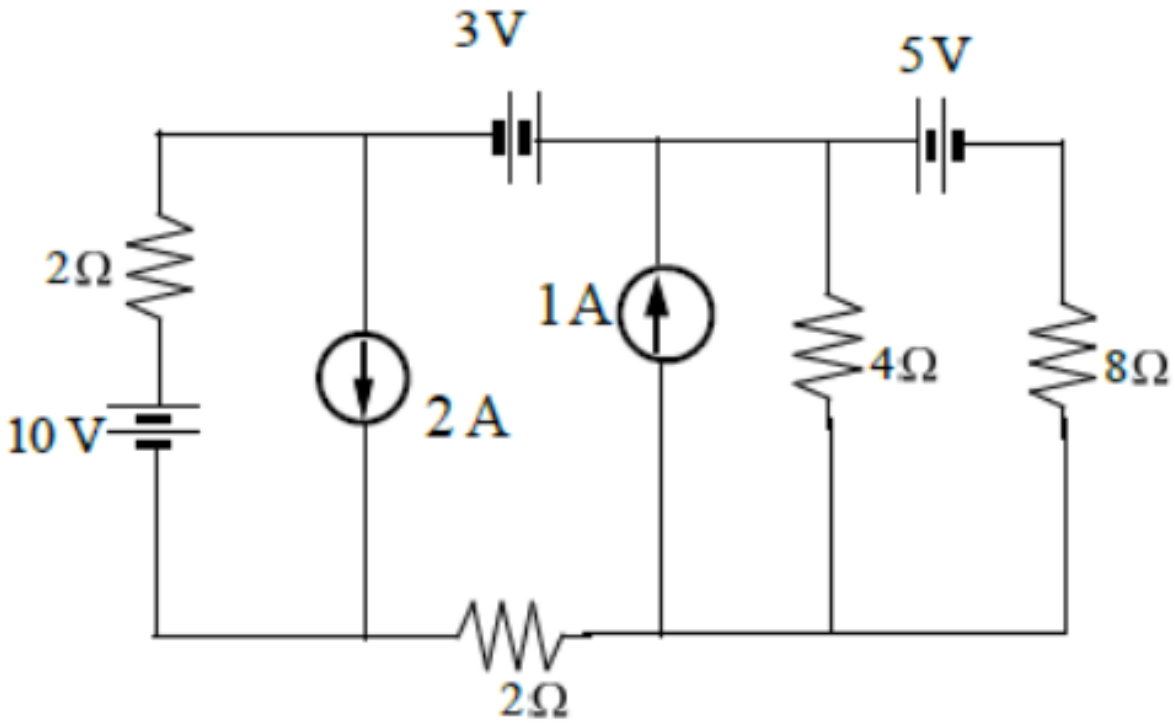
# Basic Electrical Technology

## TUTORIAL 1 - DC CIRCUITS

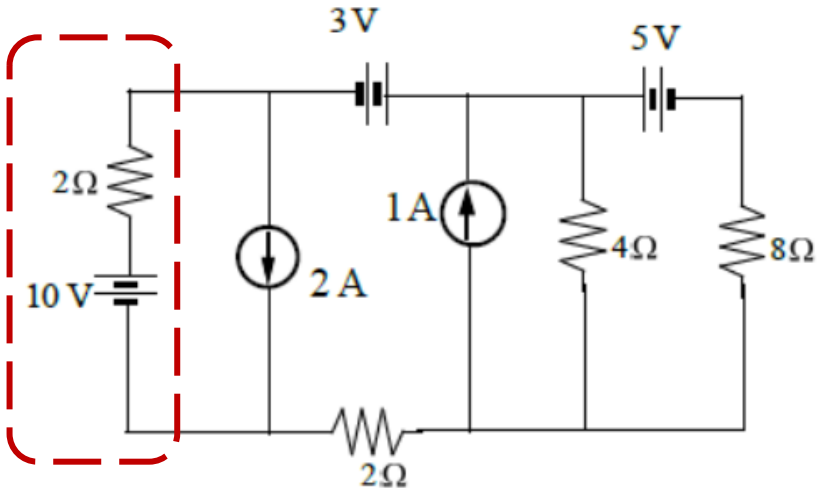
NETWORK REDUCTION | NETWORK ANALYSIS | NETWORK THEOREMS

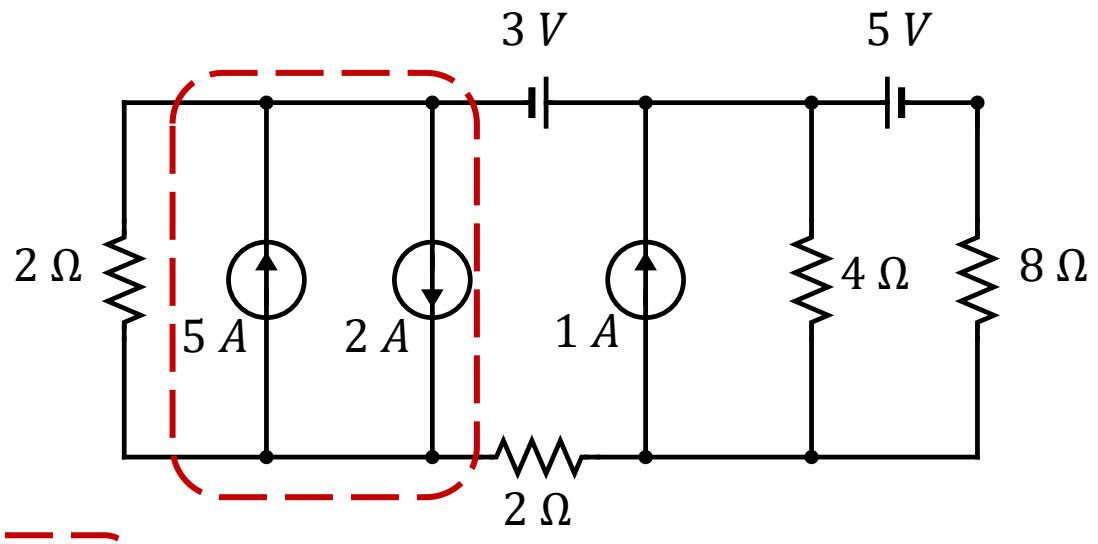
# Problem 1: Source Conversion

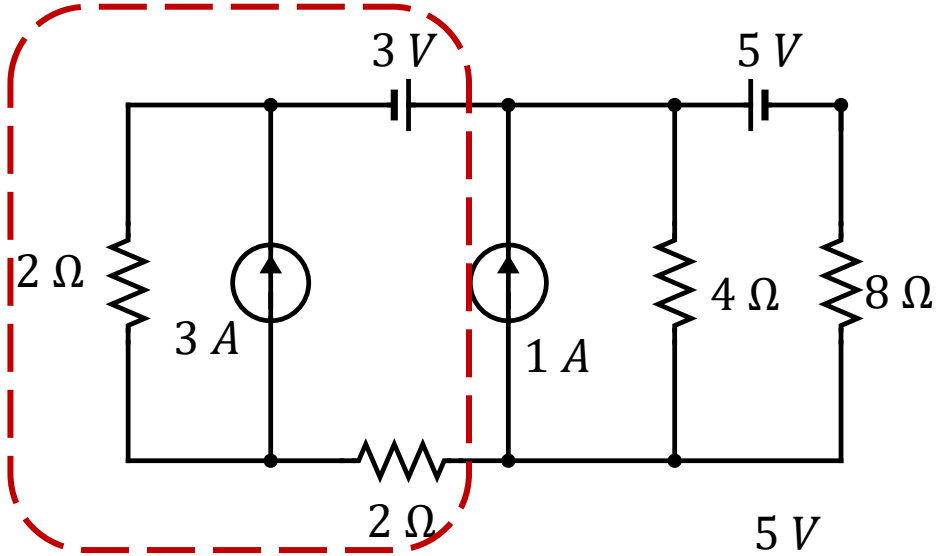
In the circuit shown, find the current through **8 Ω** resistor by **source transformation** method.

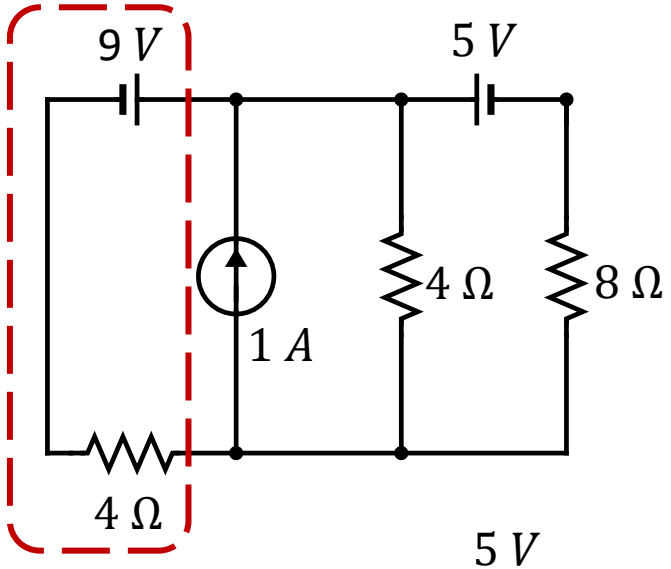


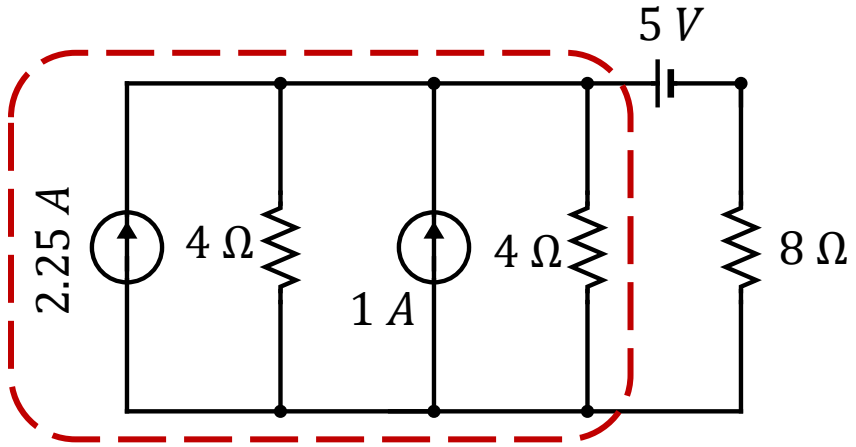

Ans: 150 mA

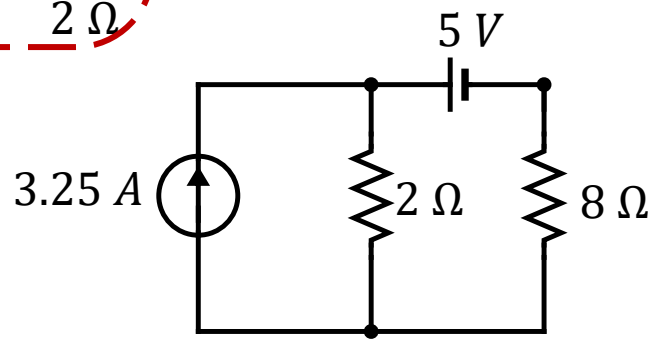


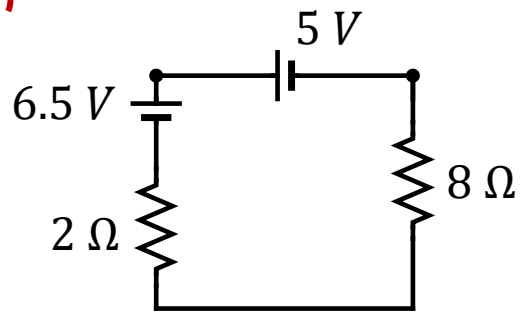



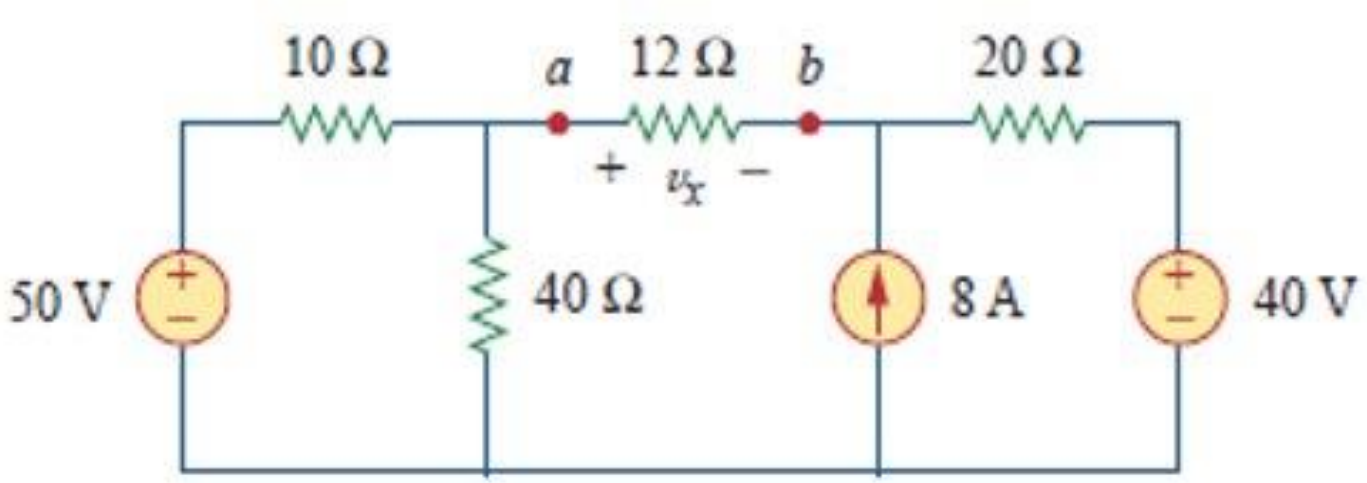




$$I_{8\Omega} = \frac{6.5 - 5}{8 + 2} = 0.15\ A$$

# Self-Practice 1: Source Conversion

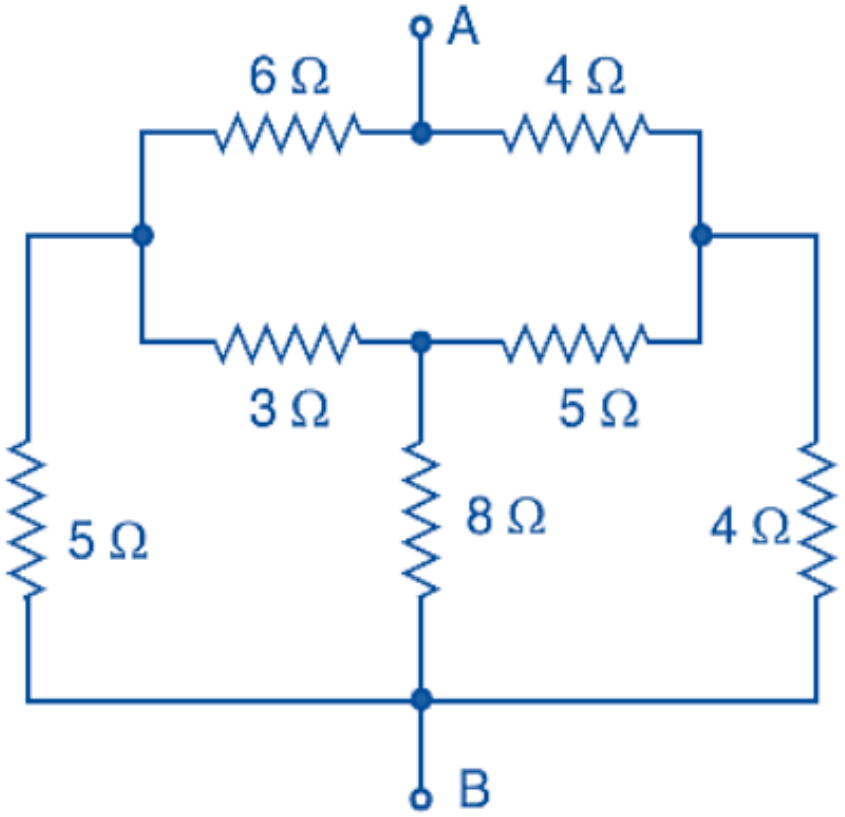
Find the voltage across **12 Ω** resistor ( labeled $V_x$) by the **source transformation** method.



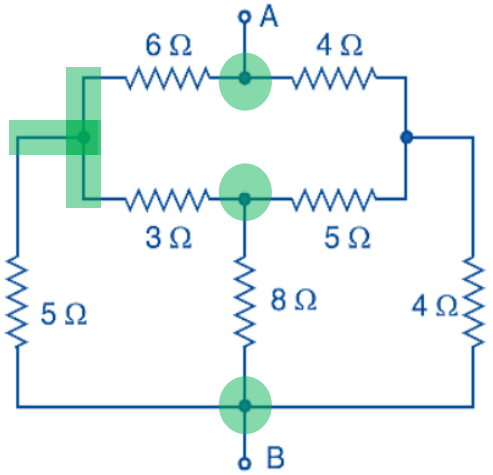

Ans: – 48 V

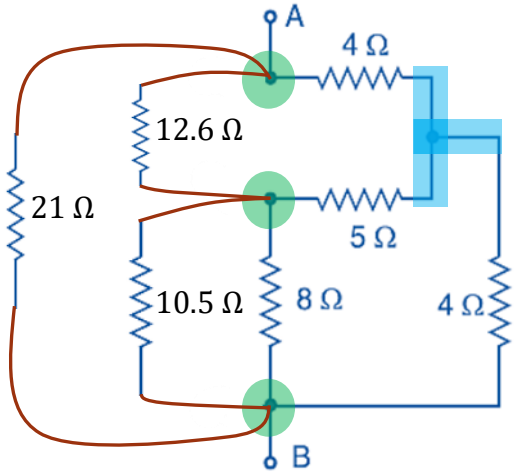
# Problem 2: Star-Delta Transformation

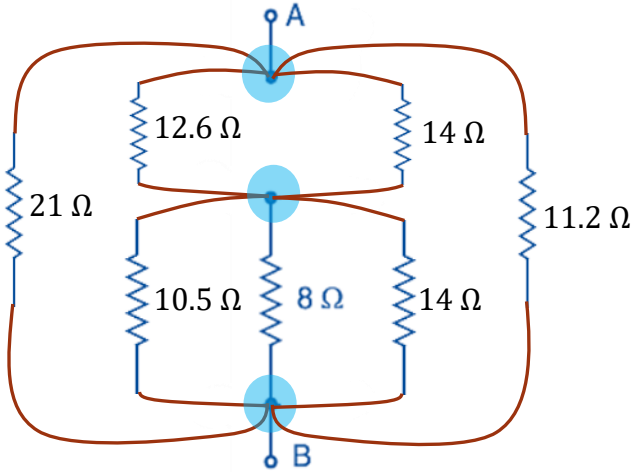
Determine the equivalent resistance across terminals **A** & **B.**

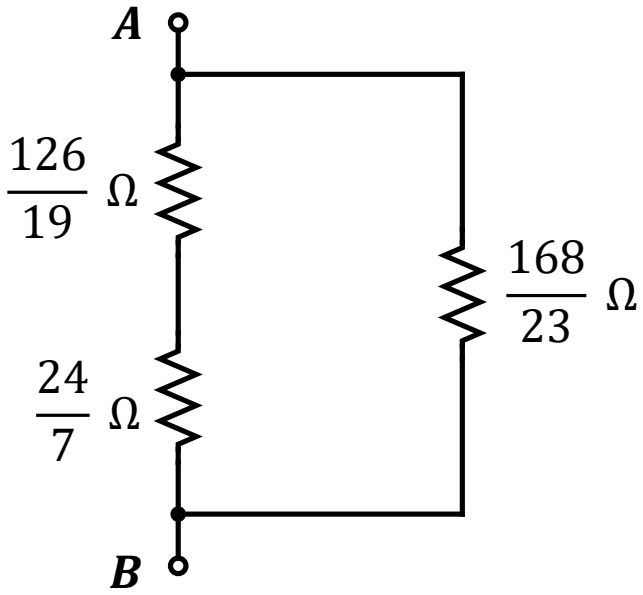



**Ans: 4.23 Ω**



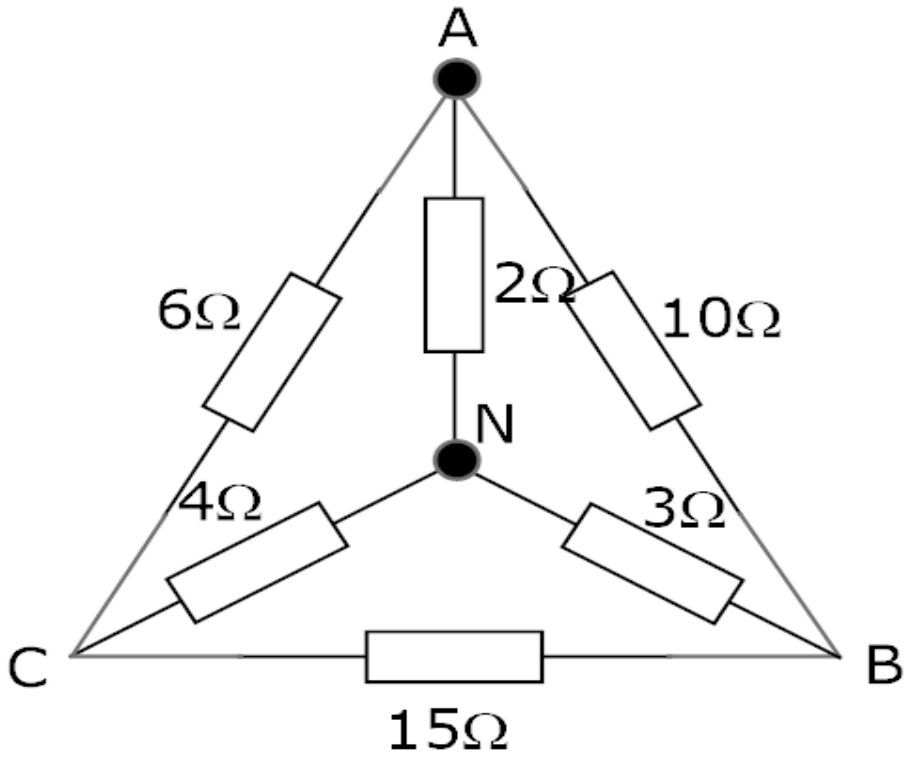




$$\boldsymbol{R_{AB} = 4.2317\ \Omega}$$

# Self-Practice 2: Star-Delta Transformation

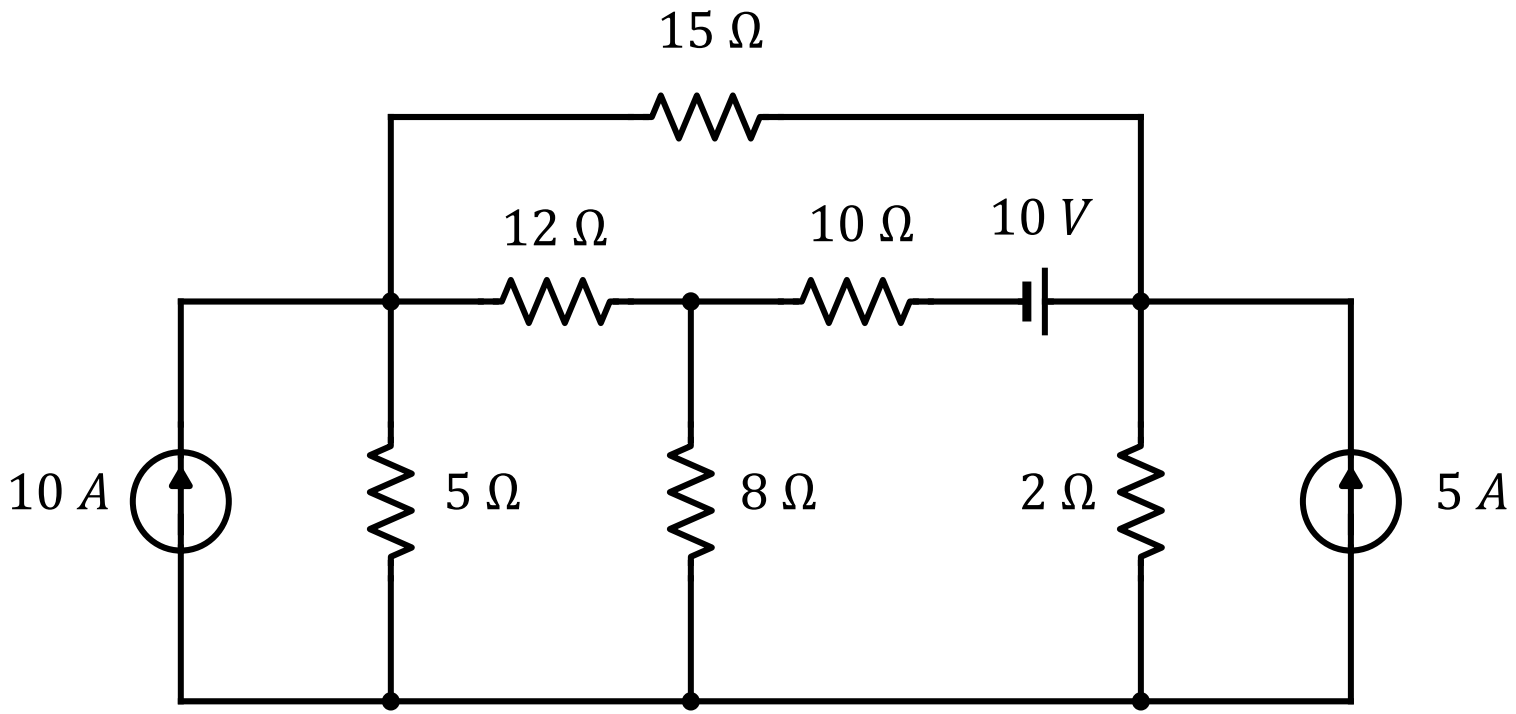
Calculate the equivalent resistance across the terminals **A** and **N** of the given network.



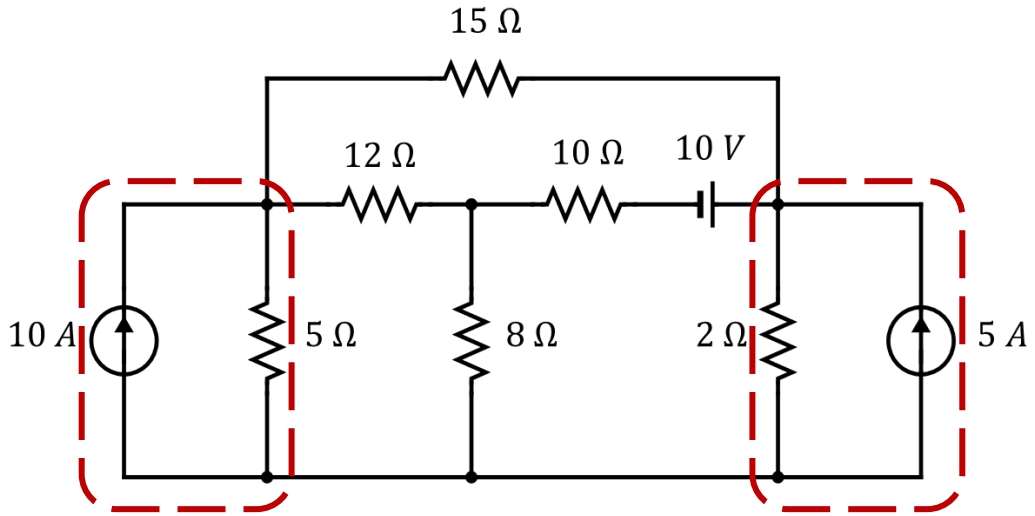

Ans: $R_{AN}$ = 1.4741 Ω

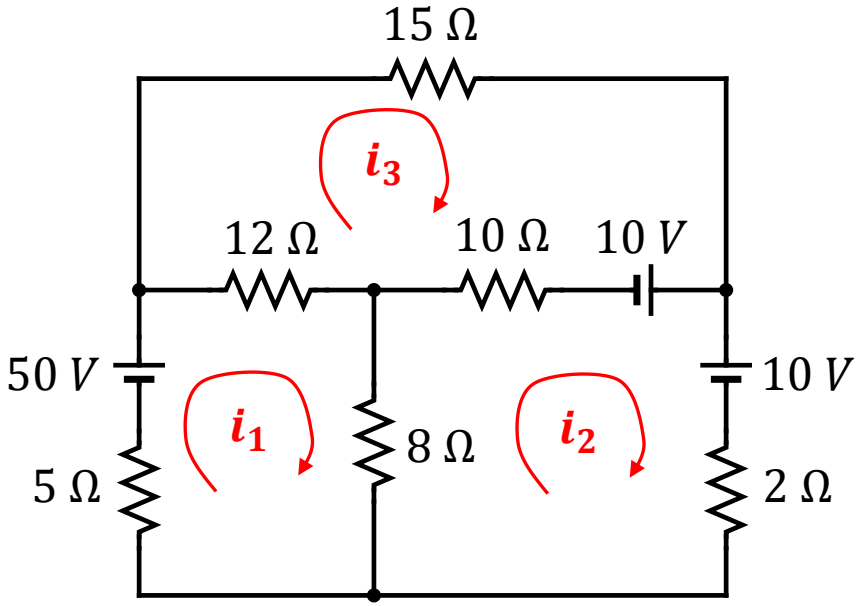
# Problem 3: Mesh Current Analysis

Find the power dissipated in **8 Ω** resistor using mesh current analysis in the circuit shown.




Ans: 13.47 W




$$\begin{bmatrix} 25 & -8 & -12 \\ -8 & 20 & -10 \\ -12 & -10 & 37 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 50 \\ 0 \\ -10 \end{bmatrix}$$

$$i_1 = 3.2608\ A$$

$$i_2 = 1.9633\ A$$

$$i_3 = 1.3179\ A$$

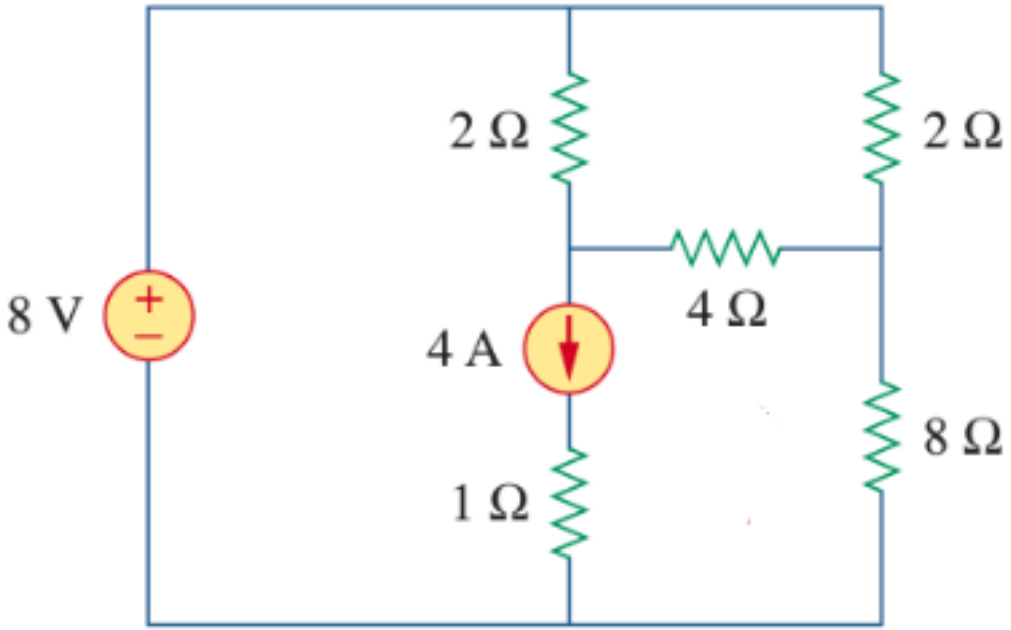
$$I_{8\Omega} = i_1 - i_2 = 1.2975\ A$$

$$\boldsymbol{P_{8\Omega} = I_{8\Omega}^2 \times 8 = 13.4680\ W}$$

# Self-Practice 3: Mesh Current Analysis

Find the power supplied by **8 V** and **4 A** sources in the circuit.

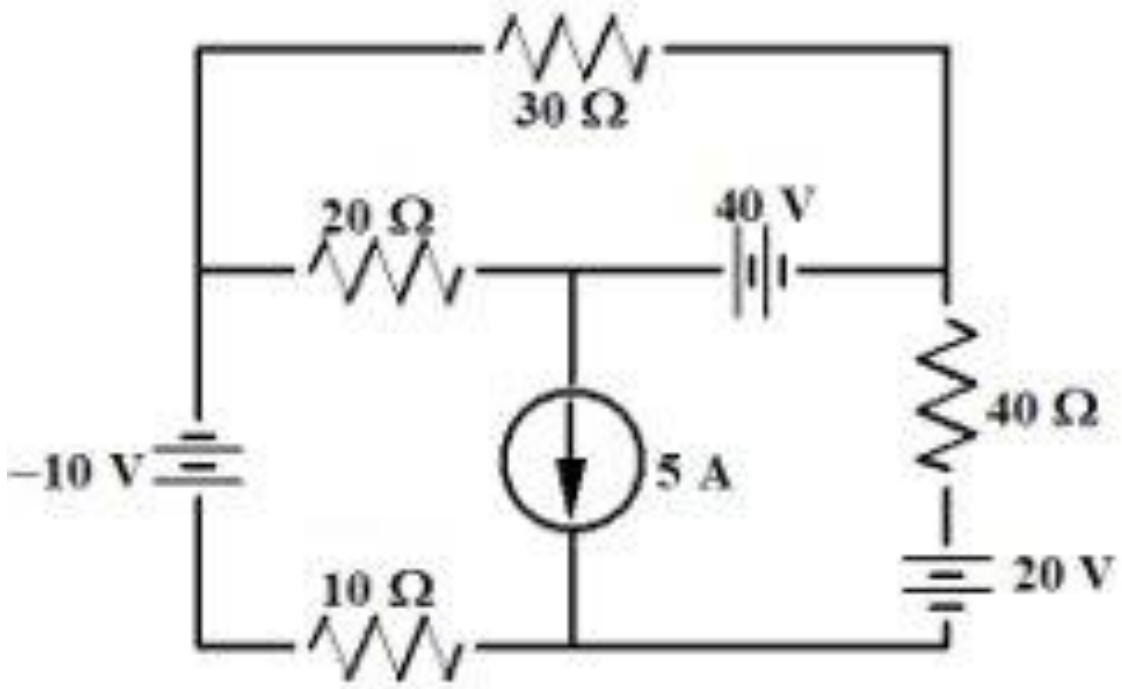
Hint: Supermesh



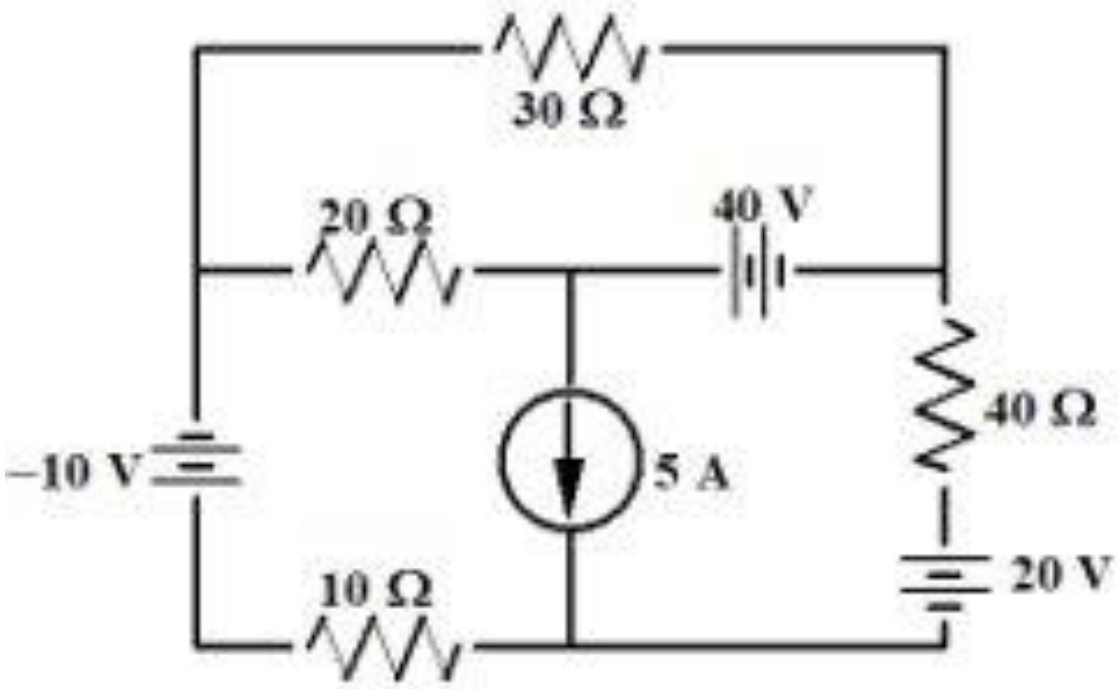

Ans:

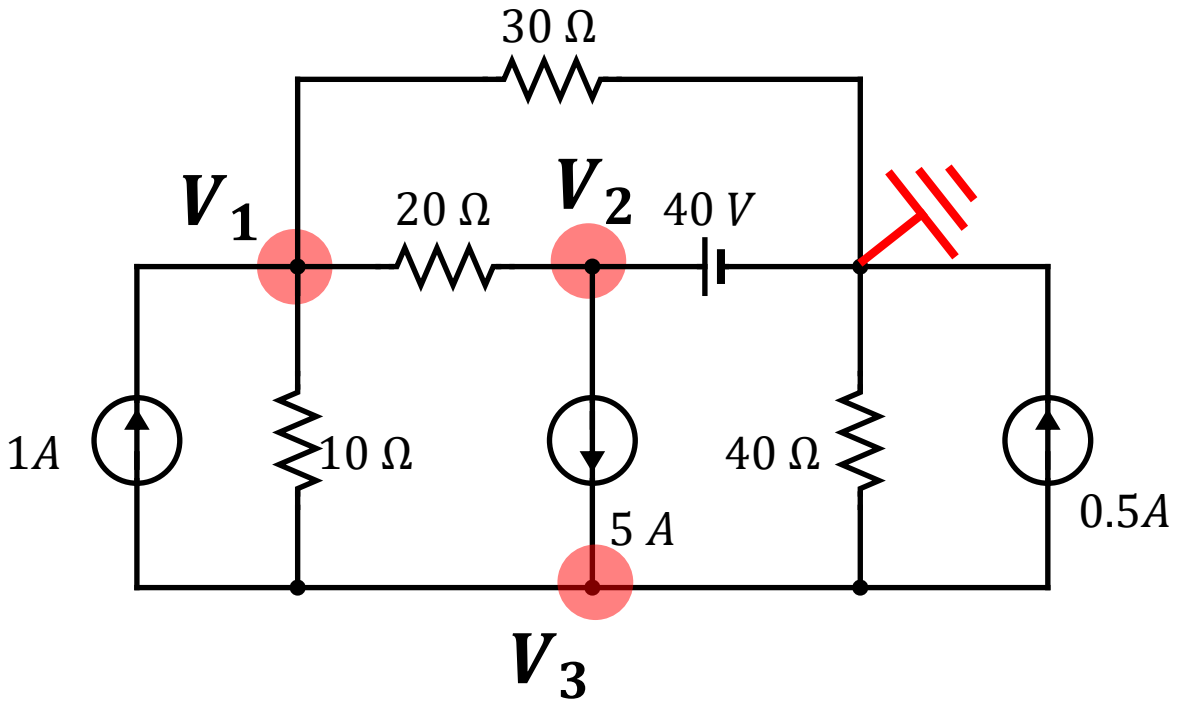
# Problem 4: Node Voltage Analysis

Find the current through **40 V** battery. Is the battery charging or discharging?




Ans: 4.19 A, Discharging



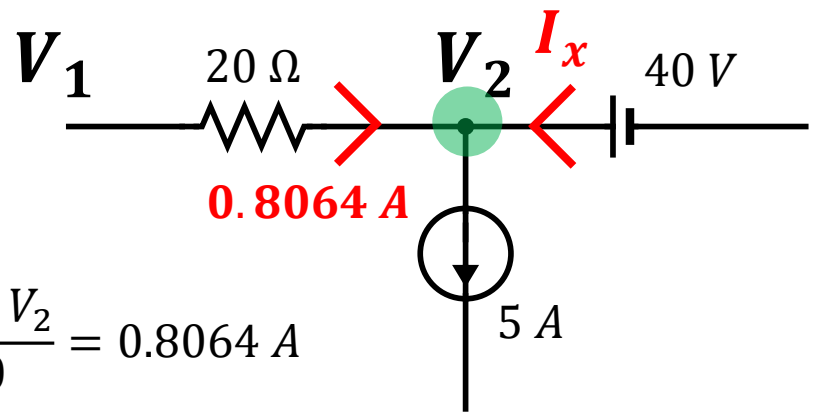

$V_2 = 40\ V$

$$\frac{V_1 - V_2}{20} + \frac{V_1 - V_3}{10} + \frac{V_1}{30} - 1 = 0$$

$$\frac{V_3 - V_1}{10} + \frac{V_3}{40} - 5 + 1 + 0.5 = 0$$

$V_1 = 56.1290\ V$

$V_3 = 72.9032\ V$




$$\frac{V_1 - V_2}{20} = 0.8064\ A$$

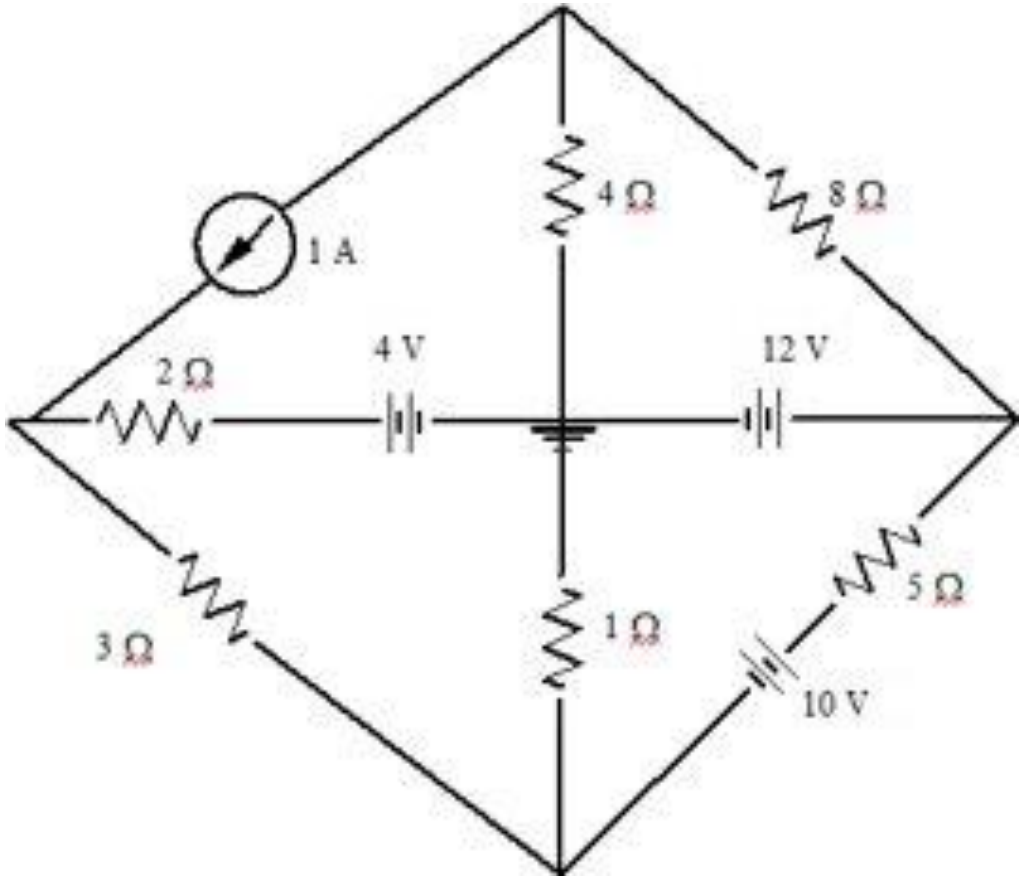
$$0.8064 + I_x = 5$$

$$\boxed{I_x = 4.1936\ A}$$

40 V battery is **discharging**

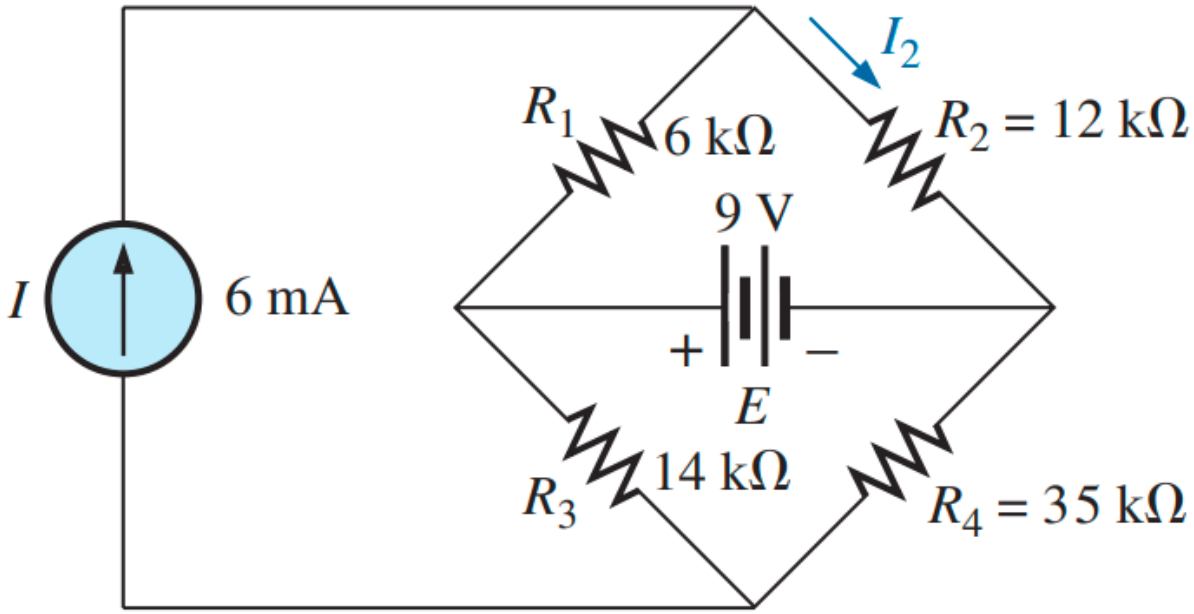
# Self-Practice 4: Node Voltage Analysis

Find the voltage of **all nodes** using node voltage analysis.

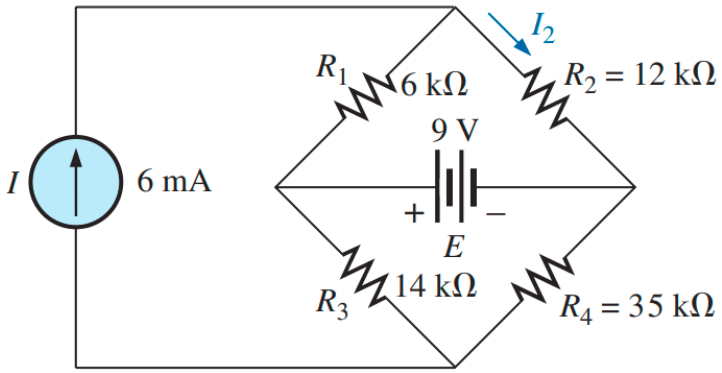


# Problem 5: Superposition Principle

Using the principle of superposition, find the current $\mathbf{I_2}$ through **12 kΩ** resistor.



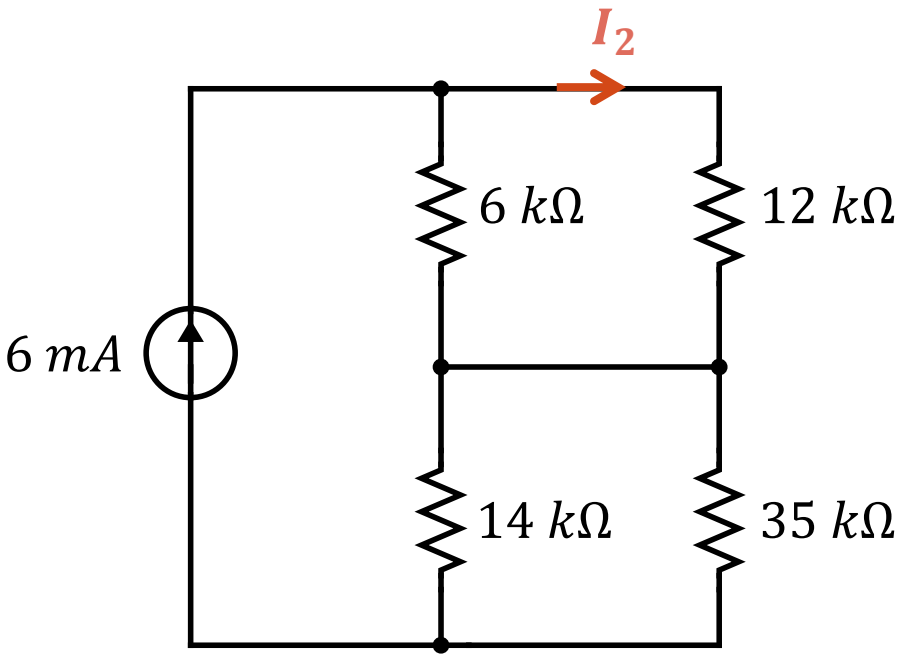

Ans:
Due to source I: 2 mA
Due to source 9 V: 0.5 mA
Total: 2.5 mA




$$I_2 = I_2|_{\,6\,mA} + I_2|_{\,9\,V}$$

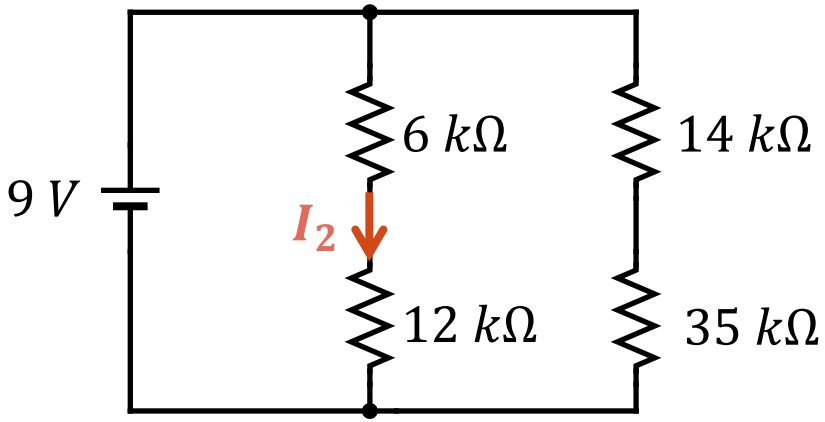
$$\boldsymbol{I_2 = 0.5\,mA + 2\,mA = 2.5\,mA}$$

Response $I_2$ due to 6 $mA$ current source,




$$I_2|_{\,6\,mA} = \frac{6 \times 10^{-3} \times 6 \times 10^{3}}{18 \times 10^{3}} = 2\ mA$$

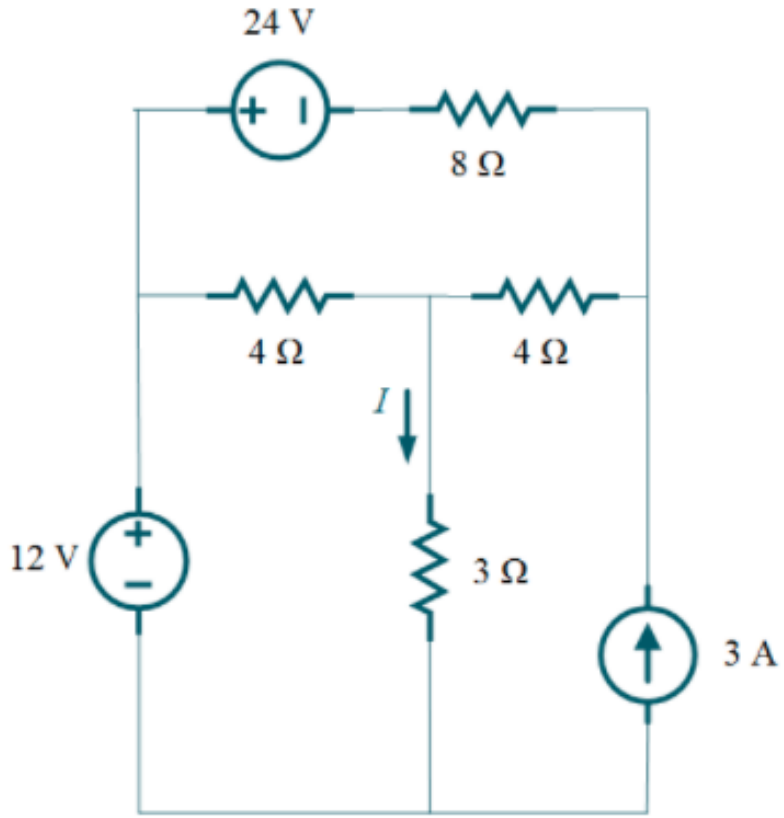
Response $I_2$ due to 9 $V$ voltage source,




$$I_2|_{\,9\,V} = \frac{9}{18 \times 10^{3}} = 0.5\ mA$$

# Self-Practice 5: Superposition Principle

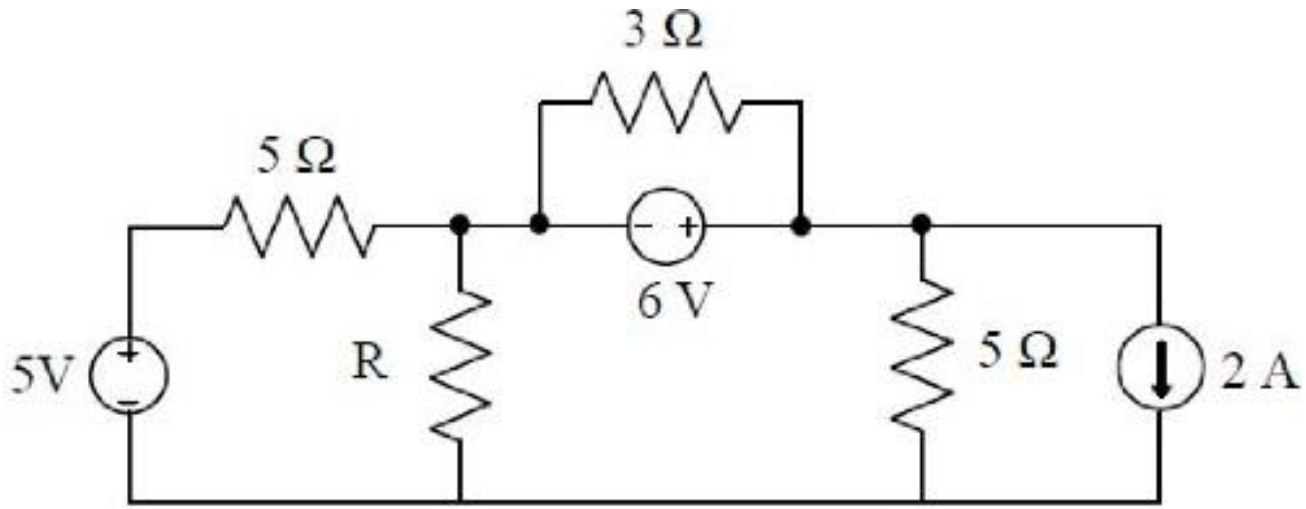
Find the current **I** using **superposition** theorem.



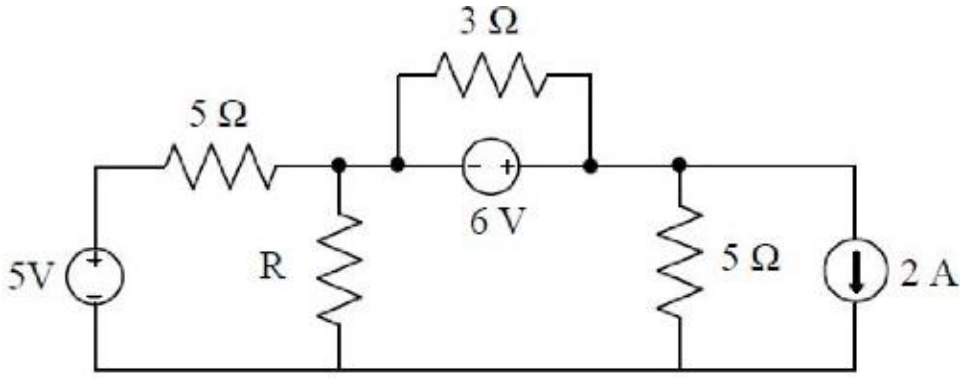

Ans:
Due to source 24 V: - 1 A
Due to source 12 V: 2 A
Due to source 3 A: 1 A
Total: 2 A

# Problem 6: Thevenin's & MPTT

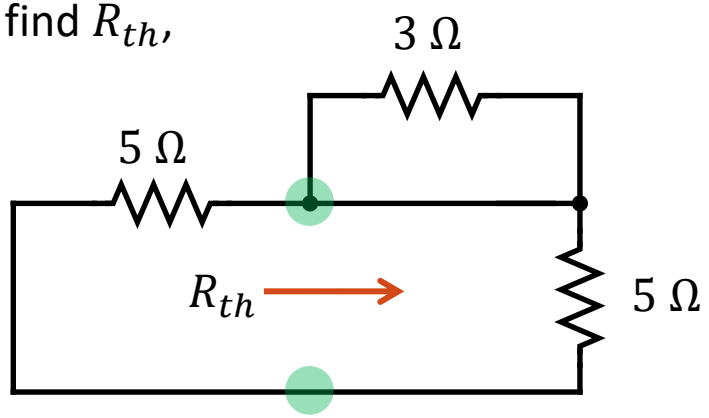
In the circuit shown, find the **maximum power** transferred to the resistor **R.**




Ans: 3.025 W

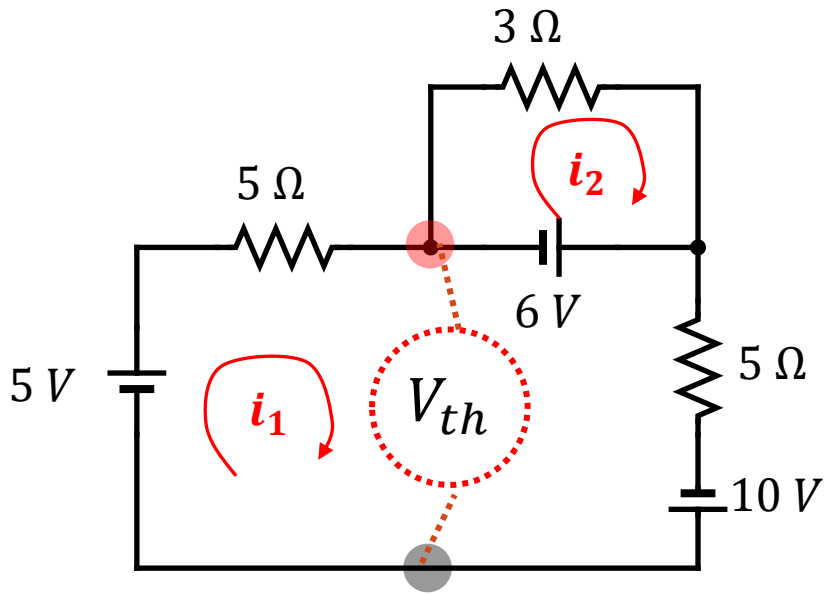



To find $R_{th}$,




$$\boldsymbol{R_{th} = 2.5\ \Omega}$$

To find $V_{th}$ across load resistance $R$,




Applying KVL,

$$5 - 5(2.1) - V_{th} = 0$$

$$\boldsymbol{V_{th} = -5.5\ V}$$

Maximum power transferred to load resistor '$R$' will be,

$$\boldsymbol{P_{max} = \frac{V_{th}^2}{4R_{th}} = \frac{5.5^2}{4 \times 2.5} = 3.025\ W}$$

$$5 - (5)(i_1) + 6 - 5(i_1) + 10 = 0$$

$$\boldsymbol{i_1 = 2.1\ A}$$

$$-3i_2 - 6 = 0$$

$$\boldsymbol{i_2 = -2\ A}$$

# Self-Practice 6: Thevenin's and MPTT

Determine the value of the load resistance to be connected across terminals **A & B** such that maximum power is transferred to it. Also, find the **maximum power** transferred.

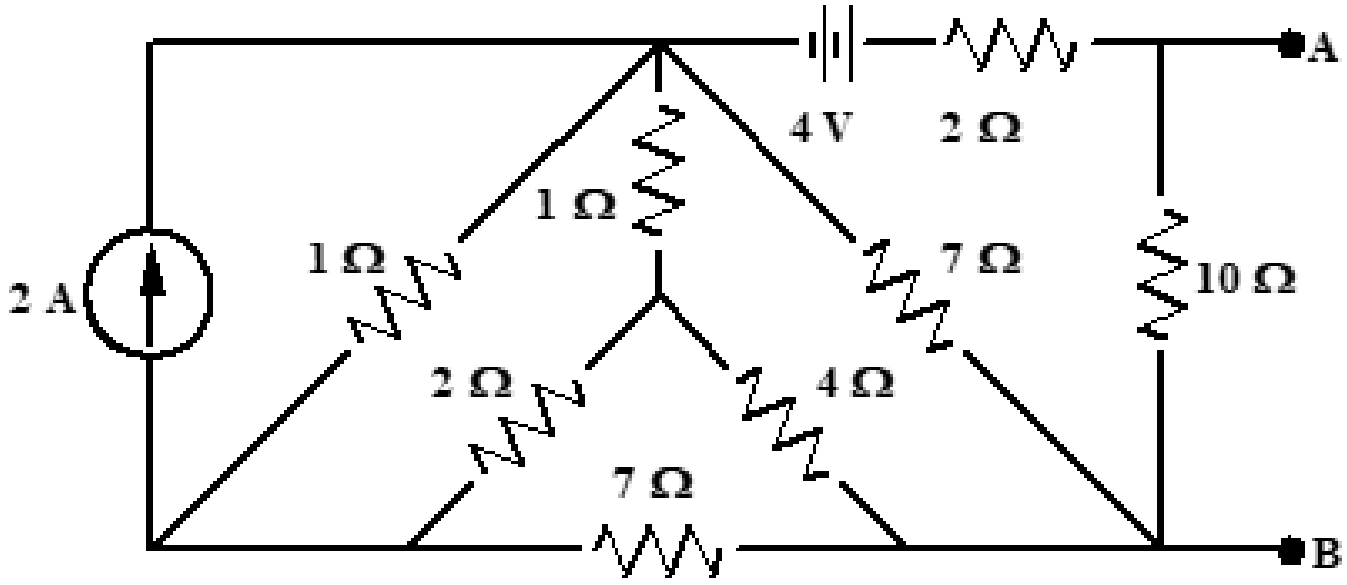



Fig. 1A

Ans: 2.923 Ω and 0.9098 W

# Miscellaneous 1

Two purely resistive incandescent bulbs have the following ratings:

**Bulb 1: 120 V, 60 W** **Bulb 2: 240 V, 480 W**

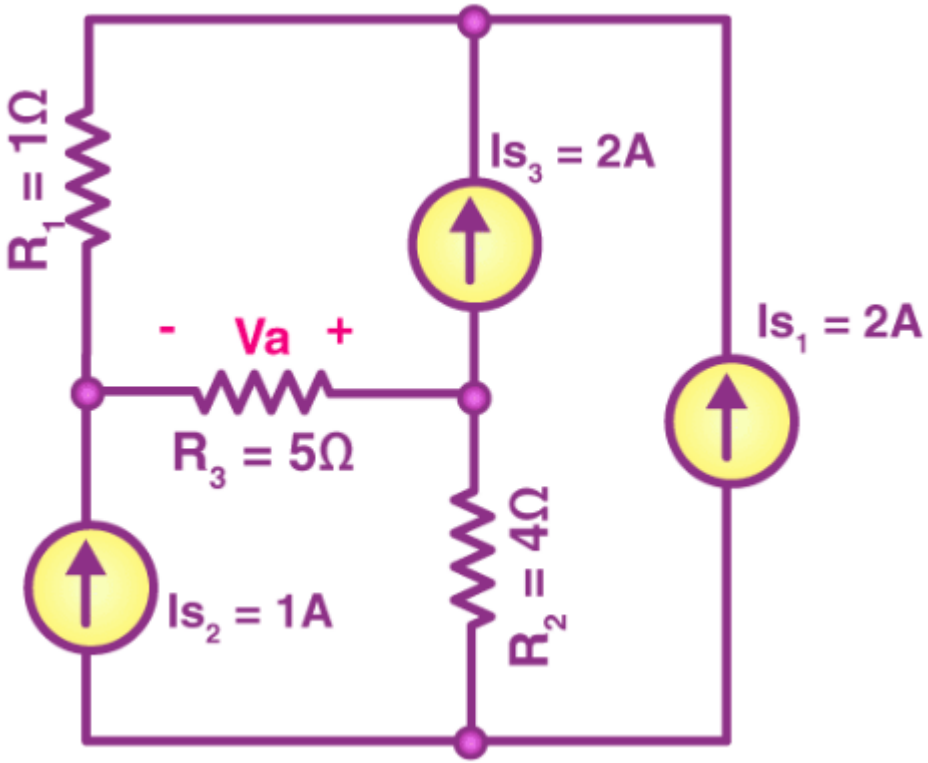
a) Both of them are connected in series across a voltage source.
   i. Which bulb will glow brighter and why?
   ii. What is the maximum voltage that can be applied so that none of the bulbs fuse?

b) Now both of them are connected in parallel across a voltage source.
   i. Which bulb will glow brighter and why?
   ii. What is the maximum voltage that can be applied so that none of the bulbs fuse?

Ans: (a) – (i) Bulb 1 will glow brighter as P1 > P2, (ii) Max. voltage = 180 V
(b) – (i) Bulb 2 will glow brighter as P2 > P1, (ii) Max. voltage = 120 V

# Miscellaneous 2

Find $\mathbf{V_a}$ using nodal analysis and verify using mesh analysis




Ans: - 25 V