Kirchhoff's Circuit Rules

Text section 28.3

Kirchhoff's circuit rules

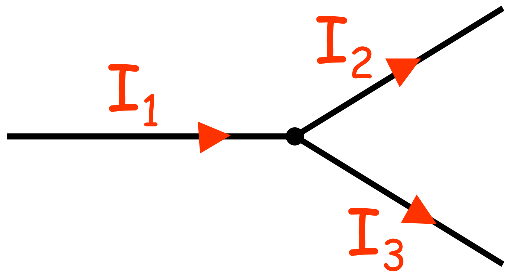
Practice: Chapter 28,
Objective Question 12
Problems 31, 57, 66, 73

Kirchhoff's Circuit Rules

Junction Rule: total current in = total current out at each junction *(from conservation of charge).*

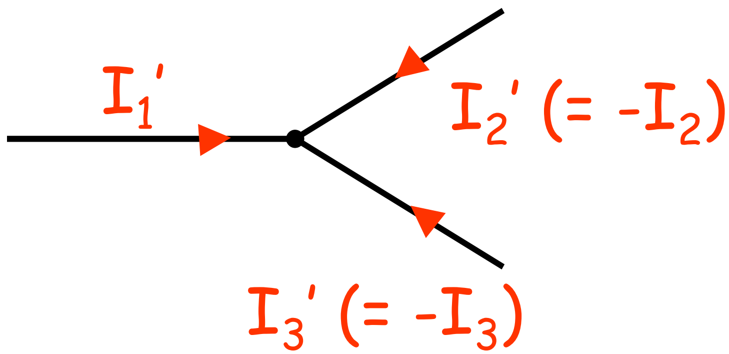
Loop Rule: Sum of *emfs* and *potential differences* around any closed loop is zero *(from conservation of energy).*

Junction Rule: conservation of <u>charge.</u>



$$I_1 = I_2 + I_3$$

<u>or</u>



$$I_1' + I_2' + I_3' = 0$$

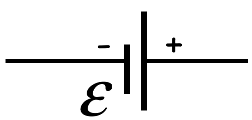
Loop Rule: conservation of <u>energy</u>.
Follow a test charge q around a loop:

→ $\sum q \times (\Delta V_i) = 0$ around <u>any</u> loop in circuit.

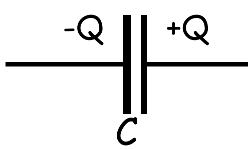
<u>changes going from left to right</u>

$\Delta V = -IR$

$\Delta V = +IR$

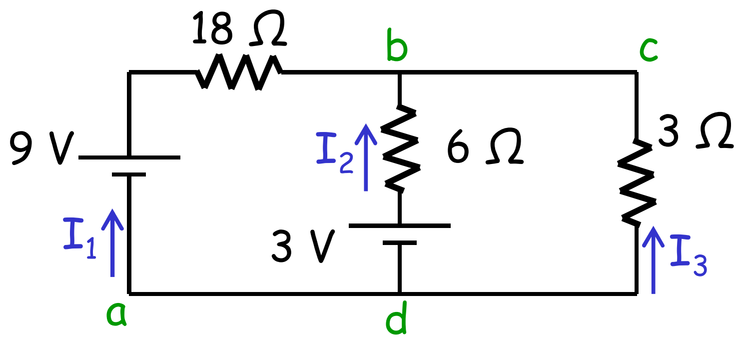


$\Delta V = \mathcal{E}$



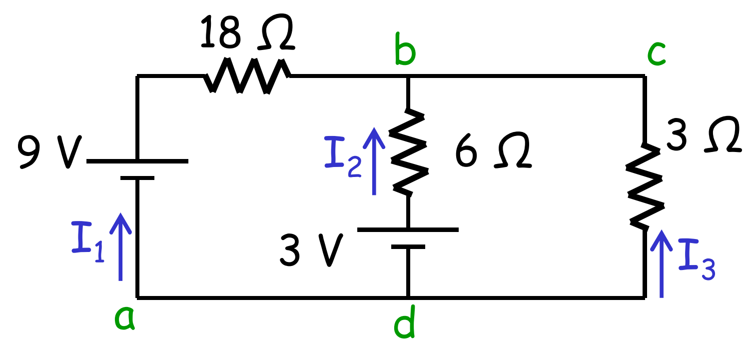
$\Delta V = Q/C$

Example



Find the current through each battery.

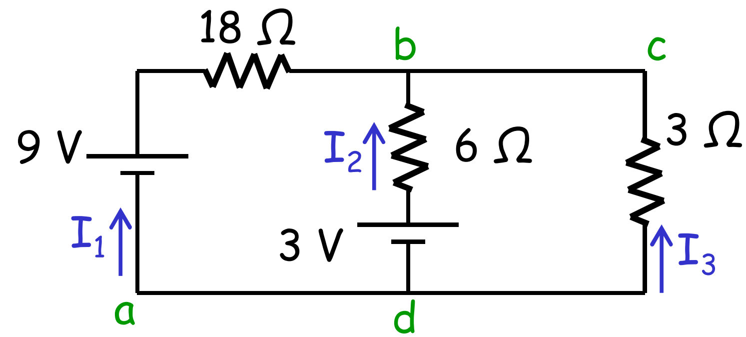
Quiz



The junction rule will give:

A) $I_1 + I_2 + I_3 = 0$
B) $-I_1 + I_2 + I_3 = 0$
C) $I_1 - I_2 + I_3 = 0$
D) $I_1 + I_2 - I_3 = 0$
E) none of these

Quiz

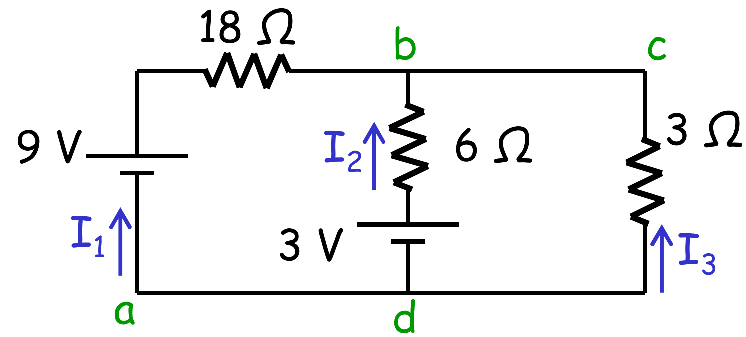


The loop rule applied to loop *abcda* will give:

A) $9A - 18I_1 - 3I_3 = 0$
B) $9A + 18I_1 - 3I_3 = 0$
C) $9A + 18I_1 + 3I_3 = 0$
D) $9A - 18I_1 + 3I_3 = 0$
E) none of these

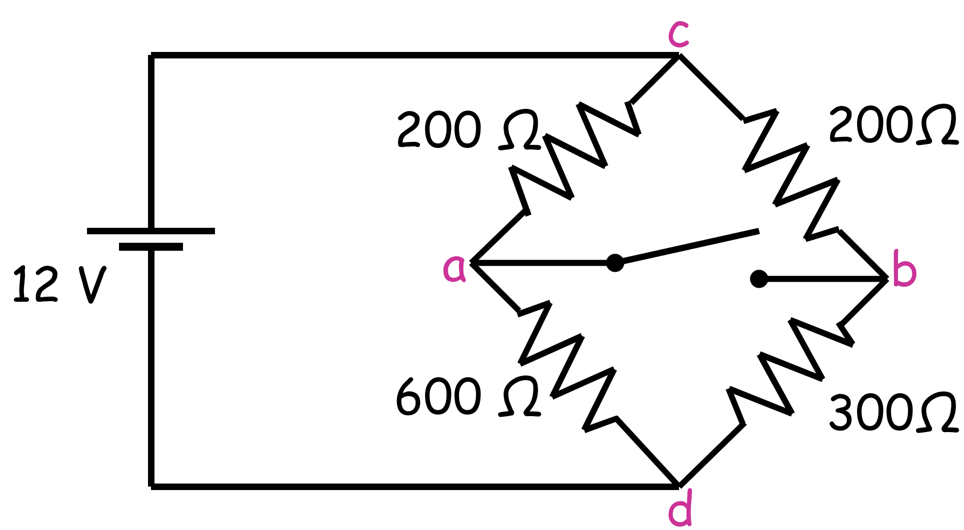
Quiz

The loop rule applied to loop *abda* will give:



A) $12A - 18I_1 + 6I_2 = 0$
B) $12A - 18I_1 - 6I_2 = 0$
C) $6A - 18I_1 - 6I_2 = 0$
D) $6A + 18I_1 + 6I_2 = 0$
E) $6A - 18I_1 + 6I_2 = 0$

Exercise

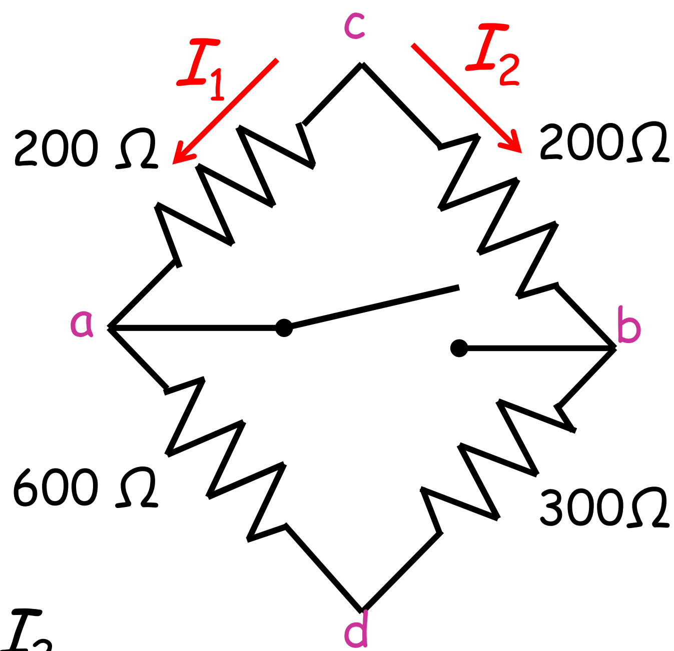


What is V_{ab} (i.e., V_a - V_b) when the switch is open?

Exercise for fun: Find the current through the switch when it is closed.

Quiz:

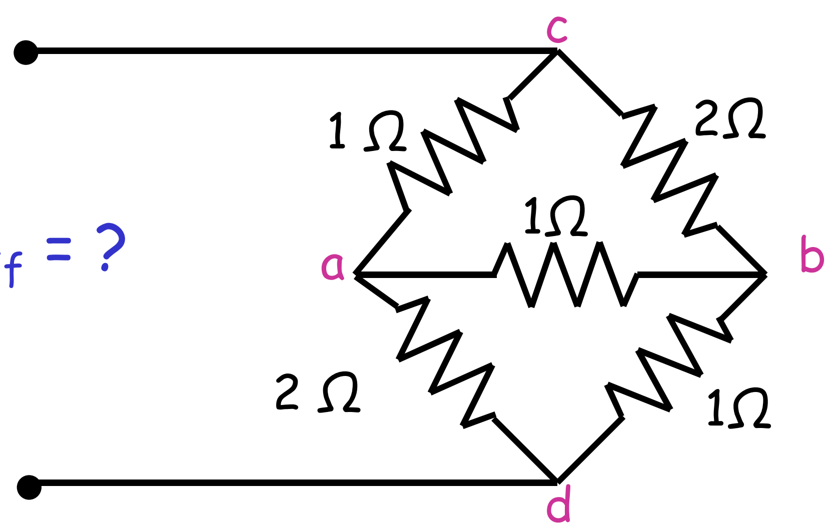
The loop rule requires that V_{ab} (i.e., $V_a - V_b$) should obey:



A) $V_{ab} = (200\Omega)I_1 + (200\Omega)I_2$
B) $V_{ab} = (200\Omega)I_1 - (200\Omega)I_2$
C) $V_{ab} = -(200\Omega)I_1 + (200\Omega)I_2$
D) $V_{ab} = -(200\Omega)I_1 - (200\Omega)I_2$

Example: Effective resistance

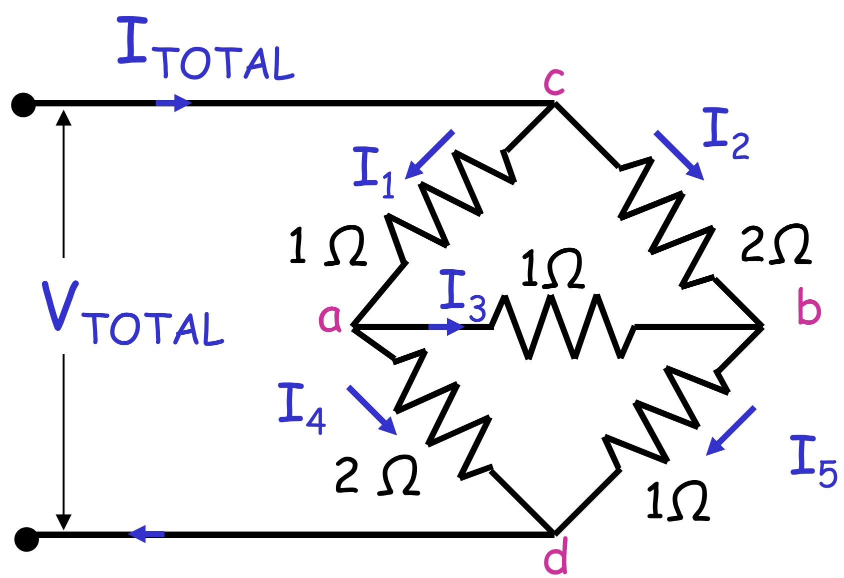
R_{eff} = ?



"Series and parallel" rules don't help in this case. You have to go back to the fundamentals—Kirchhoff's Circuit Rules.

(Answer: $R_{eff} = 1.4\Omega$)

Solution plan: $R_{eff} = V_{TOTAL}/I_{TOTAL}$



Show that:

$I_1 = I_5 = 3I_3$

$I_2 = I_4 = 2I_3$

$I_{TOTAL} = 5I_3$

$V_{TOTAL} = (7\Omega)\ I_3$

1) Use Kirchhoff's rules to write everything in terms of one variable (e.g., I_3).

2) Divide V_{TOTAL}/I_{TOTAL}.