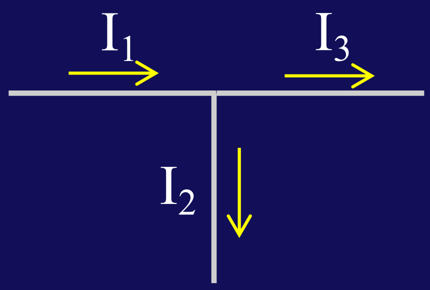
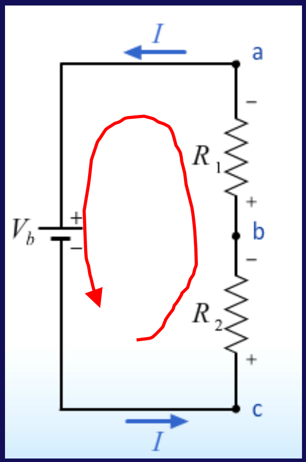
Kirchoff Loop Laws …



Rule 1: *"What goes in, must go out "*



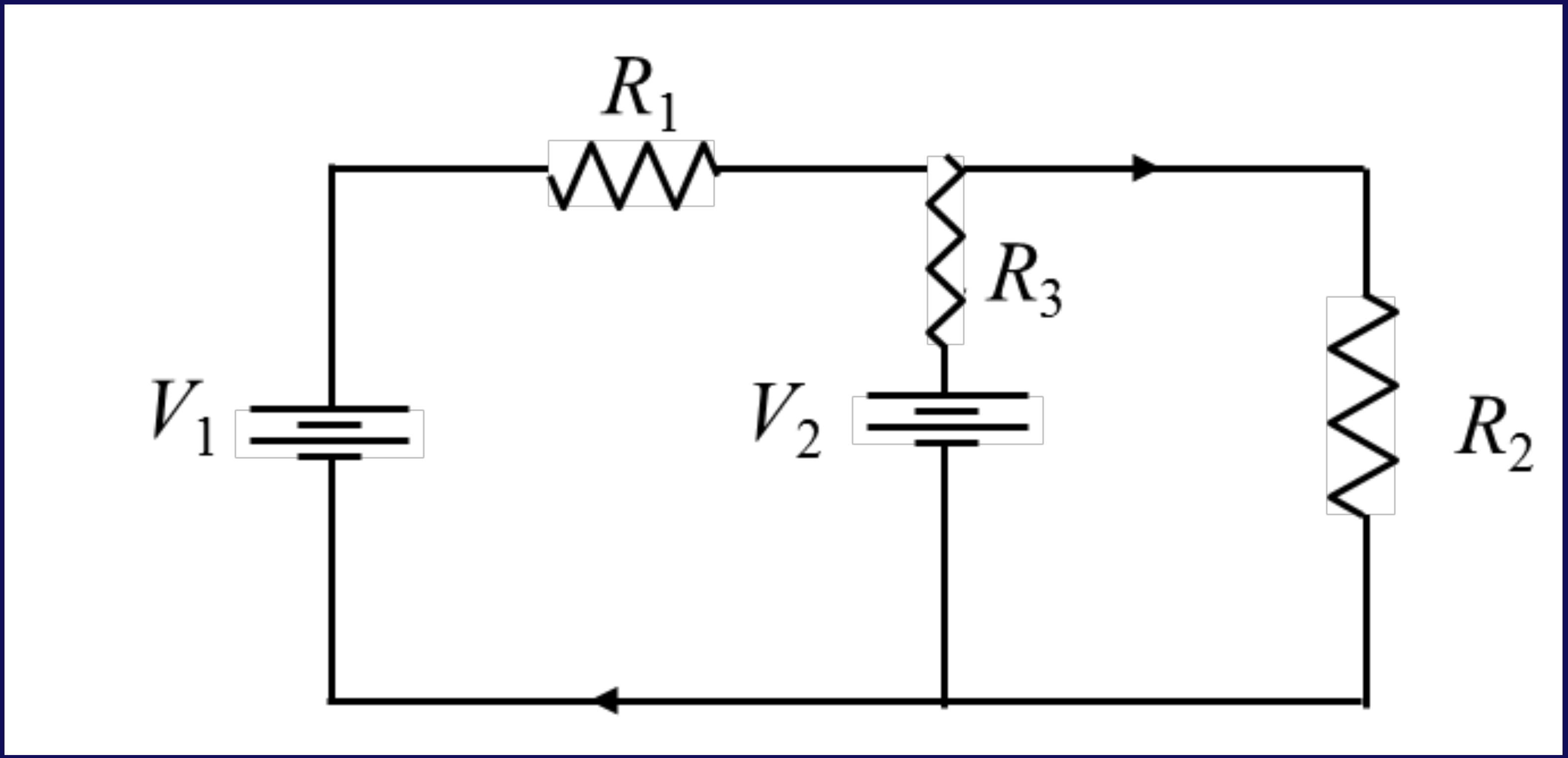
Rule 2: *"What goes up, must come down"*

Business…

- Exam next Thursday !
- Material is everything through TODAY.
  - **No RC circuits that we will cover Monday**
- Practice exam and Eqn. posted on home page after lecture
- Try the SmartPhysics HOMEWORK this week on today's lessons. Very good practice for multi-loop problems and a very pedagogical example

Can we solve this from simple series and parallel combinations?

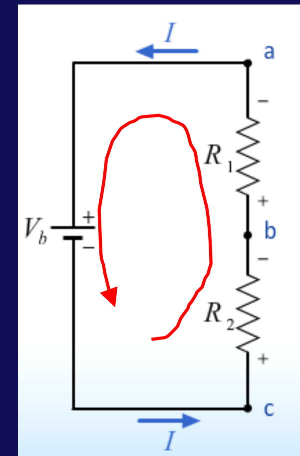
Answer: *no*



Kirchoff Voltage Law: KVL

"When any closed circuit loop is traversed, the algebraic sum of the changes in potential must equal zero."

KVL: $$\sum_{loop} V_n = 0$$



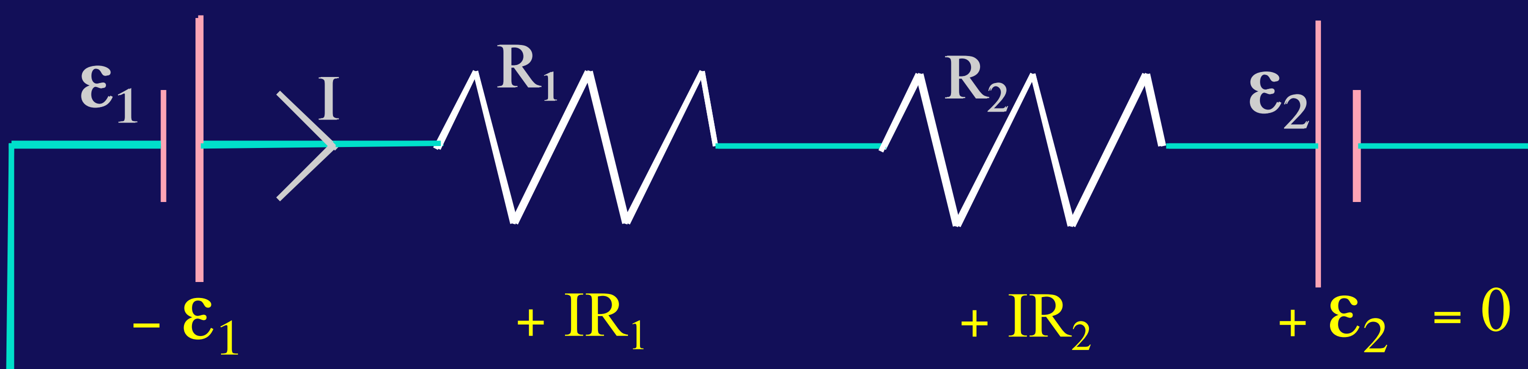
- This is just a restatement of what you already know: that the potential difference is independent of path!

We will follow the ECE conventions: (engineering)

voltage drops enter with a ***+ sign*** and

voltage gains enter with a ***- sign*** in this equation.

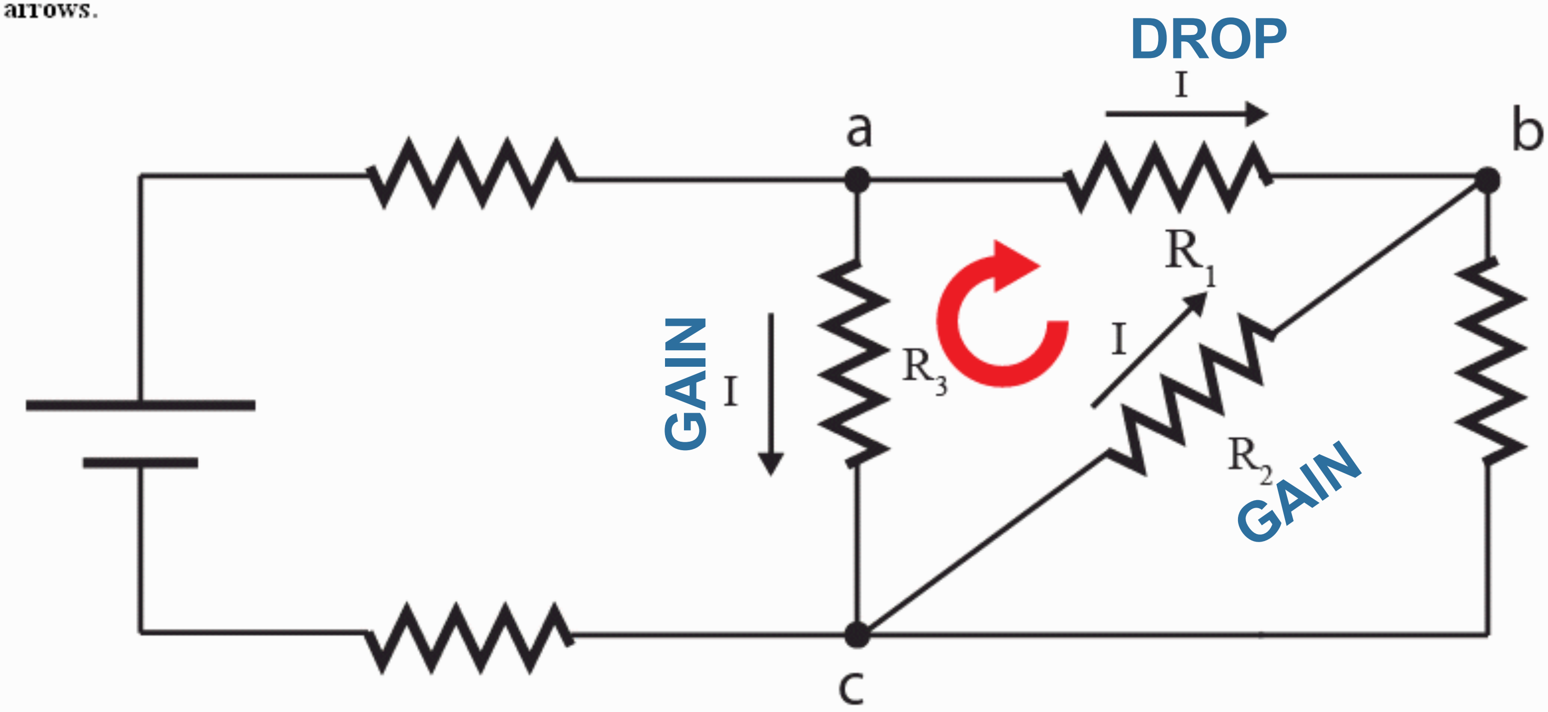
Let's go clockwise around circuit:



This resistor labyrinth stuff is crazy!

CheckPoint

5) In the follwoing circuit, consider the loop abc. The direction of the current through each resistor is indicated by black arrows.



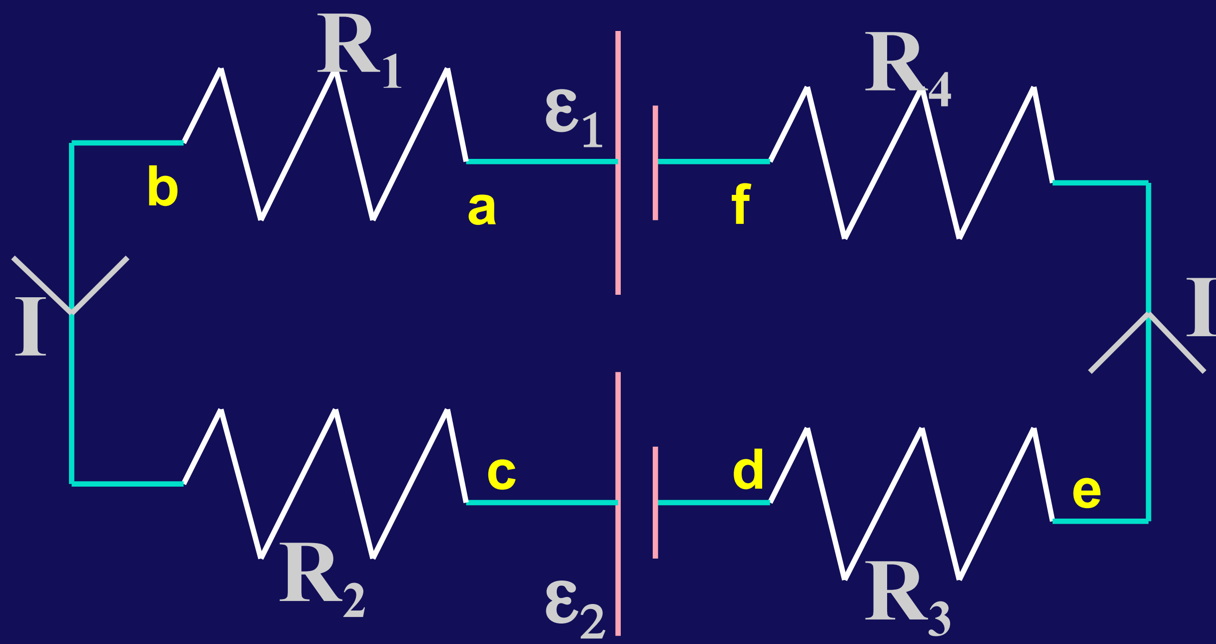
If we are to write Kirchoff's voltage equation for this loop in clockwise direction starting from point a, what is the correct order of voltage gains/dropps that we'll encounter for resistors R1, R2 and R3?

A ○ drop, drop, drop
B ○ gain, gain, gain
C ○ drop, gain, gain
D ○ gain, drop, drop
E ○ drop, drop, gain
○ other

With the current → VOLTAGE DROP

Against the current → VOLTAGE GAIN

Examine this loop



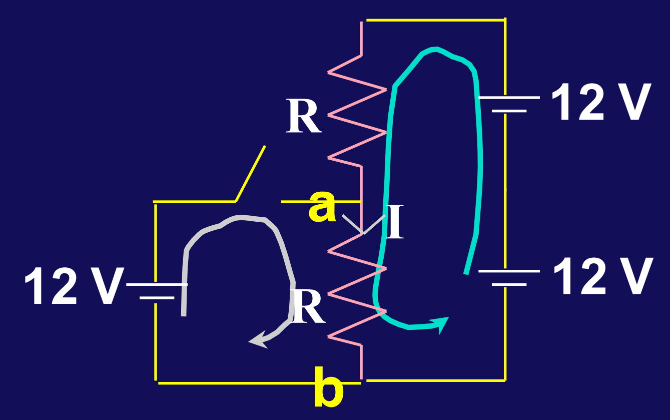
Let's go around the loop counterclockwise from a to f

KVL: $\sum_{loop} V_n = 0$ Þ $IR_1 + IR_2 + \varepsilon_2 + IR_3 + IR_4 - \varepsilon_1 = 0$

Þ $$I = \frac{\varepsilon_1 - \varepsilon_2}{R_1 + R_2 + R_3 + R_4}$$

Clicker

- Consider the circuit shown.
  - The switch is initially open and the current flowing through the bottom resistor is I_0.
  - After the switch is closed, the current flowing through the bottom resistor is I_1.
  - What is the relation between I_0 and I_1?



(a) $I_1 < I_0$

(b) $I_1 = I_0$

(c) $I_1 > I_0$

- Write a loop law for original loop:

$$-12V - 12V + I_0 R + I_0 R = 0$$

$$I_0 = 12V/R$$

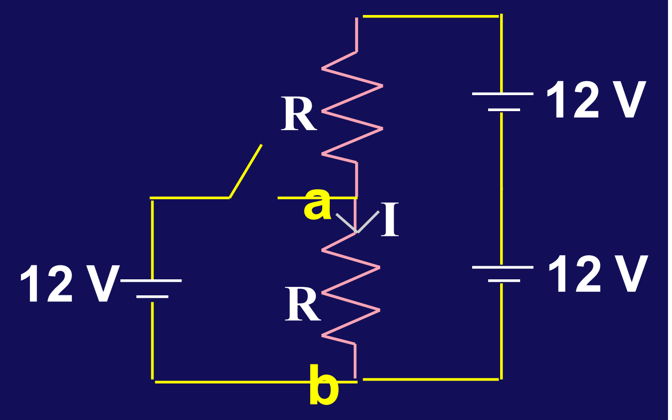
- Write a loop law for the new loop:

$$-12V + I_1 R = 0$$

$$I_1 = 12V/R$$

…or, alternative reasoning

- **Consider the circuit shown.**
  - **The switch is initially open and the current flowing through the bottom resistor is I_0.**
  - **After the switch is closed, the current flowing through the bottom resistor is I_1.**
  - **What is the relation between I_0 and I_1?**



(a) $I_1 < I_0$ **(b) $I_1 = I_0$** **(c) $I_1 > I_0$**

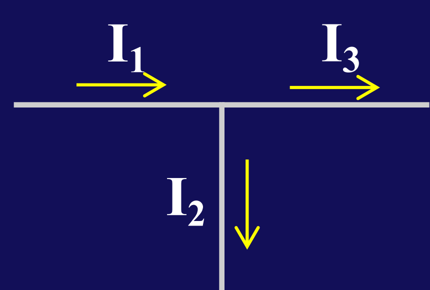
- **The key here is to determine the potential (V_a-V_b) before the switch is closed.**
- **From symmetry, (V_a-V_b) = +12V.**
- **Therefore, when the switch is closed, NO additional current will flow!**
- **Therefore, the current before the switch is closed is equal to the current after the switch is closed.**

Kirchoff's Current Law: KCL

Conservation of Charge (at a junction)

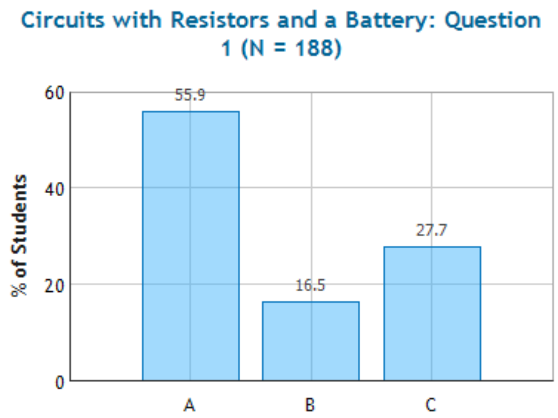
"At any junction point in a circuit where the current can divide (also called a node), the sum of the currents into the node must equal the sum of the currents out of the node."

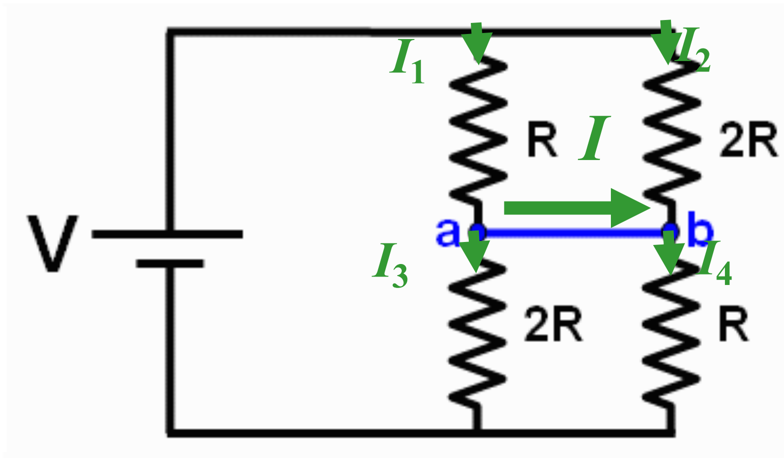
$$I_{in} = \sum I_{out}$$



CheckPoint

4) Consider the circuit shown below.





Which of the following statements best describes the current flowing in the blue wire connecting points a and b?

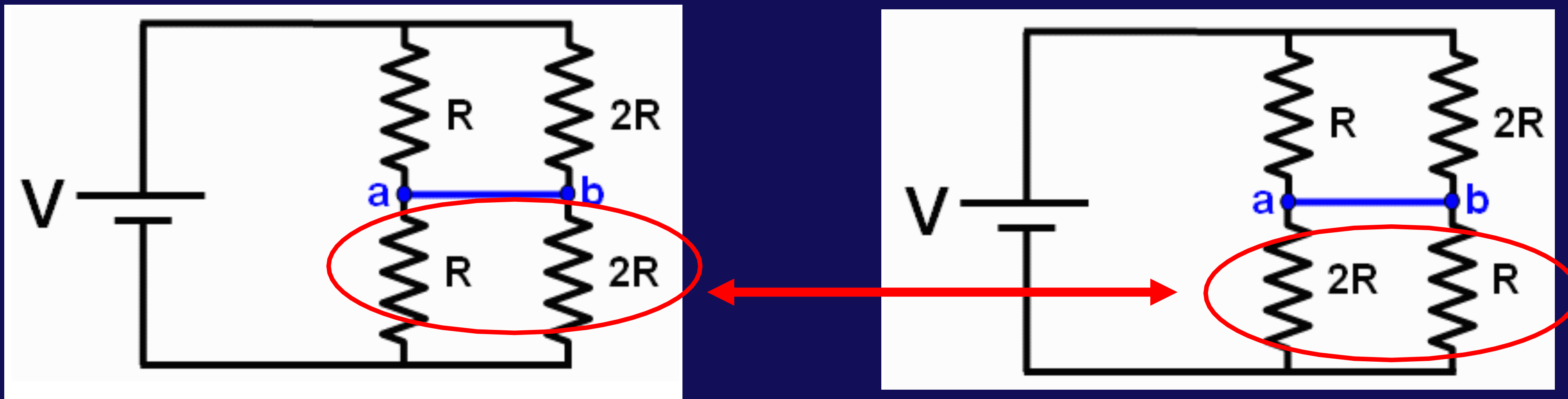
- ○ Positive current flows from **a** to **b**
- ○ Positive current flows from **b** to **a**
- ○ No current flows between **a** and **b**

Wire connects a to b; DV through R and 2R to a/b is V/2. (symmetry from below); Therefore: $I_1 R = I_2\, 2R = V/2$; $I_1 = V/2R$
(twice as much current goes down the left)

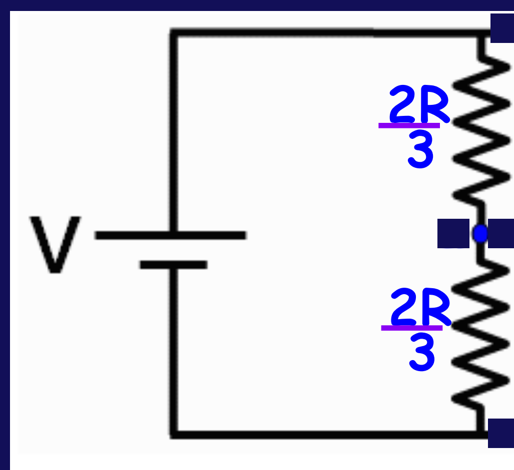
From a/b to <u>bottom</u> of circuit, $\Delta V/2$ as well; $I_3\, 2R = I_4 R = V/2$; $I_3 = V/4R$
(twice as much current down right side)

Junction Rule at a: $I_1 = I_{ab} + I_3$ → $V/(2R) = I_{ab} + V/(4R)$ → I_{ab} is positive

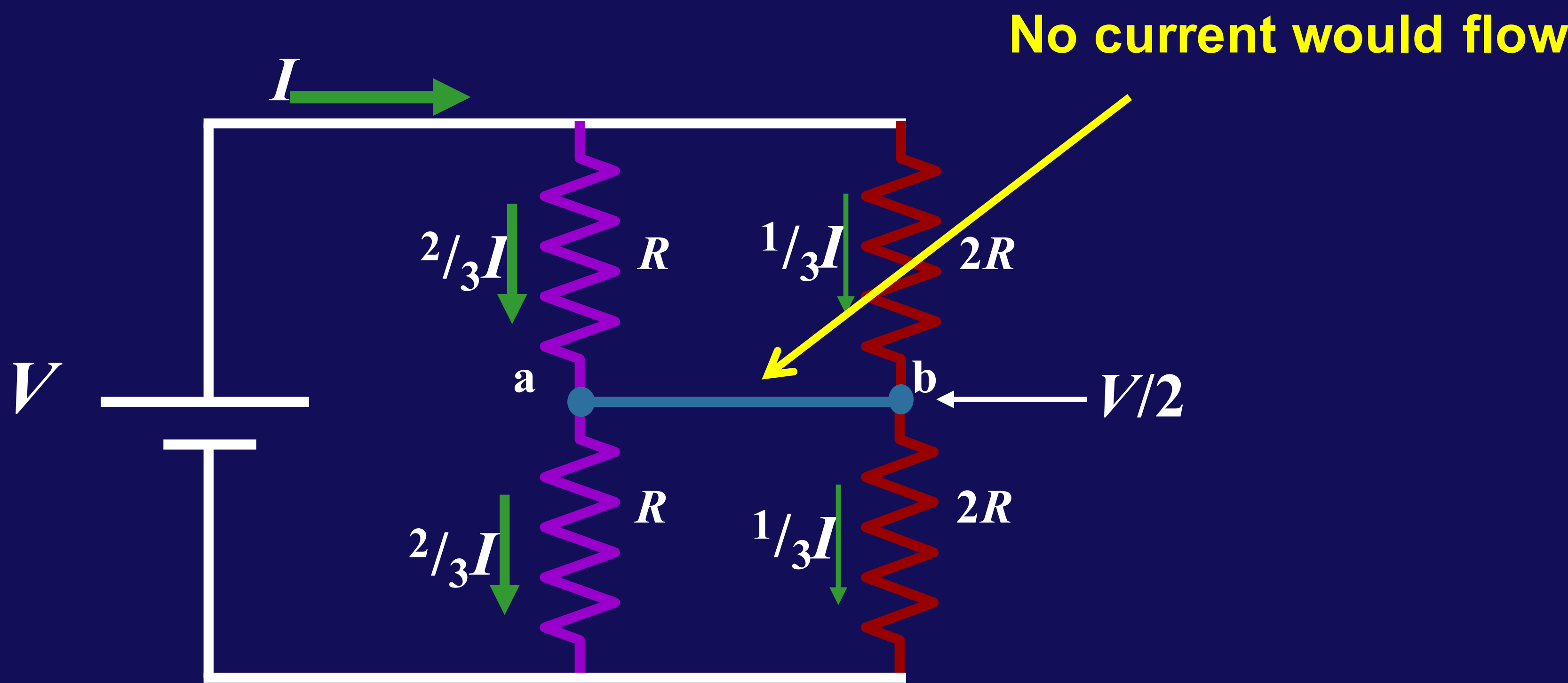
Prelecture *CheckPoint*



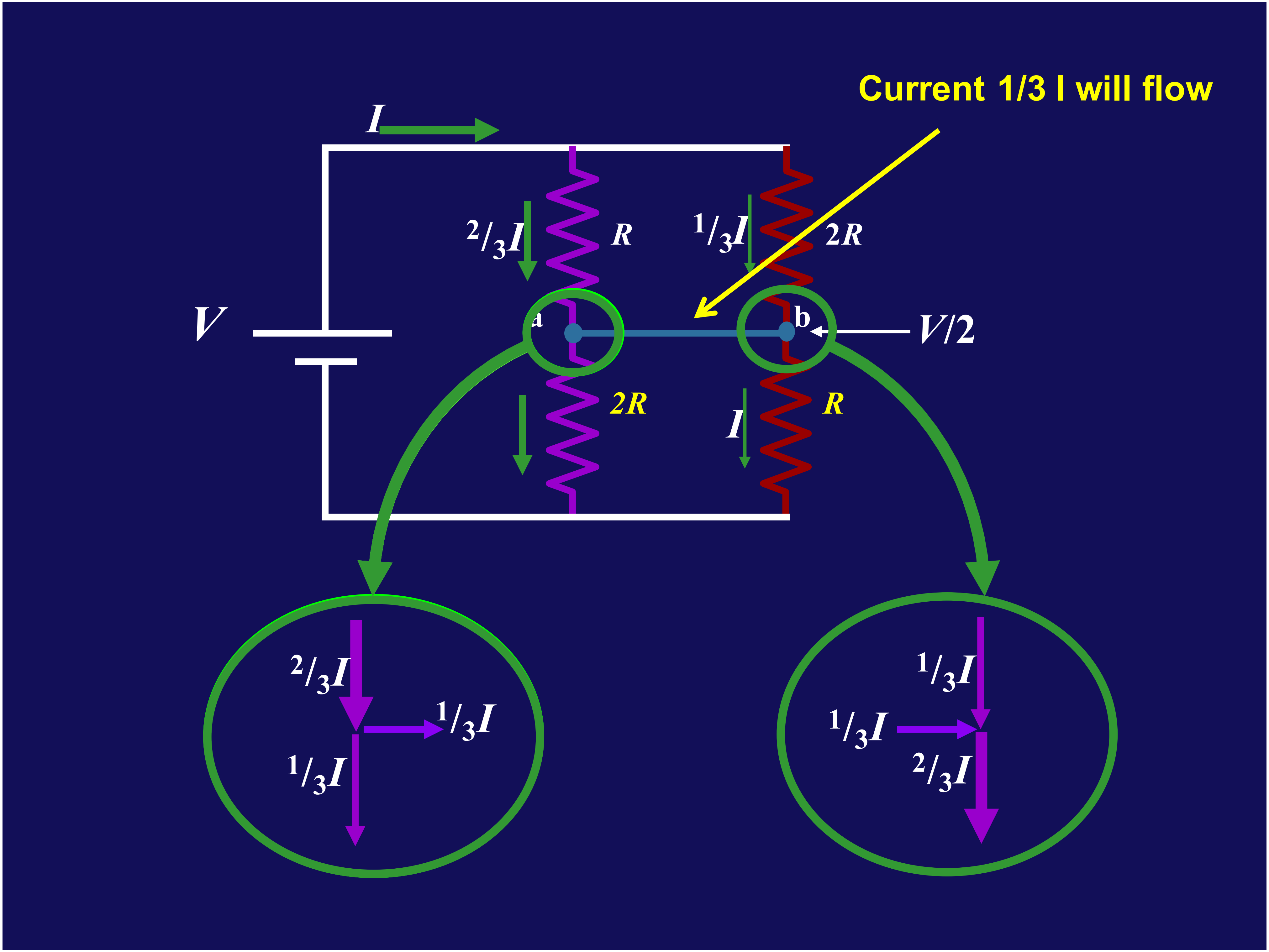
What is the same? Current flowing in and out of the battery.
Equivalent resistance is the same.



What is different? Current flowing from a to b.

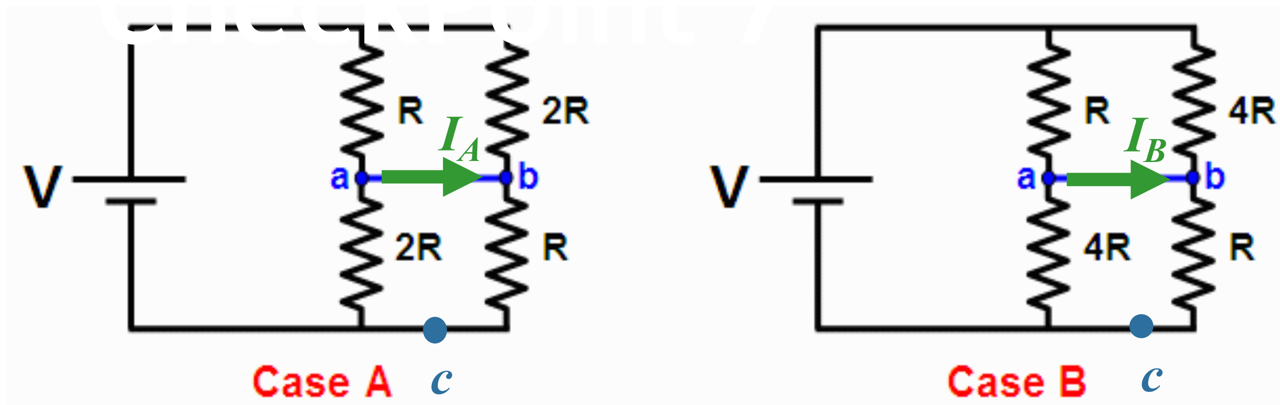


No current would flow
I
V
2/3I
R
1/3I
2R
a
b
V/2
2/3I
R
1/3I
2R


Current 1/3 I will flow
I
V
2/3I
R
1/3I
2R
a
b
V/2
2R
I
R
2/3I
1/3I
1/3I
1/3I
1/3I
2/3I

Have a look at this if you missed it. Some reasoning below …

7) Consider the circuit shown below.



In which case is the current flowing in the blue wire connecting points a and b biggest

- ◯ Case A
- ◯ Case B
- ◯ They are the same

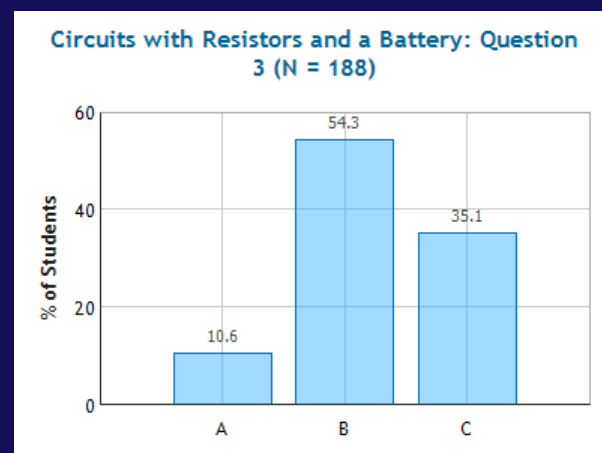
Current will flow from left to right in both cases.

In both cases, $V_{ac} = V/2$

$$I_{2R} = 2I_{4R}$$

$$I_A = I_R - I_{2R} = I_R - 2I_{4R}$$

$$I_B = I_R - I_{4R}$$



Analysis of a circuit

Junction:

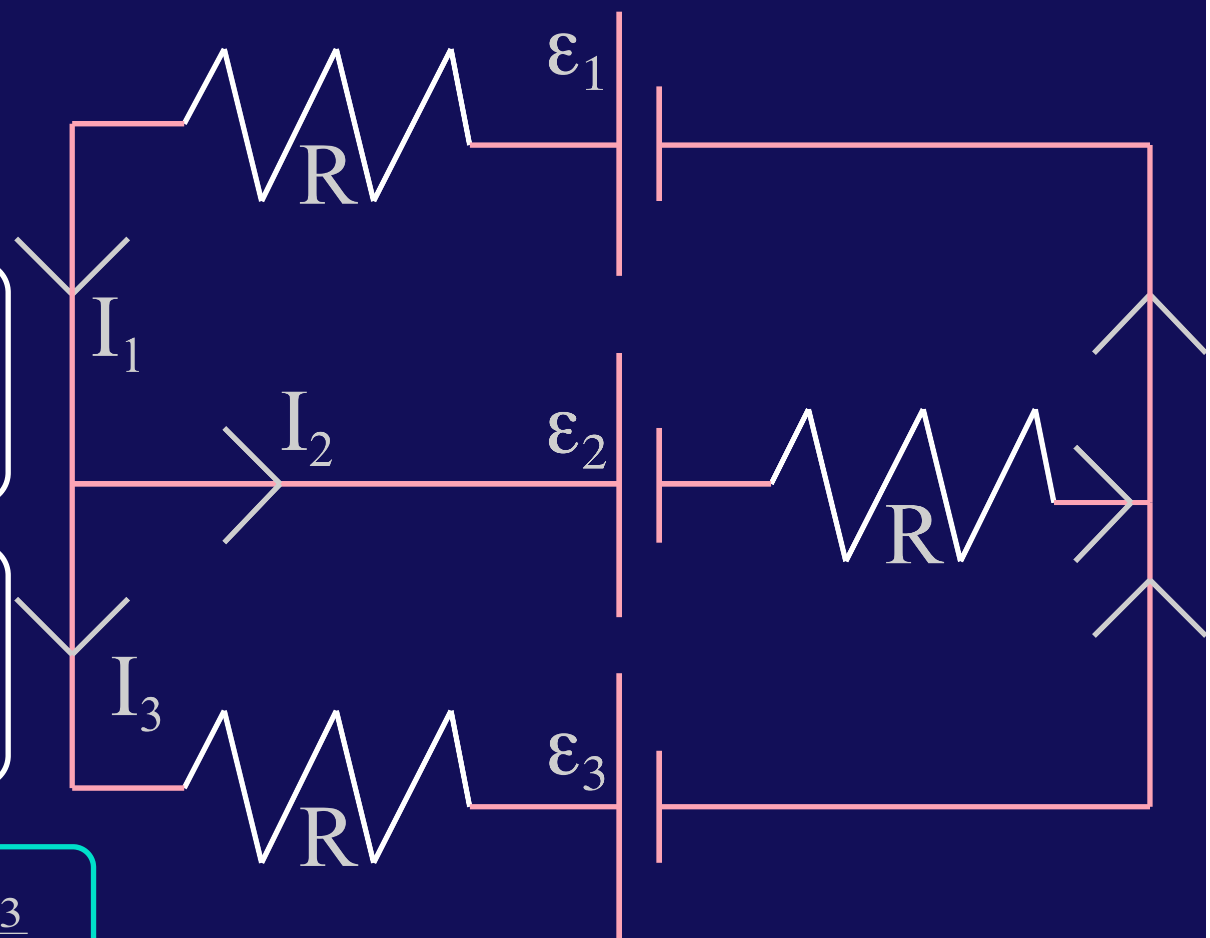
$$I_1 = I_2 + I_3$$

Outside loop:

$$I_1R + I_3R + \varepsilon_3 - \varepsilon_1 = 0$$

Top loop:

$$I_1R + \varepsilon_2 + I_2R - \varepsilon_1 = 0$$



$$I_1 = \frac{2\varepsilon_1 - \varepsilon_2 - \varepsilon_3}{3R}$$

$$I_2 = \frac{\varepsilon_1 + \varepsilon_3 - 2\varepsilon_2}{3R}$$

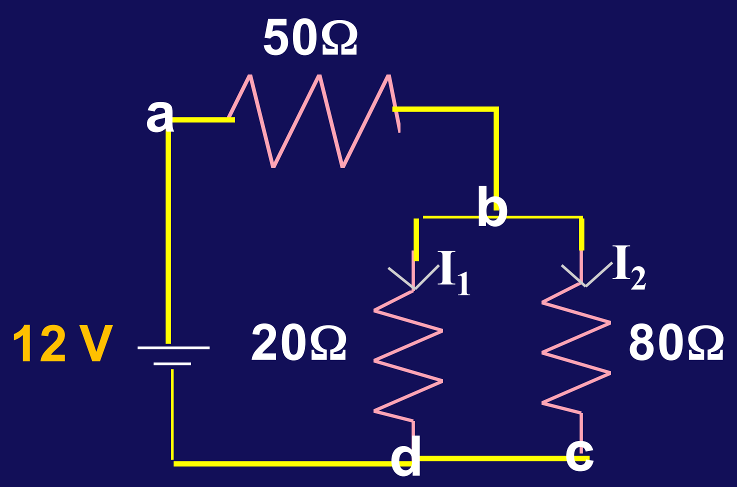
$$I_3 = \frac{\varepsilon_1 + \varepsilon_2 - 2\varepsilon_3}{3R}$$

No getting around it
3 equations/3 unknowns typically

Clicker

Consider the circuit shown:

- What is the relation between $V_a - V_d$ and $V_a - V_c$?



(a) $(V_a - V_d) < (V_a - V_c)$

(b) $(V_a - V_d) = (V_a - V_c)$

(c) $(V_a - V_d) > (V_a - V_c)$

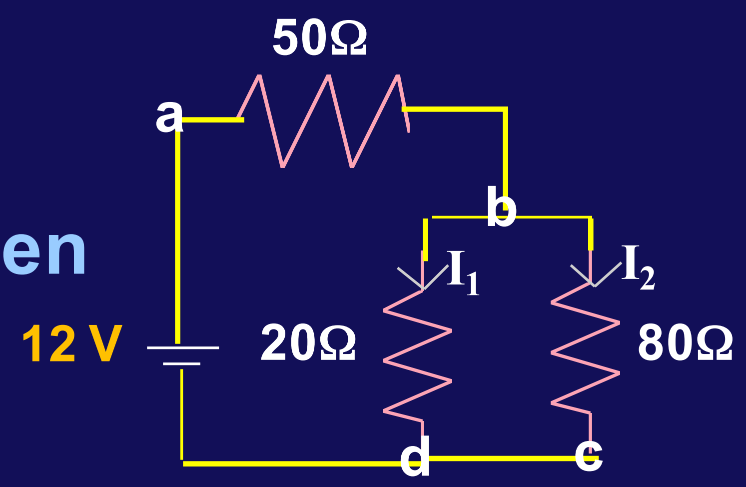
- Remember: potential is independent of path

Going from a to d or c is like going to the same place, electrically

→ $(V_a - V_d) = (V_a - V_c)$

Clicker

- Consider the circuit shown:
  - What is the relation between I_1 and I_2?



(a) $I_1 < I_2$ (b) $I_1 = I_2$ (c) $I_1 > I_2$

- Note that: $V_b - V_d = V_b - V_c$
  - Therefore,

$$I_1(20\Omega) = I_2(80\Omega) \Rightarrow I_1 = 4I_2$$