Your Comments

in the prelecture, the question about the current flowing from a to b didn't make sense. if you connect a wire from a to b as shown in the question, why does that not short out the two resistors are the bottom as current always takes the path of least resistance?

Did we earn pizza? If so, please don't offend a New Yorker with deep dish.

I would just like to point out that I only took two minutes on the prelecture tonight because ECE 110 already drilled this into me.

What was up with the scientific notation on the exam?! The way I learned it, the base/first part of the notation has to be on the interval [1,10). Is this not true in Physics or was it just to try to trick people up? If it was just to confuse people I think that that is really shady.

I'm a senior in Naval ROTC and I chose my ship today!!! To celebrate, you should show the class the ship I'm going to this summer to serve on. It's FFG 60. The USS Rodney M. Davis. Happy Valentines Day!

Professor Stelzer likes to eat while working through physics problems.. maybe I should try this method. Seemed to come easy for him while eating!

I am completely lost. How do i know if there is a voltage gain or drop? I didn't know how to do any of the checkpoints... On the plus side i think i killed the test :) :))

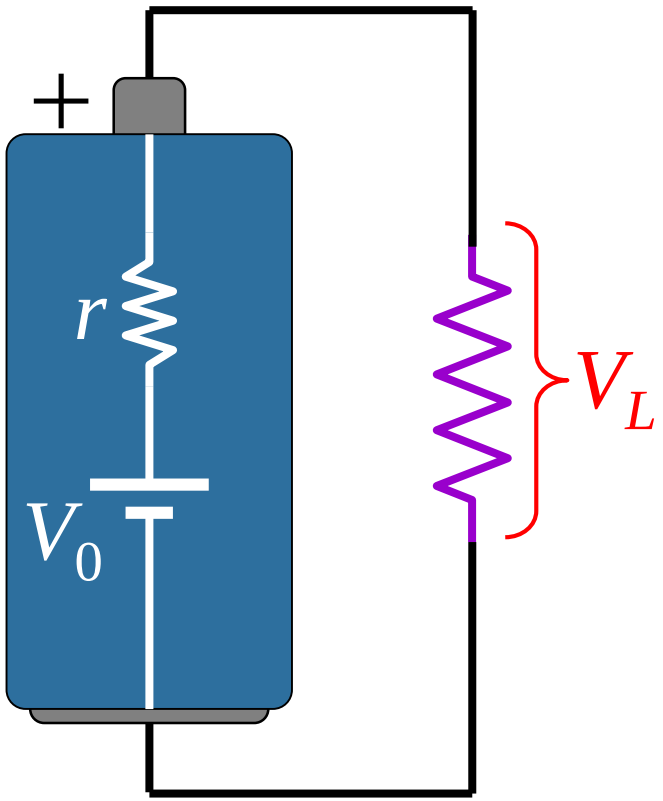
I feel like I'm standing at O'Hare airport and PHYS 212 is a Boeing 747 that literally just flew over my head. About the prelecture, the two loop example had a crazy amount of variable and I had zero idea what was going on. And for the first question and last check point, wouldn't charge want to go down the path of least resistance? I'm so confused. :'(

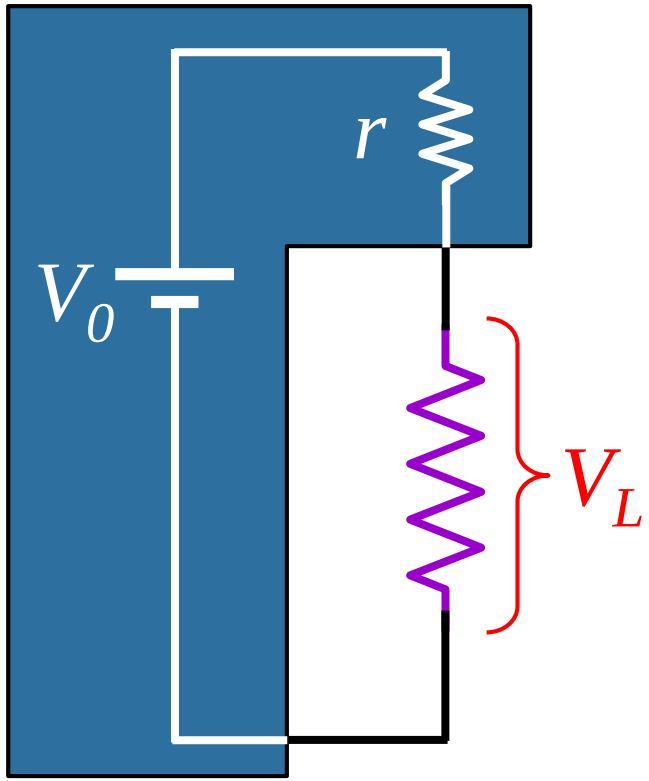
Physics 212
Lecture 10

Today's Concept:

Kirchhoff's Rules

Model for Real Battery: Internal Resistance





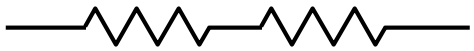
Usually can't supply too much current to the load without voltage "sagging"

Last Time

Resistors in series:

Current through is same.

Voltage drop across is IR_i

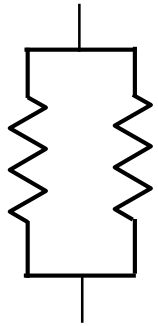


$$R_{effective} = R_1 + R_2 + R_3 + \ldots$$

Resistors in parallel:

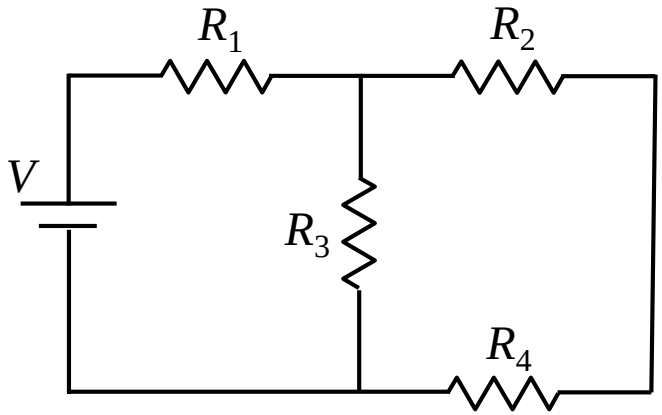
Voltage drop across is same.

Current through is V/R_i



$$\frac{1}{R_{effective}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$

Solved Circuits



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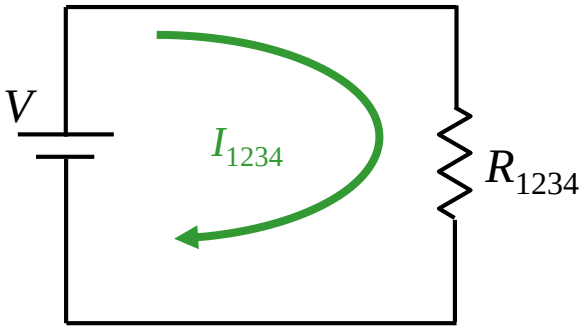
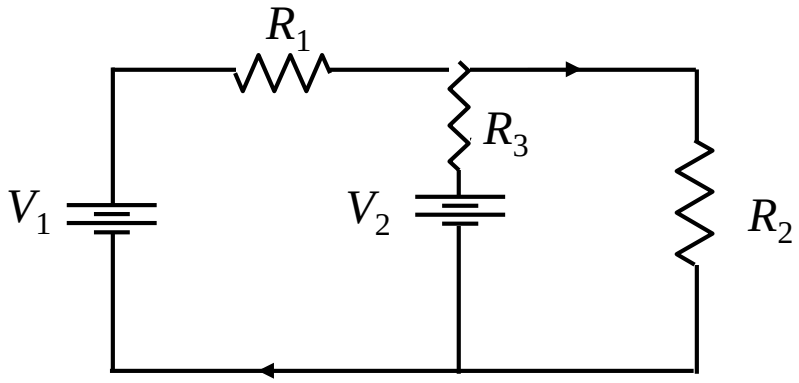
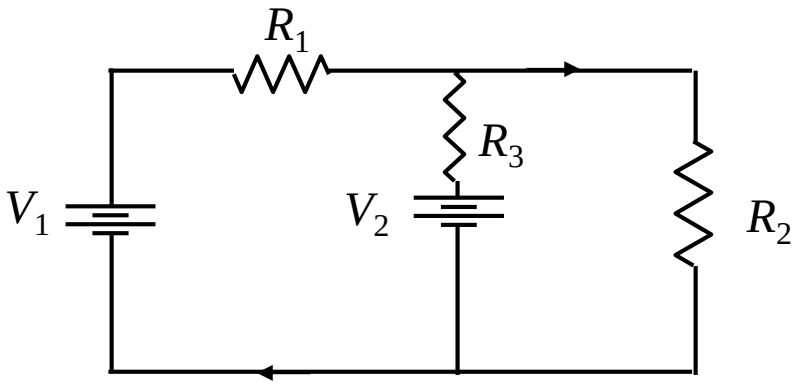


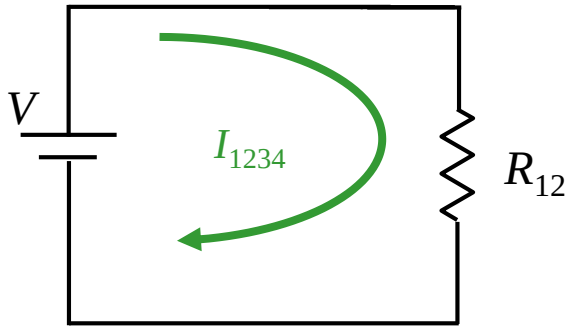
New Circuit



How Can We Solve This One?



$\neq$



THE ANSWER: Kirchhoff's Rules

Kirchhoff's Voltage Rule

$$\sum \Delta V_i = 0$$

Kirchhoff's Voltage Rule states that the sum of the voltage changes caused by any elements (like wires, batteries, and resistors) around a circuit must be zero.

WHY?

The potential difference between a point and itself is zero!

Kirchhoff's Current Rule

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

Kirchhoff's Current Rule states that the sum of all currents entering any given point in a circuit must equal the sum of all currents leaving the same point.

WHY?

Electric Charge is Conserved

Applying Kirchhoff's Laws in 5 easy steps

$-E_1 + I_1R_1 + E_3 - I_4R_4 + I_5R_5 = 0$

1) Label all currents

Choose any direction

2) Label +/– for all elements

Current goes + ⇒ – (for resistors)

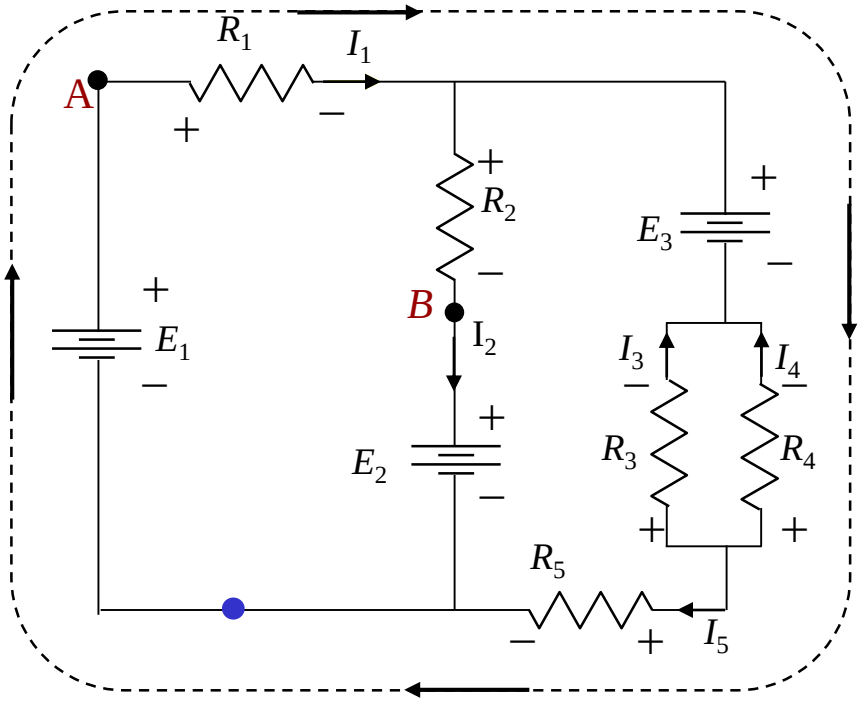
Long side is + for battery

3) Choose loop and direction

Must start on wire, not element.

4) Write down voltage drops

First sign you hit is sign to use.



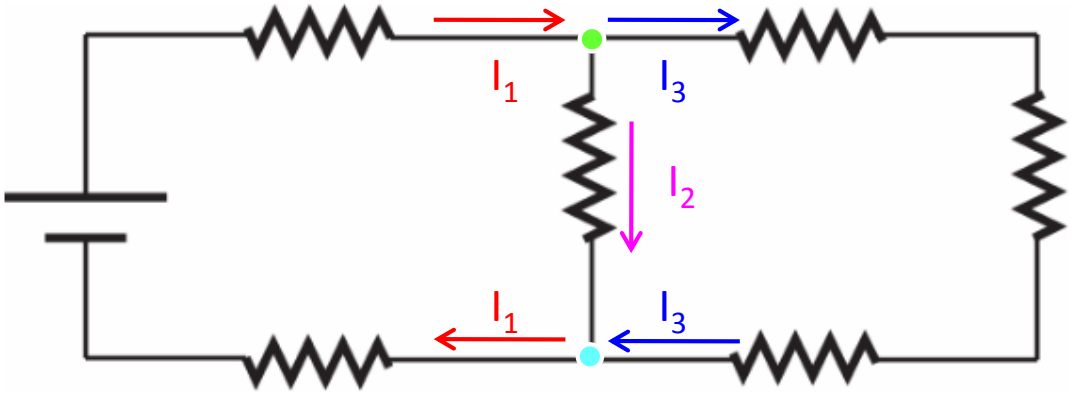
5) Write down node equation $I_{in} = I_{out}$

We'll do calculation today

It's actually the easiest thing to do!

Check Point 1

How many potentially different currents are there in the circuit shown?



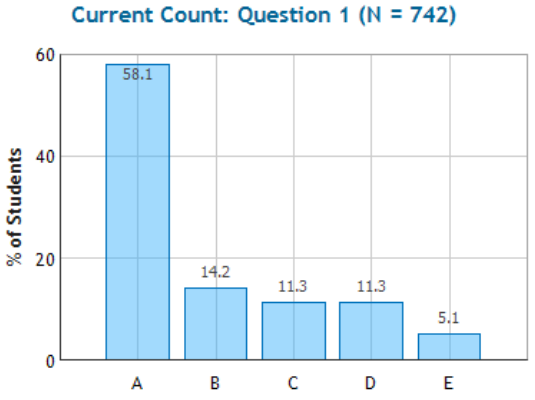
A. 3 ***B.*** 4 ***C.*** 5 ***D.*** 6 ***E.*** 7

Look at the nodes!

Top node: I_1 flows in, I_2 and I_3 flow out

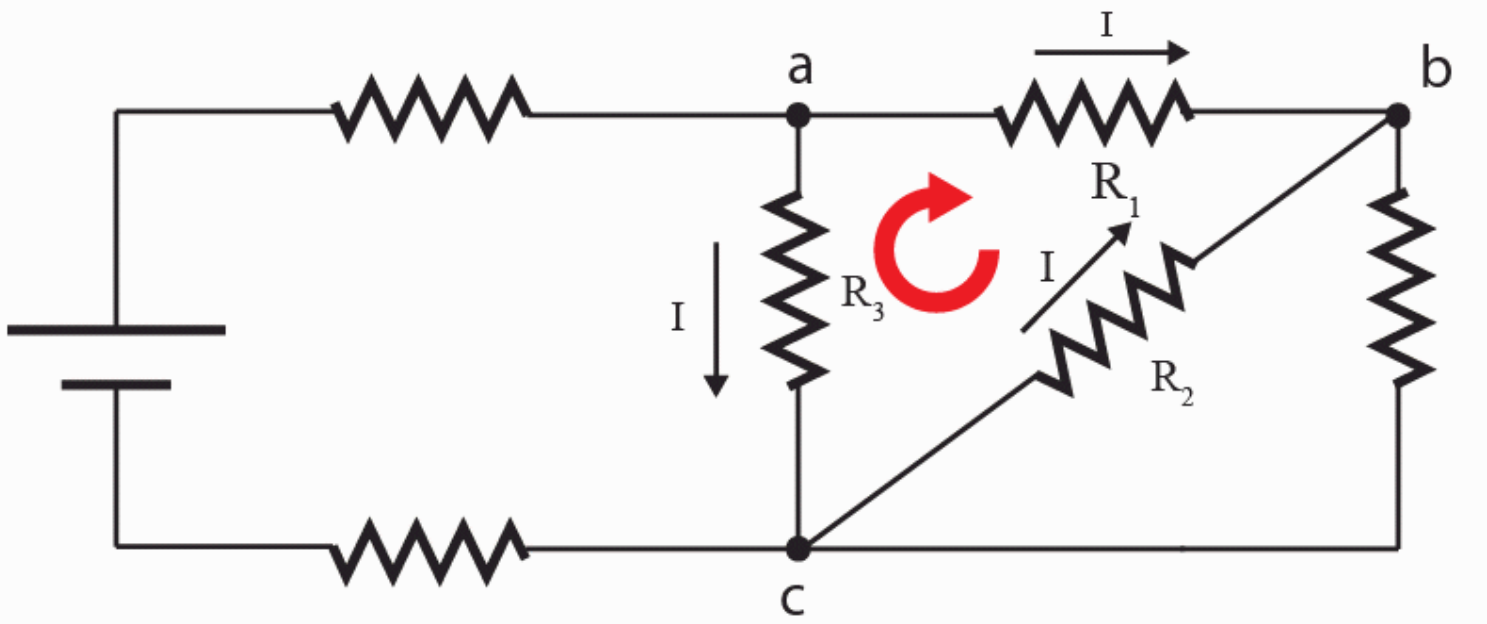
Bottom node: I_2 and I_3 flow in, I_1 flows out

That's all of them!



CheckPoint 2

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

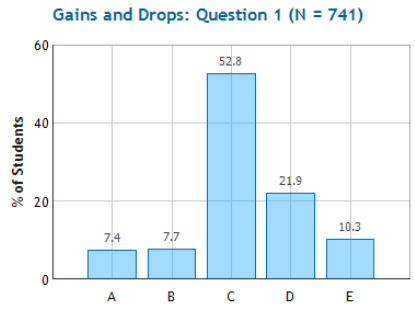


If we are to write Kirchoff's voltage equation for this loop in the clockwise direction starting from point a, what is the correct order of voltage gains/drops that we will encounter for resistors R1, R2 and R3?

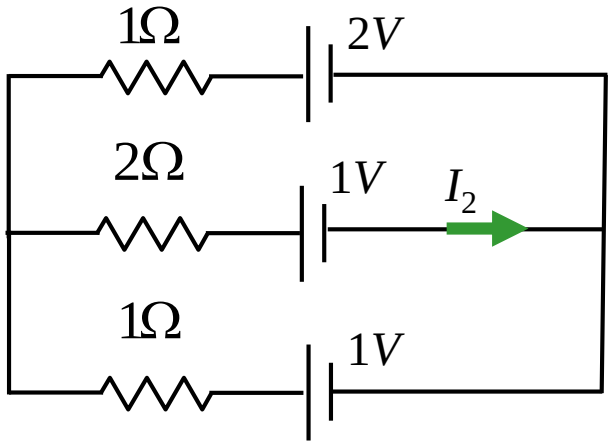
A. drop, drop, drop
B. gain, gain, gain
C. drop, gain, gain
D. gain, drop, drop
E. drop, drop, gain

With the current → VOLTAGE DROP

Against the current → VOLTAGE GAIN



Calculation



In this circuit, assume V_i and R_i are known.

What is I_2 ?

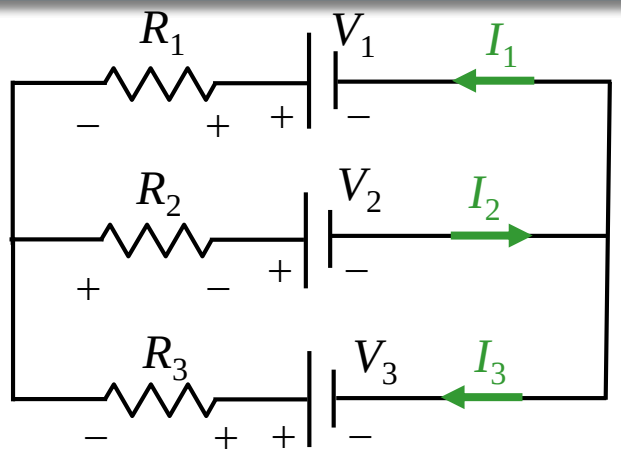
Conceptual Analysis:

- Circuit behavior described by Kirchhoff's Rules:
  - KVR: $\Sigma V_{drops} = 0$
  - KCR: $\Sigma I_{in} = \Sigma I_{out}$

Strategic Analysis

- Write down Loop Equations (KVR)
- Write down Node Equations (KCR)
- Solve

Calculation



In this circuit, assume V_i and R_i are known.

What is I_2 ?

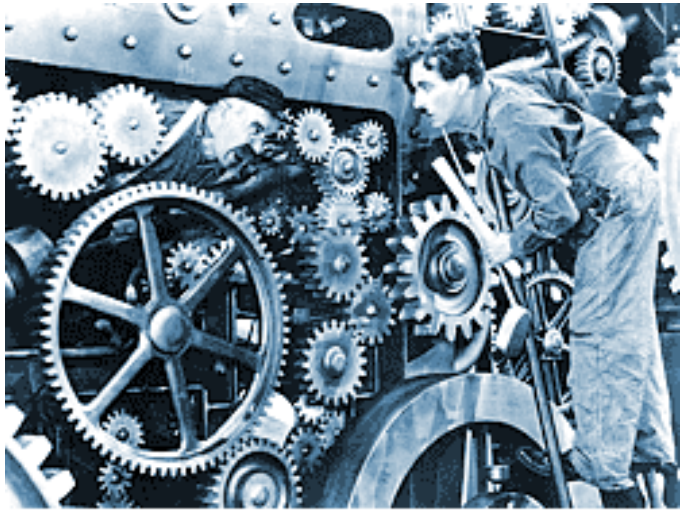
1) Label and pick directions for each current

2) Label the + and – side of each element

This is easy for batteries

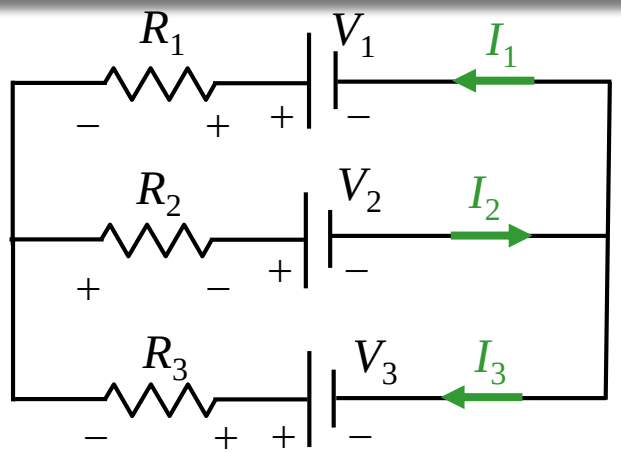
For resistors, the "upstream" side is +

Now write down loop and node equations



Just turn the crank.

Calculation



In this circuit, assume V_i and R_i are known.

What is I_2 ?

How many equations do we need to write down in order to solve for I_2?

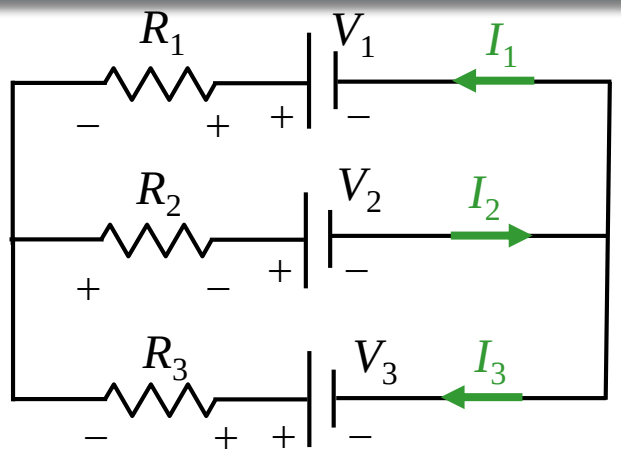
A) 1 B) 2 **C) 3** D) 4 E) 5

Why?

- We have 3 unknowns: I_1, I_2, and I_3
- We need 3 independent equations to solve for these unknowns

3) Choose Loops and Directions

Calculation



In this circuit, assume V_i and R_i are known.

What is I_2 ?

Which of the following equations is NOT correct?

A) $I_2 = I_1 + I_3$

B) $-V_1 + I_1R_1 - I_3R_3 + V_3 = 0$

C) $-V_3 + I_3R_3 + I_2R_2 + V_2 = 0$

D) $-V_2 - I_2R_2 + I_1R_1 + V_1 = 0$

4) Write down voltage drops

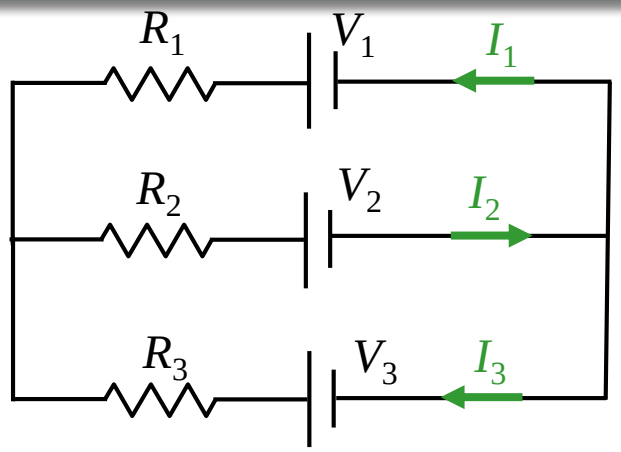
5) Write down node equation

Why?

- (D) is an attempt to write down KVR for the top loop
- Start at negative terminal of V_2 and go clockwise

  $V_{gain}\,(-V_2)$ then $V_{gain}\,(-I_2R_2)$ then $V_{gain}\,(-I_1R_1)$ then $V_{drop}\,(+V_1)$

Calculation



In this circuit, assume V_i and R_i are known.

What is I_2 ?

We need 3 equations:
Which 3 should we use?

We have the following 4 equations:

1. $I_2 = I_1 + I_3$
2. $-V_1 + I_1R_1 - I_3R_3 + V_3 = 0$
3. $-V_3 + I_3R_3 + I_2R_2 + V_2 = 0$
4. $-V_2 - I_2R_2 - I_1R_1 + V_1 = 0$

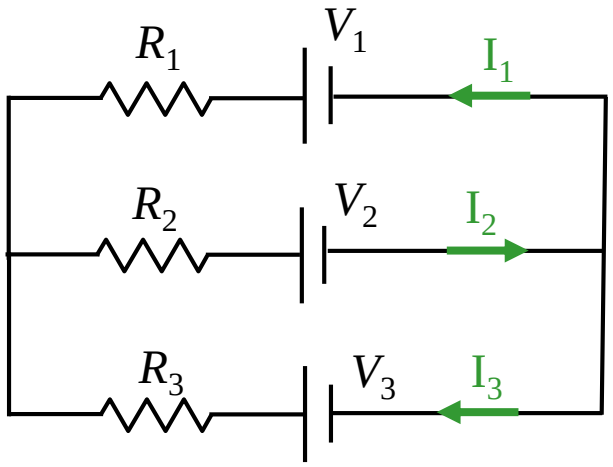
A) Any 3 will do
B) 1, 2, and 4
C) 2, 3, and 4

Why?

- We need 3 INDEPENDENT equations
- Equations 2, 3, and 4 are NOT INDEPENDENT

  Eqn 2 + Eqn 3 = – Eqn 4
- We must choose Equation 1 and any two of the remaining (2, 3, and 4)

Calculation



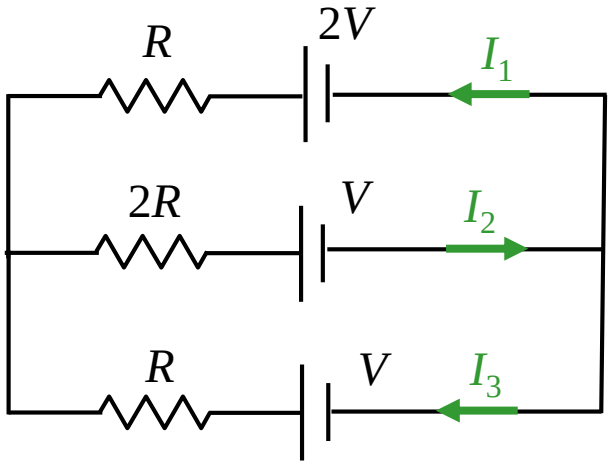
In this circuit, assume V_i and R_i are known.

What is I_2 ?

We have 3 equations and 3 unknowns.

$$I_2 = I_1 + I_3$$
$$V_1 + I_1R_1 - I_3R_3 + V_3 = 0$$
$$V_2 - I_2R_2 - I_1R_1 + V_1 = 0$$

Now just need to solve ☺



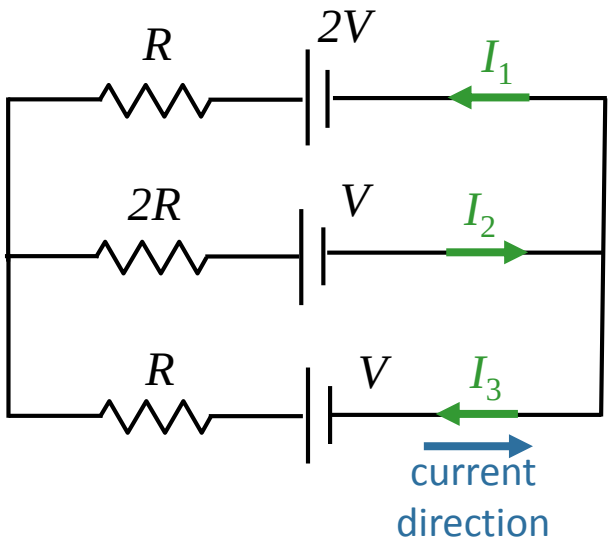
The solution will get very messy!

Simplify: assume $V_2 = V_3 = V$

$$V_1 = 2V$$
$$R_1 = R_3 = R$$
$$R_2 = 2R$$

Calculation: Simplify

In this circuit, assume V and R are known. What is I_2 ?



We have 3 equations and 3 unknowns.

$$I_2 = I_1 + I_3$$

$$-2V + I_1R - I_3R + V = 0 \quad \text{(outside)}$$

$$-V - I_2(2R) - I_1R + 2V = 0 \quad \text{(top)}$$

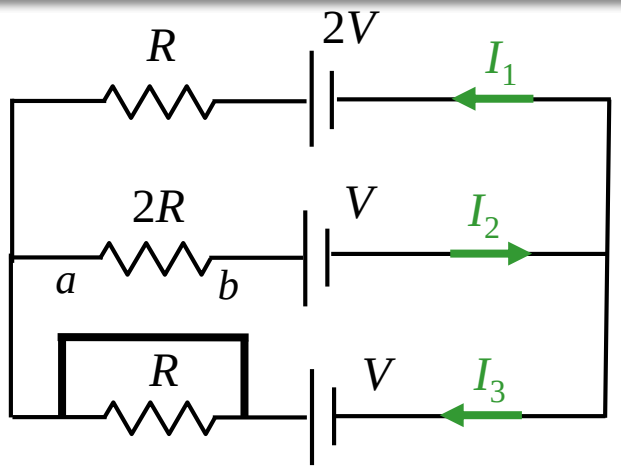
With this simplification, you can verify:

$$I_2 = (1/5)\, V/R$$

$$I_1 = (3/5)\, V/R$$

$$I_3 = (-2/5)\, V/R$$

Follow Up



We know:

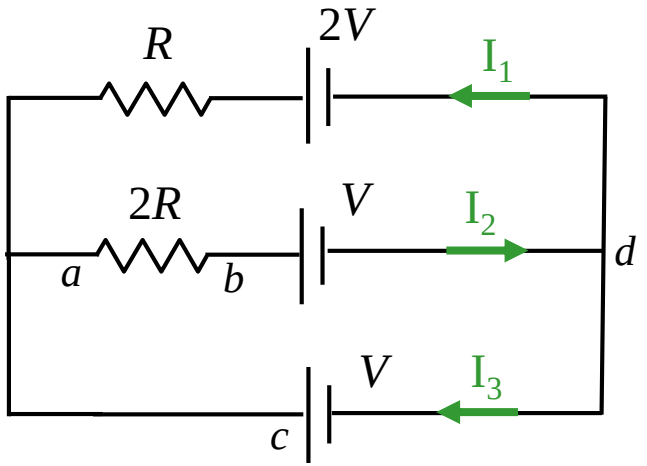
$$I_2 = (1/5)\ V/R$$
$$I_1 = (3/5)\ V/R$$
$$I_3 = (-2/5)\ V/R$$

Suppose we short R_3: What happens to V_{ab} (voltage across R_2?)

A) V_{ab} remains the same
B) V_{ab} changes sign
C) V_{ab} increases
D) V_{ab} goes to zero

Why?

Redraw:

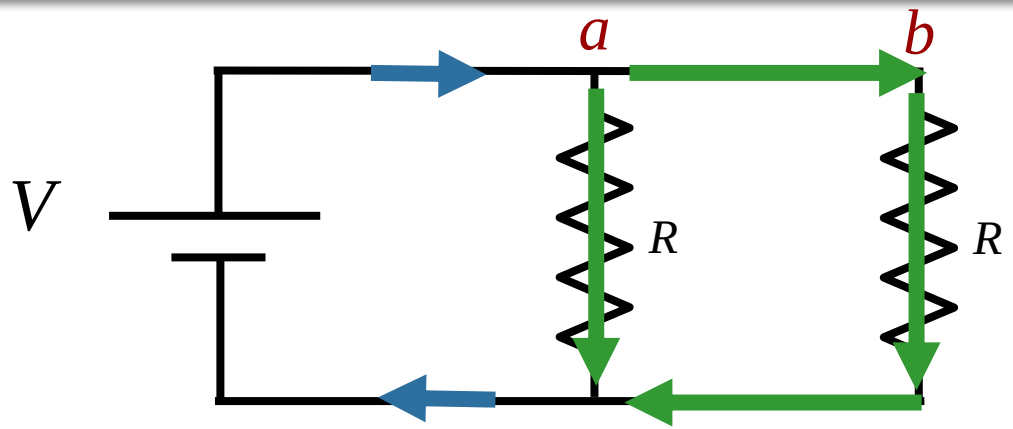


Bottom Loop Equation:

$$V_{ab} + V - V = 0$$

$$V_{ab} = 0$$

CheckPoint 3 Warm up



Is there a current flowing between a and b ?

A) Yes
B) No

a & b have the same potential

No current flows between a & b

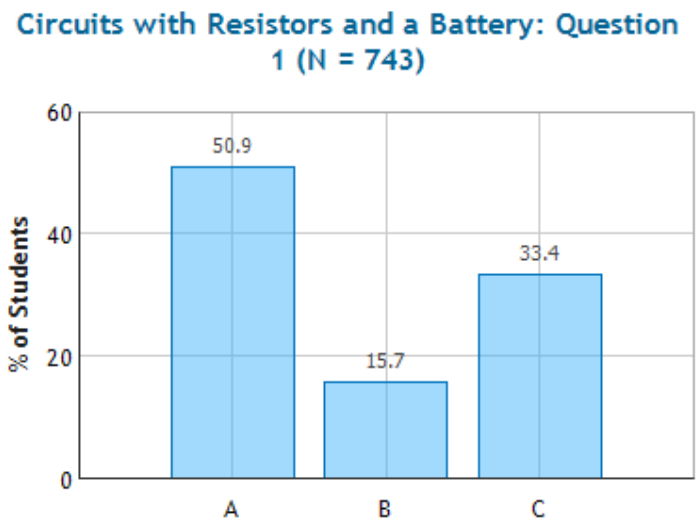
Current flows from battery and splits at a

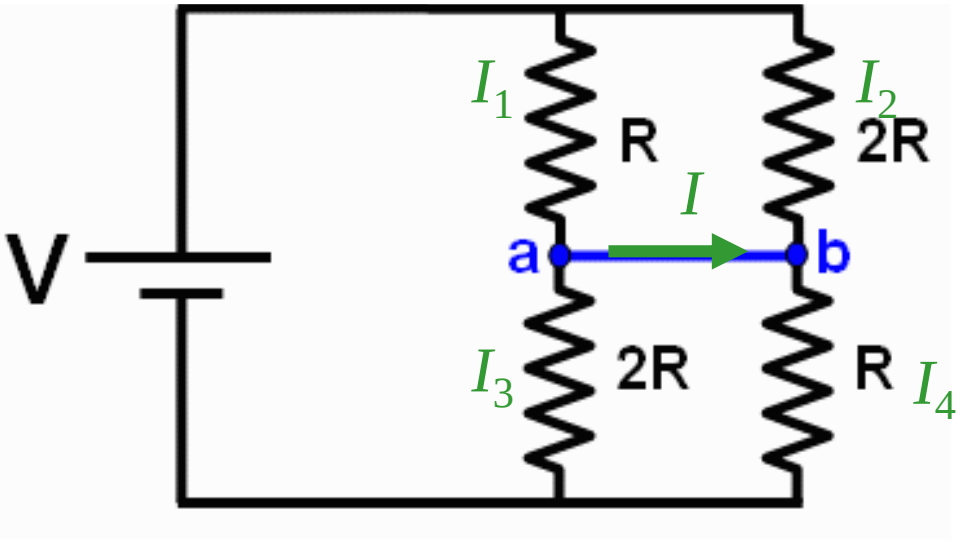
Some current flows down

Some current flows right

CheckPoint 3a

Consider the circuit shown below. Note that this question is *not* identical to the similar looking one you answered in the prelecture.





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

A. Positive current flows from *a* to *b*

B. Positive current flows from *b* to *a*

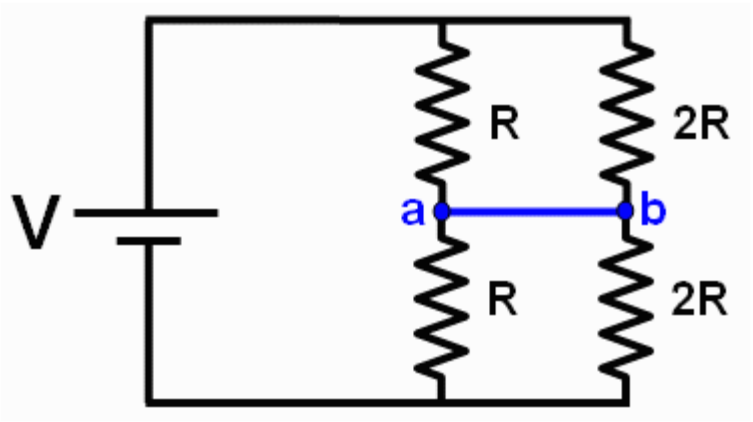
C. No current flows between *a* and *b*

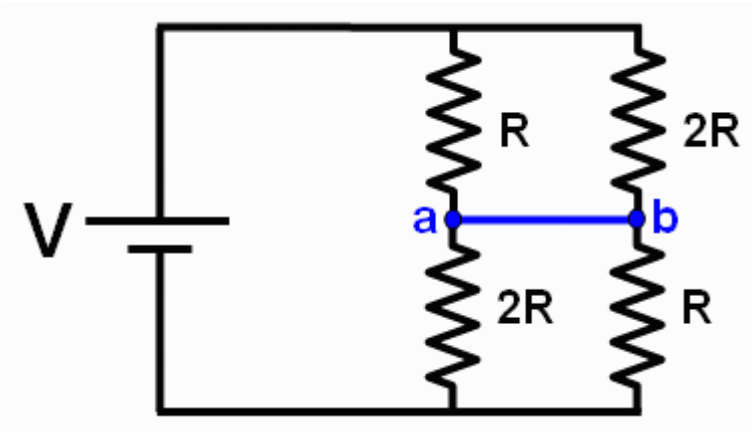
$I_1 R - I_2 (2R) = 0 \rightarrow I_2 = \frac{1}{2} I_1$

$I_4 R - I_3 (2R) = 0 \rightarrow I_4 = 2 I_3$

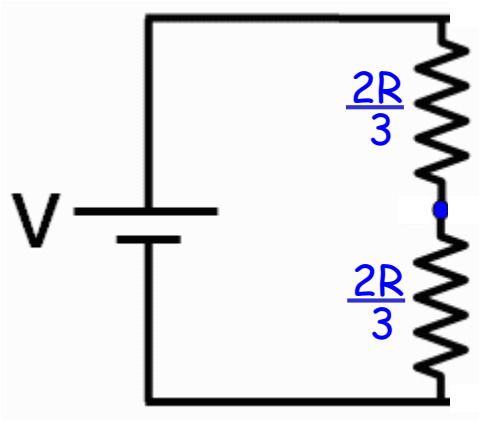
$I = I_1 - I_3$

$I + I_2 = I_4 \rightarrow I_1 - I_3 + \frac{1}{2} I_1 = 2I_3 \rightarrow I_1 = 2I_3 \rightarrow I = +I_3$

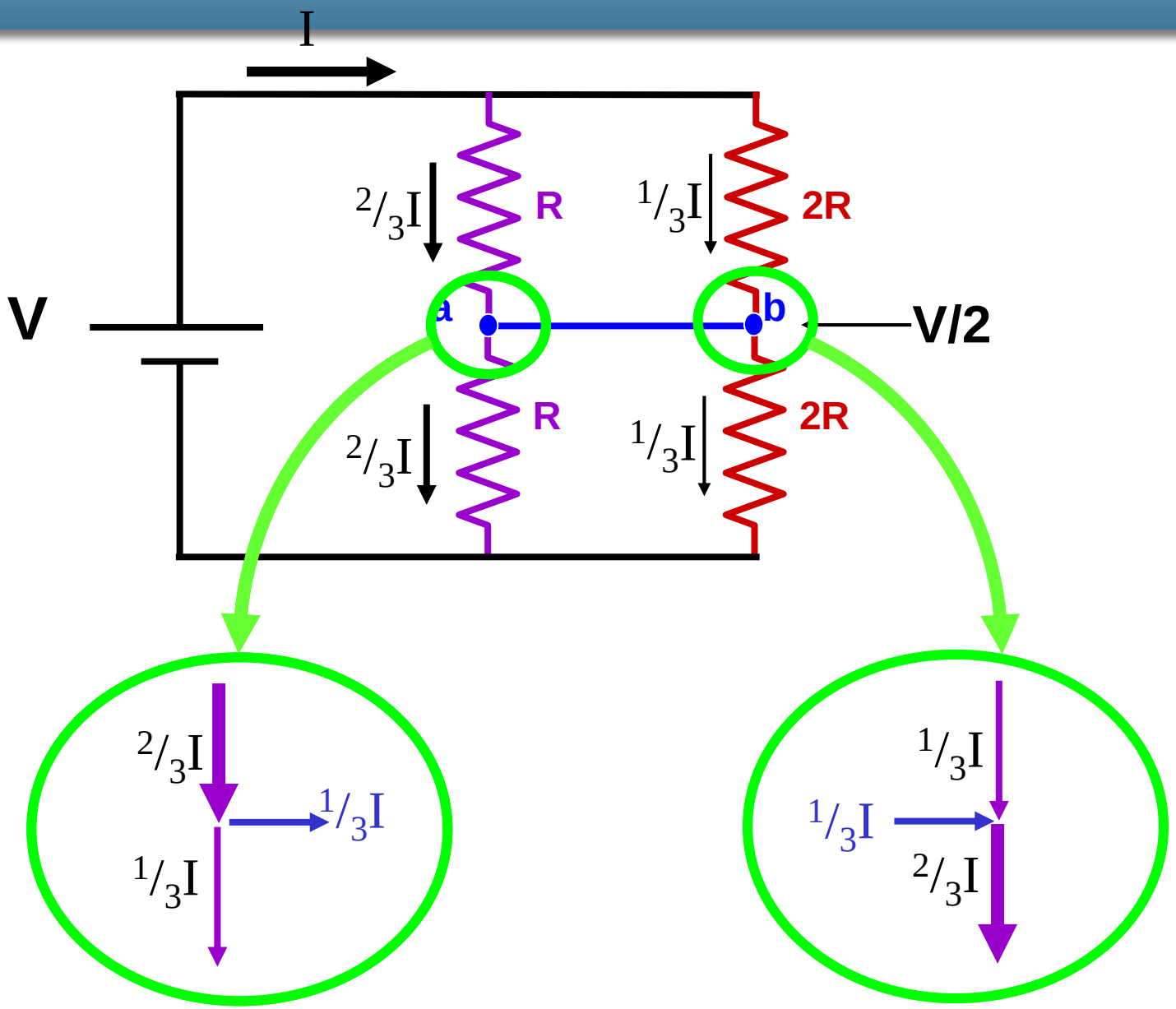




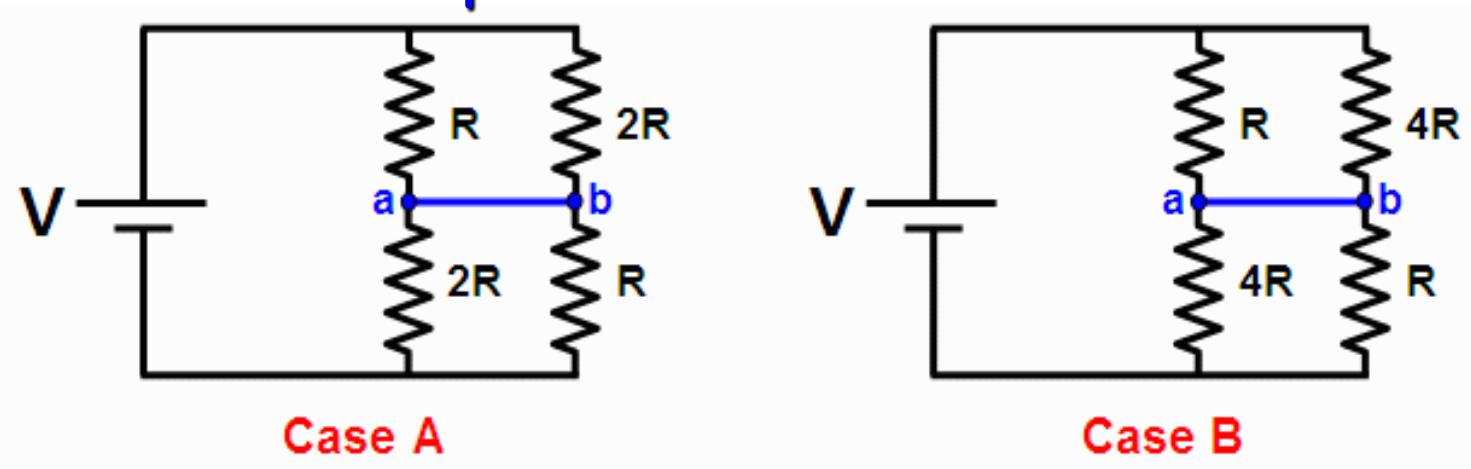
What is the same? Current flowing in and out of the battery.



What is different? Current flowing from a to b.


I
V
R
2R
R
2R
a
b
V/2
2/3I
1/3I
2/3I
1/3I
2/3I
1/3I
1/3I
1/3I
2/3I

Checkpoint 3b



which case is the current flowing in the blue wire connecting points **a** and **b** the largest?

A. Case A ***B.*** Case B ***C.*** They are both the same

Current will flow from left to right in both cases.

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

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

$$I_A = I_R - I_{2R} = I_R - 2I_{4R} \qquad I_B = I_R - I_{4R}$$