Clicker Session – Currents, DC Circuits

Wires

A wire of resistance *R* is stretched uniformly (keeping its volume constant) until it is twice its original length. What happens to the resistance?

1) it decreases by a factor 4
2) it decreases by a factor 2
3) it stays the same
4) it increases by a factor 2
5) it increases by a factor 4

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3) it stays the same
4) it increases by a factor 2
5) it increases by a factor 4

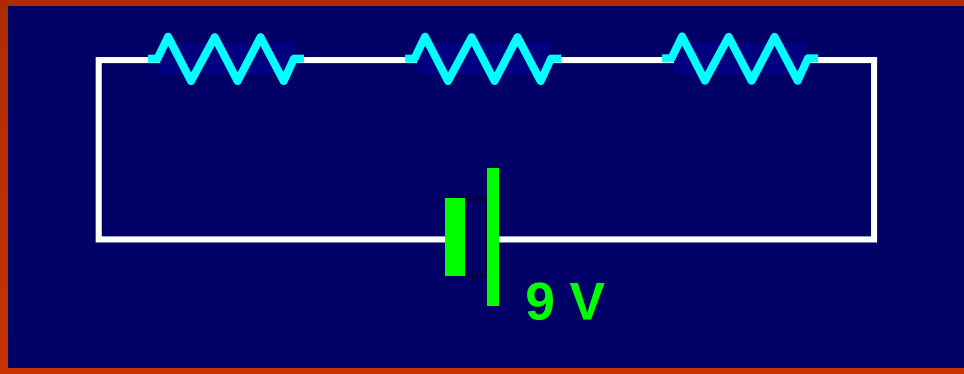
Keeping the volume (= area x length) constant means that if the length is doubled, the area is halved.

Since $R = \rho \frac{L}{A}$, this increases the resistance by four.

Series Resistors I

Assume that the voltage of the battery is 9 V and that the three resistors are identical. What is the potential difference across each resistor?

1) 12 V
2) zero
3) 3 V
4) 4 V
5) you need to know the actual value of *R*



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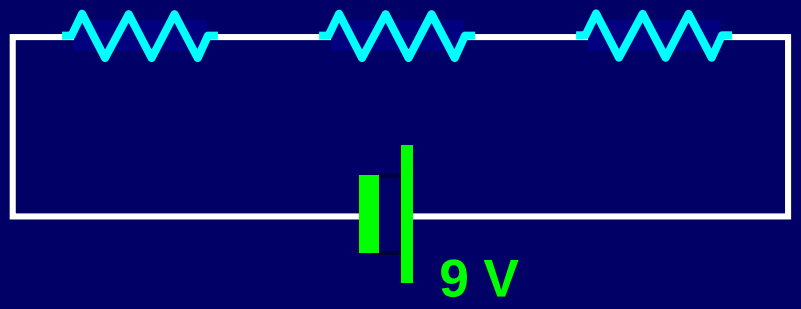
Since the resistors are all equal, the voltage will drop evenly across the 3 resistors, with 1/3 of 9 V across each one. So we get a 3 V drop across each.

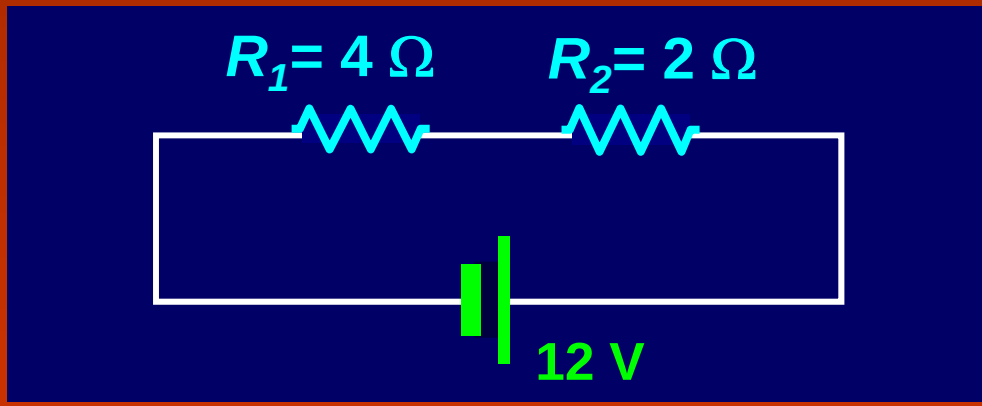


Follow-up: What would be the potential difference if *R*= 1 Ω, 2 Ω, 3 Ω

Series Resistors II

In the circuit below, what is the voltage across R_1?

1) 12 V
2) zero
3) 6 V
4) 8 V
5) 4 V



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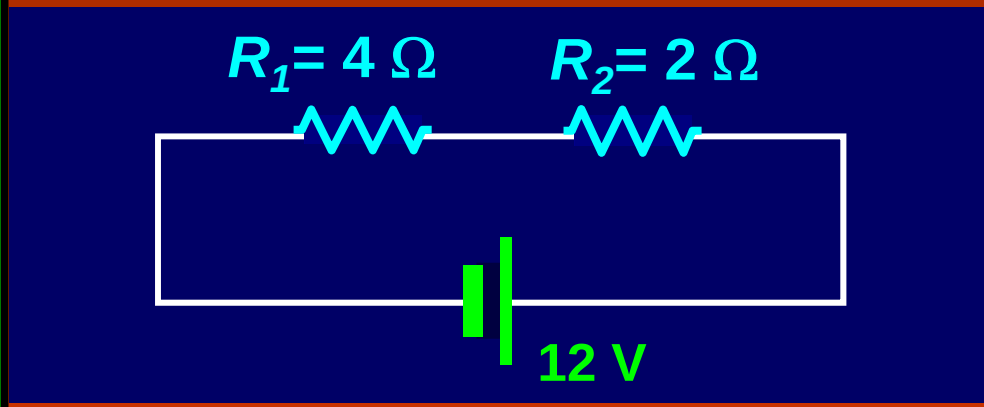
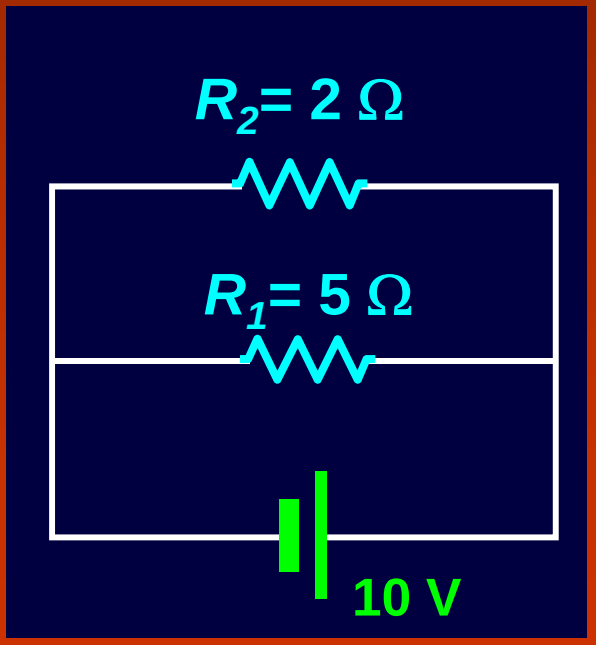


The voltage drop across R_1 has to be twice as big as the drop across R_2. This means that V_1 = 8 V and V_2 = 4 V. Or else you could find the current $I = V/R$ = (12 V)/(6 Ω) = 2 A, then use Ohm's Law to get voltages.

Parallel Resistors I

In the circuit below, what is the current through R_1?

1) 10 A
2) zero
3) 5 A
4) 2 A
5) 7 A



Parallel Resistors I

In the circuit below, what is the current through R_1?

1) 10 A
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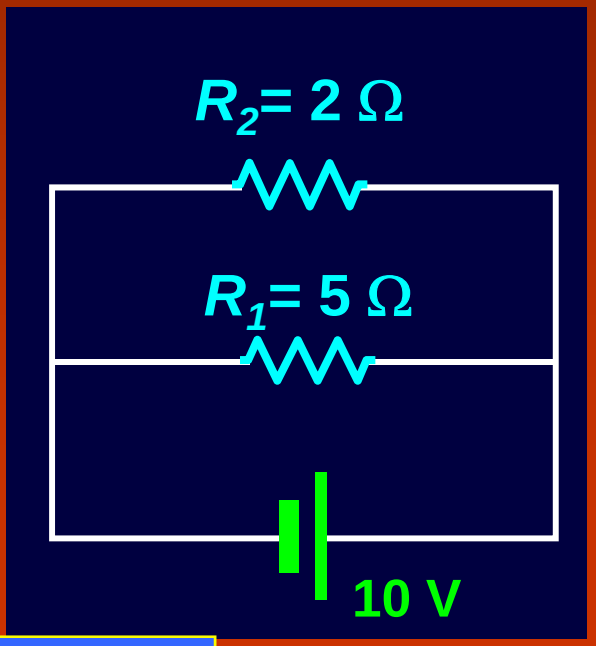
3) 5 A
4) 2 A
5) 7 A

The ***voltage*** is the ***same*** (10 V) across each resistor because they are in parallel. Thus, we can use Ohm's Law, $V_1 = I_1 R_1$ to find the current $I_1 = 2$ A.

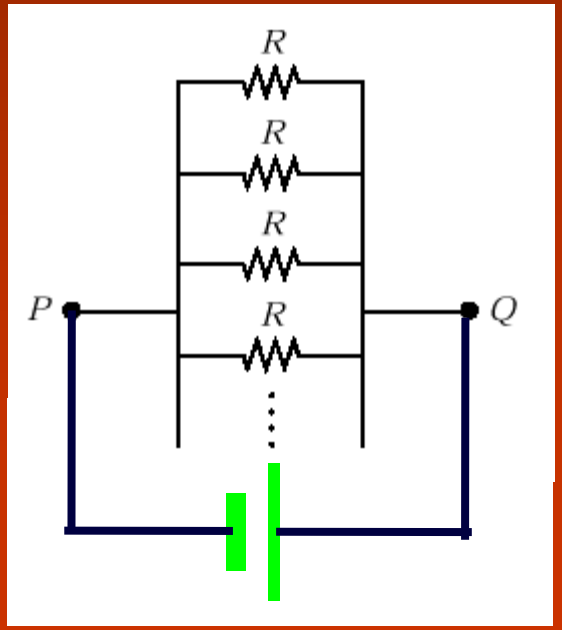


Follow-up: What is the total current through the battery?

Parallel Resistors II

Points P and Q are connected to a battery of fixed voltage. As more resistors *R* are added to the parallel circuit, what happens to the **total current** in the circuit?

1) increases
2) remains the same
3) decreases
4) drops to zero



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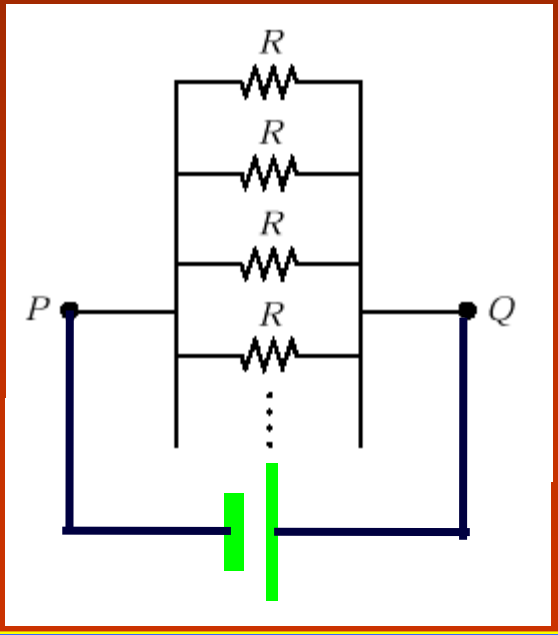
As we add parallel resistors, the overall **resistance of the circuit drops**. Since $V = IR$, and V is held constant by the battery, when **resistance decreases**, the **current must increase**.

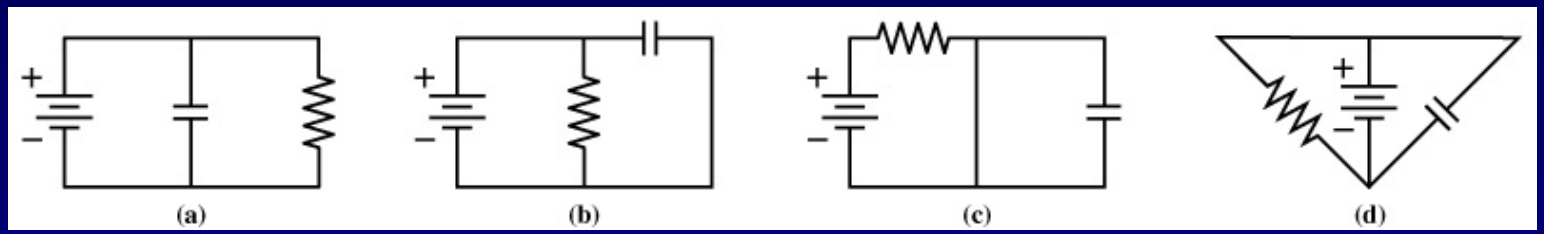


Follow-up: What happens to the current through each resistor?

Diagrams

Which of these diagrams represent the same circuit?

A. a and b
B. a and c
C. b and c
D. a, b, and c
E. a, b, and d



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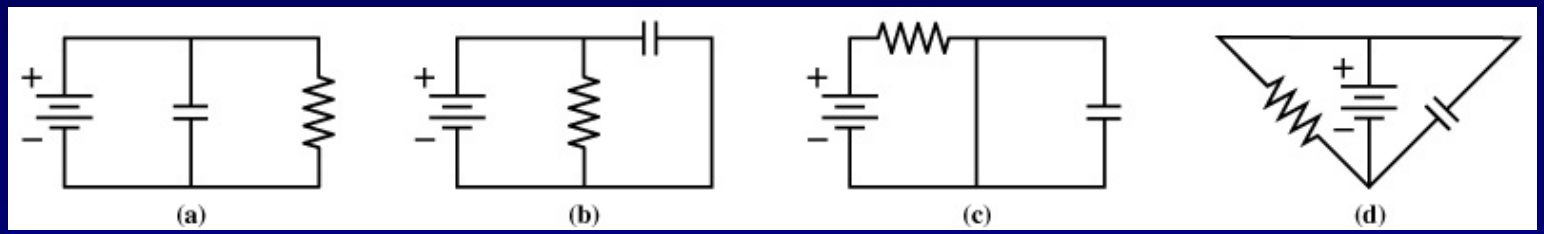
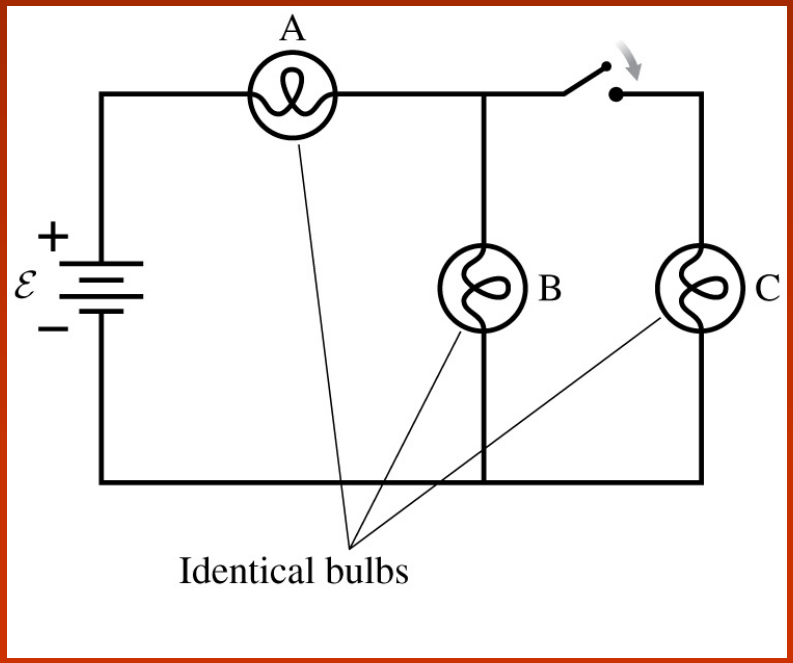


The three elements are in parallel – their ends are connected by conducting wires. The order of the elements and length of the connecting wires are immaterial.

Circuit I

Three lightbulbs, A, B and C are in the circuit shown. When the switch is closed, lightbulb A will:

1) glow brighter than before
2) glow just the same as before
3) glow dimmer than before
4) go out completely
5) explode



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2) glow just the same as before
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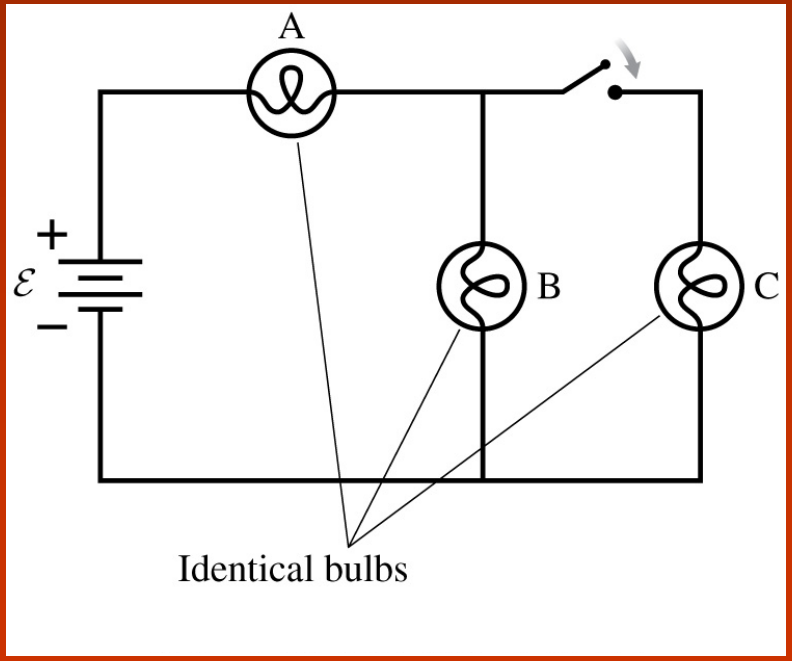
4) go out completely
5) explode

Since the total resistance through bulbs B and C is now less than the resistance through B alone, the **total resistance of the circuit decreases**. This means that the **current through bulb A increases**.

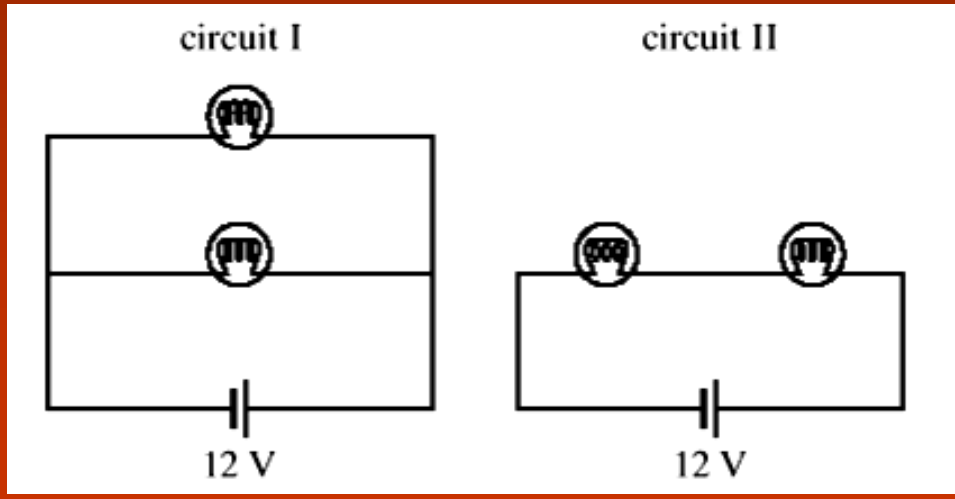


Follow-up: What happens to bulb B?

Circuits II

The lightbulbs in the circuit below are identical with the same resistance *R*. Which circuit produces more light? (brightness ⇐⇒ power)

1) circuit 1
2) circuit 2
3) both the same
4) it depends on *R*



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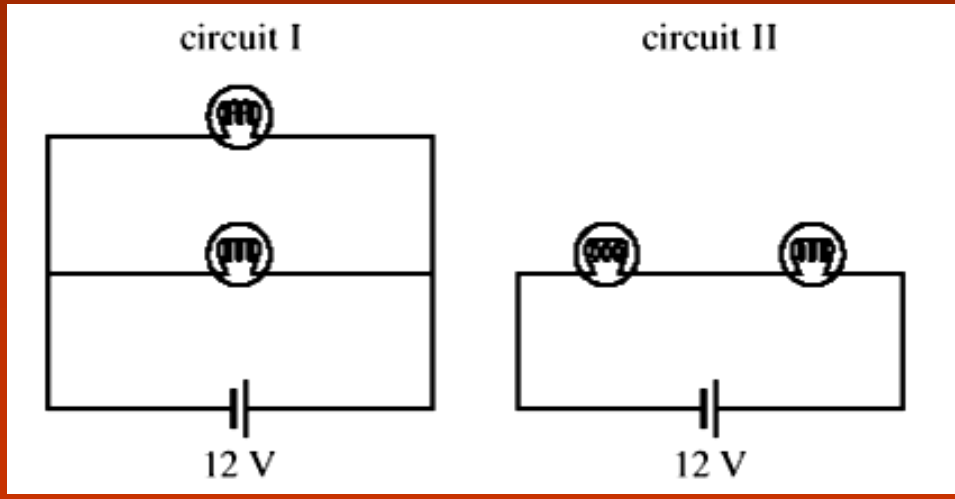
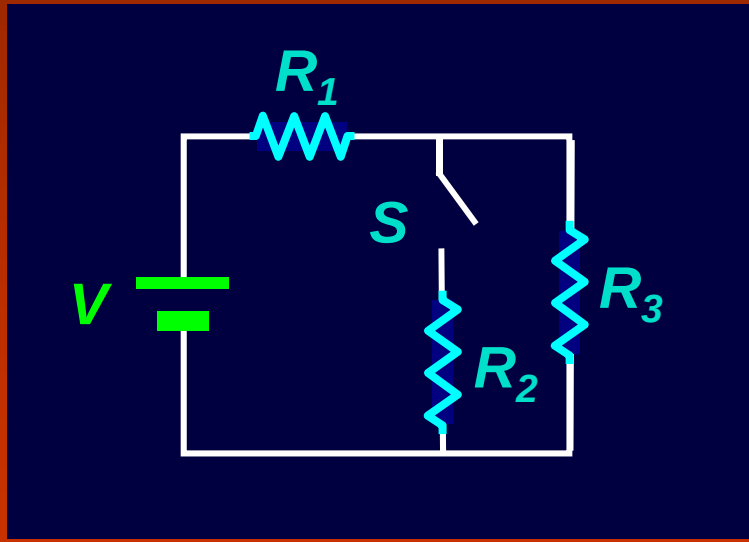
In #1, the bulbs are in parallel, lowering the total resistance of the circuit. Thus, circuit #1 will draw a higher current, which leads to more light, because $P = I V$.



More Circuits I

What happens to the voltage across the resistor R_1 when the switch is closed? The voltage will:

1) increase
2) decrease
3) stay the same



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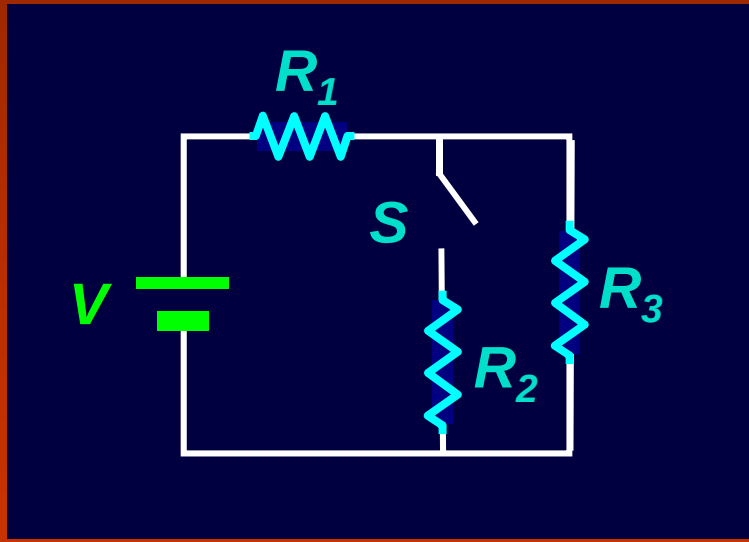
What happens to the voltage across the resistor R_1 when the switch is closed? The voltage will:

1) increase
2) decrease
3) stay the same

With the switch closed, the addition of R_2 to R_3 decreases the equivalent resistance, so the current from the battery increases. This will cause an increase in the voltage across R_1 .

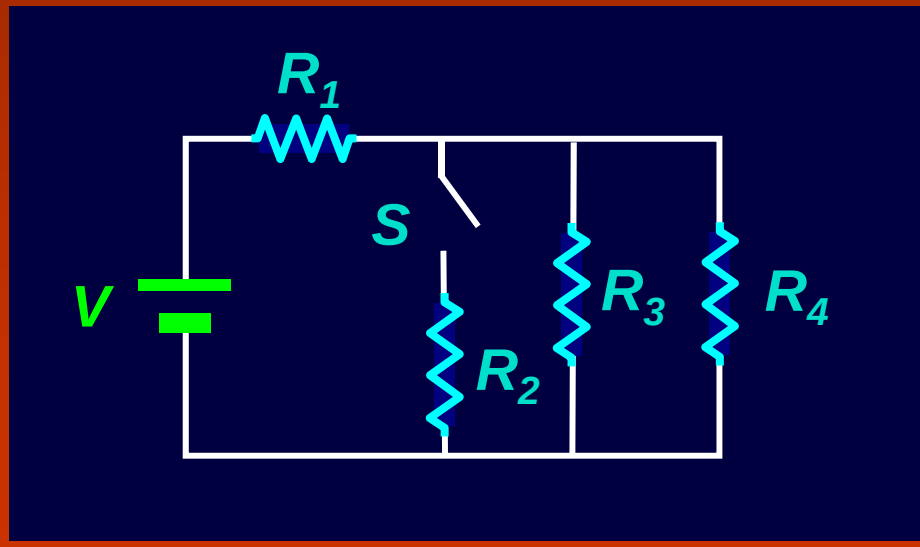


Follow-up: What happens to the current through R_3?

More Circuits II

What happens to the voltage across the resistor R_4 when the switch is closed?

1) increases
2) decreases
3) stays the same

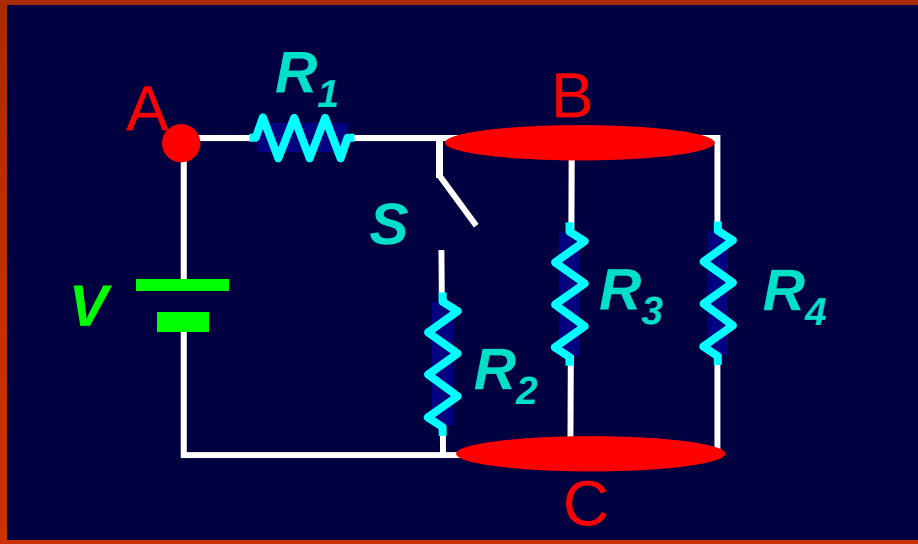


More Circuits II

What happens to the voltage across the resistor R_4 when the switch is closed?

1) increases
2) decreases
3) stays the same

We just saw that closing the switch causes an increase in the voltage across R_1 (which is V_{AB}). The voltage of the battery is constant, so if V_{AB} increases, then V_{BC} must decrease!

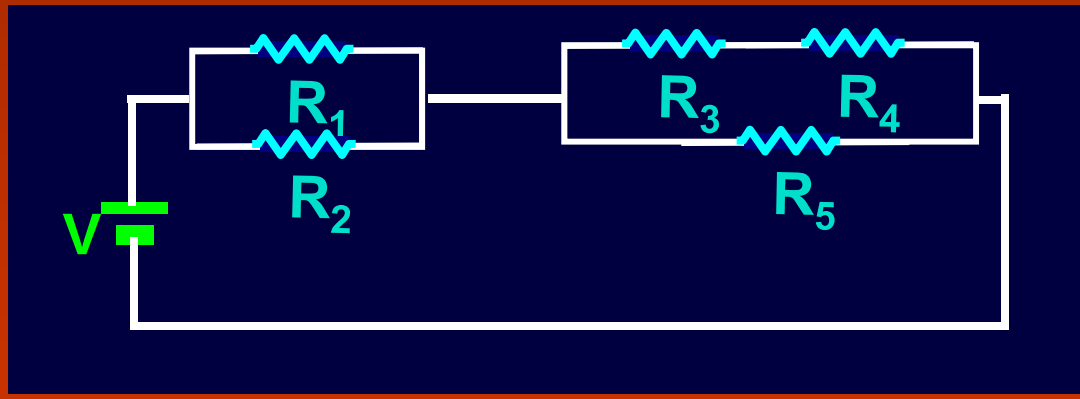


Follow-up: What happens to the current through R_4?

Even More Circuits

Which resistor has the greatest current going through it? Assume that all the resistors are equal.

1) R_1
2) both R_1 and R_2 equally
3) R_3 and R_4
4) R_5
5) all the same



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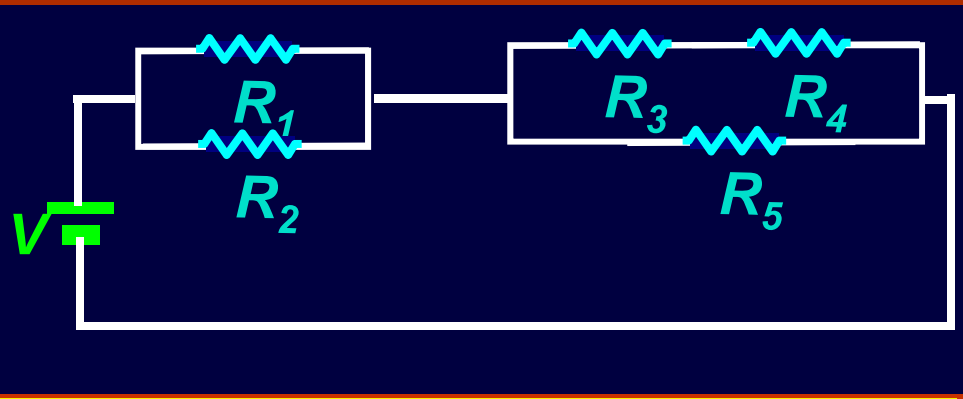
The same current must flow through left and right combinations of resistors. On the LEFT, the current splits equally, so $I_1 = I_2$. On the RIGHT, more current will go through R_5 than $R_3 + R_4$ since the branch containing R_5 has less resistance.



Follow-up: Which one has the smallest voltage drop?

Dimmer

When you rotate the knob of a light dimmer, what is being changed in the electric circuit?

1) the power
2) the current
3) the voltage
4) both (1) and (2)
5) both (2) and (3)

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The voltage is provided at 120 V from the outside. The light dimmer **increases the resistance** and therefore **decreases the current** that flows through the lightbulb.

Follow-up: Why does the voltage not change?

Space Heaters

Two space heaters in your living room are operated at 120 V. Heater 1 has twice the resistance of heater 2. Which one will give off more heat?

1) heater 1
2) heater 2
3) both equally

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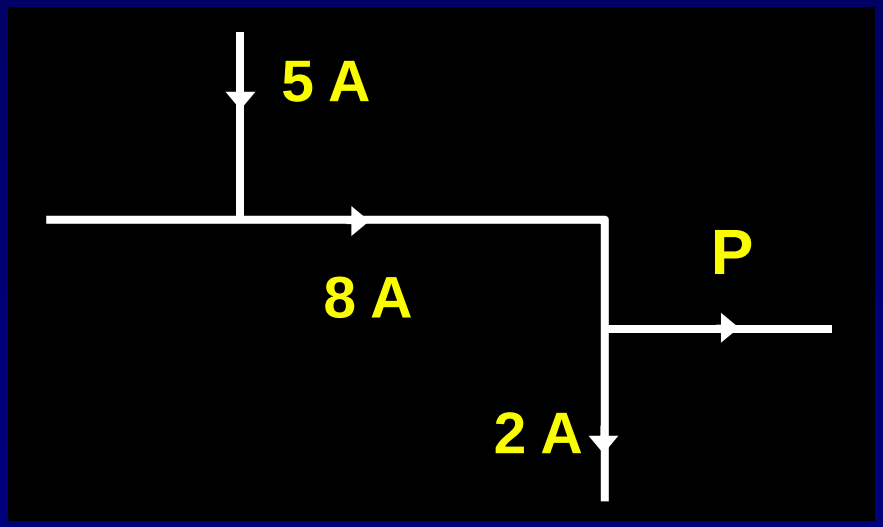
Using $P = V^2 / R$, the heater with the smaller resistance will have the larger power output. Thus, heater 2 will give off more heat.

Follow-up: Which one carries the greater current?

Junction Rule

What is the current in branch P?

1) 2 A
2) 3 A
3) 5 A
4) 6 A
5) 10 A



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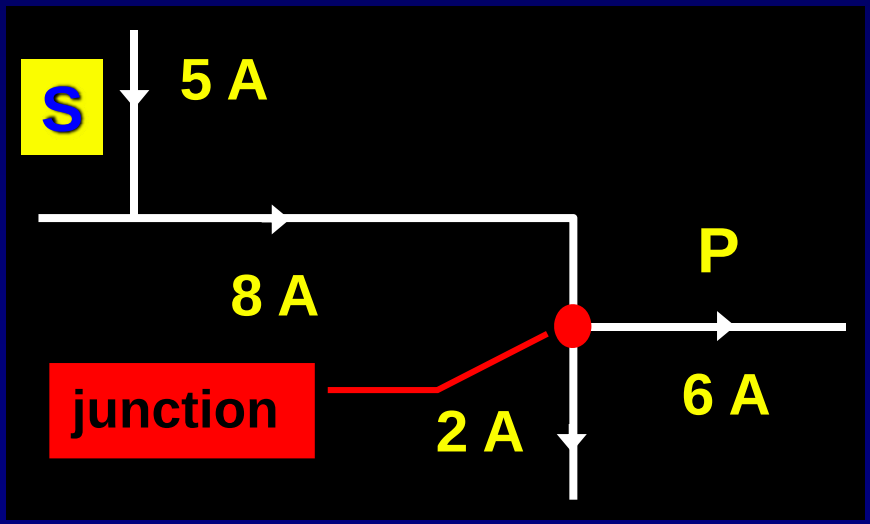
5) 10 A

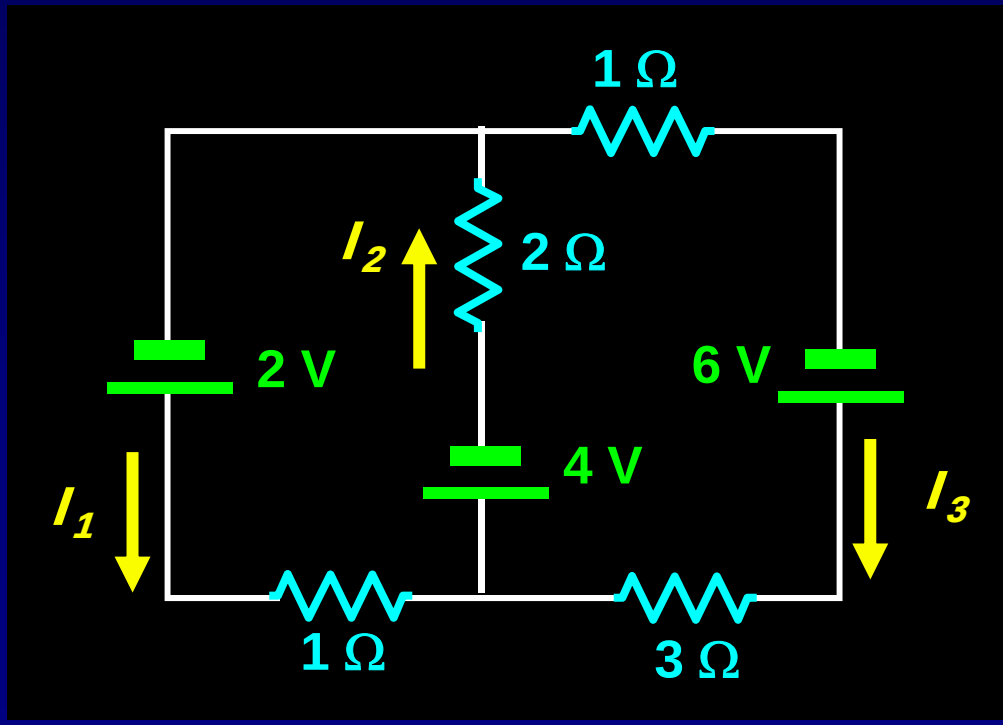
The current entering the junction in red is 8 A, so the current leaving must also be 8 A. One exiting branch has 2 A, so the other branch (at P) must have 6 A.



Kirchhoff's Rules

Which of the equations is valid for the circuit below?

1) $2 - I_1 - 2I_2 = 0$
2) $2 - 2I_1 - 2I_2 - 4I_3 = 0$
3) $2 - I_1 - 4 - 2I_2 = 0$
4) $I_3 - 4 - 2I_2 + 6 = 0$
5) $2 - I_1 - 3I_3 - 6 = 0$



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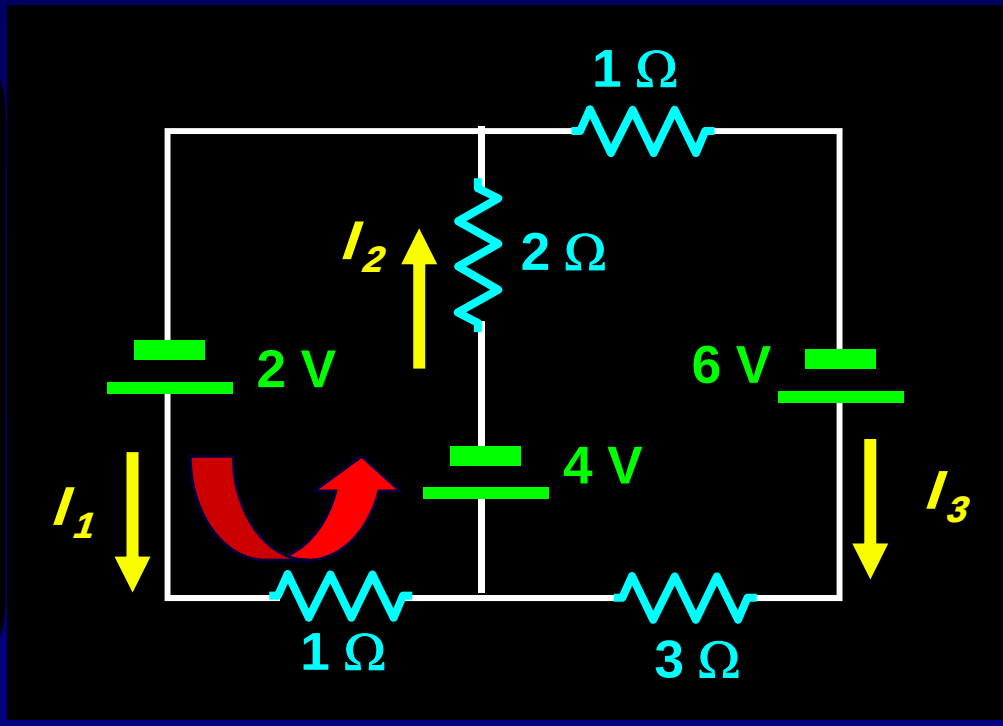
3) $2 - I_1 - 4 - 2I_2 = 0$

4) $I_3 - 4 - 2I_2 + 6 = 0$

5) $2 - I_1 - 3I_3 - 6 = 0$

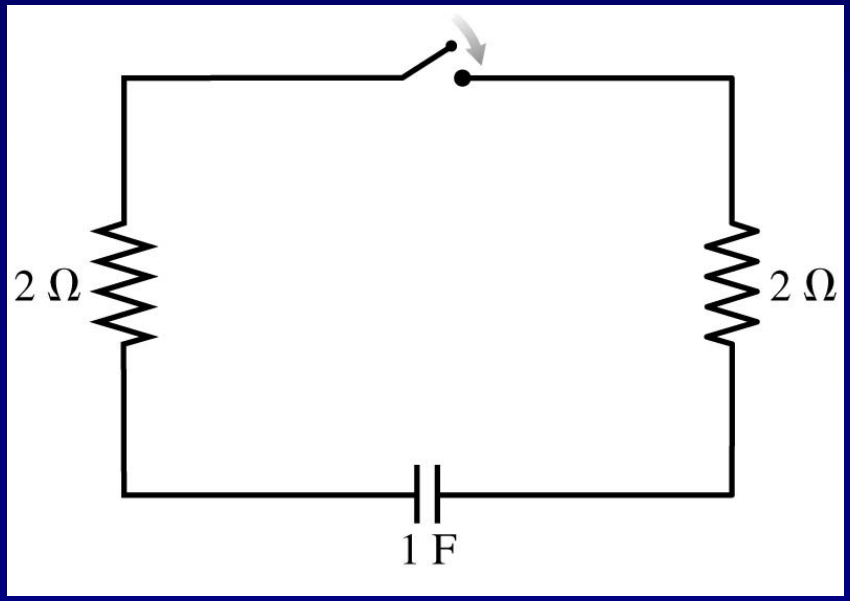
Eqn. 3 is valid for the left loop: The left battery gives +2V, then there is a drop through a 1Ω resistor with current I_1 flowing. Then we go through the middle battery (but from + to – !), which gives –4V. Finally, there is a drop through a 2Ω resistor with current I_2.



RC Circuits

The time constant for the discharge of this capacitor is

A. 1 s.
B. 2 s.
C. 4 s.
D. 5 s.
E. The capacitor doesn't discharge because the resistors cancel each other.



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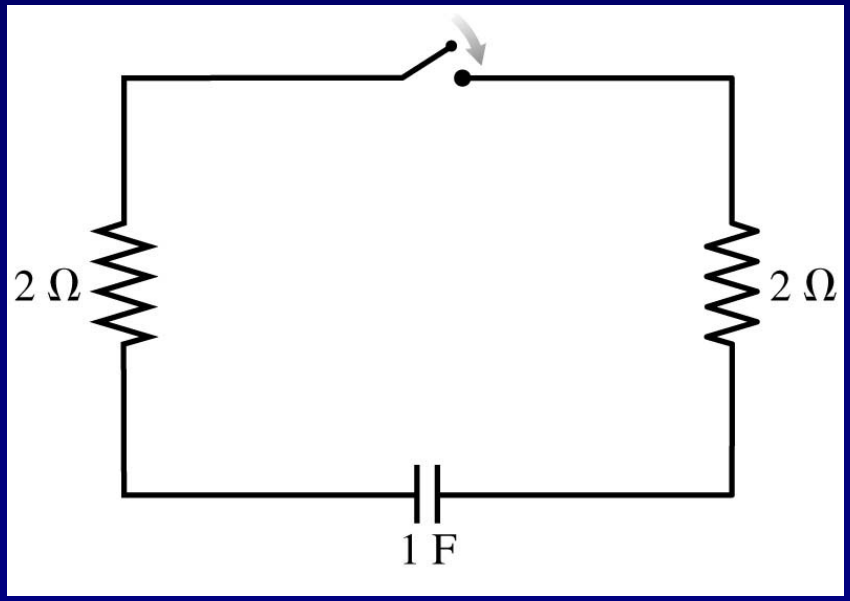
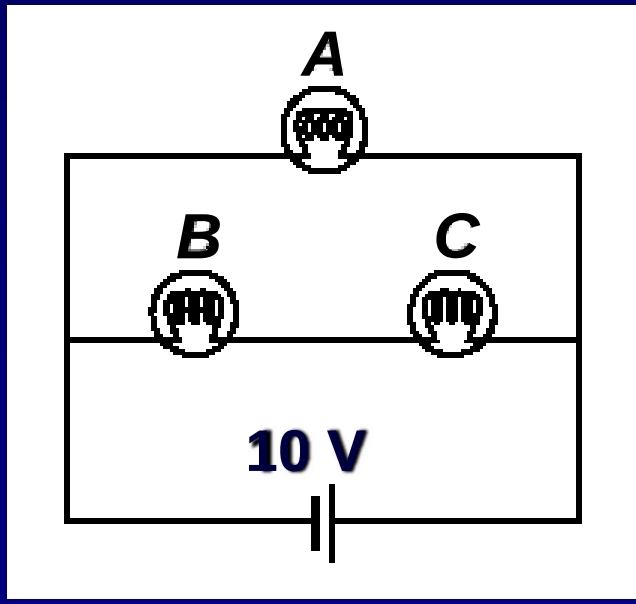


Circuits III

The three lightbulbs in the circuit all have the same resistance of 1 Ω. By how much is the brightness of bulb B greater or smaller than the brightness of bulb A? (brightness $\Leftrightarrow$ power)

1) twice as much
2) the same
3) 1/2 as much
4) 1/4 as much
5) 4 times as much



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1) twice as much
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3) 1/2 as much
4) 1/4 as much
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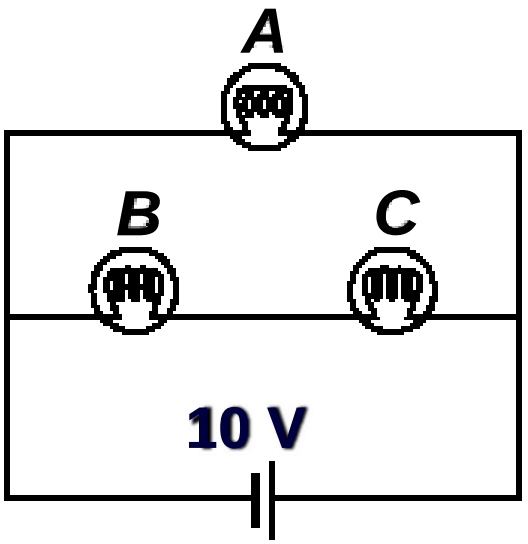
We can use $P = V^2/R$ to compare the power:

$P_A = (V_A)^2/R_A = (10\ V)^2/1\ \Omega = 100\ W$

$P_B = (V_B)^2/R_B = (5\ V)^2/1\ \Omega = 25\ W$



Follow-up: What is the total current in the circuit?