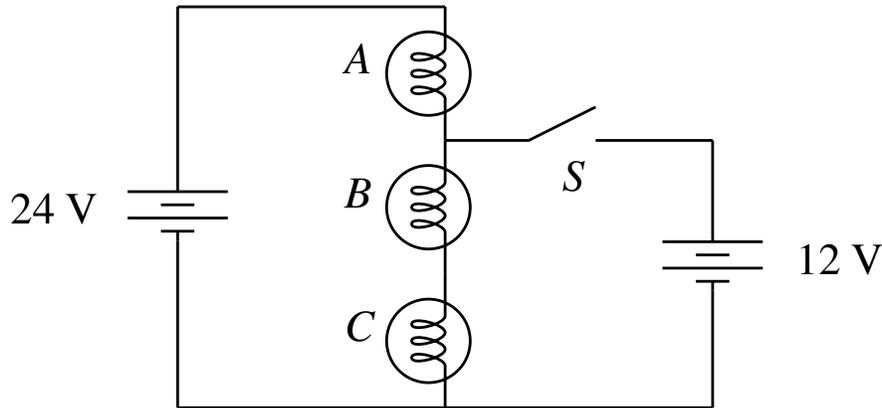


Light Bulb II

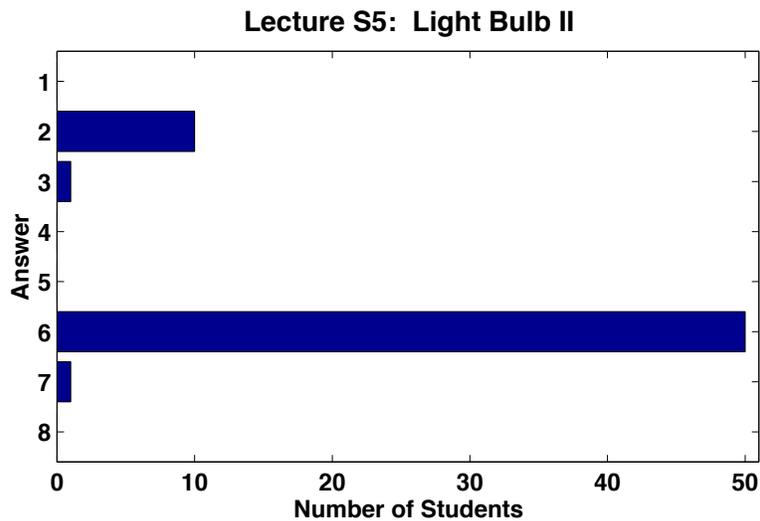
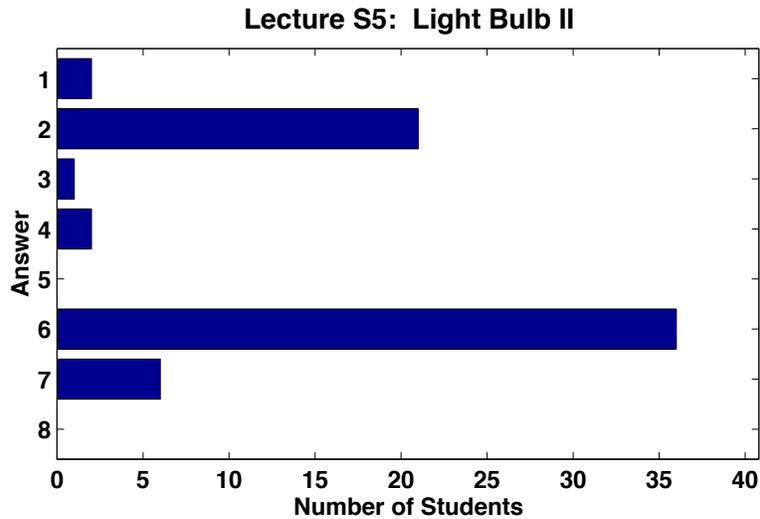
Concept Test



The light bulbs in the circuit are identical.
When the switch is closed,

1. The intensities of light bulbs *B* and *C* increase.
2. The intensities of light bulbs *B* and *C* decrease.
3. The intensity of light bulb *A* increases.
4. The intensity of light bulb *A* decreases.
5. A combination of 1 and 4
6. A combination of 2 and 3
7. Nothing happens
8. None of the above

Light Bulb II Solution



Before the switch is closed, the current through the three bulbs must be the same. Thus, the voltage drop across each bulb is the same. Because the total voltage drop across the three bulbs is 24 V, the drop across each bulb must be 8 V. Therefore, if we designate the lower node as ground, the

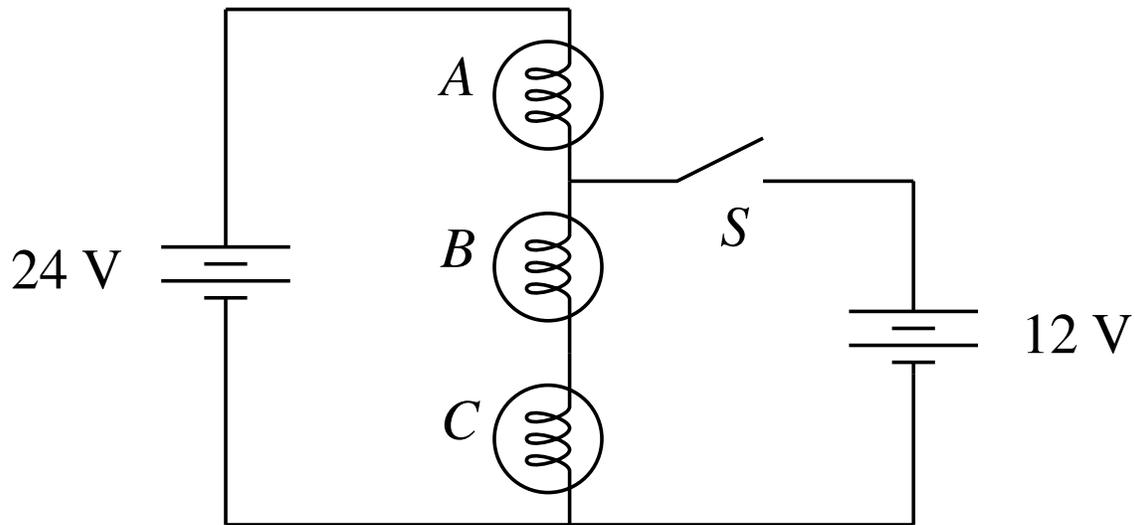
potential of the node to the left of the switch is 16 V.

After the switch is closed, the potential of the node to the left of the switch must be 12 V, since the upper terminal of the battery is 12 V above ground potential. Therefore, the voltage across bulb A increases, and therefore its intensity increases. Likewise, the total voltage across bulbs B and C decreases, and hence their intensities decrease. This is a combination of #2 and #3, so answer #6 is correct.

By the second try, most students had either answer #2 (which is partially correct) or #6 (the correct answer). The answer is a little surprising — adding a battery in parallel to the lower bulbs makes them *dimmer*, not brighter.

Light Bulb III

Concept Test

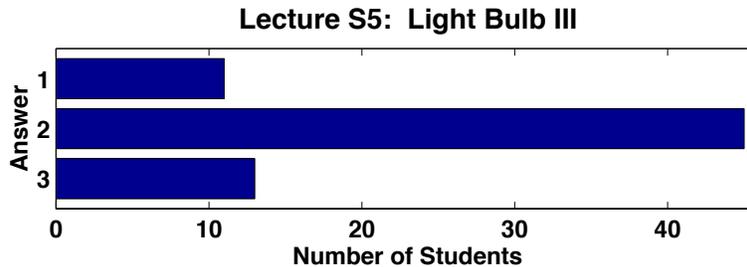


The light bulbs in the circuit are identical.
After the switch is closed, the 12 V battery

1. Supplies power to the circuit.
2. Absorbs power.
3. Neither of the above.

Light Bulb III

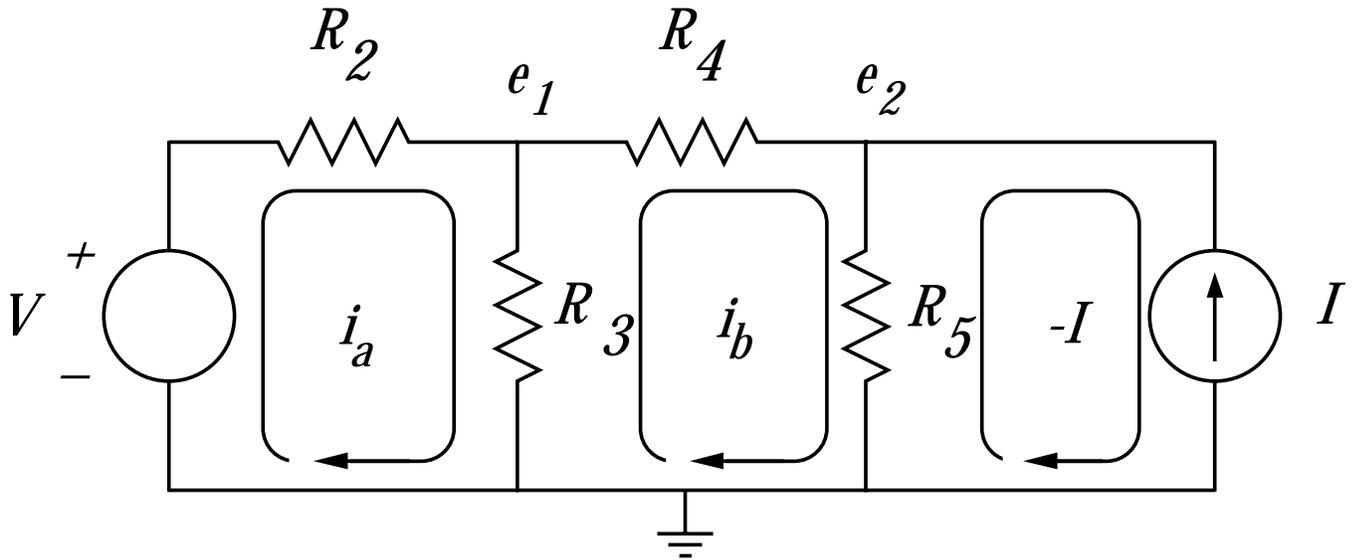
Solution



Before the switch is closed, the current through the three bulbs must be the same. Thus, the voltage drop across each bulb is the same. Because the total voltage drop across the three bulbs is 24 V, the drop across each bulb must be 8 V. Therefore, if we designate the lower node as ground, the potential of the node to the left of the switch is 16 V.

After the switch is closed, the potential of the node to the left of the switch must be 12 V, since the upper terminal of the battery is 12 V above ground potential. Therefore, the voltage across bulb A increases, and therefore its current through it increases. Likewise, the total voltage across bulbs B and C decreases, and hence the current through them decreases. So the current through bulb A is greater than the current through bulb B. To satisfy KCL at the node to the left of the switch, there must be current to the right through the switch, and down through the 12 V battery. With current flowing into the positive terminal, the current through the battery is *positive* (if we are using the passive sign convention), and therefore the power $iv > 0$, and hence the battery *absorbs* power. The correct answer is #2. In effect, this circuit is a sort of battery charger, using the 24 V battery to charge the 12 V battery.

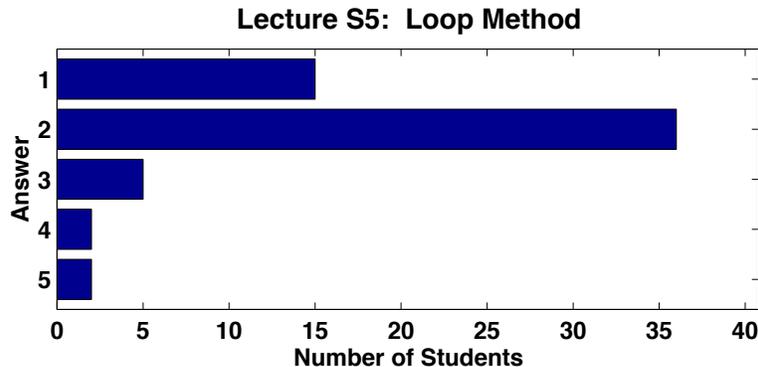
Loop Method Concept Test



For the network above, find the equation that expresses Kirchhoff's Voltage Law for the loop i_b . My answer was

1. $-R_3 i_a + (R_3 + R_4 + R_5) i_b = R_5 I$
2. $-R_3 i_a + (R_3 + R_4 + R_5) i_b = -R_5 I$
3. $-R_3 i_a + (R_3 + R_4) i_b = R_5 I$
4. Not among the answers above
5. I was unable to get an answer

Loop Method Solution



The correct answer is Number 2. The voltage drop across R_4 (in the i_b direction) is $R_4 i_b$. The voltage drop across R_5 (in the i_b direction) is $R_5 (i_b - (-I)) = R_5 (i_b + I)$. The voltage drop across R_3 (in the i_b direction) is $R_3 (i_b - i_a)$. The total voltage drop around the loop is zero, so

$$-R_3 i_a + (R_3 + R_4) i_b + R_5 I = 0$$

Therefore,

$$-R_3 i_a + (R_3 + R_4) i_b = -R_5 I$$

Many students answered #1. It is a little tricky. To correctly get the minus sign on the right hand side, you must recognize that there are *three* minus signs floating around — one because the current in the right hand loop is $-I$ to match the direction of the current source, one because the loop as drawn flows in the opposite direction as i_b through R_5 , and one because the source term has been moved to the right hand side of the equation.