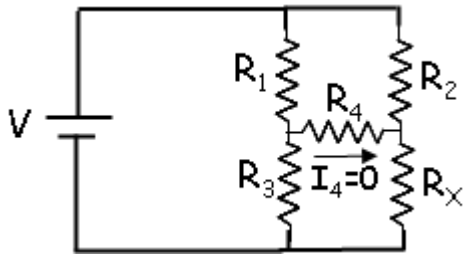
A circuit is constructed with five resistors and a battery as shown. The battery voltage is V = 12 V. The values for the resistors are: R_1 = 54 Ω, R_2 = 132 Ω, R_3 = 175 Ω, and R_4 = 70 Ω. The value for R_X is unknown, but it is known that I_4, the current that flows through resistor R_4, is zero.



1) What is I_1, the magnitude of the current that flows through the resistor R_1?

$$I_1 = \frac{V}{R_1 + R_3}$$

I=12V(54 Ω+175Ω)=.052 A

2) What is V_2, the magnitude of the voltage across the resistor R_2?

$$V_2 = V_1 = I_1 R_1 = V \frac{R_1}{R_1 + R_3}$$

V2=12V(54Ω/(54Ω+175Ω))=2.83 V

3) What is I_2, the magnitude of the current that flows through the resistor R_2?

$$I_2 = \frac{V_2}{R_2}$$

I2=2.83V/132Ω=.0214 A

4) What is R_X, the value of the unknown resistor R_X?

$$R_X = \frac{V_3}{I_2} = \frac{I_1 R_3}{I_1 R_1 / R_2} = R_2 \frac{R_3}{R_1}$$

Rx=132Ω(175Ω)/54Ω=427.77 Ω

5) What is V_1, the magnitude of the voltage across the resistor R_1?

$$V_1 = V_2$$

=2.83 V (from above)

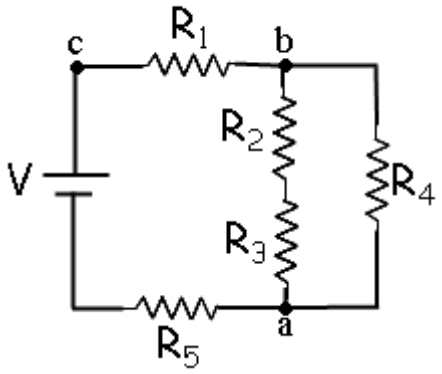
6) If the value of the resistor R_2 were doubled, how would the value of the resistor R_3 have to change in order to keep the current through R_4 equal to zero?

Right Answer:
2

Feedback:
Your answer is correct! This circuit is called a bridge circuit. It can be used to determine the value of an unknown resistor (R_X) by varying one of the other resistors until the current between the two legs is zero. You should have found that this condition requires R_X to be determined totally by the values of the three remaining resistors.

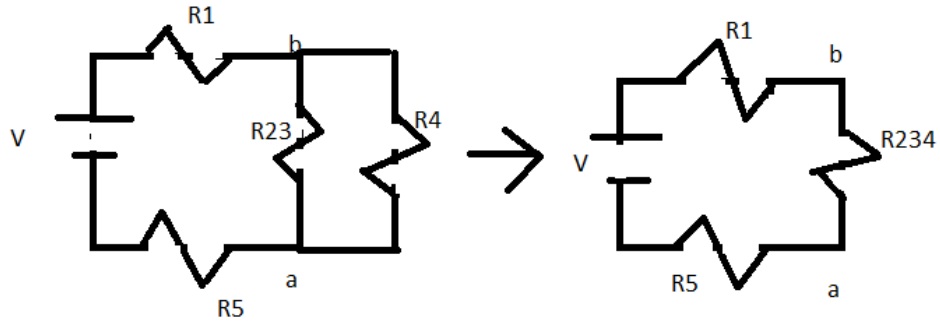
Look at the equation for Rx, problem 4, and what happens if I2 is varied (while assuming that the current across R4 is still 0).

A circuit is constructed with five resistors and a battery as shown. The values for the resistors are: R_1 = R_5 = 77 Ω, R_2 = 90 Ω, R_3 = 83 Ω, and R_4 = 88 Ω. The battery voltage is V = 12 V.



1) What is R_{ab}, the equivalent resistance between points a and b?

$$R_{23} = R_2 + R_3 \Rightarrow R_{ab} = \frac{R_4 R_{23}}{R_4 + R_{23}} = \frac{R_4 (R_2 + R_3)}{R_4 + R_2 + R_3}$$



You try making an awesome looking circuit diagram in Paint! There is the reduction of the circuit into equivalent circuits shown by the equations above.

R234=88(90+83)/(88+90+83) Ω= 58.33 Ω

2) What is R_{ac}, the equivalent resistance between points a and c?

$$R_{ac} = R_1 + R_{ab}$$

Rac= 77Ω+58.33Ω=135.33 Ω

3) What is I_5, the current that flows through resistor R_5?

$$R_{equiv} = R_5 + R_{ac} \Rightarrow I_5 = \frac{V}{R_{equiv}}$$

Requiv=77Ω+135.33Ω=212.33 Ω

I5=12V/212.33Ω=.056 A

4) What is I_2, the current that flows through resistor R_2?

$$V_{ab} = V - 2V_{bc} = V - 2I_5R_5 = V - 2R_5\frac{V}{R_5 + R_{ac}} = V\left(\frac{R_{ac} - R_5}{R_{ac} + R_5}\right)$$

$$V_{ab} = I_2(R_2 + R_3) \Rightarrow I_2 = \frac{V_{ab}}{(R_2 + R_3)} = \frac{V}{(R_2 + R_3)}\left(\frac{R_{ac} - R_5}{R_{ac} + R_5}\right)$$

I2=12 V(135.33-77)Ω/[(90+83)(135.33+77)]Ω = .019 A

5) What is I_1, the current that flows through the resistor R_1?

$$I_1 = I_5 \Rightarrow I_1 = \frac{V}{R_5 + R_{ac}}$$

I1=12V/(77+135.33)Ω = .056 A

6) What is V_4, the voltage across resistor R_4?

$$V_4 = V_{ab} = V - 2V_{bc} = V\left(\frac{R_{ac} - R_5}{R_{ac} + R_5}\right)$$

Look at prob 4, you probably already calculated this.

V4=12 V(135.33-77)Ω/(135.33+77)Ω=3.296.. V