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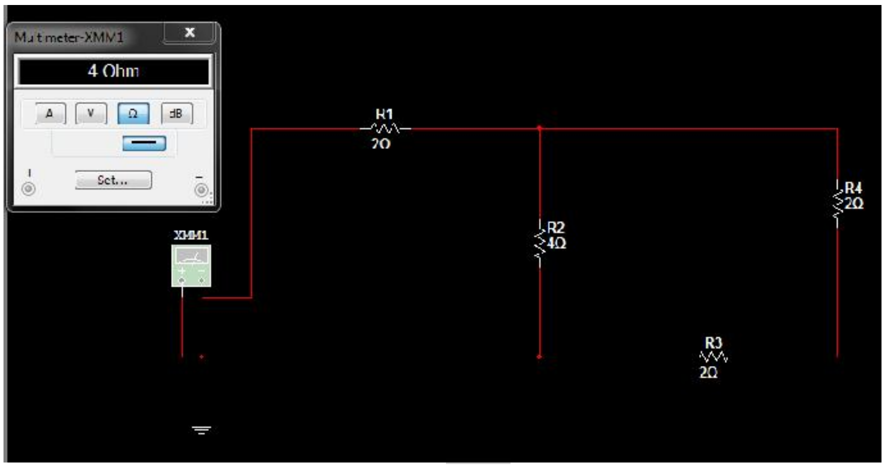
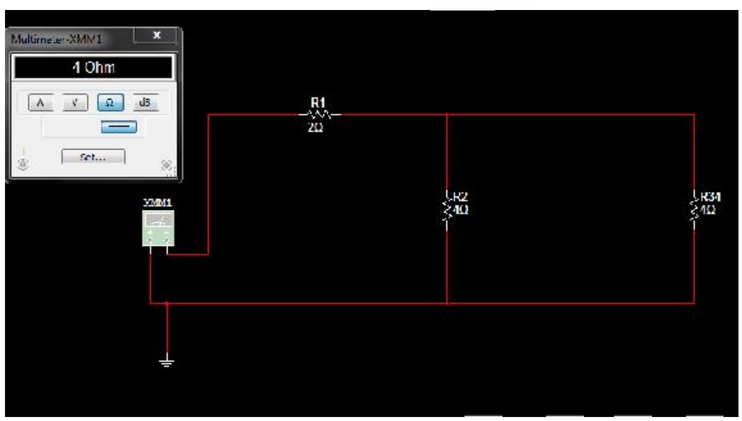
EE Science 1
10/1/2012

Reworked Exam

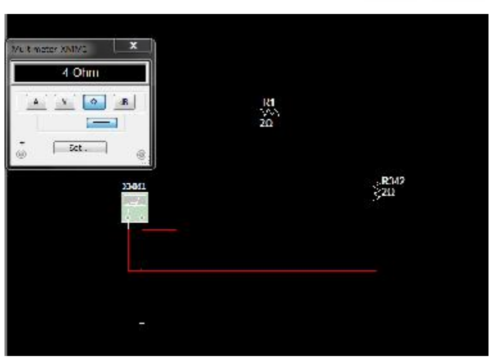
1a.



R4 and R3 are in series, and therefore $R_{34} = 2\Omega + 2\Omega = 4\Omega$

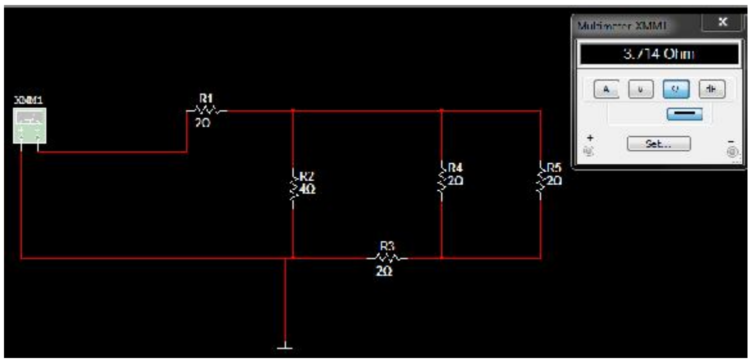


Since R34 and R2 are in parallel, then $\frac{1}{R_{342}} = \frac{1}{4\Omega} + \frac{1}{4\Omega} = \frac{1}{2\Omega}$ and $R_{342} = 2\Omega$

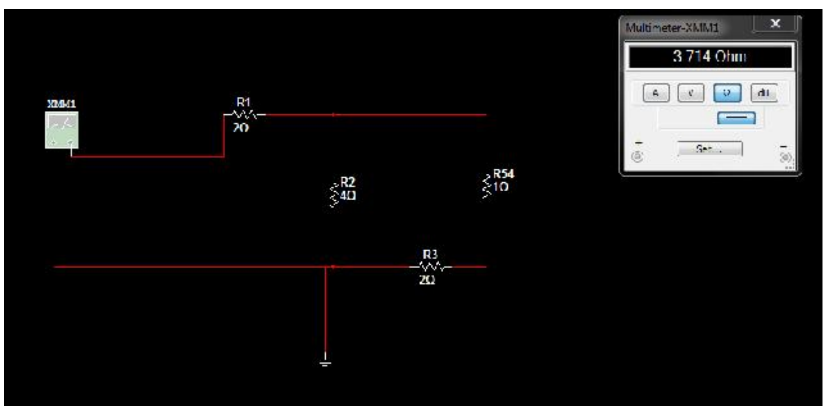


Finally, R342 AND R1 are in series, which means that $R_{eq} = 2\Omega + 2\Omega = 4\Omega$.

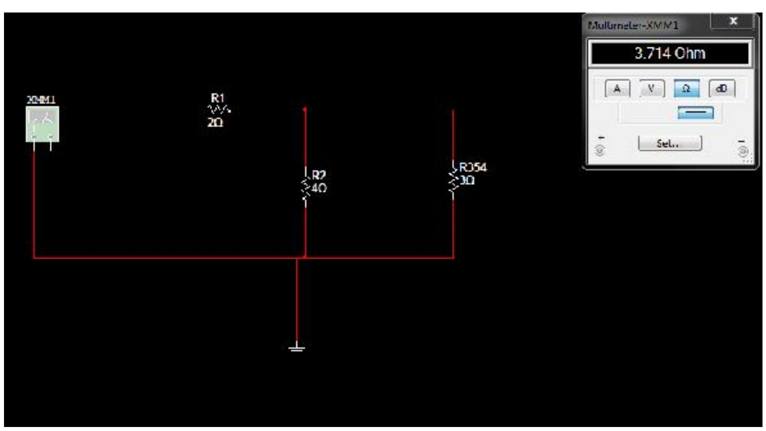
1b.



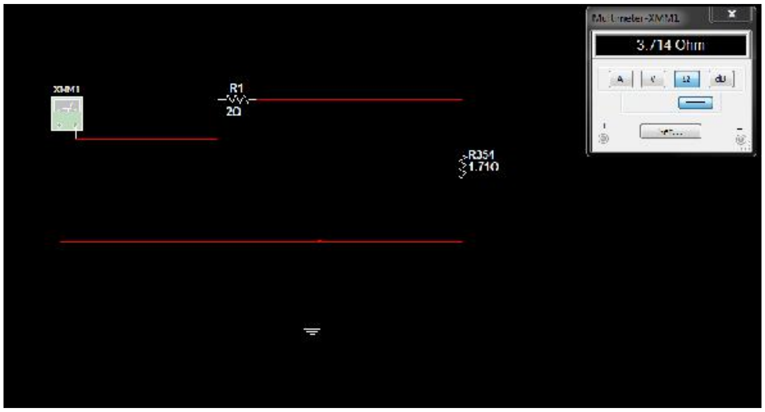
It can be noticed that R5 and R4 are in parallel, so $\frac{1}{R_{54}} = \frac{1}{2\Omega} + \frac{1}{2\Omega} = \frac{1}{1\Omega}$ and $R_{54} = 1\Omega$.



R54 and R3 are in series and therefore R354=1Ω+2Ω = 3Ω



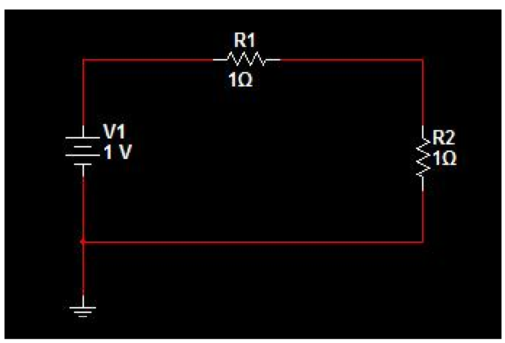
It can be seen that R354 and R2 are in series, and therefore $\frac{1}{R_{2354}} = \frac{1}{3\Omega} + \frac{1}{4\Omega}$ which means that R2354 = $\frac{12}{7}\Omega$.



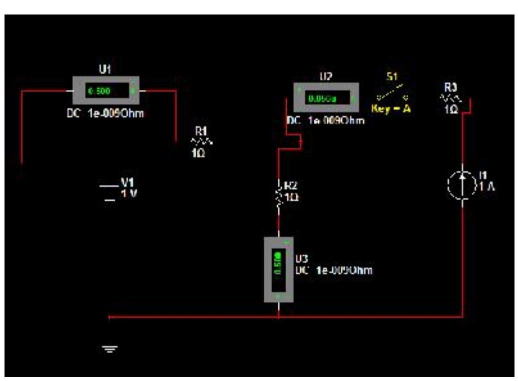
Since R2354 and R1 are in series, then Req = R2354 + R1 = 1.71Ω + 2Ω = 3.71Ω

3.71Ω < 4Ω this makes sense because the new resistance added a path for the electrons, increasing the current flow. Since the voltage source needs to stay constant, the total resistance must decrease (Ohm's Law).

2a. Since the switch is open, there is no current coming from the current source and therefore, the circuit can be redrawn as follows:

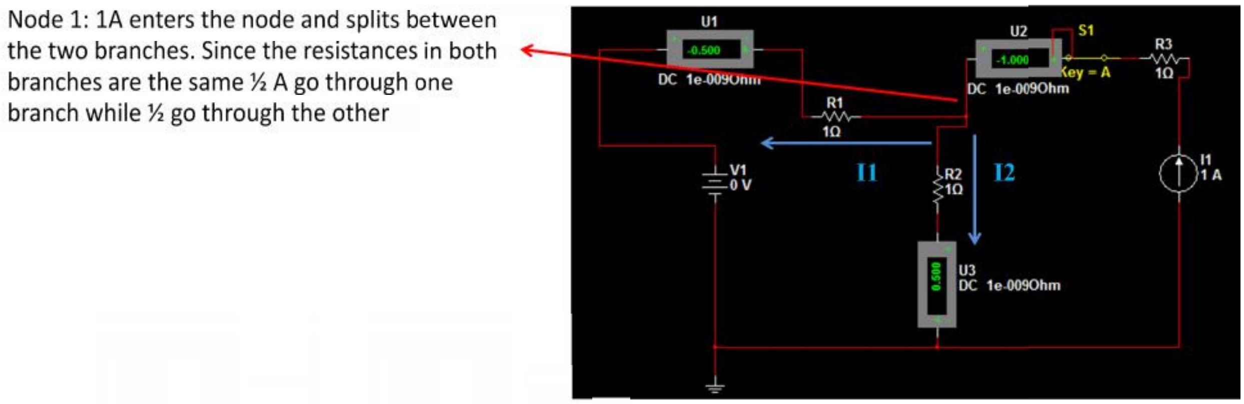


From Ohm's law it can be calculated that the current is the voltage across the circuit over the total resistance. Since the resistors are arranged in series, then $I = \frac{1}{2}A$. The following figure shows the Multisim simulation with the different currents through the circuit:



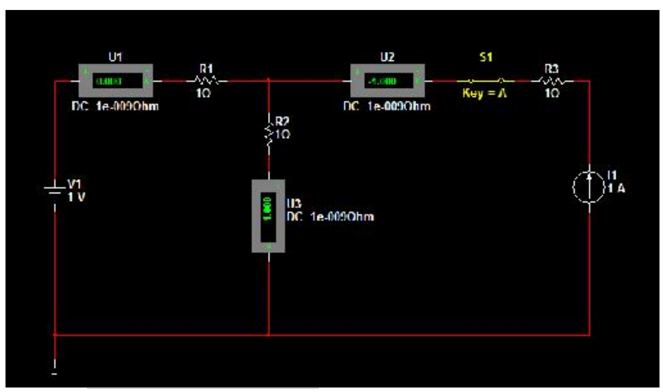
It can be seen that the ammeter measuring the current through the right loop reads a value that approaches zero.

2b. since the voltage source from the left loop is zero, the Ic can be calculated through Kirchhoff's Current Law.



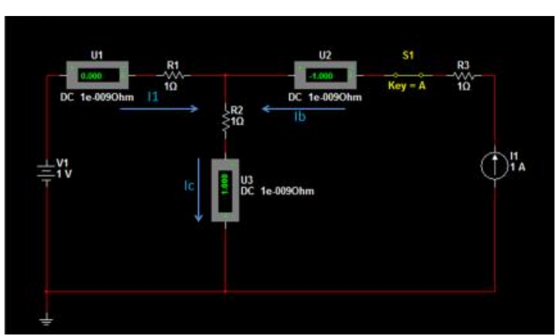
$I_c + I_1 - 1A = 0$ Or $I_c + I_1 = 1A$ since the resistors are the same in both branches the current can be divided in half. Therefore$I_c = \frac{1}{2}$

2c.



This circuit can be analyzed through loop analysis.

Analyzing the left mesh: $-1 + I_1 + (I_1 + I_b) = 0$ since Ib is the current produced by the DC source, then Ib = 1A. Then $-1 + 2I_1 + 1 = 0$ and therefore I1 = 0A. By Kirchhoff's Current Law Ic can be then calculated:



$-I_b - I_1 + I_c = 0$ Which is $-1 - 0 + I_c = 0$ and then $I_c = 1A$. Having all the currents around the circuits, the voltage can be easily calculated through Ohm's Law.

$V_1 = I_1 R_1$
$V_1 = (0)1\Omega$ = 0V

$V_2 = I_2 R_2$

$V_2 = (1A)(1\Omega)$ = 1V

$V_3 = I_3 R_3$

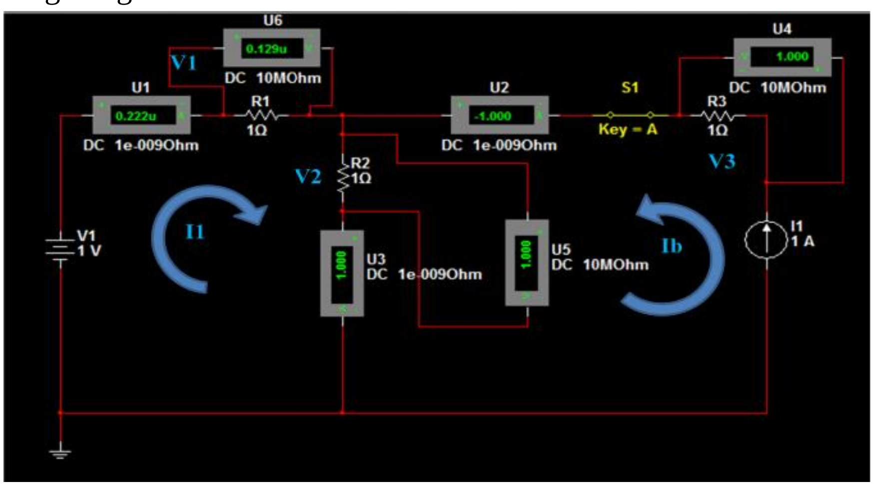
$V_3 = (1A)(1\Omega)$ = 1V

The obtained results can be tested by applying KVL to the circuit. For the left loop it can be written that:

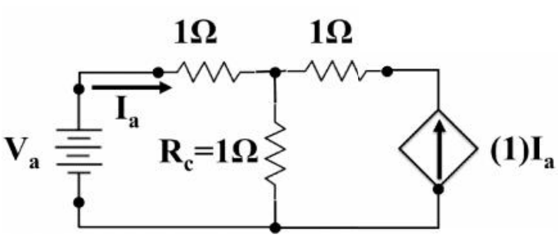
$-V_s + V_2 + V_1 = 0$ since Vs is -1,V1 is 0 and V2 is 1, Kirchhoff's Voltage law holds for this mesh.

For the right mesh, it can be said that $-V_1 + V_2 = 0$ since V1 and V2 are both 1, then Kirchhoff's Voltage law also holds for this loop.

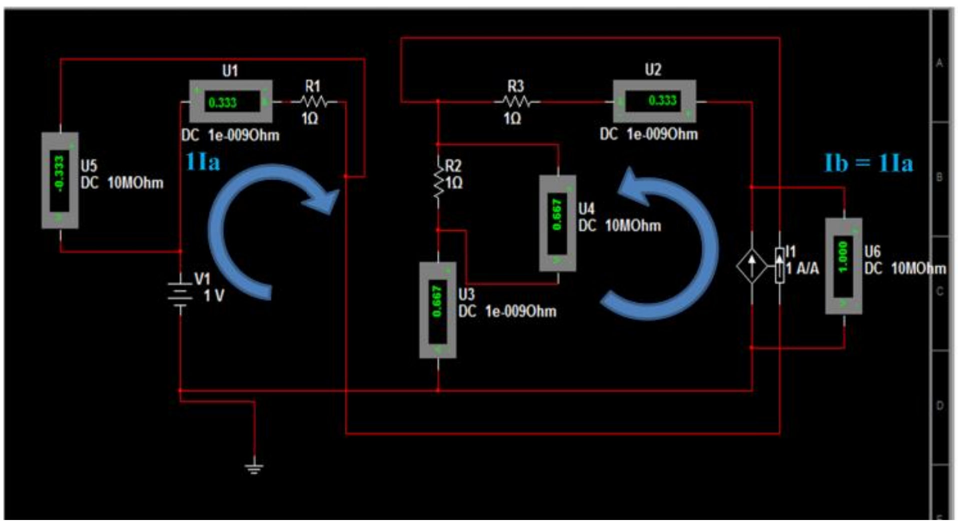
The following image shows the Multisim simulation for this circuit:



2c. Yes, the result of c equal the sum of 2a and 2b. This occurs because of the linear properties of the circuit. This circuit is linear because only linear elements such as independent sources are used on it. One of the characteristics of a linear circuit is the superposition. By this property, the current or voltage in any branch of a bilateral linear circuit having more than one independent source equals the algebraic sum of the currents or voltages caused by each independent source acting alone.

3a. 

The following image shows the Multisim simulation for this circuit with all the voltage and Current measurements:



This circuit can be evaluated through loop analysis as follows:

Left Mesh: -1V + Ia(1Ω) + (Ia1Ω + Ib1Ω) = 0

-1V + 2Ia + Ib = 0

Since Ib = (1)Ia, then -1V + 3Ia = 0, which means that

Ia = 1/3A

Because Ia = Ib, Ib = 1/3A

If KCL is applied to the node of the circuit the following equation is obtained:

-Ib –Ia + Ic = 0, or -1/3 -1/3 + Ic = 0. This means that Ic = 2/3A.

Now that the currents are known, the voltage across each resistor can be calculated through Ohm’s law. The voltage across R2 can be represented as:

$V2 = (R2)(Ic)$, then $V2 = 2/3V$

Similarly, for V1 and V3 the voltages are both 1/3V

With this information, the power dissipation by R2 can be easily calculated through $P = IV$, or $P= (2/3A)(2/3V) = 4/9W$

The solutions can be checked through KVL:

Left Mesh: $-Va + V1 + V2 = 0$, which is $-1+ 1/3 + 2/3 = 0$, or $-1 + 1 = 0$

It can be seen that KVL holds for this mesh.

Right Mesh: Vds (dependent source) – V3 – V2 = 0, or $1 – 1/3 – 2/3 = 0$, which is $1 – 1 = 0$ and therefore, KVL also holds for this mesh.

3b. The power delivered by the source Va is given by $P = (Ia)(Vs)$

$P = (1/3A)(-1V)$ and therefore $P = -1/3W$.

The power can be also calculated through Tellegen's Theorem as follows

$P1 = 1/9W$

$P2 = 1/9W$

$P3 = 4/9 W$

Pds (dependent source) = -1/3W

By Tellegen's Law $1/9 + 1/9 + 4/9 – 1/3 + Va = 0$, that is $1/3 + Va = 0$, and therefore:

$Va = -1/3W$