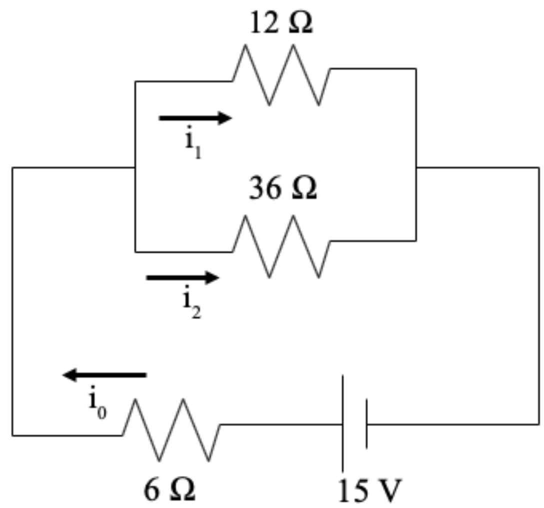
Off-the-wall question #2: Consider the circuit shown to the right.



a.) It is noted that the current i_o is 1.0 amps. An astute students looks at the circuit and, within seconds (obviously not using Kirchoff's Law) states that the current through the 12 Ω resistor must be 0.75 amps. Explain how she deduced that.

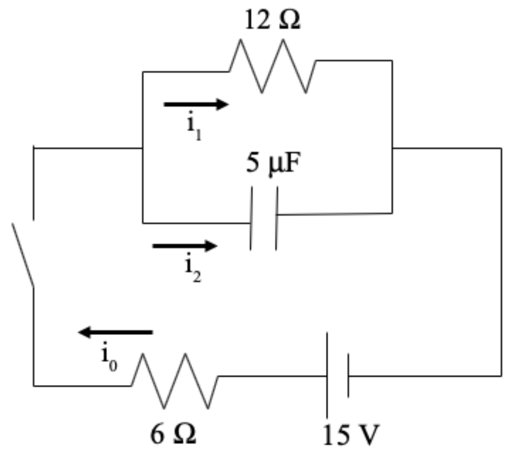
--the current coming into the parallel combination is 1.0 amps;
--the ratio of the resistors is 3 (the larger resistor) to 1 (the smaller resistor);
--the total of 3 and 1 is 4, so if four parts of current (.25 amps per part) enter the node, 1 part will go through the larger resistor and 3 parts will go through the smaller resistor;
--given the ratio and the parts-observation, the smaller resistor should have 3(.25 A)'s worth of current flowing through it.

b.) If you were to use Kirchoff's Laws on this circuit and you wrote out three loop equations to accommodate the three unknown currents, your resulting values after solving the equations simultaneously would all have been zero. Explain why?

--for a circuit with three loops, Kirchoff's second law will only produce two independent equations (the third equation will be the combination of the other two);
--(a similar problem will arise if you try to use two node equations (Kirchoff's First Law) for two of the required equations—in a circuit with only two nodes, only one of the node equations will be independent with the second one being the rearranging of the first;)
--back to the question: trying to solve for three unknown with only two independent equations will yield mush;

Space . . .

c.) At some point, the circuit is altered with a switch being placed in the main body of the circuit and a 5 microfarad capacitor replacing the 36 Ω resistor. If the cap is initially uncharged with the switch open, and if the switch is closed at t = 0 seconds:



i.) Without doing calculations, will the initial current drawn from the batter in this circuit be:

_x__ greater than ___ the same as ____ smaller than

the current being drawn from the battery in the all resistor circuit (that current was, if you will remember, 1.0 amp). Justify your response.

--with no charge initially on the cap, it will act like a short and almost all of the current moving through the parallel combination will pass through that lower branch;
--the circuits initial net resistance in that situation will be the 6 ohm resistor;
--the circuit's initial current will be V/R = (15 v)/(6 ohms) = 2.5 A, which is greater than 1.0 A;

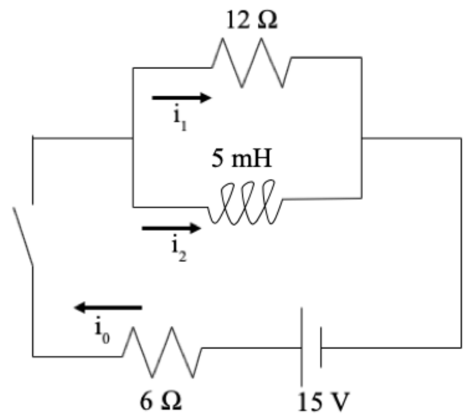
Alternative explanation:

--with no charge initially on the cap, it will act like a short with essentially no resistance across the nodes;
--the equivalent resistance of a parallel combination is smaller than the smallest resistor in the circuit;
--as the smallest resistance in the circuit is initially zero (due to the cap's lack of charge), the equivalent resistance of the parallel combination of resistors will effectively be zero and the circuits initial net resistance will simply be the 6 ohm resistor;
--the circuit's initial current will be V/R = (15 v)/(6 ohms) = 2.5 A, which is greater than 1.0 A;

ii.) What will the current in the circuit do with time? That is, will it increase or decrease or go to steady state or what? Explain fully what you think will happen.

--with time, the capacitor will charge up to its maximum and current will cease to flow through that branch;
--with no current flowing through the lower branch of the parallel combination, the net resistance in the circuit will be the 6 ohm and 12 ohm resistors in series, or 18 ohms;
--the net current in that case will be V/R = (15 v) / (18 ohms) = something less than 1.0 A with is also less than the initial 2.5 A
--therefore the current will decrease.

d.) At some point, the circuit is altered. The switch remains but a 5 millihenry inductor replaces the capacitor. If the switch is closed at t = 0 seconds:



iii.) Without doing calculations, will the initial current drawn from the batter in this circuit be:

___ greater than ___ the same as __x__ smaller than

the current being drawn from the battery in the all resistor circuit (that current was, if you will remember, 1.0 amp). Justify your response.

--as current attempts to increase in the inductor, the changing magnetic flux through the coil will produce a back emf that will initially stop initial current flow in that branch;
--that means all the current coming into that node will go through the 12 ohm resistor;
--that means the net initial resistance in the circuit will be 6 ohms plus 12 ohms equals 18 ohms;
--the net current in that case will be V/R = (15 v) / (18 ohms) = something LESS THAN 1.0 A.

iv.) What will the current in the circuit do with time? That is, will it increase or decrease or go to steady state or what? Explain fully what you think will happen.

--once the current hits steady-state in the inductor branch, the inductor will act like any other resistor (though its resistance will probably be small).
--as the equivalent resistance of a parallel combination is smaller than smallest resistor in the combination, in all cases the equivalent resistance for this parallel combination will be less than 12 ohms;
--that means the effective net resistance for the circuit will be less than 18 ohms;
--that means the net current will be V/R = (15 v) / (less than18 ohms) = a number greater than (15 v) / (18 ohms), which was the current initially, so;
--apparently, the current goes UP with time.