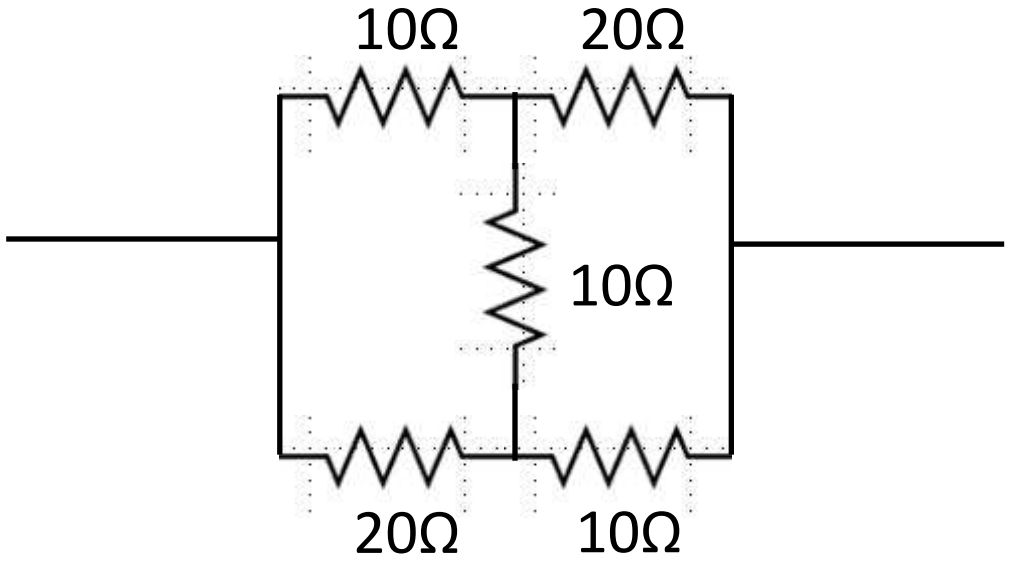
A Challenge…

- What is the total resistance of this circuit?

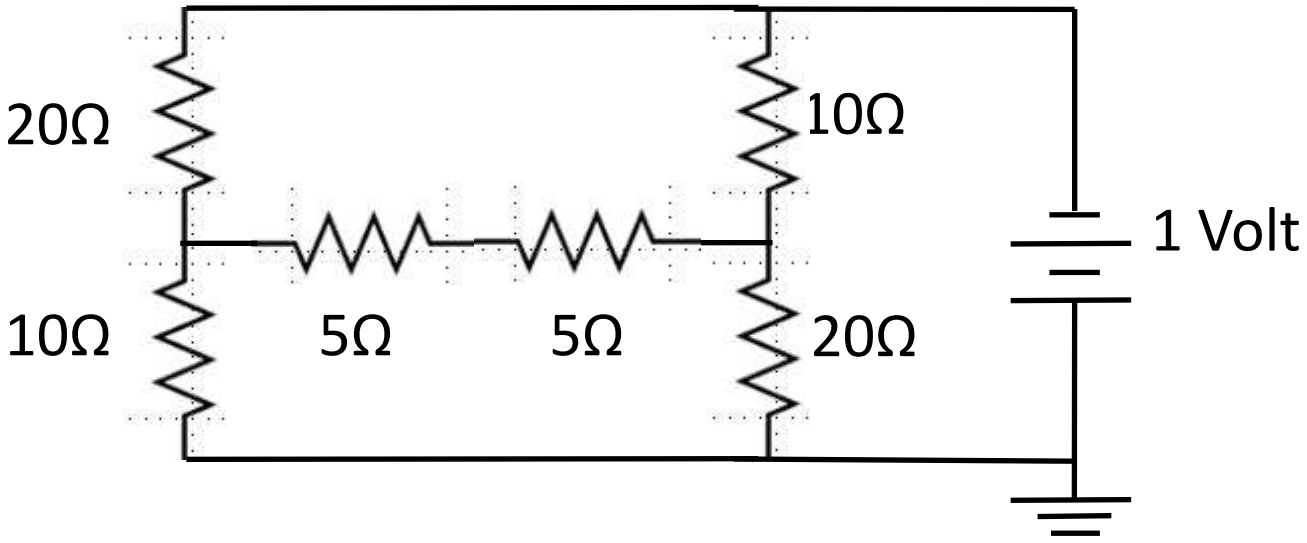


Hint: It is not easy!!!!
Another hint: the answer is an even number.

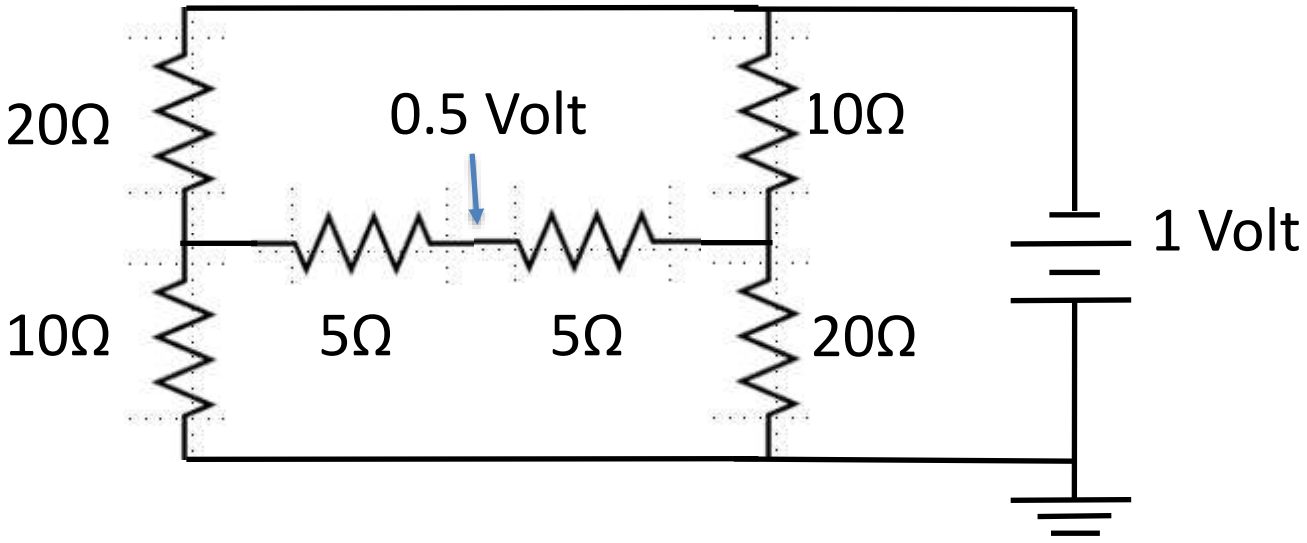
Solution USING SYMMETRY

Connect it to a 1 volt battery. (If we figure out the current this battery supplies, then we easily calculate the resistance)

Split the middle resistor into two.

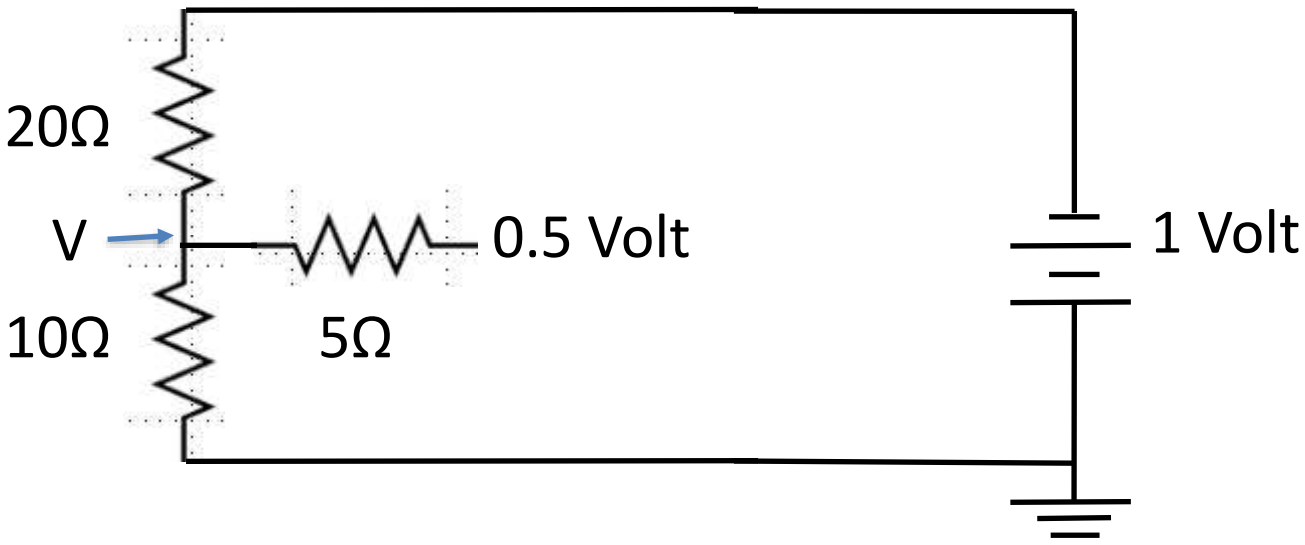


From symmetry, we can determine that the middle node is half way, therefore at 0.5V



Now consider this smaller circuit.
Kirchoff's law says that the total current in these three resistors must be zero. We use ohms law 3 times

So: $\frac{V}{10} = \frac{1-V}{20} + \frac{0.5-V}{5}$



Algebra

$$\frac{V}{10} = \frac{1-V}{20} + \frac{0.5-V}{5}$$

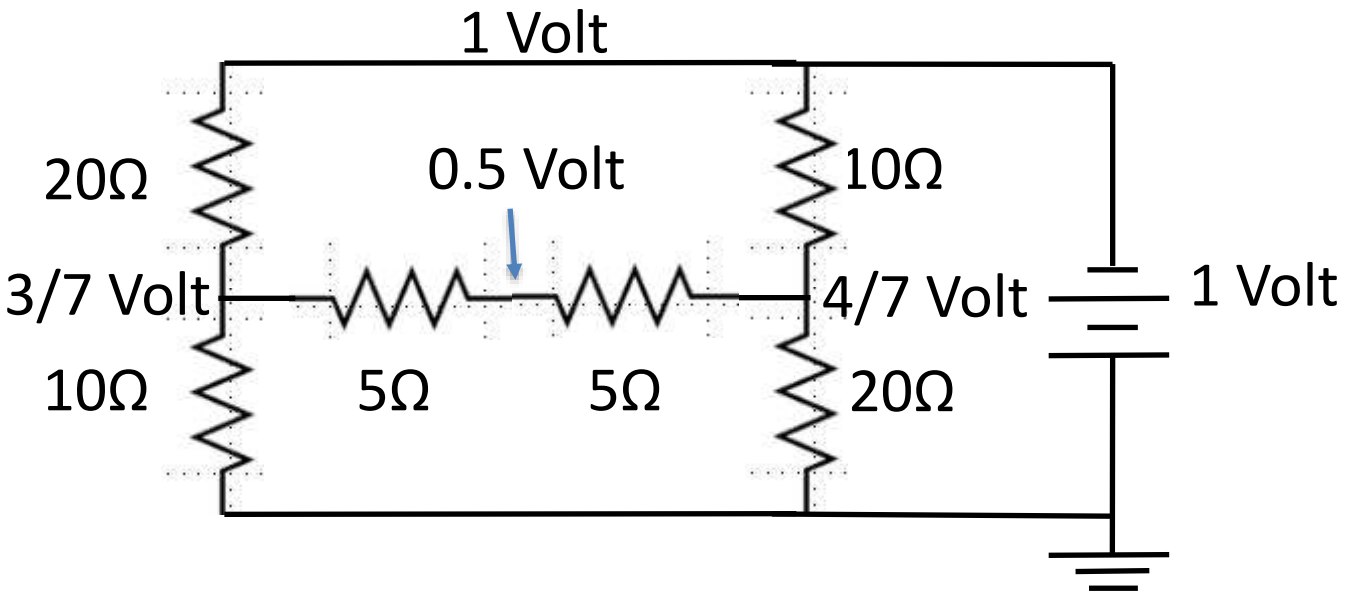
$$\frac{2*V}{20} = \frac{1-V}{20} + \frac{2-4*V}{20}$$

$$2*V = 1 - V + 2 - 4 * V$$

$$7*V = 3$$

$$V = \frac{3}{7}$$

Now we know all of the node voltages

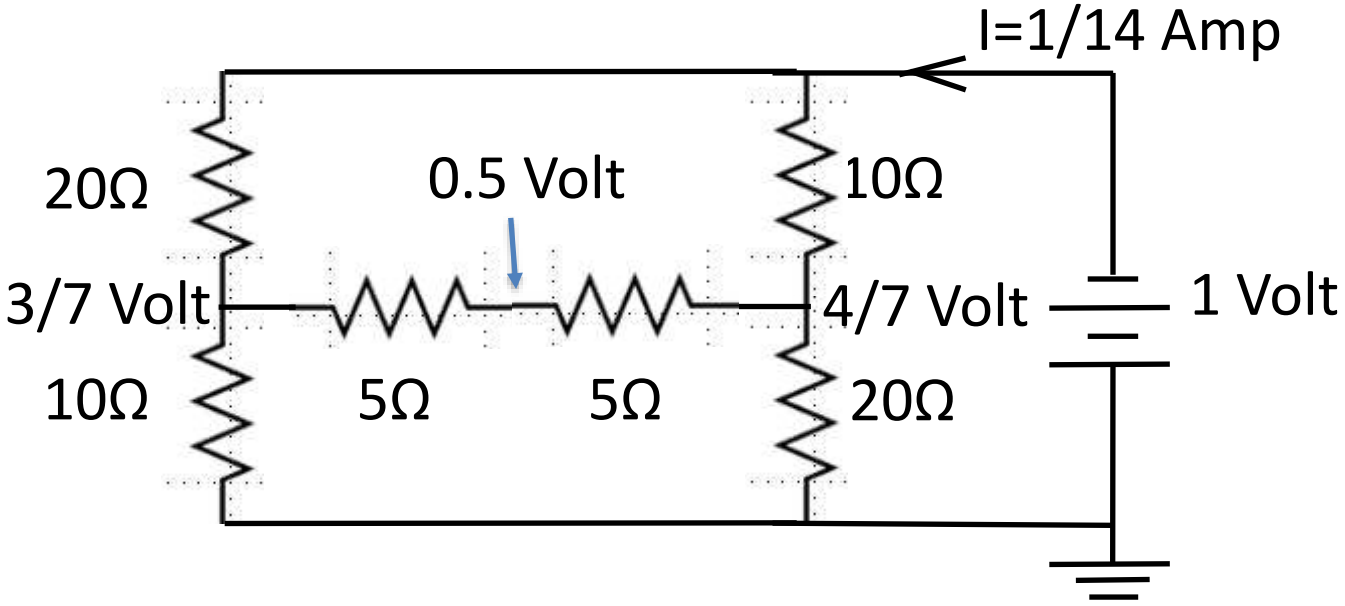


We can calculate the total current now, looking at the two bottom resistors.

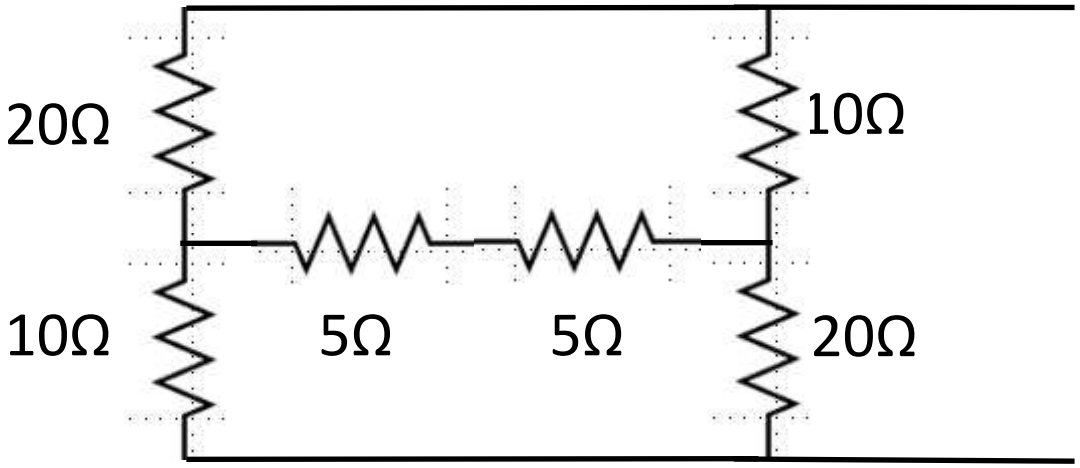
$$I = \frac{\left(\frac{3}{7}\right)}{10} + \frac{\left(\frac{4}{7}\right)}{20}$$

$$I = \frac{3}{70} + \frac{4}{140}$$

$$I = \frac{6}{140} + \frac{4}{140} = \frac{10}{140}$$



And the resistance is 1V divided by the total current: 140/10 = 14 ohms.



14 Ohms

There are other ways

- The brute force are to solve the 3 loops for voltage (3 equations in 3 unknowns).
- OR 4 node equations.