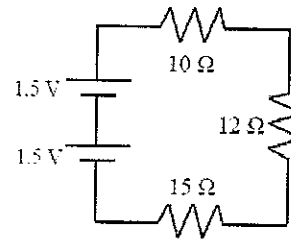
Equivalent Resistance

Resistors in Series

$$R_{total} = R_1 + R_2 + R_3 \ldots$$

As you add resistors in series, you increase resistance. Simply add the amounts together.

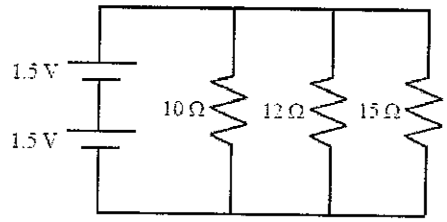


Example: Calculate the total resistance of this circuit.

$R_T = R_1 + R_2 + R_3 \ldots$
$R_T = 10 + 12 + 15$
$R_T = 37\Omega$

Resistors in Parallel

$$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots$$



Example: Calculate the total resistance of this circuit.

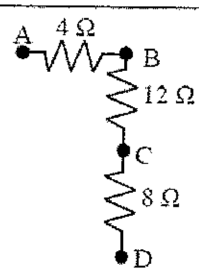
$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$$

$$\frac{1}{R_T} = \frac{1}{10} + \frac{1}{12} + \frac{1}{15} = .1 + .083 + .067$$

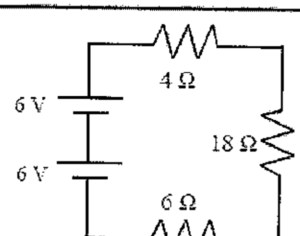
$$\frac{1}{R_T} = .25 \qquad R_T = \frac{1}{.25} = 4\Omega$$

As you add resistors in parallel, you open more paths for the electricity to flow, increasing total current, and decreasing total resistance. For resistors in parallel, the total resistance is always less than the smallest resistor.

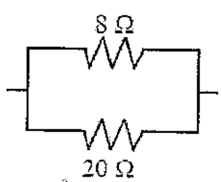
1. These resistors are in: Series
2. What is R_{total} from A to C? 16 Ω
3. What is R_{total} from B to D? 20 Ω
4. What is R_{total} from A to D? 24 Ω



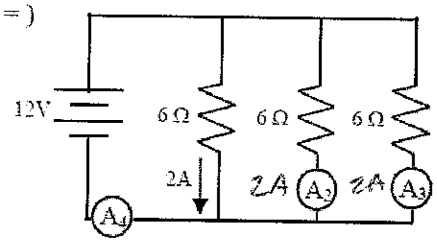
5. Calculate the total resistance.
   28 Ω
6. Calculate total voltage.
   12V
7. Calculate total current.
   $I = \frac{V}{R} = \frac{12}{28\Omega} = .43 A$



8. Calculate the total resistance.
   $\frac{1}{R} = \frac{1}{8\Omega} + \frac{1}{20\Omega} = .125 + .05$
   $\frac{1}{R} = 0.175 = 5.7\Omega$
9. How does R_{total} compare with the individual resistors?
   It is lower.
10. Why? ~~more~~ current (path)
    Less Resistance

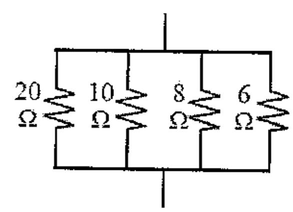


11. A_2 reads (current 2 =)
    2A
12. A_3 = 2A
13. A_4 = 6A
14. Since V = IR and R = V/I. R_{total} =
    $R = \frac{12V}{6A} = 2\Omega$
15. If one of the resistors is removed, R_{total} = $R = \frac{12V}{4A} = 3\Omega$

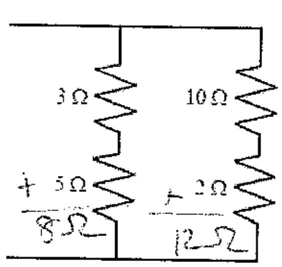


16. You are given four 100 Ω resistors.
    A. If in series R_{total} = 400 Ω
    B. If in parallel R_{total} = $\frac{1}{R} = \frac{1}{100} + \frac{1}{100} + \frac{1}{100} + \frac{1}{100} = 25\Omega$

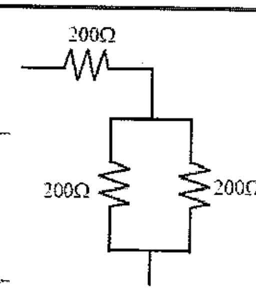
17. Without calculating, you know that R_{total} must be less than:
    >42 Ω
18. Calculate R_{total}.
    $\frac{1}{R} = \frac{1}{20} + \frac{1}{10} + \frac{1}{8} + \frac{1}{6}$
    $.05 + .1 + .125 + .17$
    $\frac{1}{R} = 0.445 = 2.25\Omega$



19. Calculate and label the total resistance for each pair of resistors in series.
20. Calculate the total resistance for the two parallel branches.
    $\frac{1}{R} = \frac{1}{8\Omega} + \frac{1}{12\Omega} = 0.125 + .083$
    $\frac{1}{0.2} = 5\Omega$



21. What is the equivalent resistance of the parallel resistors?
    $\frac{1}{R} = \frac{1}{200\Omega} + \frac{1}{200\Omega} = 100\Omega$
22. Calculate R_{total} for all three resistors.
    $200\Omega + 100\Omega = 300\Omega$



The kilowatt-hour

Electrical utility companies who provide energy for homes provide a monthly bill charging those homes for the electrical energy that they used. A typical bill can be very complicated with a number of line items indicating charges for various aspects of the utility service. But somewhere on the bill will be a charge for the number of kilowatt-hours of *electricity* that were consumed. Exactly what is a kilowatt-hour? Is it a unit of power? time? energy? or some other quantity? And when we pay for the electricity that we use, what exactly is it that we are paying for?

A careful inspection of the unit *kilowatt-hour* reveals the answers to these questions. A kilowatt is a unit of power and an hour is a unit of time. So a kilowatt • hour is a unit of Power • time. If Power = ΔEnergy / time, then Power • time = ΔEnergy. So a unit of power • time is a unit of energy. The kilowatt • hour is a unit of energy. When an electrical utility company charges a household for the electricity that they used, they are charging them for electrical energy. A utility company in the United States is responsible for assuring that the electric potential difference across the two main wires of the house is 110 to 120 volts. And maintaining this difference in potential requires energy.

It is a common misconception that the utility company provides electricity in the form of charge carriers or electrons. The fact is that the mobile electrons that are in the wires of our homes would be there whether there was a utility company or not. The electrons come with the atoms that make up the wires of our household circuits. The utility company simply provides the energy that causes the motion of the charge carriers within the household circuits. And when they charge us for a few hundred kilowatt-hours of electricity, they are providing us with an energy bill.

Calluation:

(_____ X _____) / 1,000 = _____ kW (Electricity used to run this appliance)

Watts — Avg daily use (hrs) — kWh

$10 = $0.15 • kwhr = 66.7 kwhr

66.7kwhr = (60w • t) / 1000 = 1111.7 hrs

Then,

_____ X .10 = $ _____ Daily cost

kW — cost of electricity per kW

Then,

_____ X 365 = $ _____ **Annual cost**

Daily Cost — days in a year

Alfredo deDarke often leaves household appliances on for *no good reason* (at least according to his parents). The deDarke family pays 15¢/kilowatt-hour (i.e., $.15/kW•hr) for their electrical energy. Express your understanding of *dollar power* by filling in the following table.

Power Rating (Watt)	Time (hrs)	Energy Used (kilowatt-hour)	Cost ($)
60 Watt Bulb	1	0.060 kW•hr	$0.009
60 Watt Bulb	4	0.24kwhr	$ 0.036
Ten 60 Watt Bulb	24	1.44 kwhr	$ 0.216
60 Watt Bulb	1111.7 hrs	66.7 kwhr	$10
7 Watt Night Light	168	1.176 kwhr	$ 0.1764
7 Watt Night Light	8760		$ 9.198