Automotive Electrical Systems

Basic Electricity

Donald Jones
Brookhaven College

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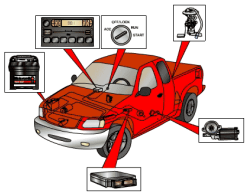
What is Electricity?

- Electricity is the flow of charges through a conductor
- This flow of charges can be used to generate heat, light or magnetism
- List several specific automotive applications of electricity



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Elements

- An element is composed of one type of atom
- There are over a 100 different elements in the Periodic Table of Elements
- The number of protons in an atom determines its atomic number

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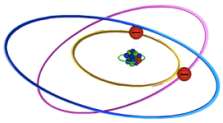
Atomic Structure

- Protons
  - Positive charge
  - Located in nucleus
- Neutrons
  - Neutral charge
  - Acts as the glue holding protons in the nucleus together
- Electrons
  - Negative charge
  - Orbit the nucleus



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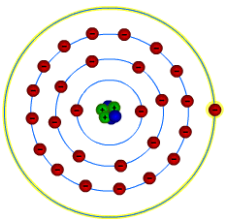
Electron Shells

- $2n^2$ rule
- First shell – K
  - 2 electrons
- Second shell – L
  - 8 electrons
- Third shell – M
  - 18 electrons
- Fourth shell – N
  - 32 electrons



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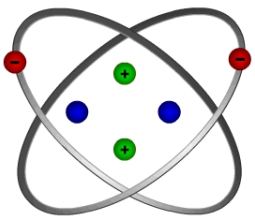
Valence Shells

- An atom's outer most ring or shell is referred to as its valence ring
- The number of electrons in the valence ring determines if a material is a
  - Conductor
  - Insulator
  - Semiconductor



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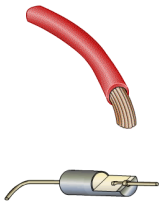
Conductors and Insulators

- Conductor
  - Materials with three or less electrons in the valence shell
- Insulator
  - Materials with 5 or more electrons in the valence shell
- Semiconductor
  - Materials with four electrons in the valence shell



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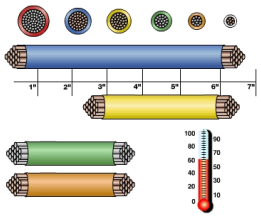
Conductor Characteristics

- A conductor's resistance is influenced by:
  - Atomic structure
  - Length
  - Diameter
  - Temperature
  - Condition



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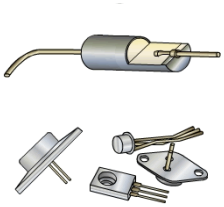
Semiconductors

- Semiconductors have exactly four electrons in their valence shell
- Semiconductors only conduct electricity under very specific conditions
- Diodes and transistors are examples of semiconductors



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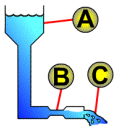
Basic Electricity

- Electrical Pressure
  - voltage
  - measured in volts
- Current Flow
  - amperage
  - measured in amps
- Opposition to Current Flow
  - resistance
  - measured in ohms



A - voltage
B - resistance
C - amperage

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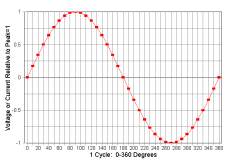
AC and DC Current

- Direct current flows in a single direction, from positive to negative
- Alternating current changes directions from positive to negative many times a second

Sine Curve of AC Voltage or Current



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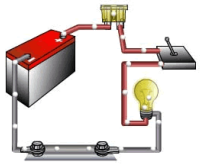
Circuit Components

- Power Source
- Conductor
- Load
- Switch
- Circuit Protection



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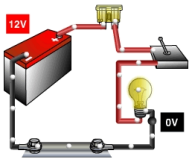
Circuit Voltage

- Voltage is dropped across each load in a circuit
- A voltage drop occurs only when current is flowing
- Voltmeters measure the difference in electrical pressure between two points in a circuit



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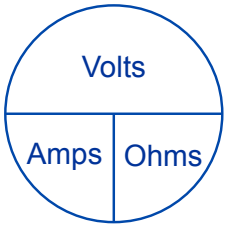
Ohm's Law

- V = A x O
- A = V / O
- O = V / A



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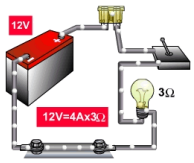
Applying Ohms Law

- $V_S = I_T \times R_T$
  - 12V = 4A x 3Ω
- How will low battery voltage impact cranking speed?



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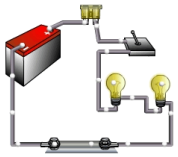
Series Circuit

- One path for current flow
- Total circuit resistance is the sum of all the circuit's resistances
- The sum of the voltage drops equals source voltage



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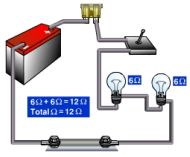
Series Circuit Resistance

- $R_T = R_1 + R_2 \ldots$
  - 6Ω + 6Ω = 12Ω
- Increasing the number of loads in a series circuit increases the circuit's resistance



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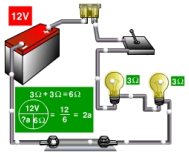
Series Circuit Current Flow

- V_S = 12V
- Calculate R_T
  - $R_T = R_1 + R_2 \ldots$
  - 3Ω + 3Ω = 6Ω
- $I_T = V_S / R_T$
  - 12V / 6Ω = 2A
- What would happen to the current flow if resistance increased?



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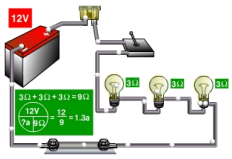
Series Circuit Calculations

- $R_T = R_1 + R_2 \ldots$
  - $3\Omega + 3\Omega + 3\Omega = 9\Omega$
- $I_T = V_S / R_T$
  - $12V / 9\Omega = 1.3A$
- What happens to the bulbs' intensity as compared to the previous circuit?



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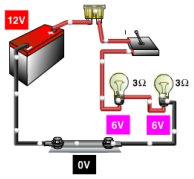
Series Circuit Voltage Drops

- Voltage drops may be calculated by multiplying the load's resistance by the current flowing through the load or:
  - $V_D R_x = R_x \times I_T$
- $R_T = R_1 + R_2 \ldots$
  - $3\Omega + 3\Omega = 6\Omega$
- $I_T = V_S / R_T$
  - $12V / 6\Omega = 2A$
- $V_D R_1 = R_1 \times I_T$
  - $6V = 2A \times 3\ \Omega$



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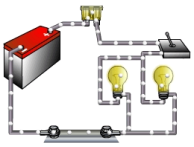
Parallel Circuits

- There are multiple paths for current flow
- Source voltage is dropped across each path
- Total current is equal to the sum of current flowing through all the branches
- Total circuit resistance is always less than the least resistive branch



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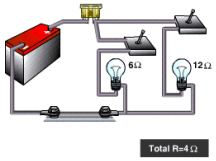
Parallel Circuit Calculations

- Source voltage is dropped across each load
- $I_T = (V_S / R_1) + (V_S / R_2)$
  - $3A = (12V / 6\Omega) + (12V / 12\Omega)$
- $R_T = V_S / I_T$
  - $12V / 3A = 4\Omega$
- What happens to a parallel circuit's resistance if additional loads are added?



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Digital Volt Ohm Meters

- Display
  - number of digits
  - V, A or Ω
  - units indicator
- Range Selection
  - auto-ranging
  - manual operation
- Test Lead Connection

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Units of Measurement

- mega - M
  - multiply meter reading by 1,000,000
- kilo - k
  - multiply meter reading by 1,000
- milli - m
  - multiply meter reading by .001
- micro - μ
  - multiply meter reading by .000001

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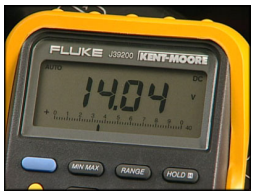
Meter Operation

- Voltage drop must be measured with the current flowing
- An ammeter must be in series with the circuit being tested
- An ohmmeter should be used only with the circuit or component removed from the circuit (no power applied)



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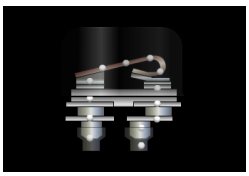
Measuring Voltage

- Be certain the leads are connected correctly
- Select the correct scale if the meter is not auto-ranging
- Connect the leads to the component being tested
- Current must be flowing to measure voltage drop



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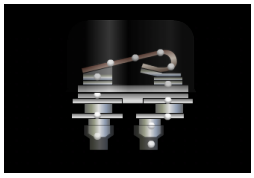
Continuity Tests

- Always isolate the circuit you are testing for continuity
- A meter reading of OL indicates no continuity
- A numeric reading indicates continuity although it may not be desired or within specifications



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Shorts and Opens

- Short
  - unwanted continuity exists between two or more circuits
  - the meter displays a resistance less than specifications
- Open
  - the desired continuity between two points in a circuit is not present
  - the meter shows OL