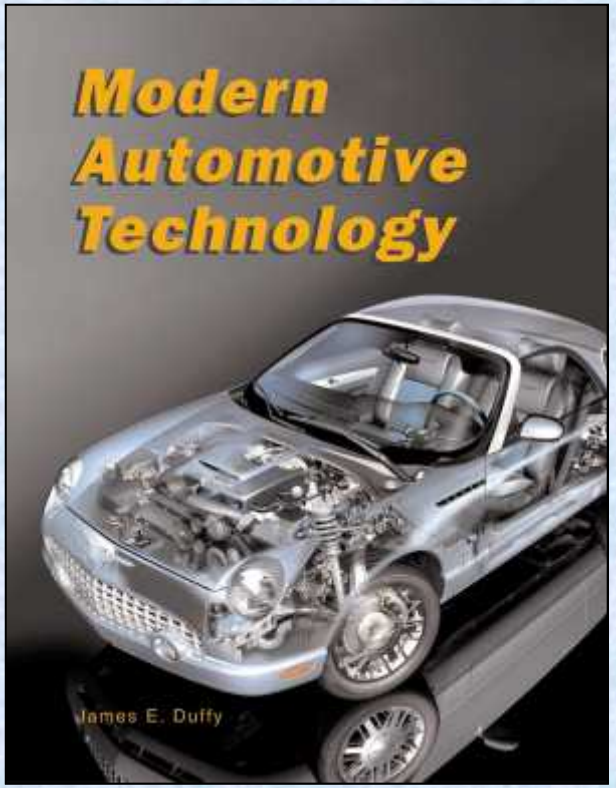
PowerPoint for

Modern Automotive Technology



by

Russell Krick

Publisher
The Goodheart-Willcox Co., Inc.
Tinley Park, Illinois

Chapter 8

Basic Electricity and Electronics

Contents

- Electricity
- Automotive electronics
- Automotive wiring
- Basic electrical tests
- Oscilloscope
- Scan tools

Electricity

- The movement of electrons from atom to atom
- The atom is the smallest particle of matter

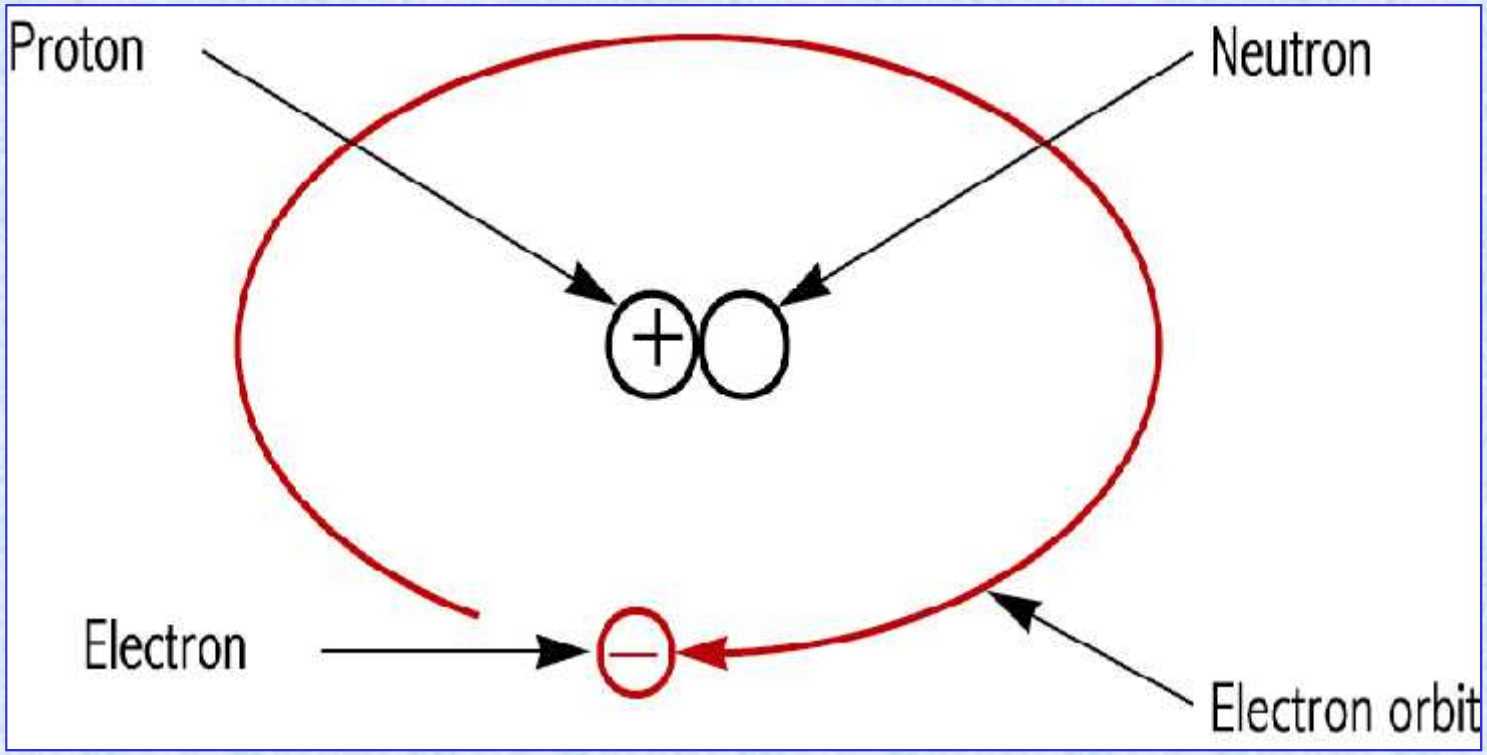
Matter

- All substances are made of matter
- Matter is anything that has mass and occupies space
- All matter is made from about 100 types of atoms

Atom

- Made up of three parts:
  - Protons–positively charged particles
  - Neutrons–particles with no charge
  - Electrons–negatively charged particles

Atom



Atom

- Protons and neutrons combine to form the nucleus
- Since opposite charges attract each other, the negatively charged electrons tend to remain in orbit around the positively charged nucleus

Conductors

- Allow the flow of electricity
- Contain atoms with free electrons
  - one to three electrons in the outer orbit
- Free electrons are not locked in orbit around the nucleus
  - electrons can be forced to move from one atom to another
- Copper, gold, and silver are good conductors

Insulators

- Resist the flow of electricity
- Contain atoms with bound electrons
  - five to eight electrons in the outer orbit
- Bound electrons will not leave their orbit around the nucleus
- Plastic, rubber, and ceramics are good insulators

Electrical Terms

- Three terms are used in the study of electricity:
  - current
  - voltage
  - resistance

Current

- Flow of electrons through a conductor
- Measured in Amperes (A)
- I is the abbreviation for current

Current

- Two theories are used to describe current:
- Conventional (current) theory
  - states that current flows from positive to negative
- Electron theory
  - states that current flows from negative to positive

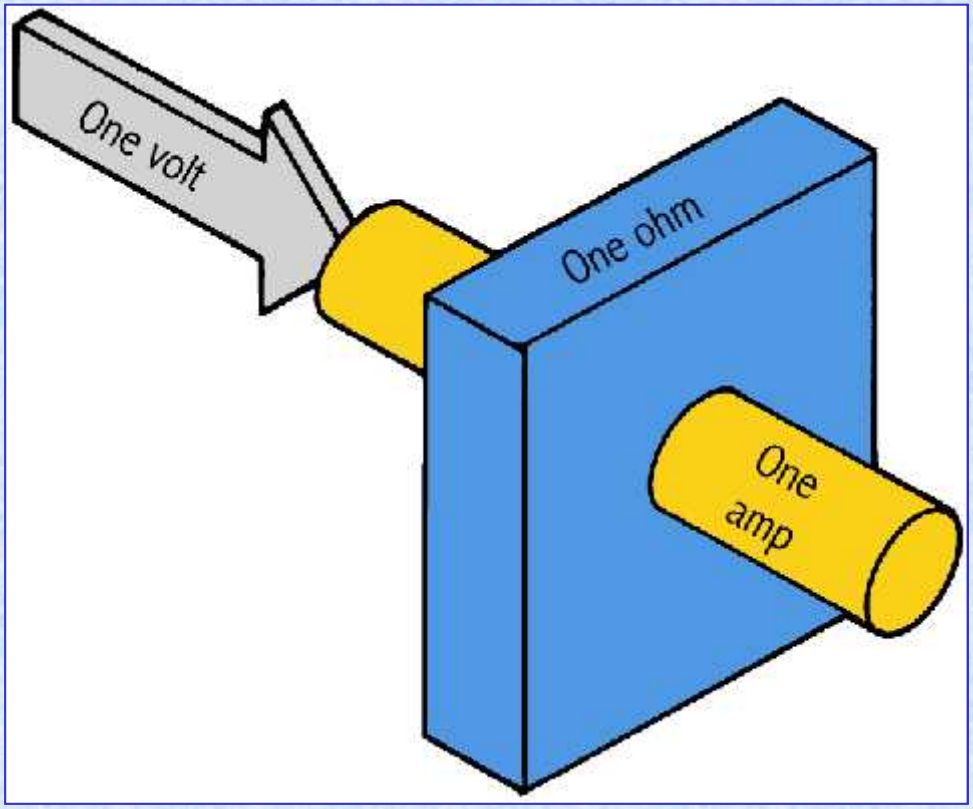
Voltage

- Electrical pressure that causes electron flow
- Measured in Volts
- V or E is the abbreviation for voltage
- Higher voltage increases current flow
- Lower voltage decreases current flow

Resistance

- Opposition to current flow
- Measured in ohms (Ω)
- R is the abbreviation for resistance
- High resistance reduces current
- Low resistance increases current

Current, Voltage, and Resistance

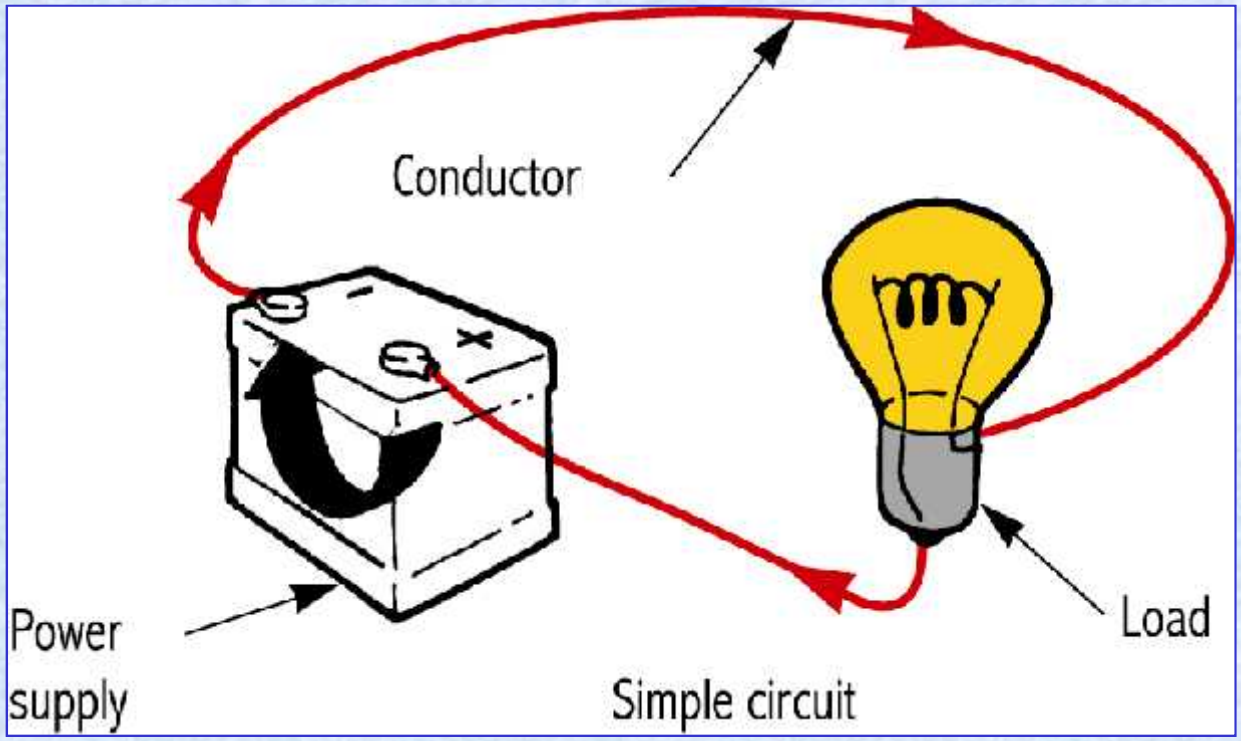


One volt can push one amp of current through one ohm of resistance

Types of Circuits

- A simple circuit consists of the following:
- Power source
  - battery, alternator, or generator
- Load
  - electrical device that uses electricity
- Conductors
  - wires or metal parts that carry current between the power source and load

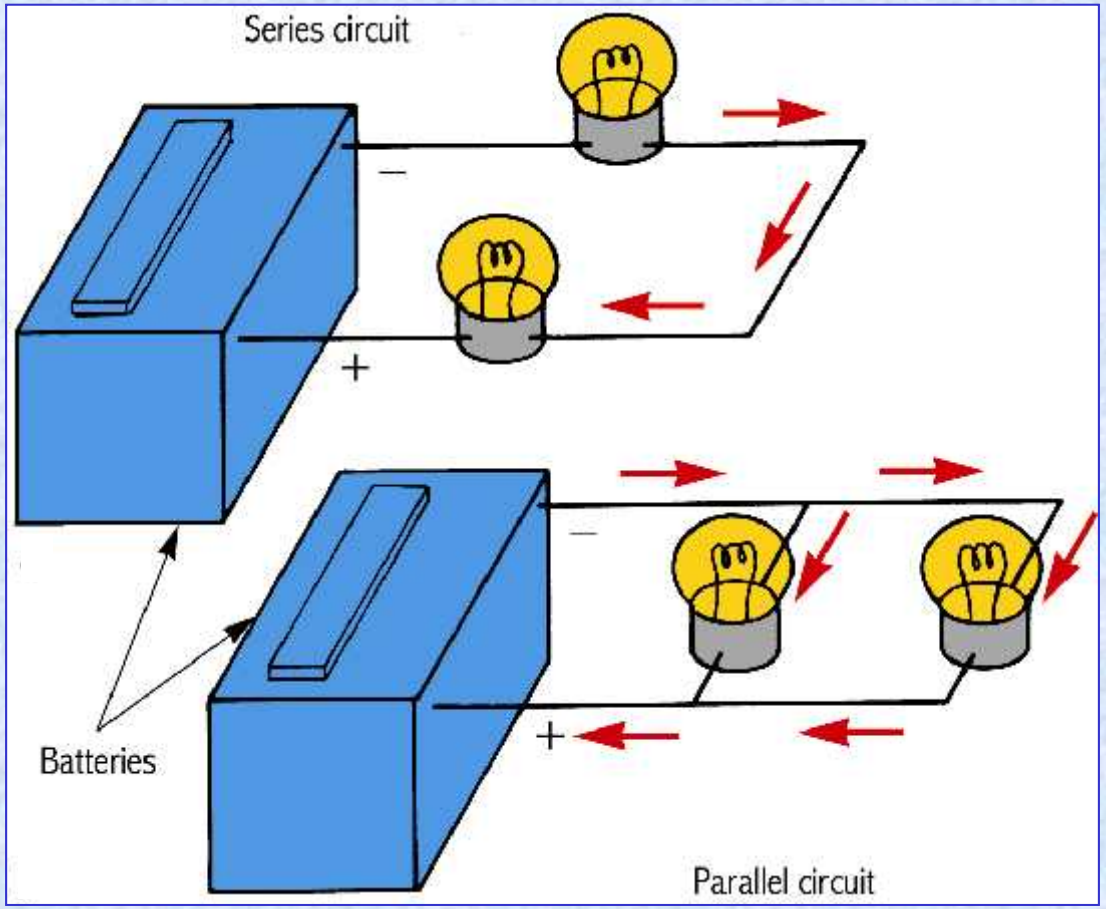
Simple Circuit



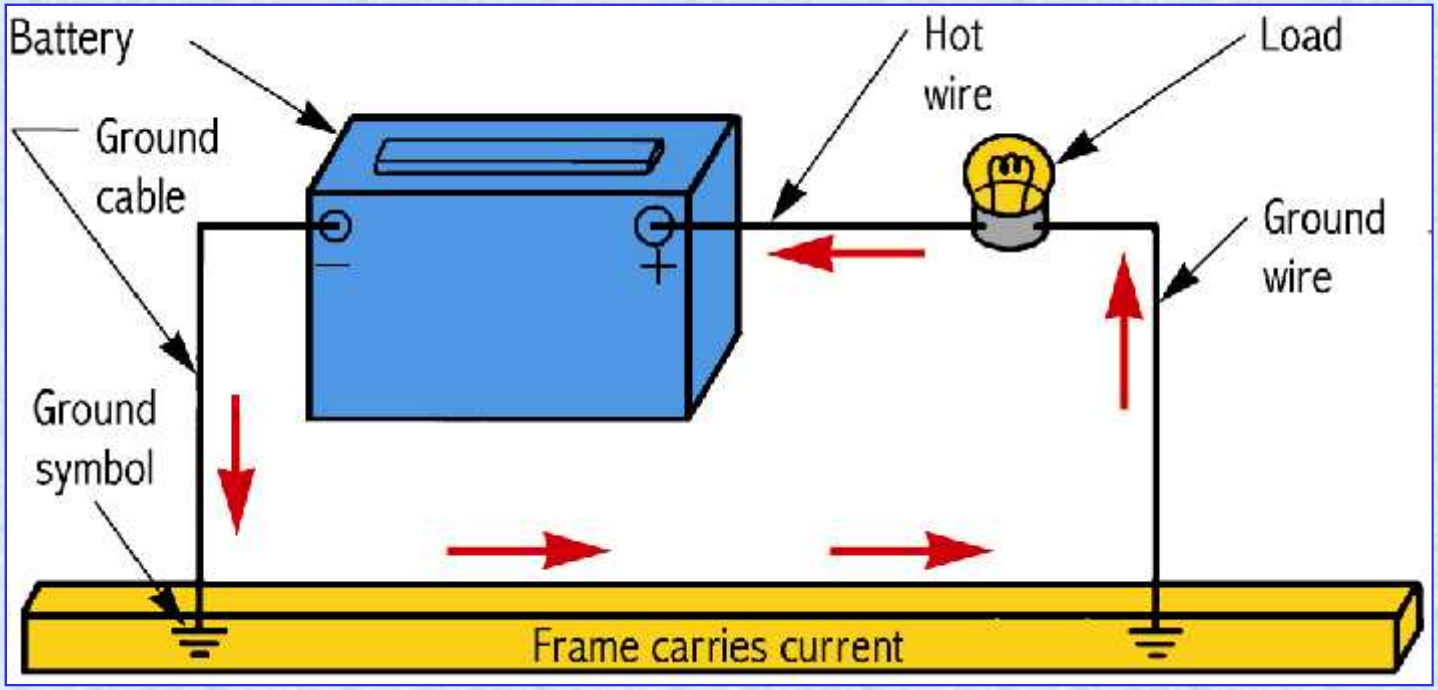
Types of Circuits

- Series circuit
  - has more than one load connected in a single electrical path
- Parallel circuit
  - has more than one electrical path
- Series-parallel circuit
  - contains both a series circuit and a parallel circuit

Series and Parallel Circuits



One-Wire Circuit

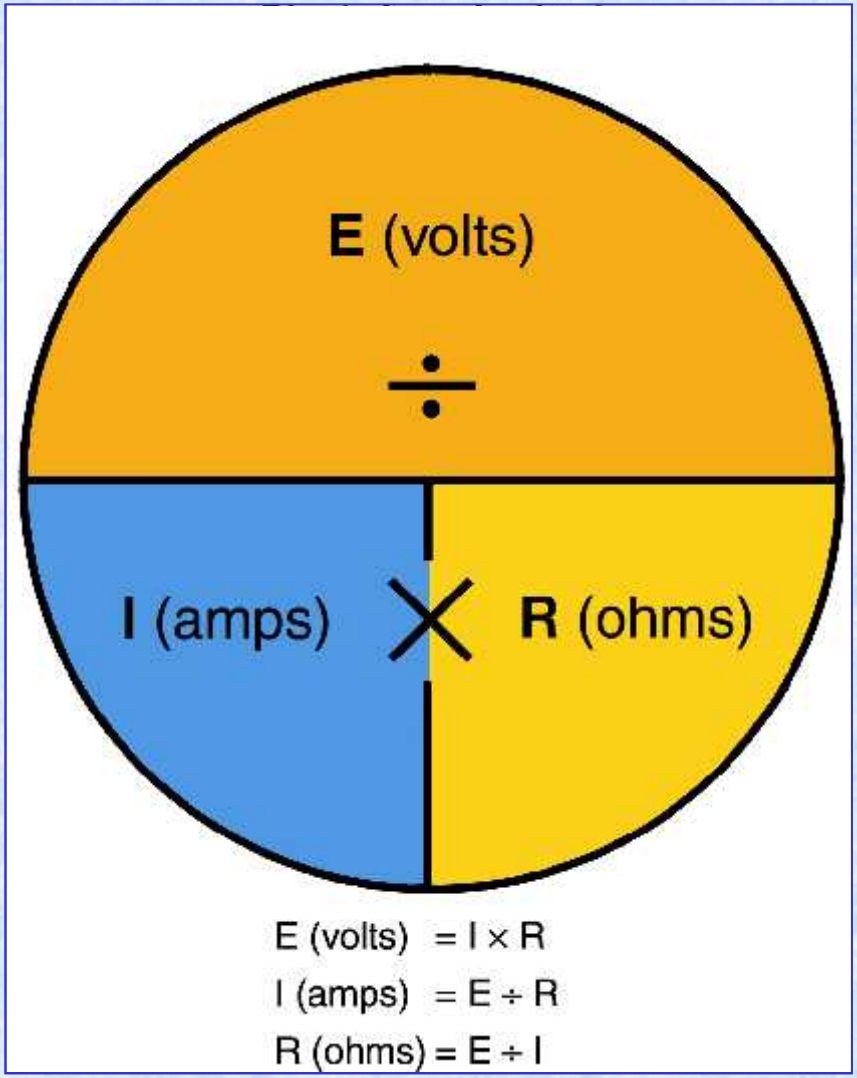


Vehicle's frame or body serves as an electrical conductor

Ohm’s Law

- Formula for calculating voltage, amperage, or resistance when two of the three values are known

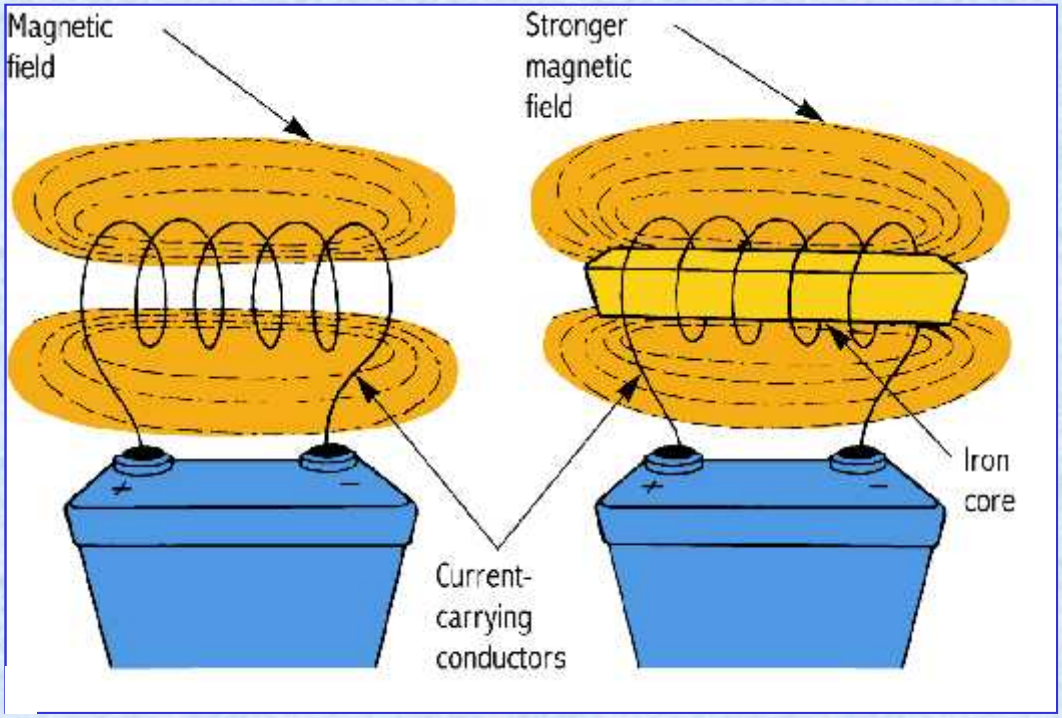
Ohm's Law



Magnetism

- When current flows through a wire, a magnetic field is formed around the wire
- Winding the wire into a coil strengthens the field
- Inserting an iron core strengthens the field even more

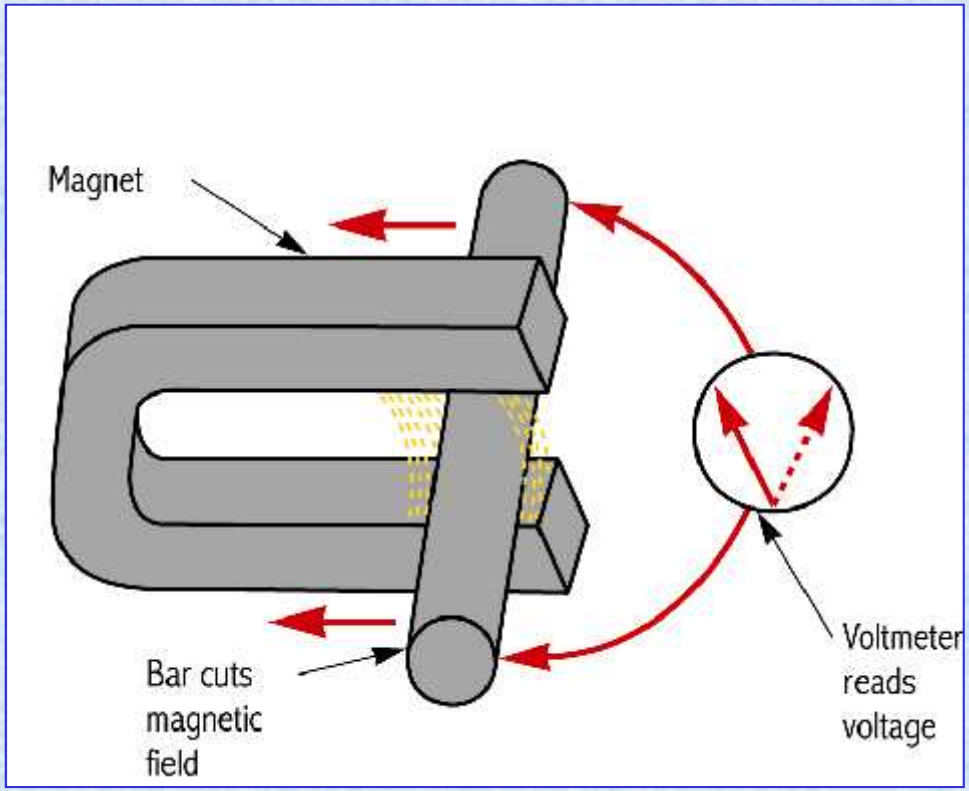
Magnetism



Magnetism

- If a conductor passes through a magnetic field, an electric current will be generated in the conductor
- As the conductor cuts the lines of force, a tiny amount of electricity will flow through the conductor
- This action is called induction

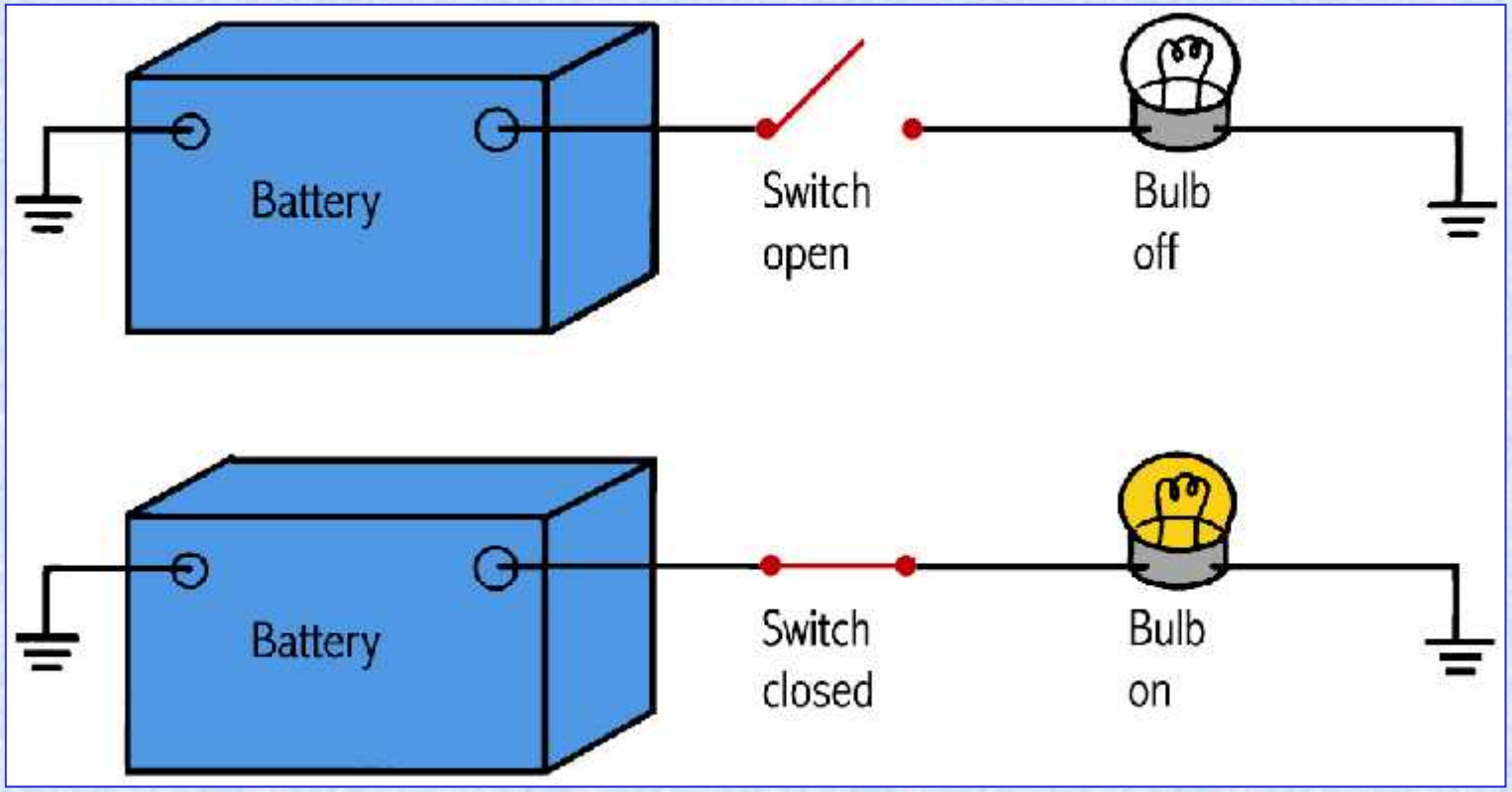
Induction



Switch

- Allows an electric circuit to be turned on or off
- When the switch is closed, the circuit is complete and operates
- When the switch is open, the circuit is broken and does not function

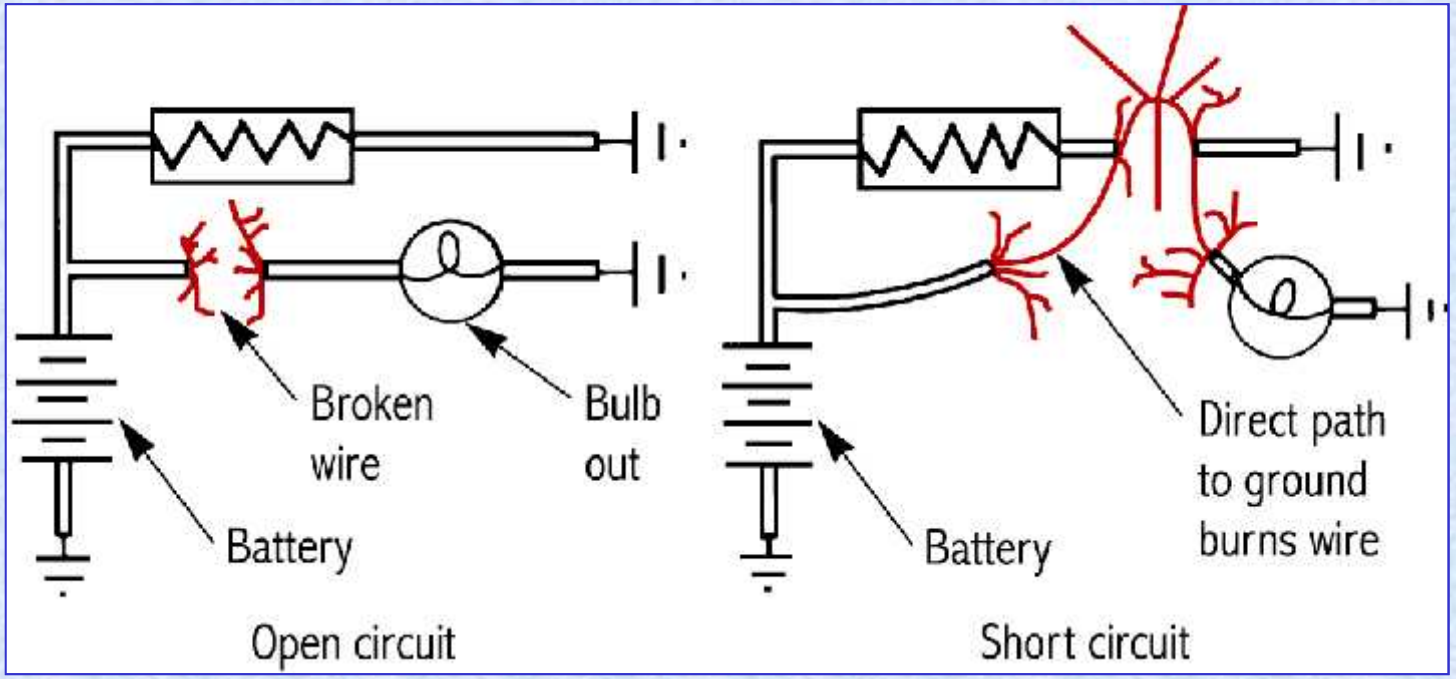
Switch



Short Circuit

- Accidental low-resistance connection that results in excessive current flow
- If a short to ground exists between the battery and load, high current flow can melt and burn the wire insulation

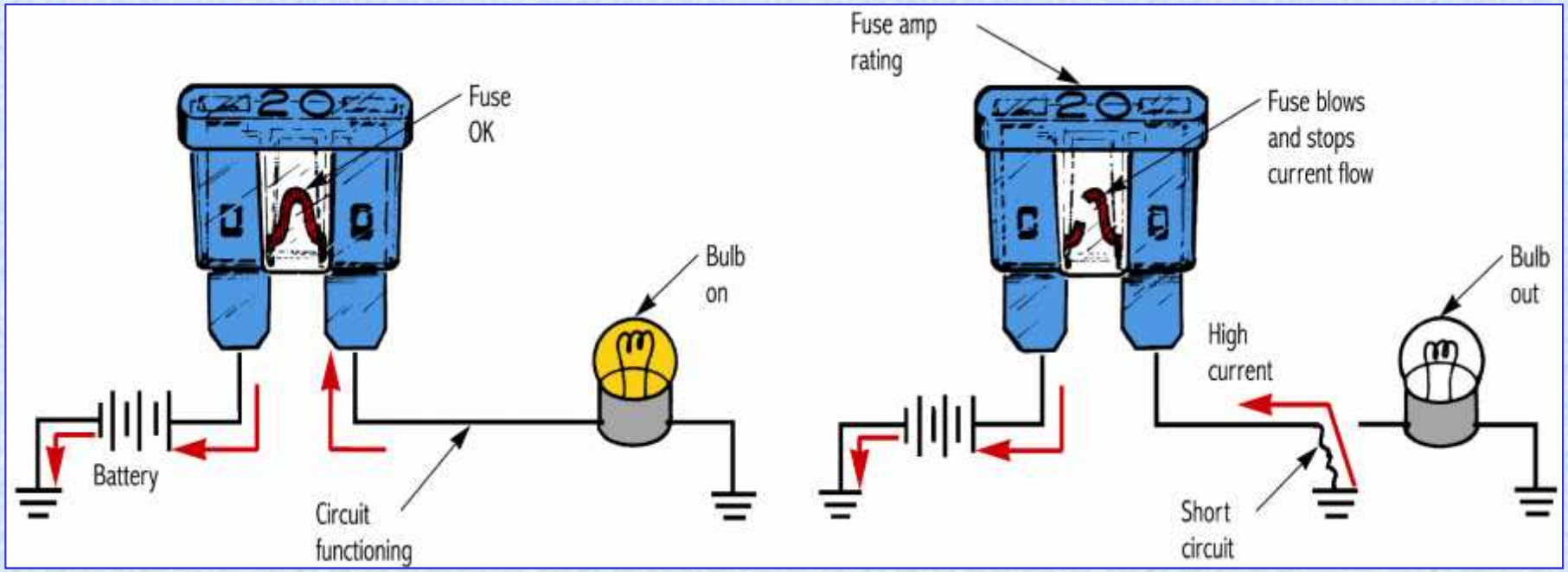
Circuit Faults



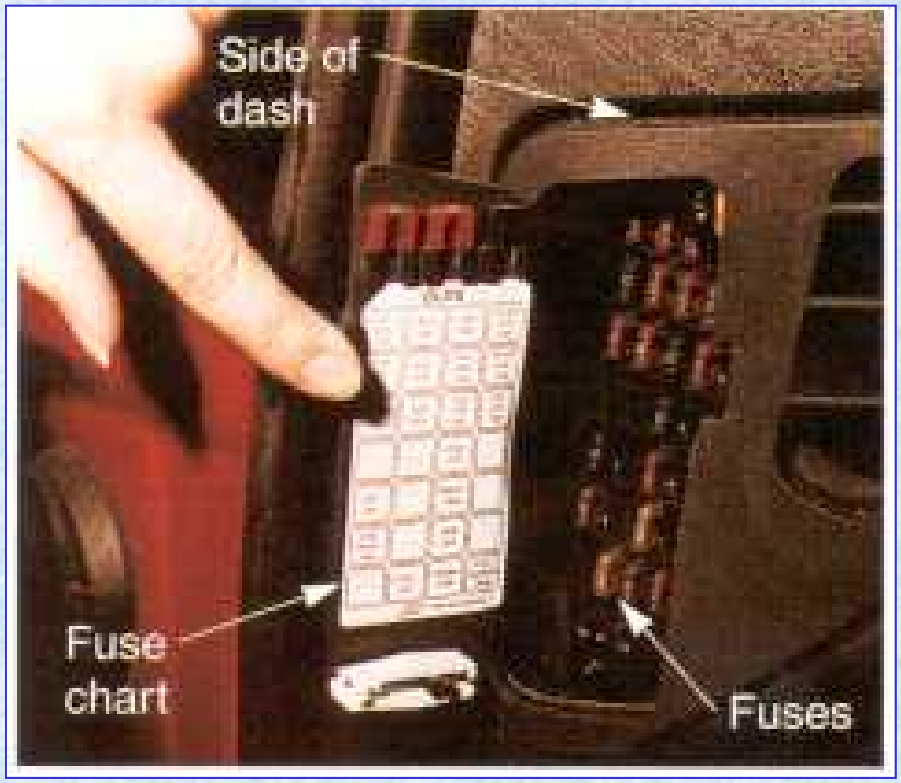
Fuse

- Protects a circuit against damage caused by a short circuit
- High current heats and melts the link, creating an open circuit
- Current stops flowing in the circuit

Fuse



Fuse Box



Contains fuses for various circuits

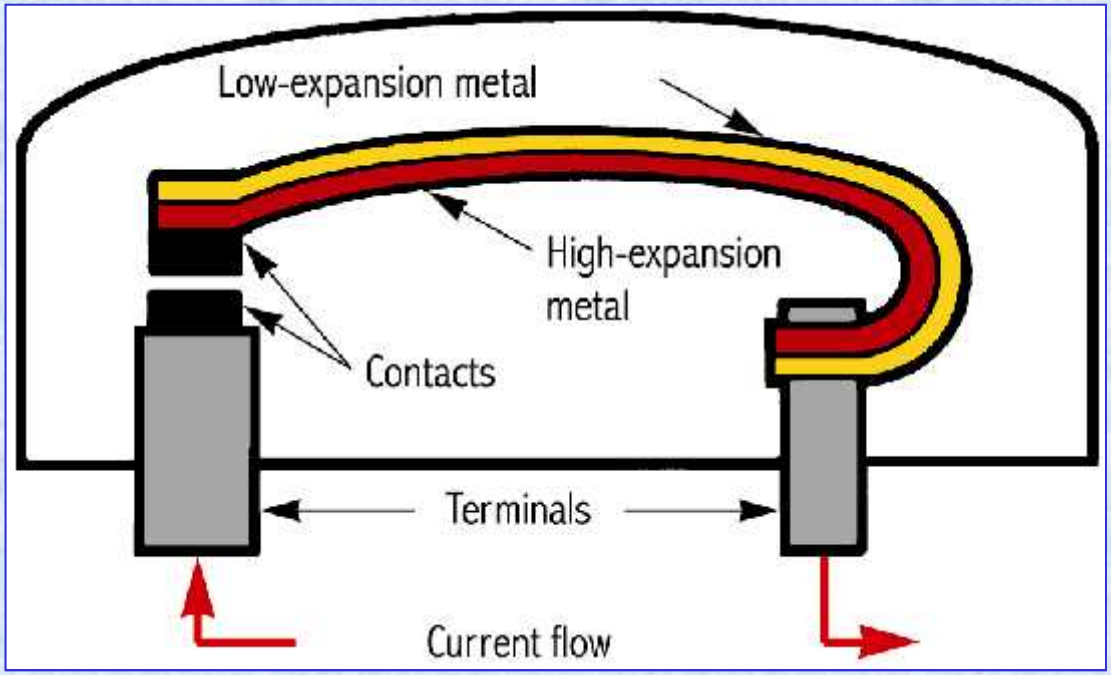
Fusible Link

- Small section of wire designed to burn in half when excess current is present in the circuit
- Often used as protection between the battery and main fuse box
- If a major wire is shorted, the fusible link will burn in half to prevent an electrical fire and further damage

Circuit Breaker

- Performs the same function as a fuse
- Disconnects the power source from the circuit when current becomes too high
- Most breakers will reset when current returns to a normal level

Circuit Breaker

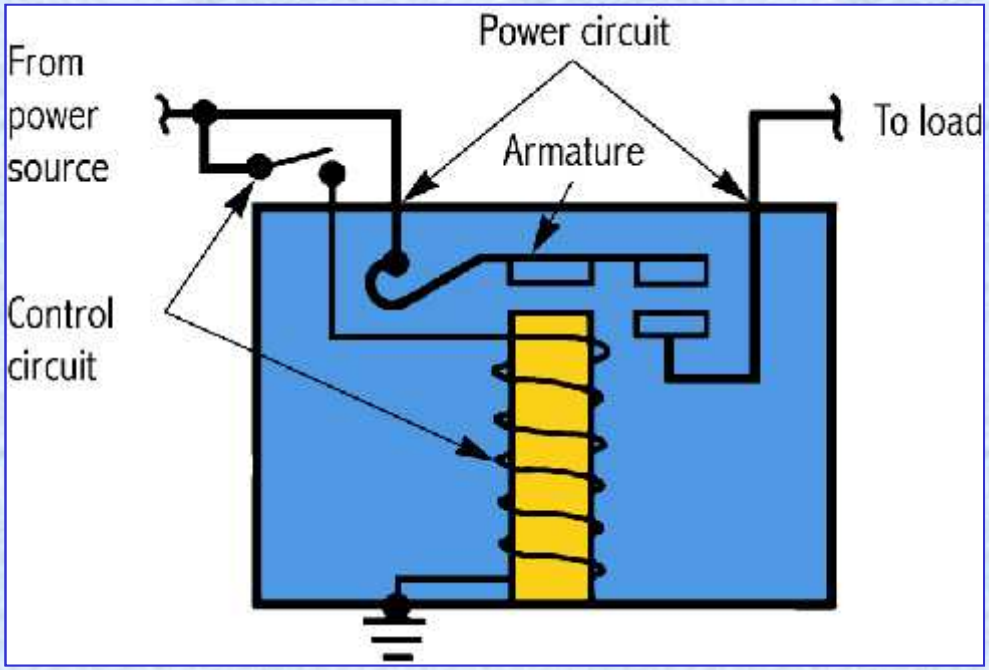


High current heats the bimetal strip, causing it to deform and open the contacts

Relay

- Electrically operated switch
- Allows a small, low-current device, such as a dash switch, to control a high-current circuit from a distant point
- Allows very small wires to be used behind the dash, while large wires may be needed in the relay-operated circuit

Relay



Control circuit current flow creates a magnetic field that pulls the points closed

Automotive Electronics

- In electronic systems, the components are solid state and do not have moving parts
- Solid state circuits use semiconductors

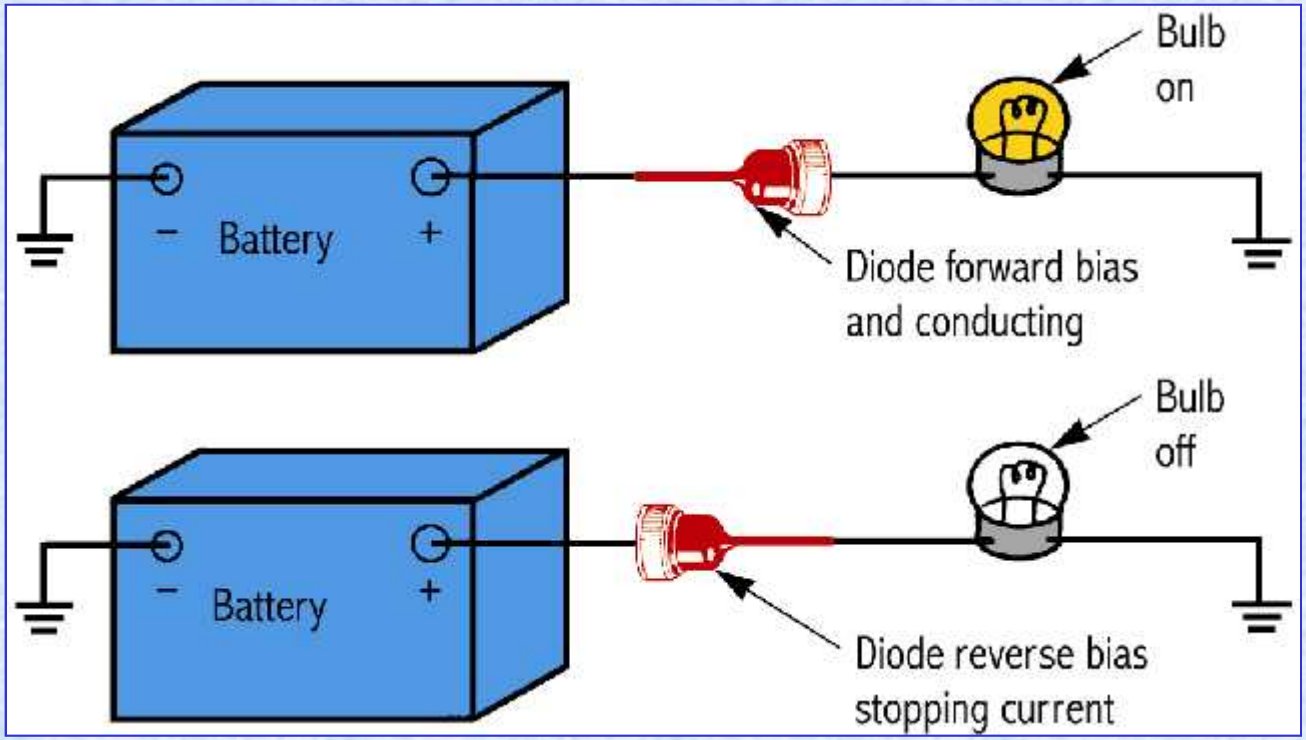
Semiconductor

- Substance capable of acting as both a conductor and an insulator
  - this enables semiconductor devices to control current without mechanical points
- Semiconductor devices include:
  - diodes
  - transistors
  - integrated circuits

Diode

- An “electronic check valve” that allows current to flow in only one direction
  - when a diode is forward biased, it acts as a conductor
  - when a diode is reverse biased, it acts as an insulator

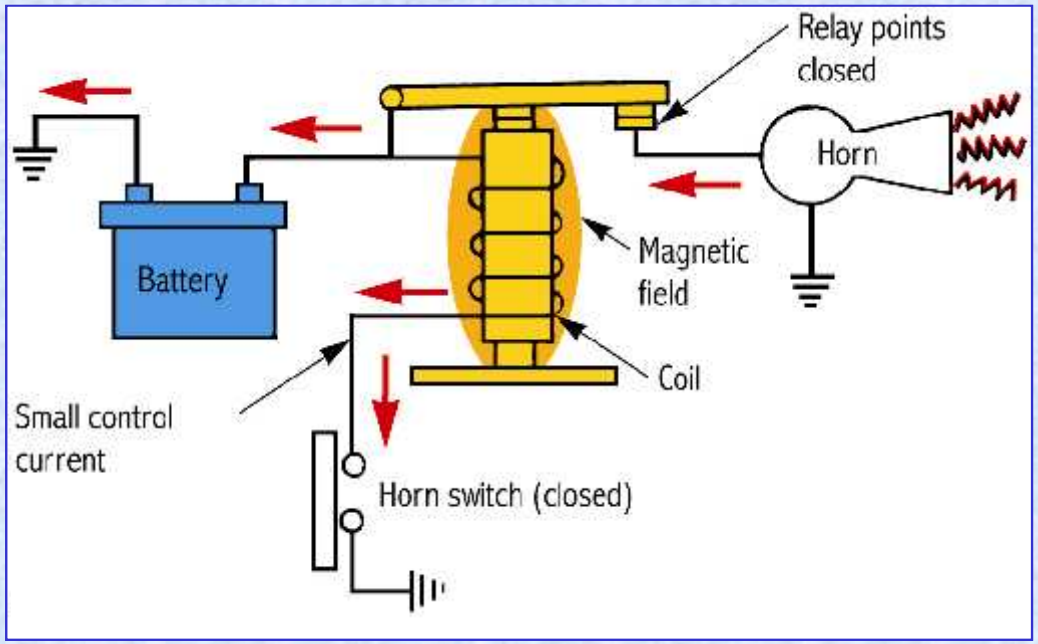
Diode Operation



Transistor

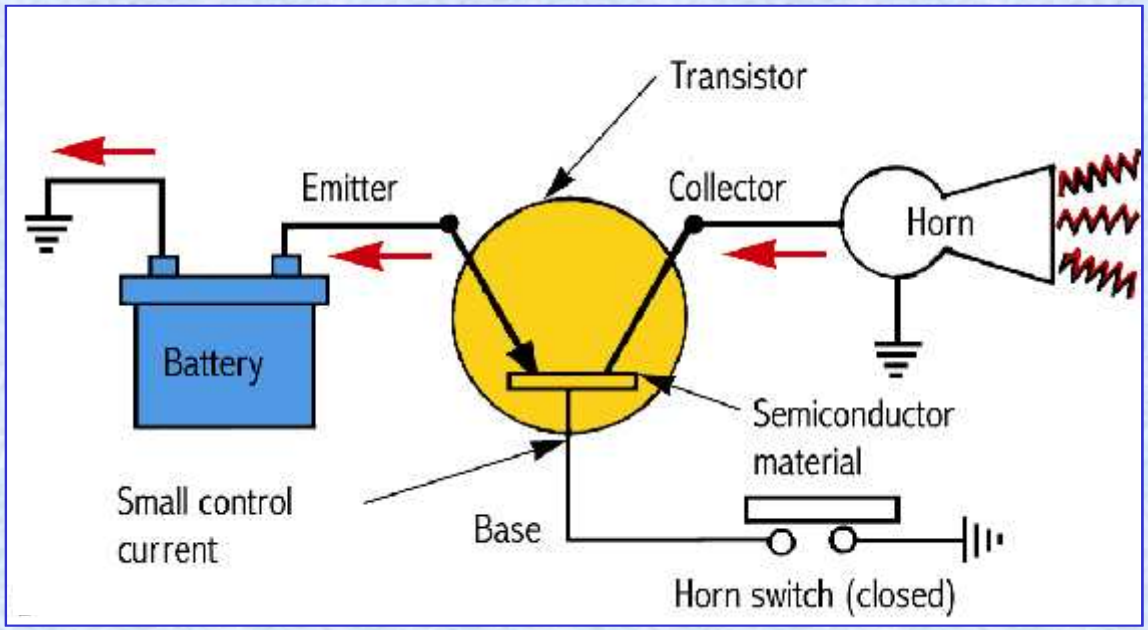
- Allows the control of a high current circuit with a low current circuit
  - performs the same basic function as a relay
- Acts as a remote switch or current amplifier
- Operates more quickly than a mechanical device can
- Has no moving parts to wear or deteriorate

Transistor versus Relay



Relay operation

Transistor versus Relay



Transistor operation

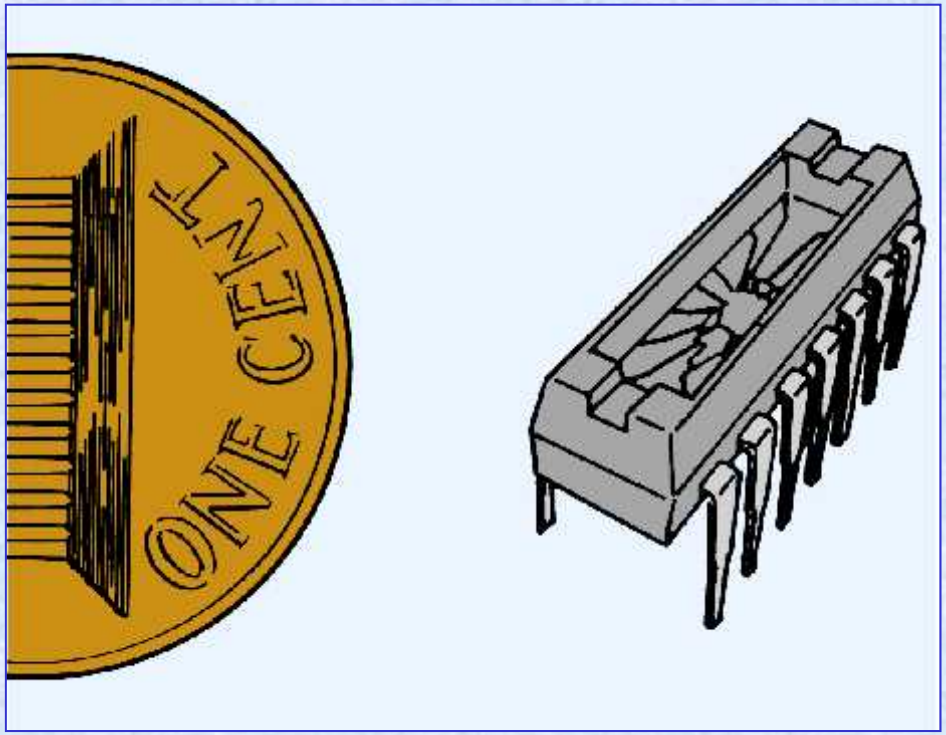
Transistor Operation

- Small base current energizes the semiconductor material, changing it from an insulator to a conductor
- Higher current can pass through the collector and emitter terminals

Capacitors

- Devices used to absorb unwanted electrical pulses, such as voltage fluctuations
- Used in various types of electrical and electronic circuits
- Connected to the supply wires for the car radio
  - absorbs alternator or ignition system “noise” that may be heard in the speakers

Integrated Circuit (IC)

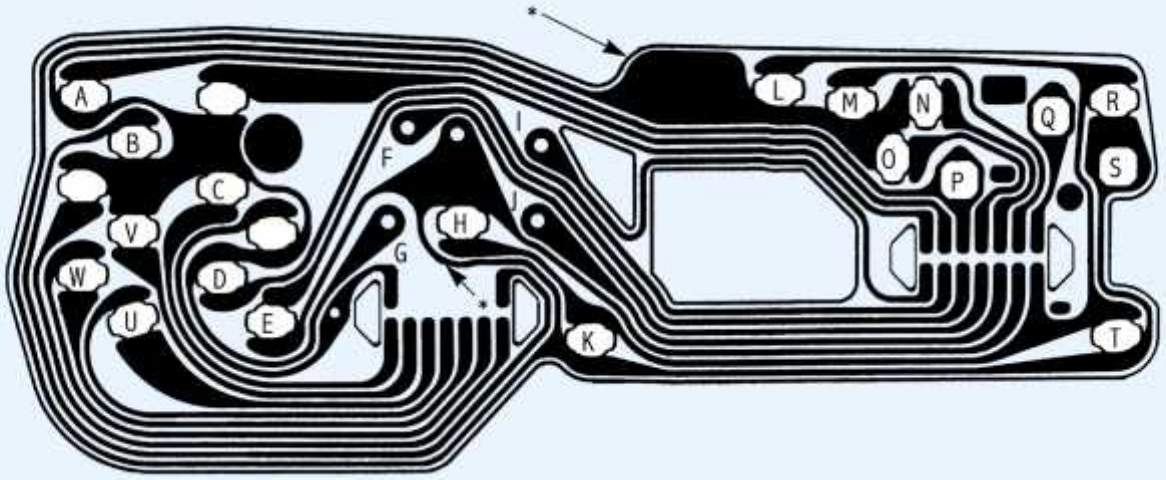


Contains microscopic diodes, transistors, resistors, and capacitors in a wafer-like chip

Printed Circuit

- Uses flat conductor strips mounted on an insulating board
- Reduces weight and bulk by replacing separate wires

Instrument Panel Printed Circuit



A = Generator
B = Low fuel
C = Fasten seat belts
D = Brake
E = Fasten seat belts
F = Oil pressure gauge
G = Voltmeter
H = Panel light
I = Temperature gauge
J = Fuel gauge
K = Panel light
L = Panel light
M = Right turn indicator
N = Left turn indicator
O = Hi beam indicator
P = 12V (IGN)
Q = Tachometer
R = Panel light
S = Ground
T = Panel light
U = Lights on
V = Wait
W = Start
*Ground foil

Amplifier

- Electronic circuit designed to use a very small current to control a very large current
- Ignition control module is an amplifier
  - uses small electrical pulses from the distributor to produce strong on/off cycles to operate the ignition coil

Automotive Wiring

An automobile uses various types of wiring in its many electrical systems

Wire Size

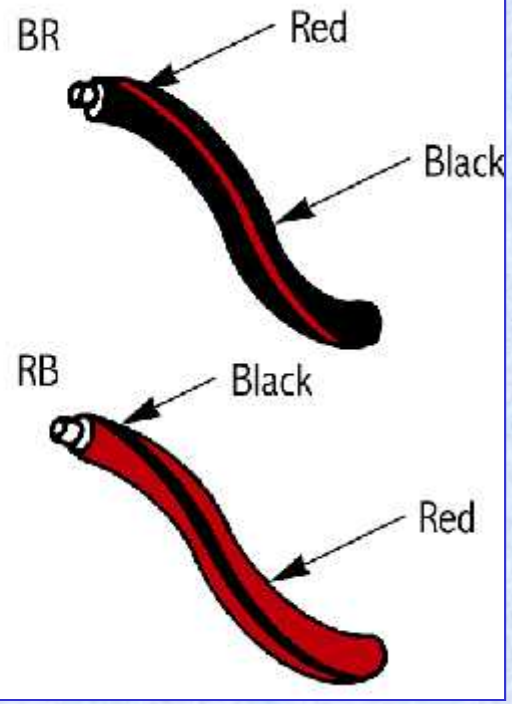
- Determined by the diameter of the wire's metal conductor
- Stated in a relative numbering system called gauge size
- Wires become smaller as gauge numbers increase
- When replacing a wire, always use wire of equal size
  - a smaller wire could overheat

Primary Wire

- Carries battery or alternator voltage
- Uses thin plastic insulation
- The insulation is color-coded for easy troubleshooting

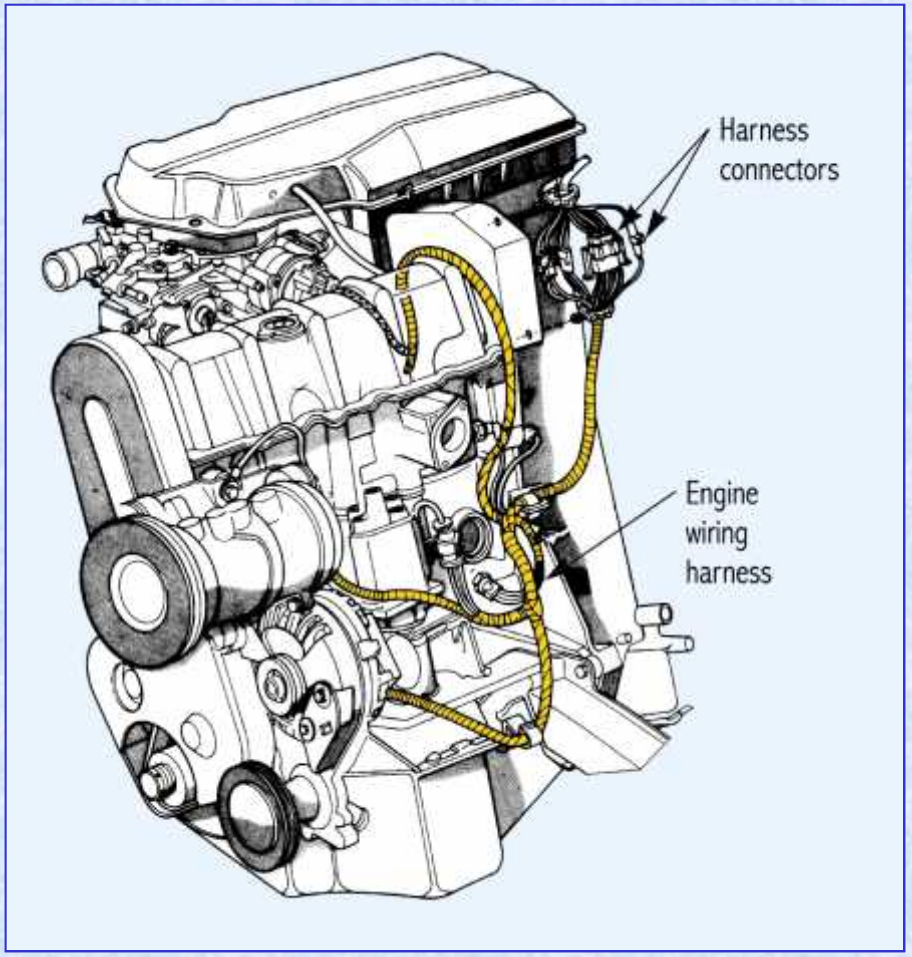
Wire Color-Coding

Code	Color
B	Black
Br	Brown
G	Green
Gy	Gray
L	Blue
Lb	Light blue
Lg	Light green
O	Orange
R	Red
W	White
Y	Yellow



Wiring Harness

A group of wires enclosed in a plastic or tape covering that helps protect and organize the wires



Secondary Wire

- Used in a vehicle's ignition system for spark plug or coil wires
- Extra thick insulation prevents high voltage from short circuiting
- Core may be a metal conductor or a carbon-impregnated cord

Battery Cable

- Extremely large-gauge wire capable of carrying high current from the battery to the starting motor
- Current flow is often well over 100 amperes

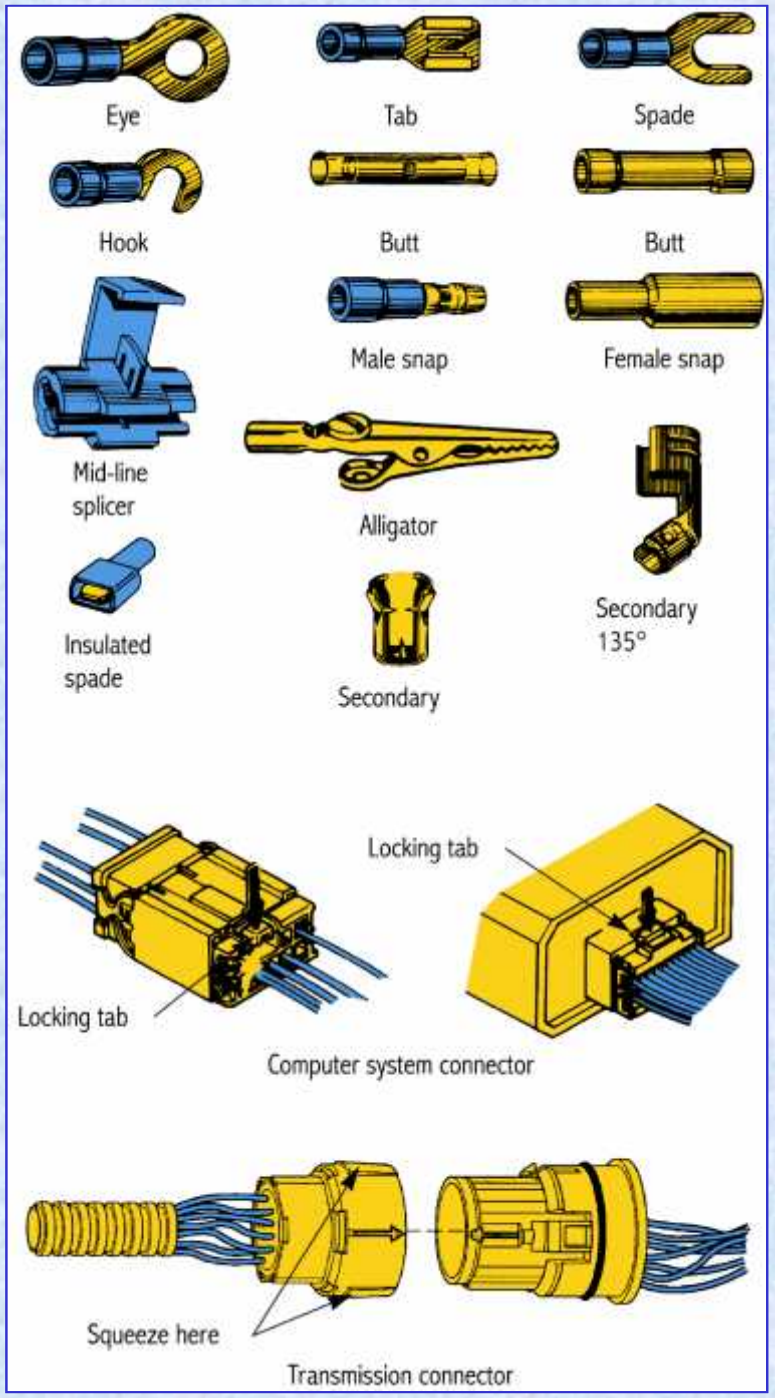
Ground Wires (Straps)

- Connect electrical components to the chassis or ground of the car
- Insulation may not be used on these wires

Wiring Repairs

- Crimp connectors and terminals
  - used to quickly repair wiring
  - allow a wire to be connected to another wire or component
- Harness connectors
  - multi-wire terminals that connect several wires together
  - two-part plastic housing snaps together

Wire Terminals and Connectors



Crimping Pliers

Stripping off a short section of insulation

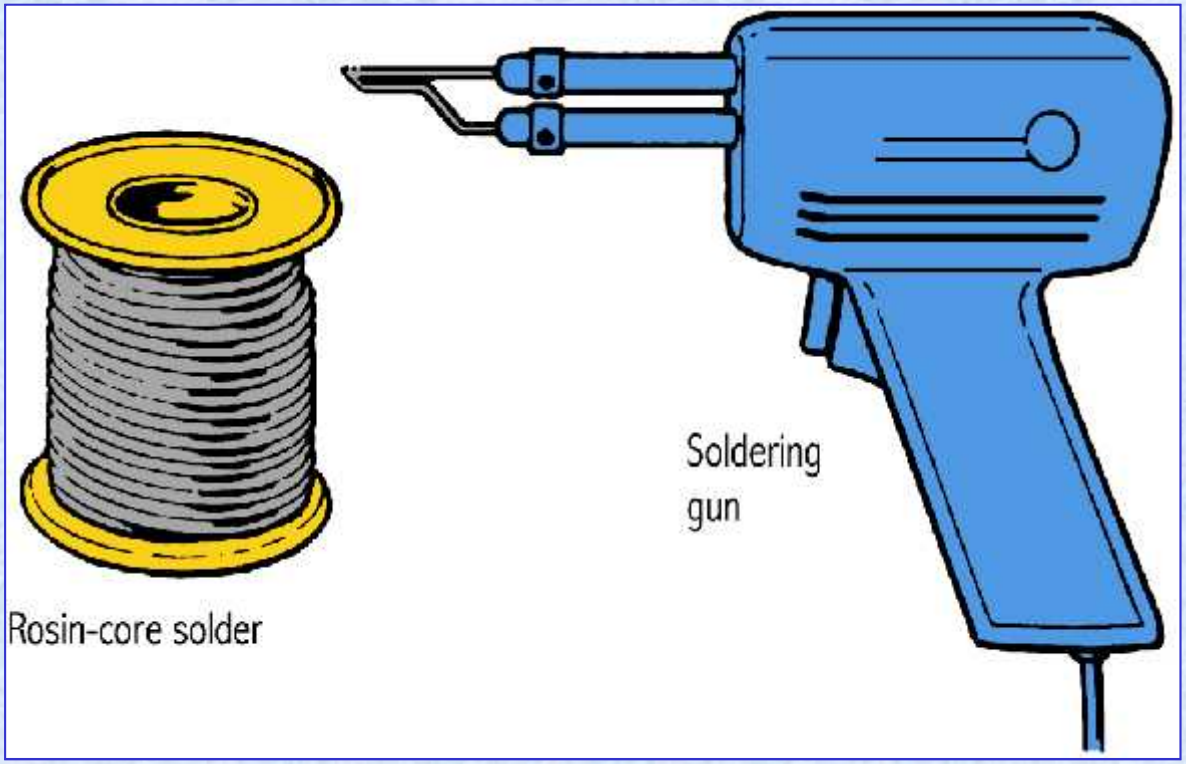
Crimping Pliers

The crimping jaw was used to form this connector around the wire

Soldering

- Used to permanently fasten wires to terminals or to other wires
- To solder wires:
  - touch the hot soldering gun to the wire and component to preheat them
  - touch the solder to the joint until it melts and flows as desired
  - hold the joint steady until the solder cools

Soldering



Use rosin-core solder on electrical repairs

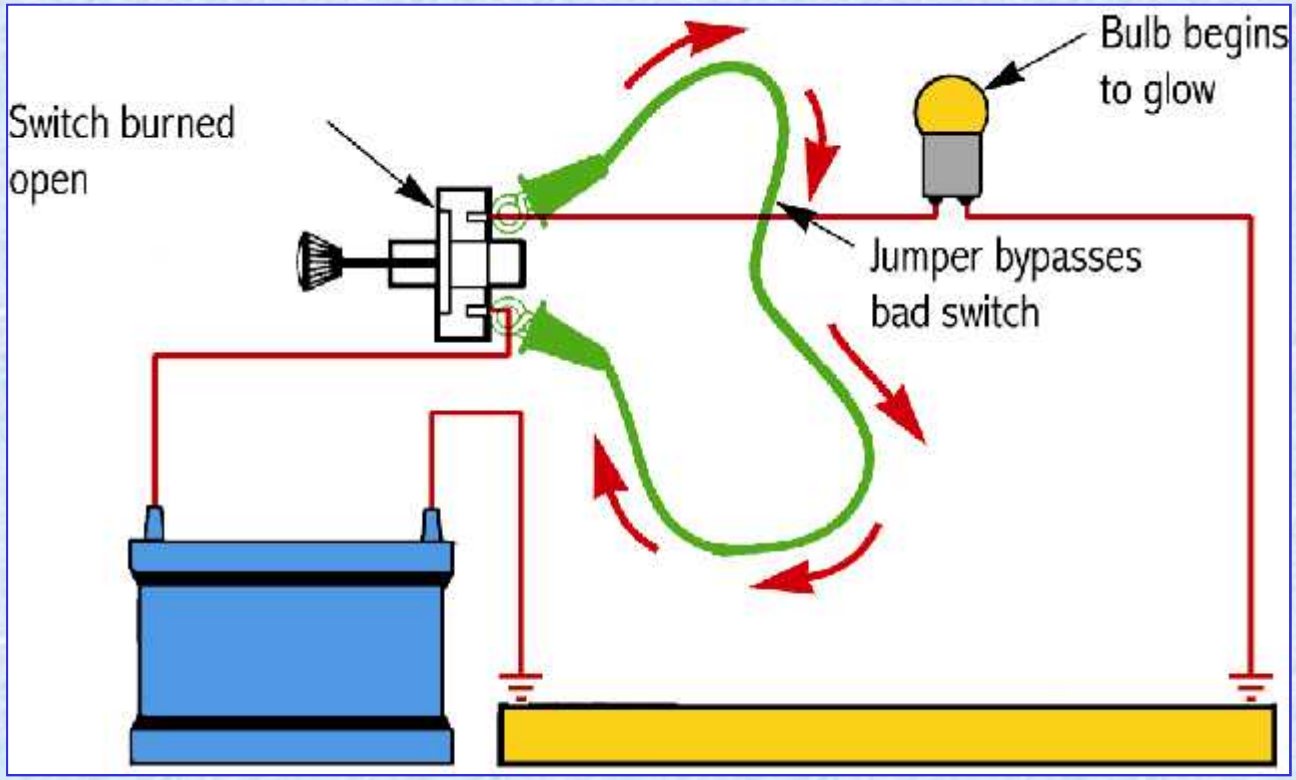
Basic Electrical Tests

Various electrical tests and testing devices are used by an automotive technician

Jumper Wire

- Handy for testing switches, relays, solenoids, wires, and other components
- Jumper can be substituted for a component such as a switch
  - if the circuit begins to function with the jumper in place, the component being bypassed is defective

Jumper Wire



Test Light

- Used to quickly check a circuit for power
- To use a test light:
  - connect the alligator clip to ground
  - touch the pointed tip to the test point in the circuit
  - if power is present, the light will illuminate

Test Light

Checking a fuse with a test light

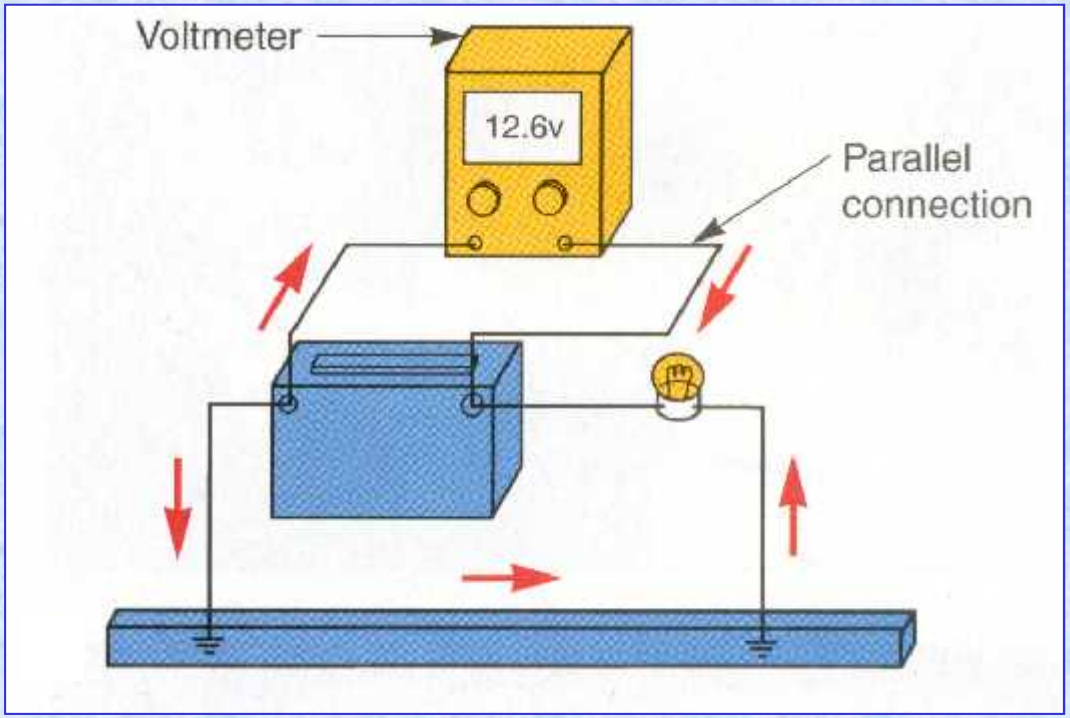
Self-Powered Test Light

- Used to check for a complete electrical path
- To use a self-powered test light:
  - disconnect the circuit power source
  - connect the test light leads across the desired part of the circuit
  - if the light illuminates, the circuit or part has continuity

Voltmeter

- Used to measure the amount of voltage in a circuit
- Connected in parallel with the circuit
- Voltmeter reading can be compared to specifications to determine whether an electrical problem exists

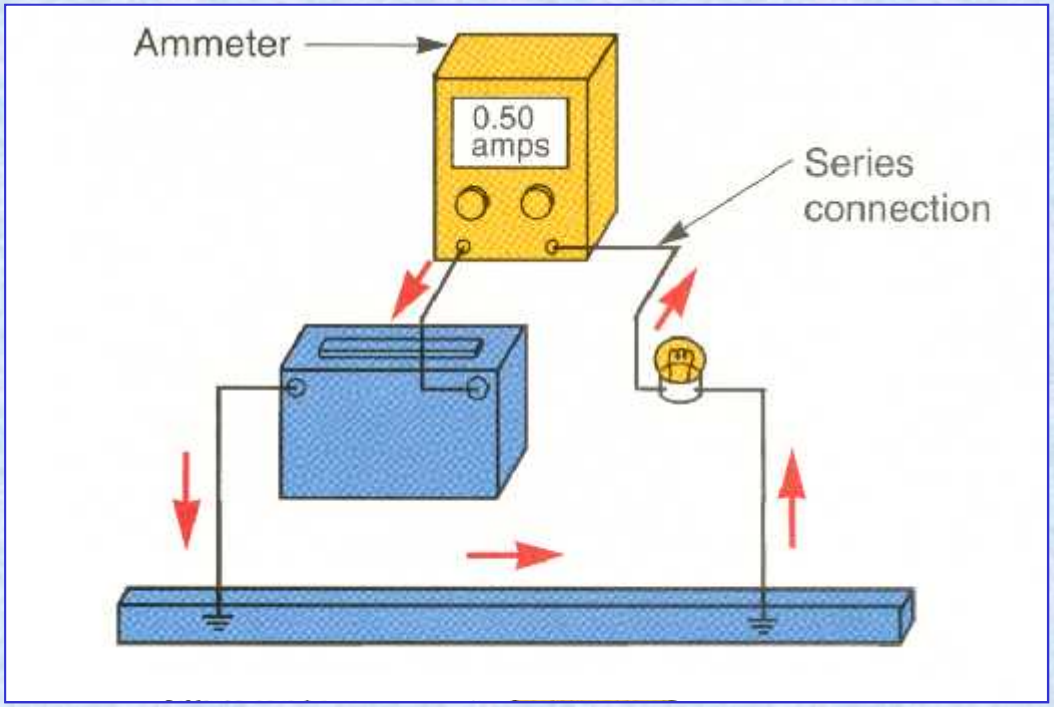
Voltmeter Connections



Ammeter

- Measures the amount of current in a circuit
- Connected in series with the circuit
- All the current in the circuit must pass through a conventional ammeter
- Inductive ammeters have a special pickup that is clamped around the wire
  - uses the magnetic field around the wire to determine the amount of current in the wire

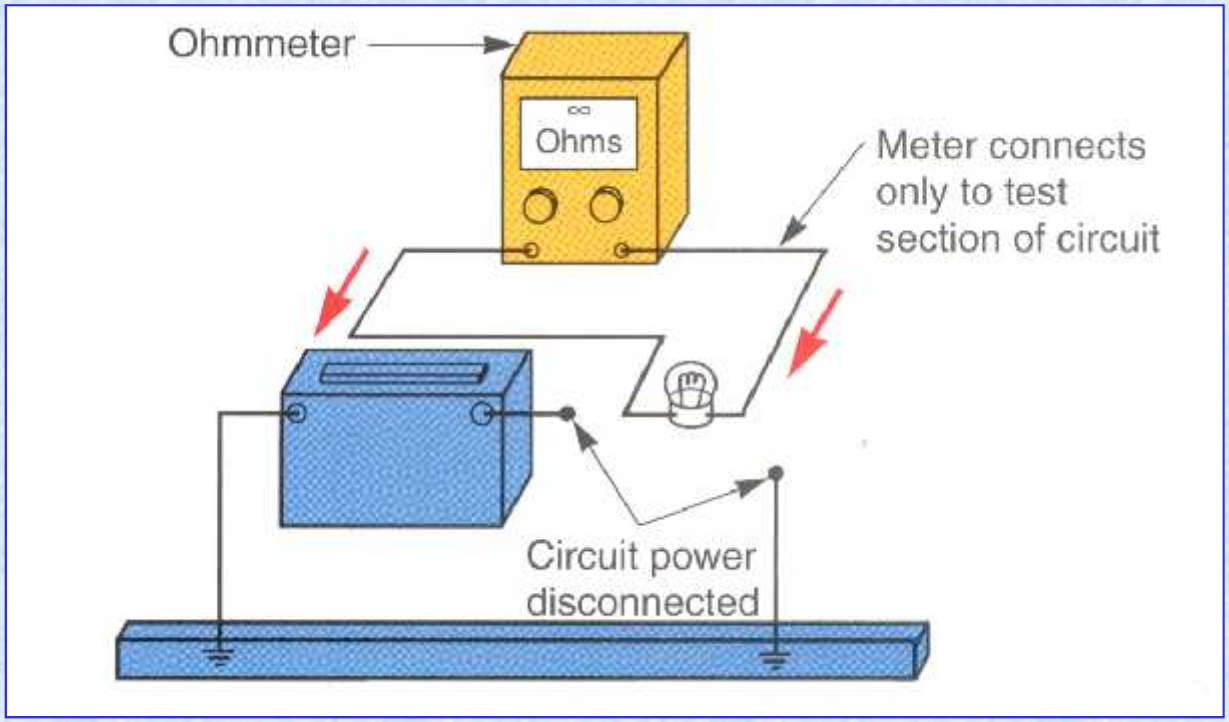
Ammeter Connections



Ohmmeter

- Measures the amount of resistance in ohms in a circuit or component
- Connected in parallel with the wire or component being tested
- Wire or component being tested must be disconnected from power
- Ohmmeter reading can be compared to specifications to determine if a part is defective

Ohmmeter Connections



Multimeter

Also called a VOM—combines an ohmmeter, ammeter, and voltmeter in one case

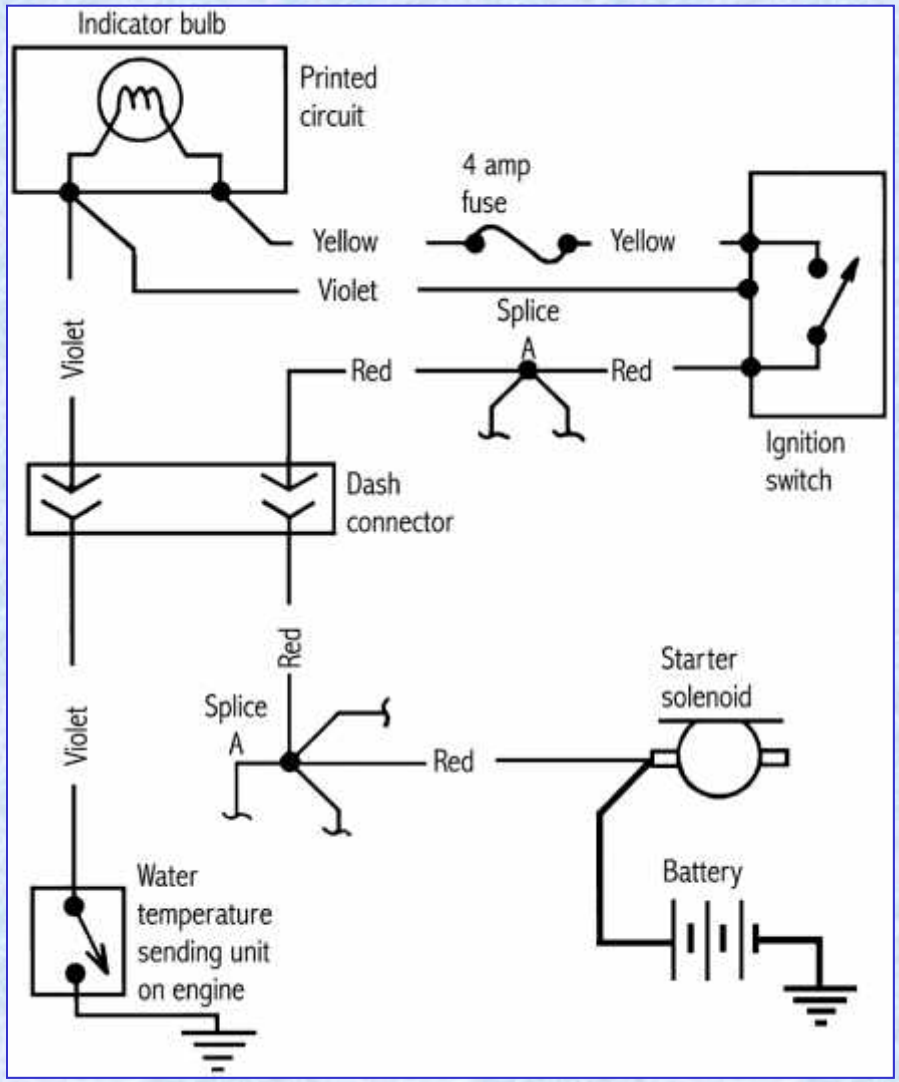
Multimeter

Digital display on a modern multimeter

Wiring Diagram

- Shows how electrical components are connected by wires
- Serves as an electrical map to help the technician with difficult electrical repairs
- Symbols represent the electrical components in a circuit
- Lines represent the wires

Wiring Diagram



Oscilloscope

- Electronic measuring instrument that displays voltage as a trace on the screen
- Waveforms are created that represent voltage variations over time
- Excellent tool for advanced diagnostics on computer inputs and outputs

Oscilloscope

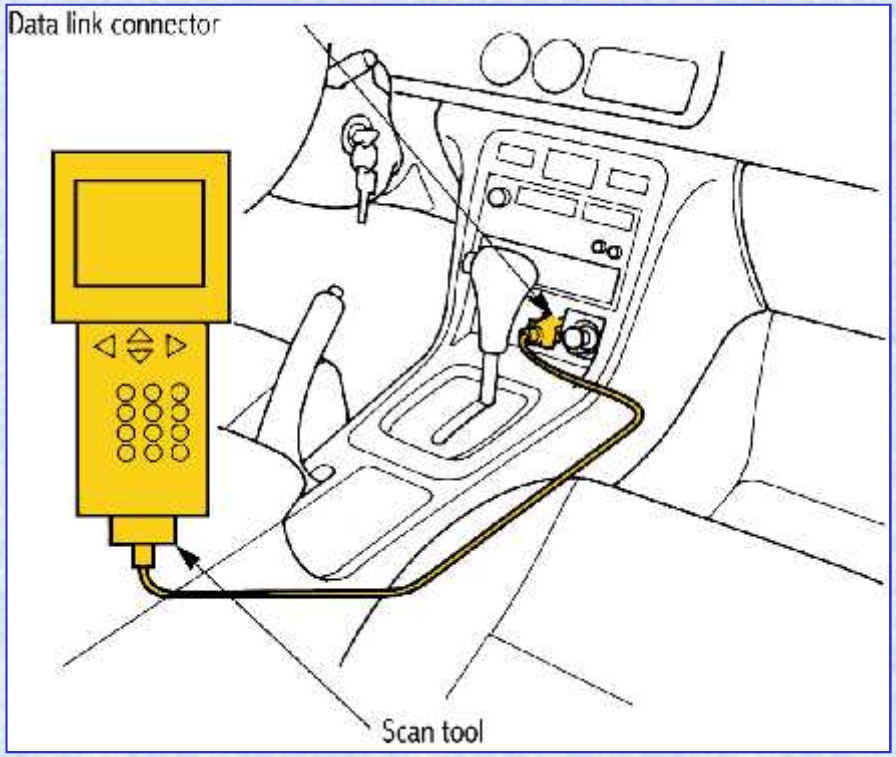
Dual trace scopes can read and show two separate waveforms simultaneously

Scan Tools

- Diagnostic tools that help find and diagnose vehicle problems
- Plug into the vehicle's diagnostic connector
- Communicate with the vehicle's control modules to read diagnostic trouble codes, display input and output data, and perform special tests

Scan Tool Kit

Scan Tool Connection



Power, ground, and communication lines are all provided in this data link connector