

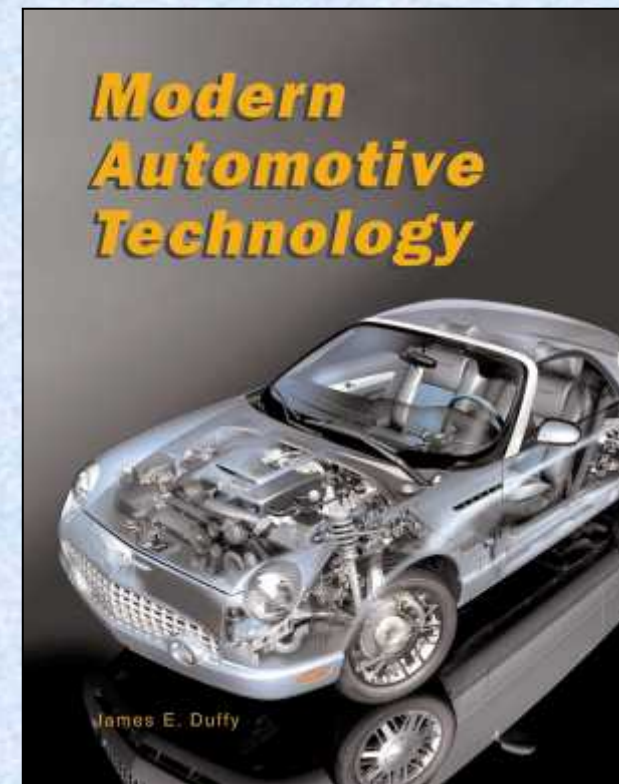
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# Modern Automotive Technology

by  
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# **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

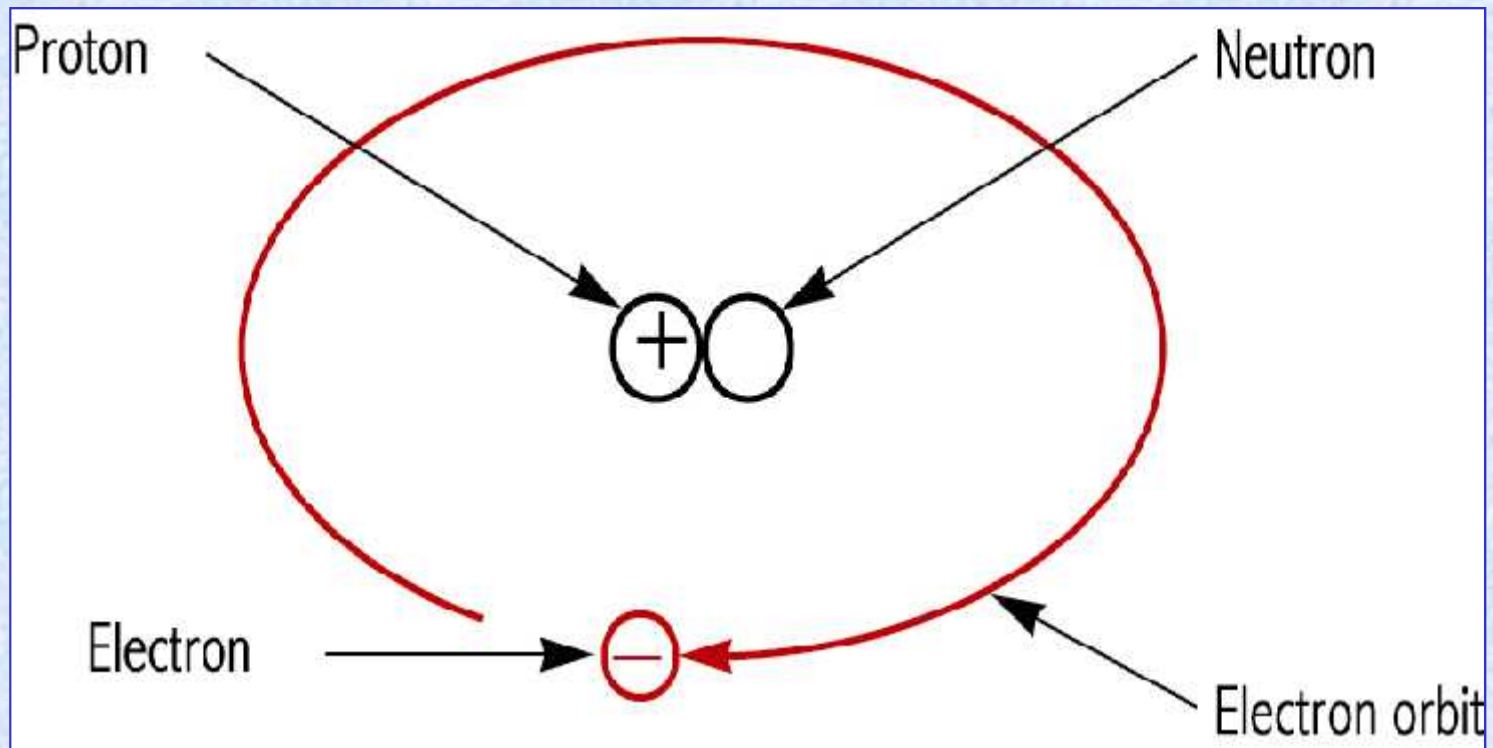
- ❑ All substances are made of matter
- ❑ Matter is anything that has mass and occupies space
- ❑ All matter is made from about 100 types of atoms

# 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

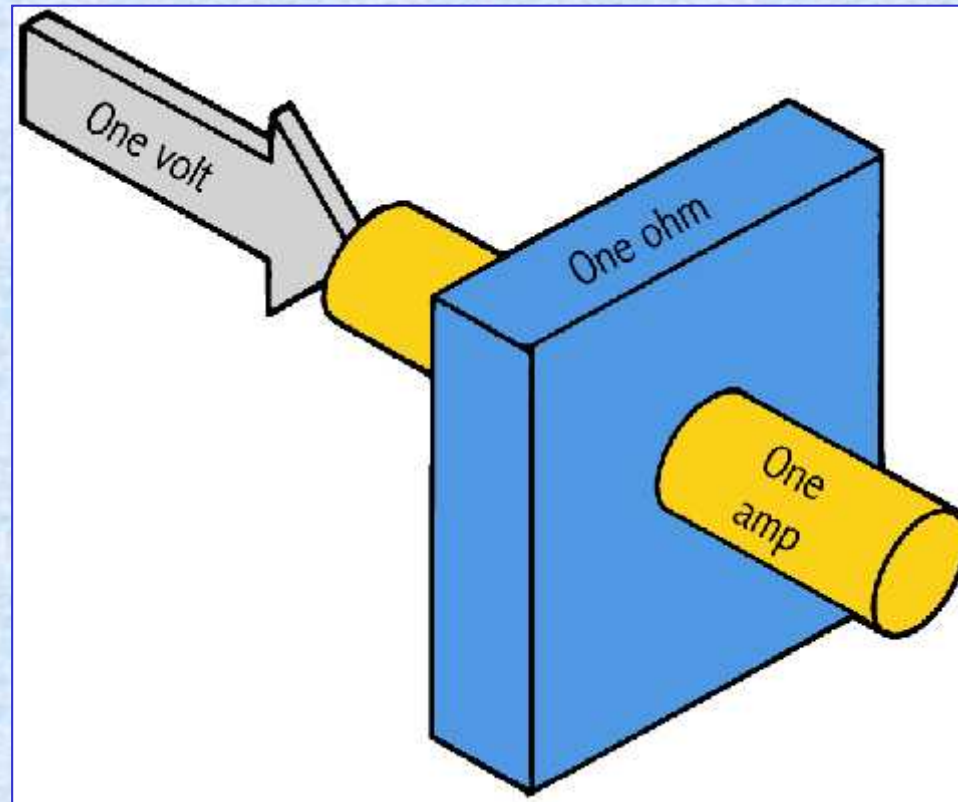
- ❑ Electrical pressure that causes electron flow
- ❑ Measured in Volts
- ❑ V or E is the abbreviation for voltage
- ❑ Higher voltage increases current flow
- ❑ Lower voltage decreases current flow



# Resistance

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

# Current, Voltage, and Resistance



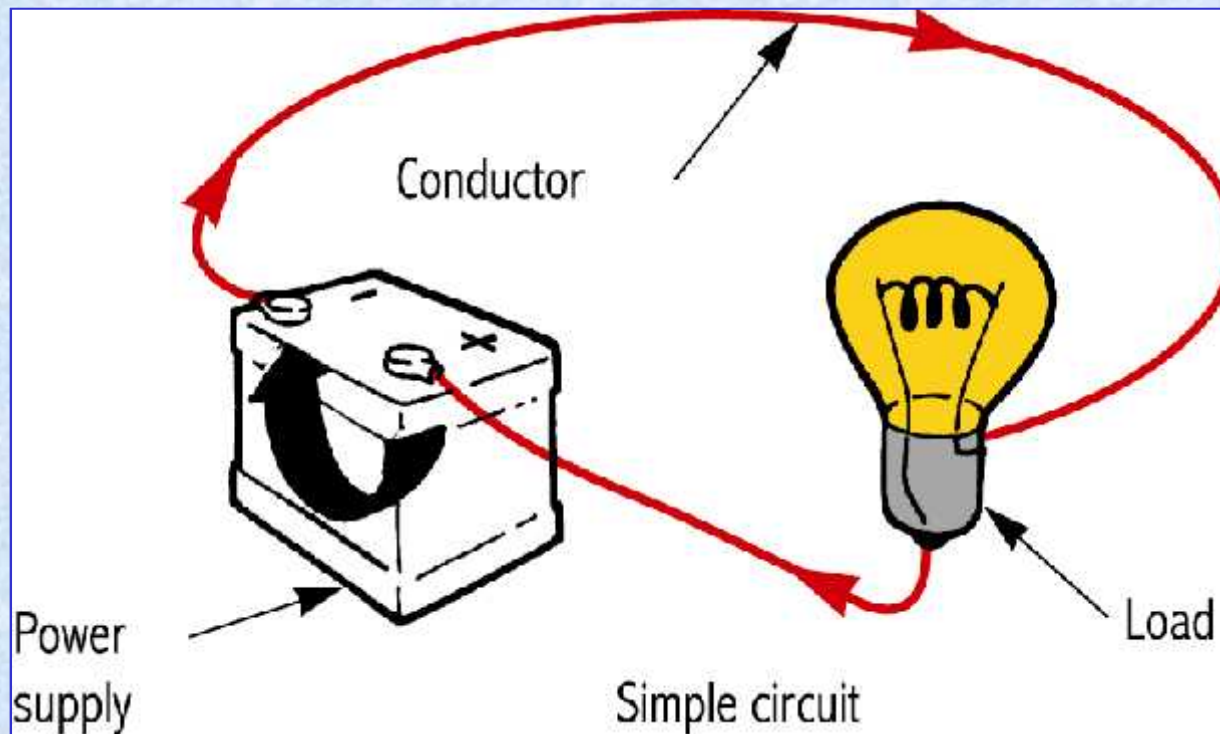
One volt can push one amp of current through one ohm of resistance



# 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

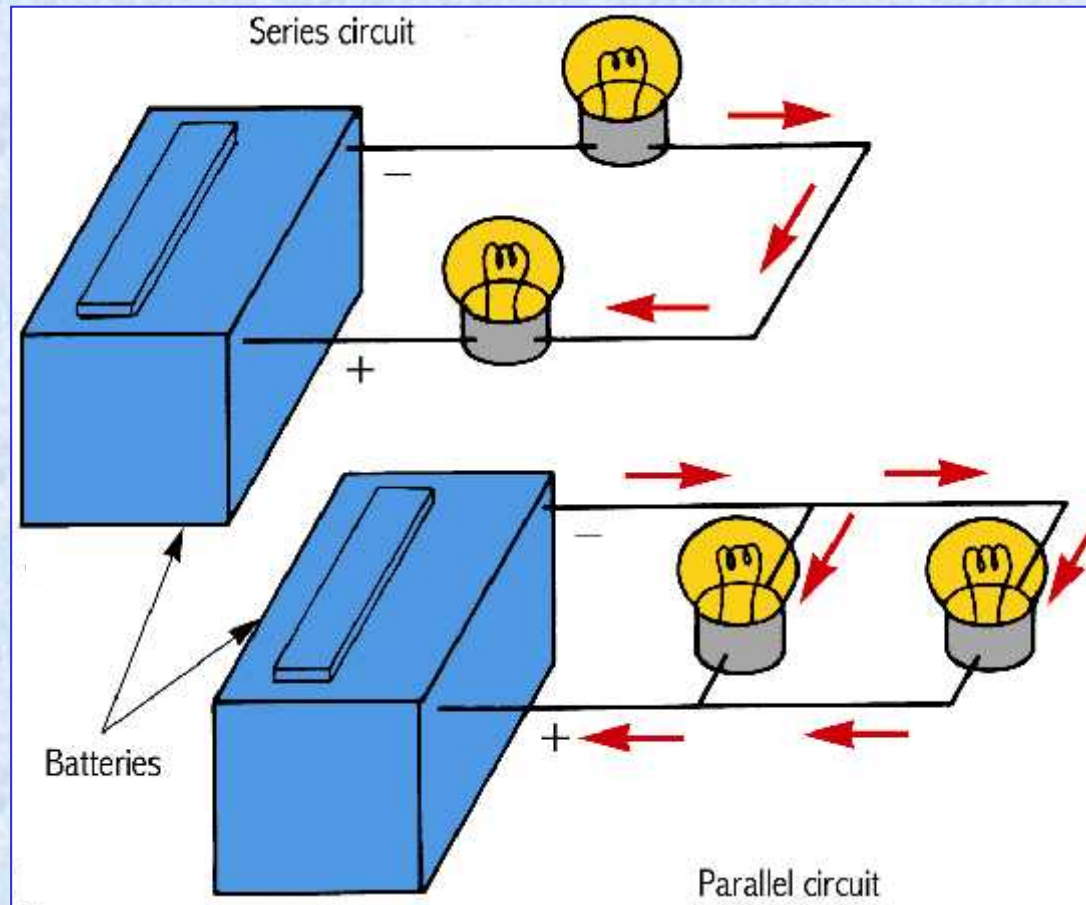
- Parallel circuit

- has more than one electrical path

- Series-parallel circuit

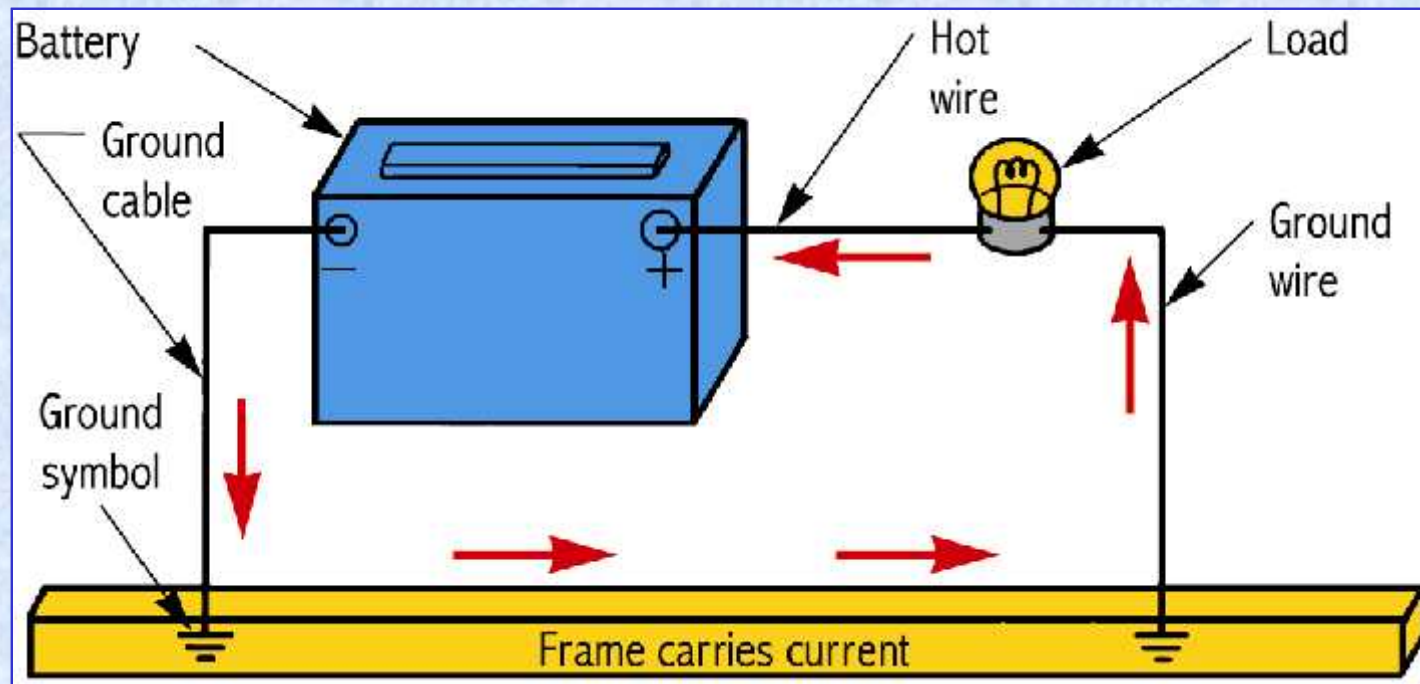
- contains both a series circuit and a parallel circuit

# Series and Parallel Circuits





# One-Wire Circuit



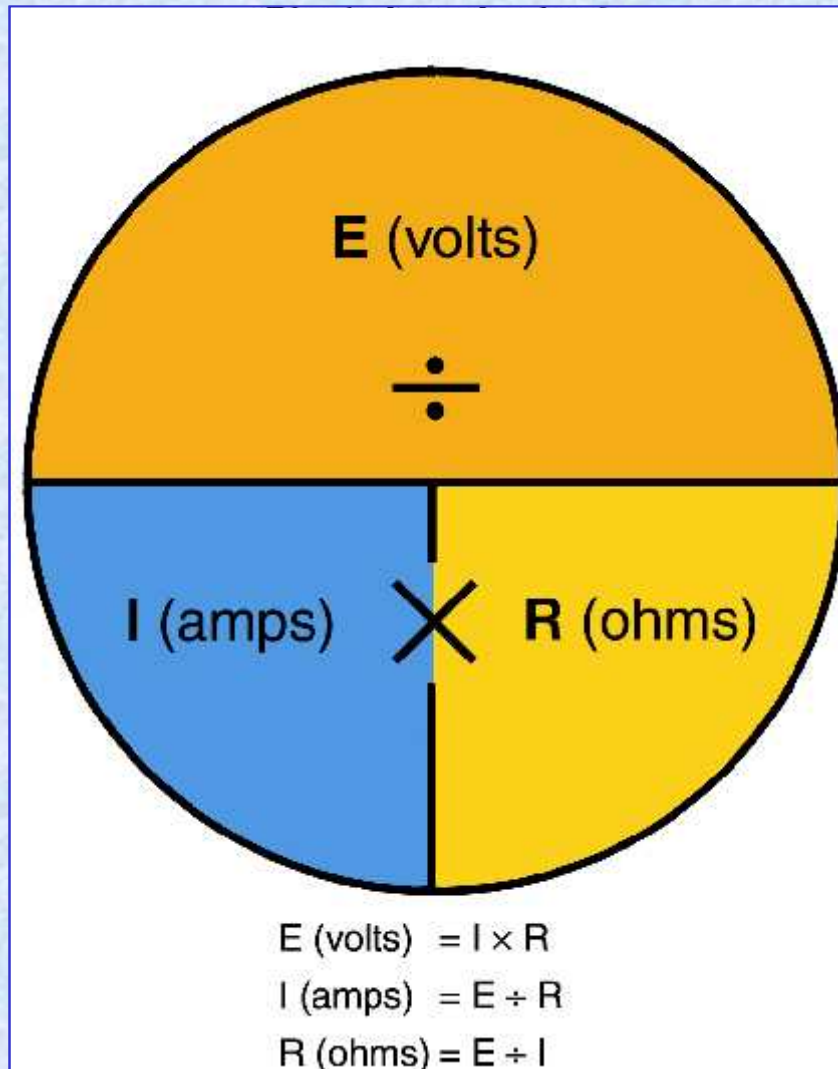
Vehicle's frame or body serves as an electrical conductor

# Ohm's Law

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



# Ohm's Law

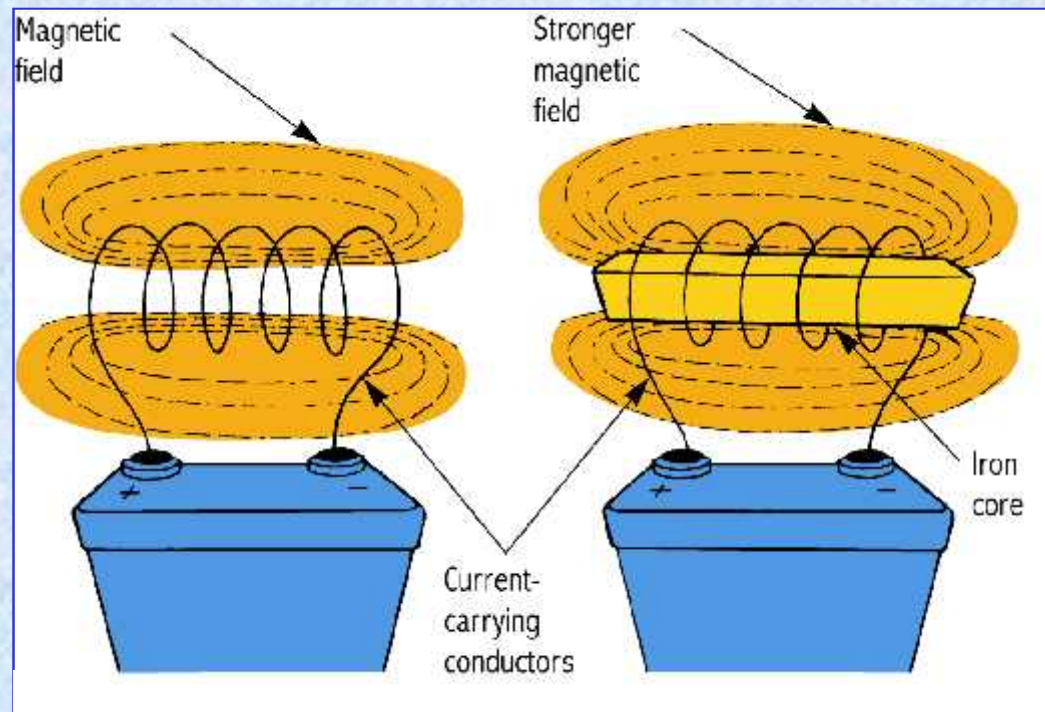


# Magnetism

- ❑ 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

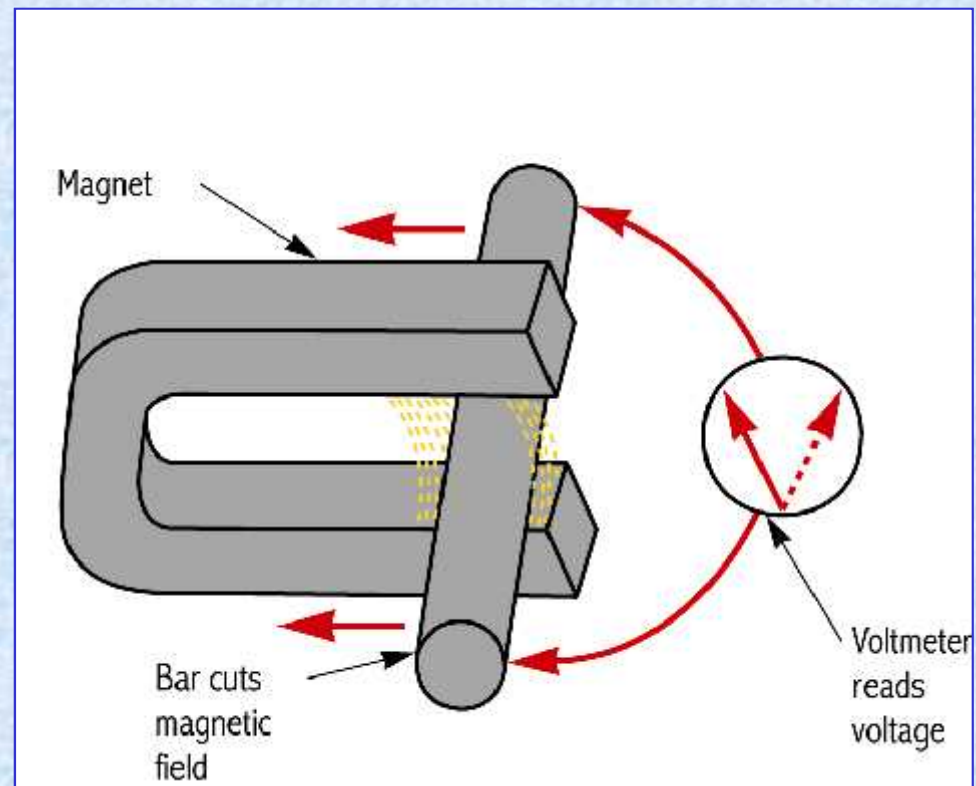


# Magnetism

- ❑ 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

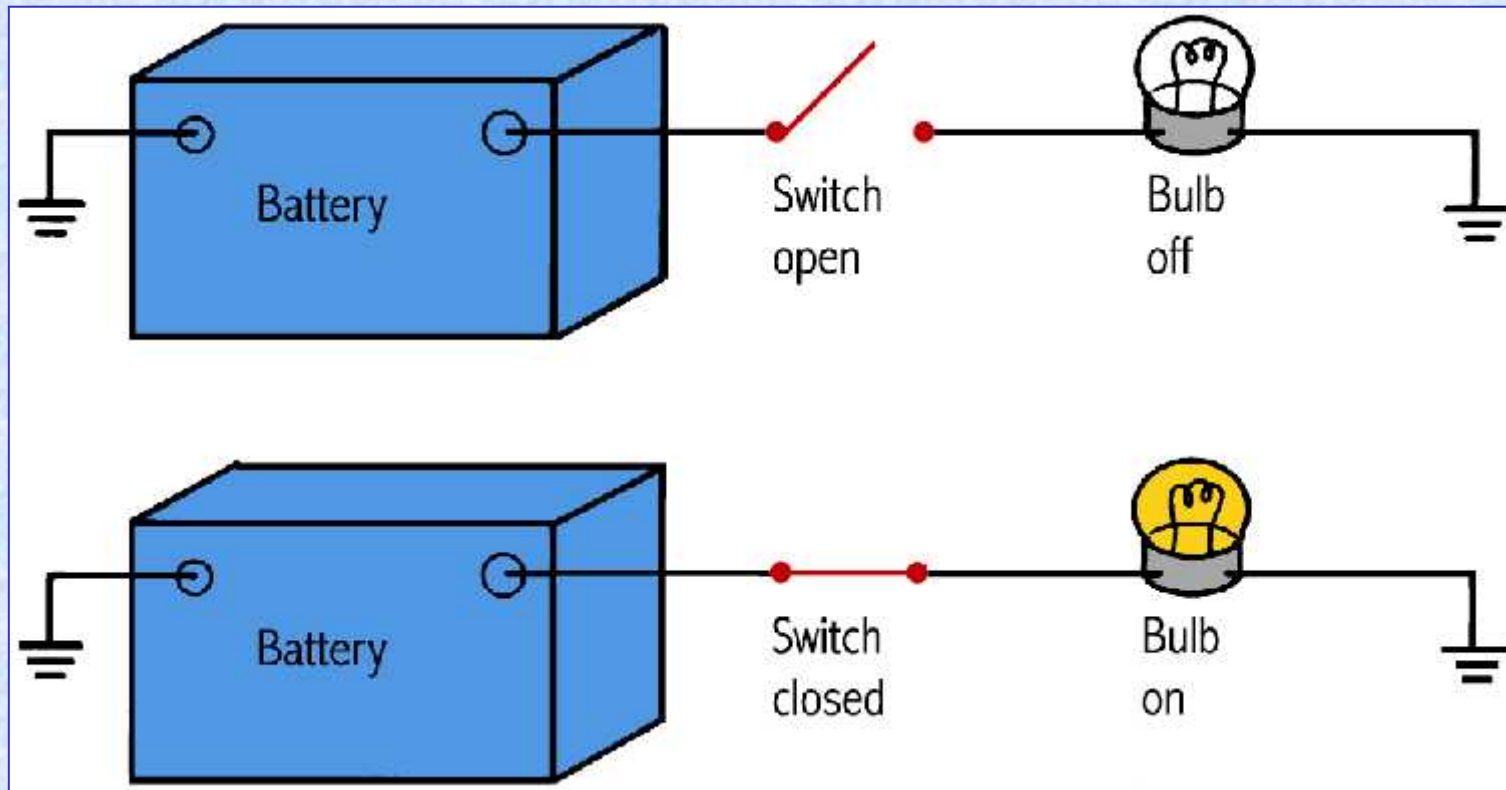


# Switch

- ❑ 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

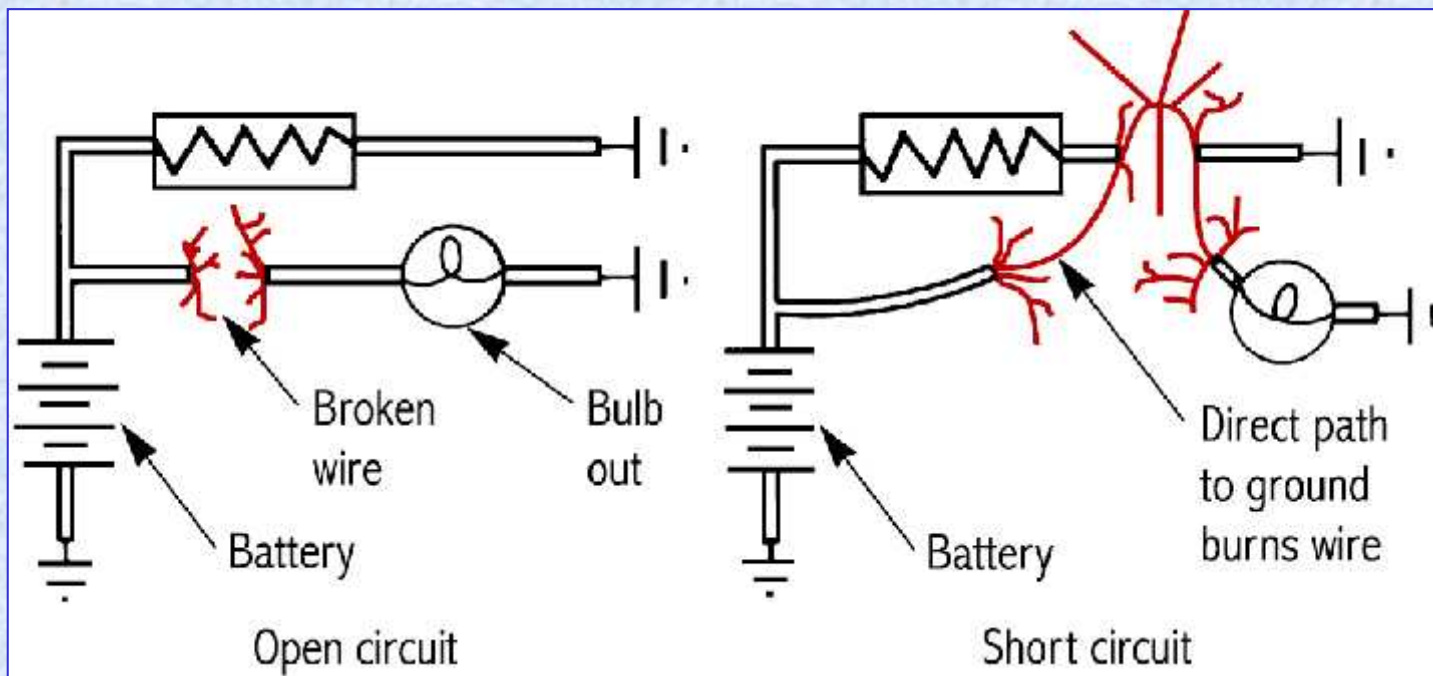


# Short Circuit

- ❑ 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

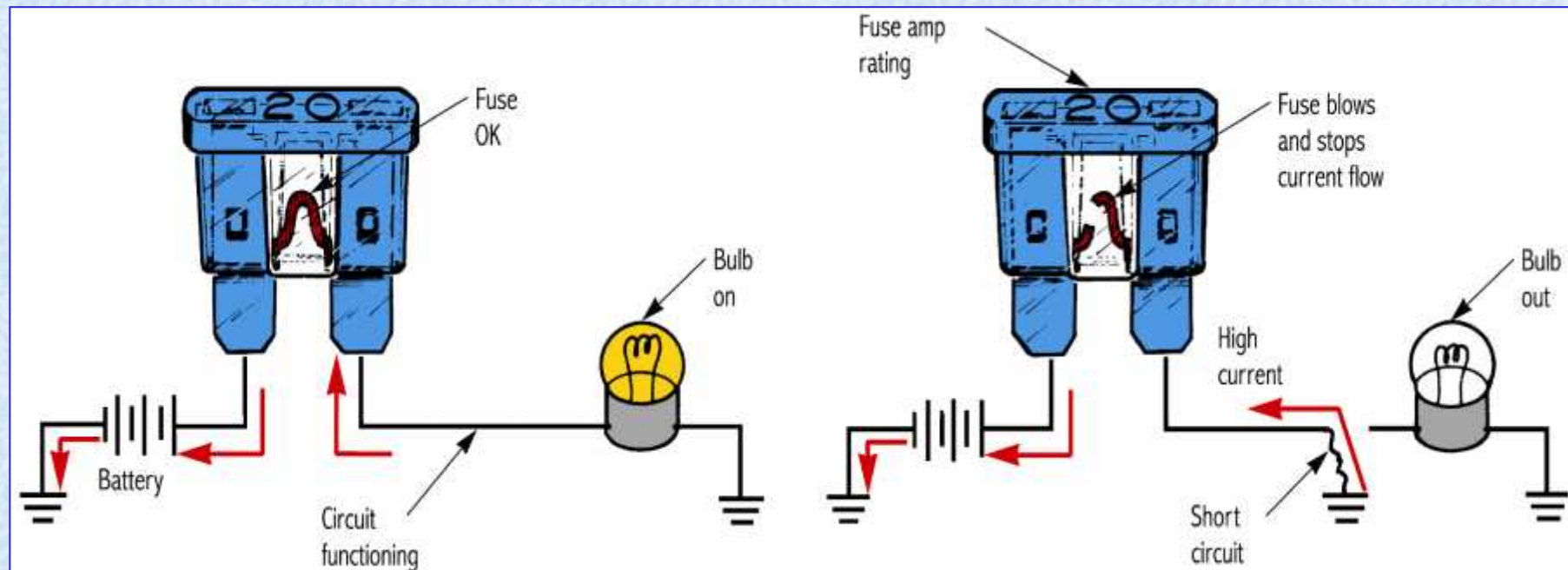


# Fuse

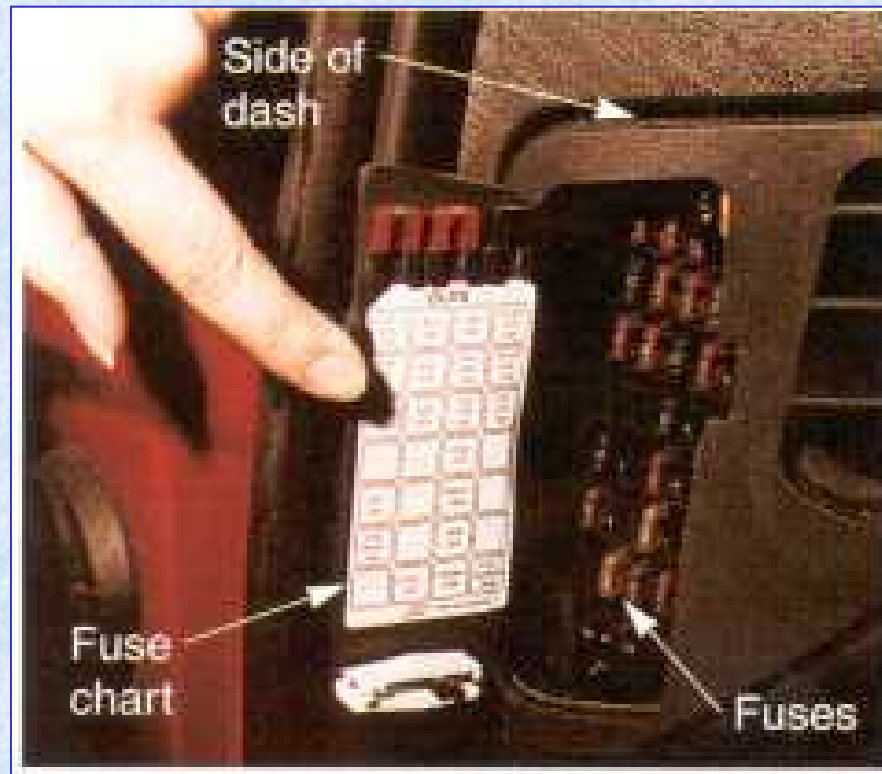
- ❑ Protects a circuit against damage caused by a short circuit
- ❑ High current heats and melts the link, creating an open circuit
- ❑ Current stops flowing in the circuit



# Fuse



# Fuse Box



Contains fuses for various circuits



# Fusible Link

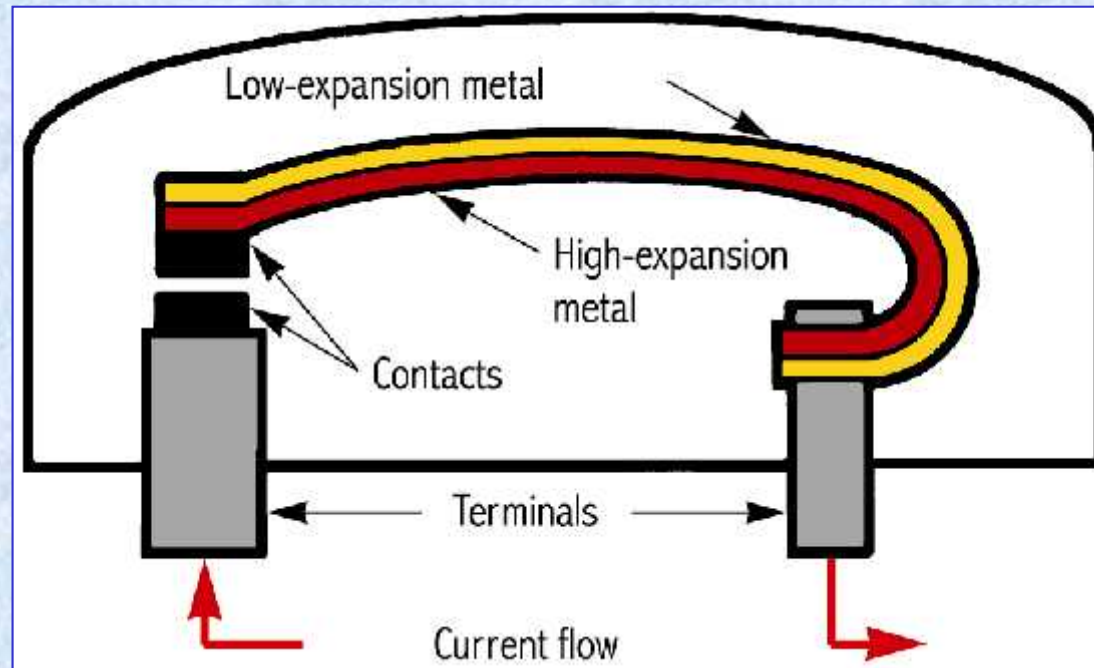
- ❑ Small section of wire designed to burn in half when excess current is present in the circuit
- ❑ Often used as protection between the battery and main fuse box
- ❑ If a major wire is shorted, the fusible link will burn in half to prevent an electrical fire and further damage

# 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



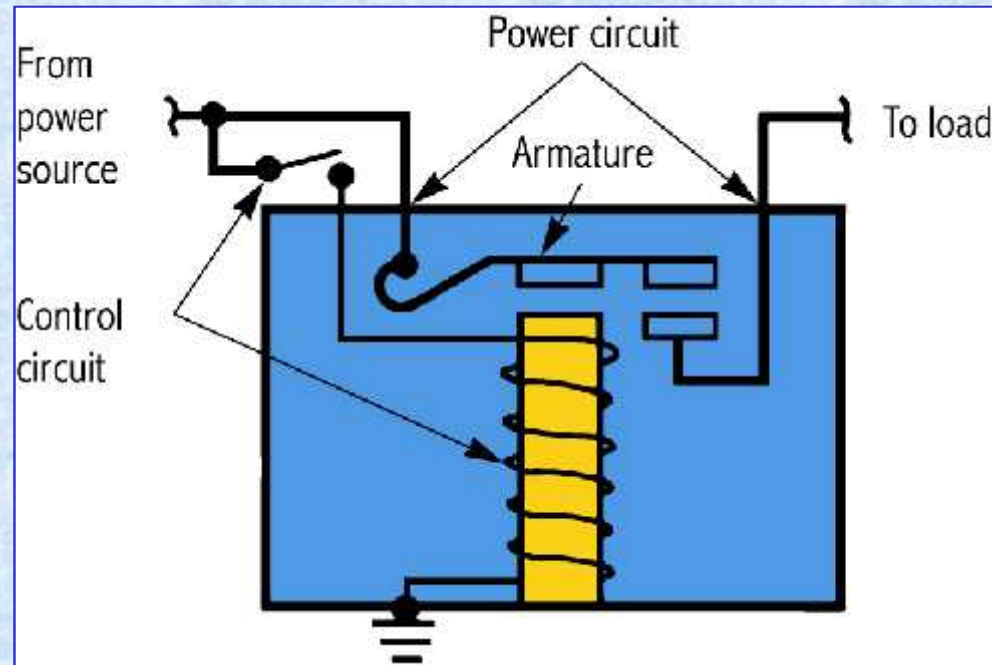
High current heats the bimetal strip, causing it to deform and open the contacts

# 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

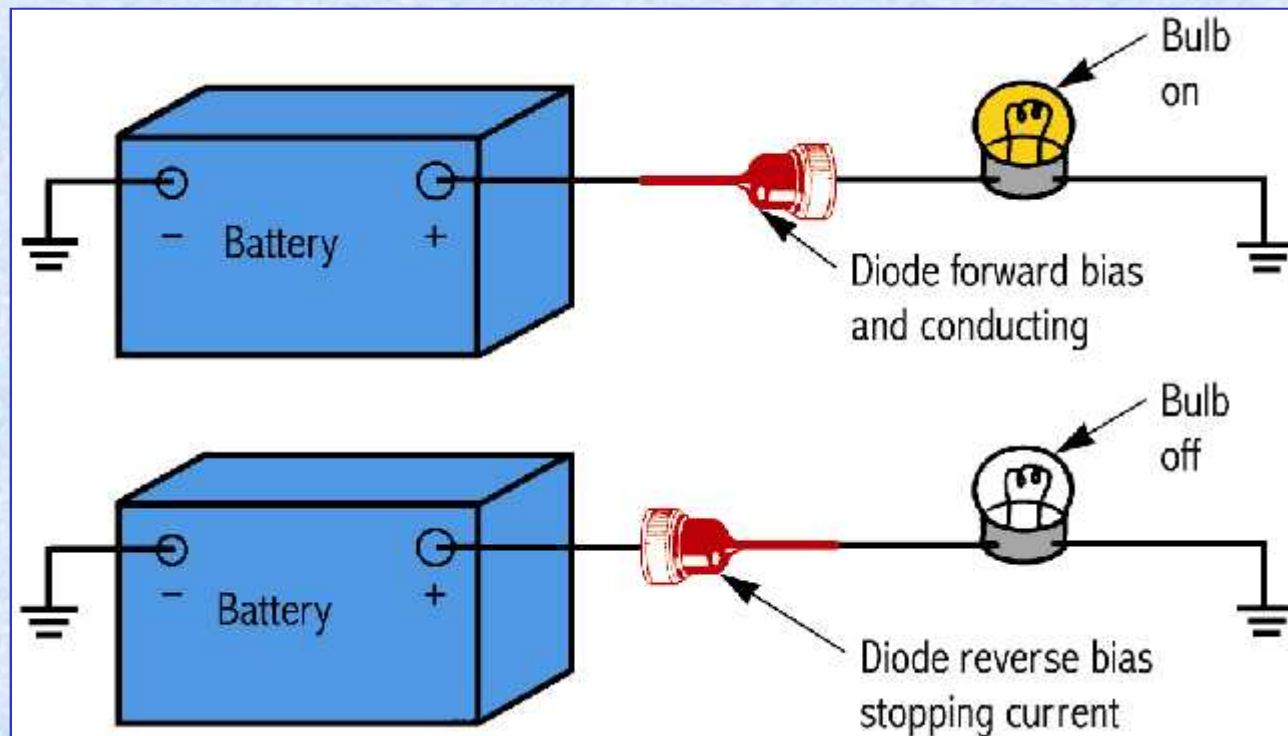
- ❑ Substance capable of acting as both a conductor and an insulator
  - this enables semiconductor devices to control current without mechanical points
- ❑ Semiconductor devices include:
  - diodes
  - transistors
  - integrated circuits

# 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

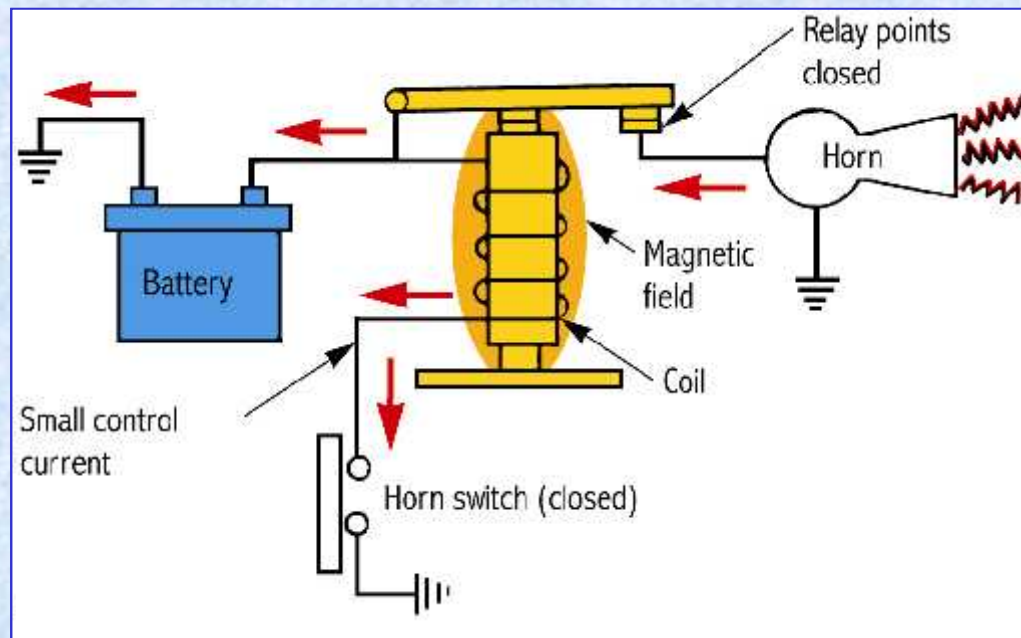


# Transistor

- ❑ 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

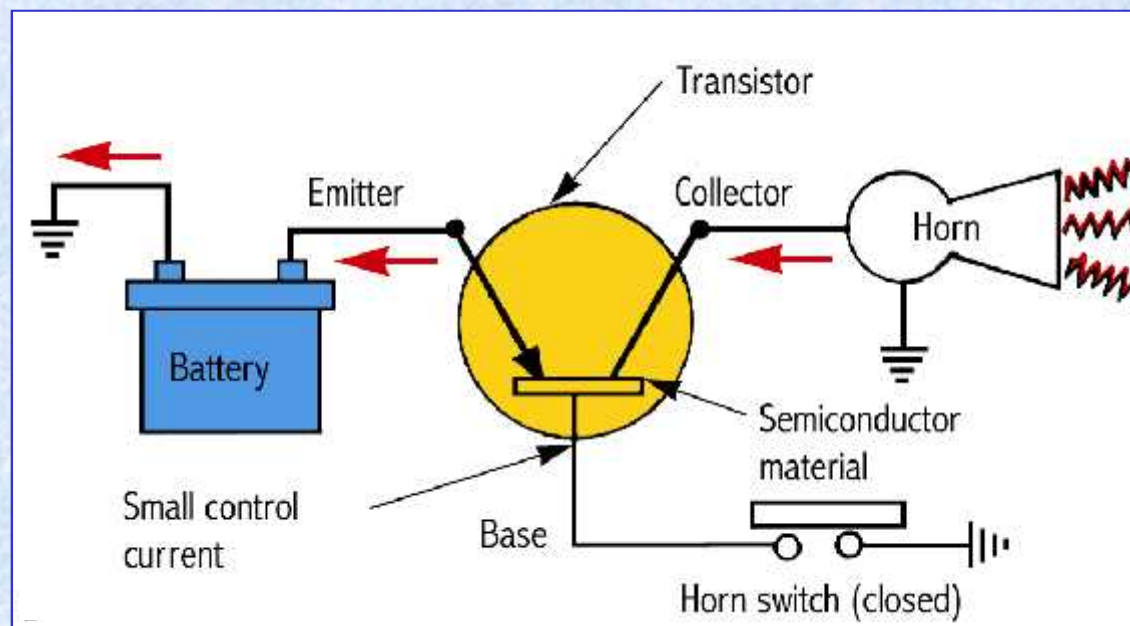


# Transistor versus Relay



Relay operation

# Transistor versus Relay



## Transistor operation



# Transistor Operation

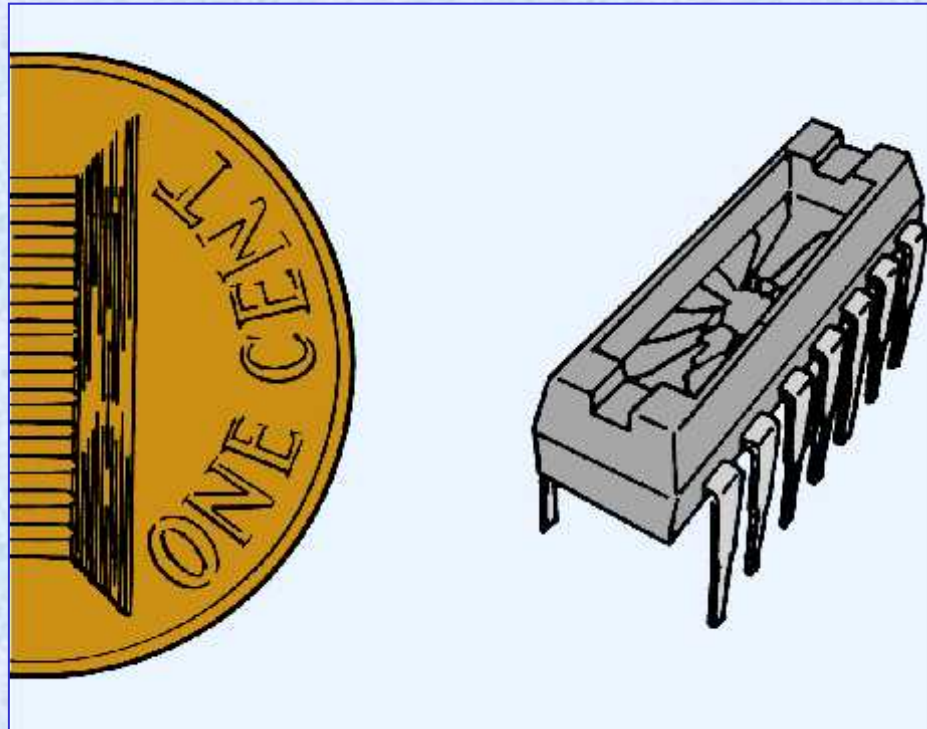
- ❑ Small base current energizes the semiconductor material, changing it from an insulator to a conductor
- ❑ Higher current can pass through the collector and emitter terminals

# 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)



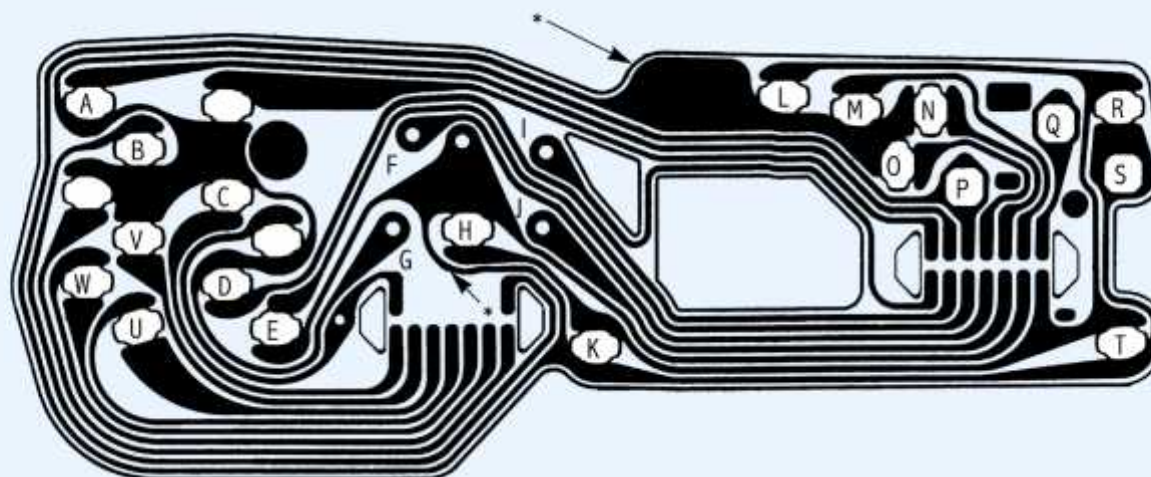
Contains microscopic diodes, transistors, resistors, and capacitors in a wafer-like chip

# 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

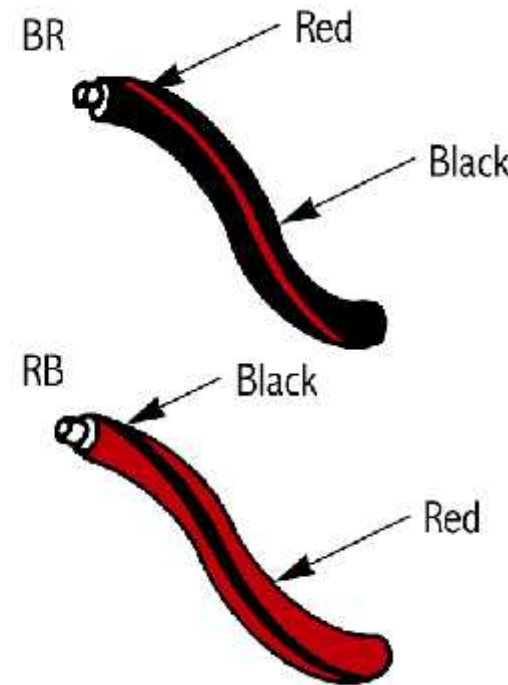


# Primary Wire

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

# Wire Color-Coding

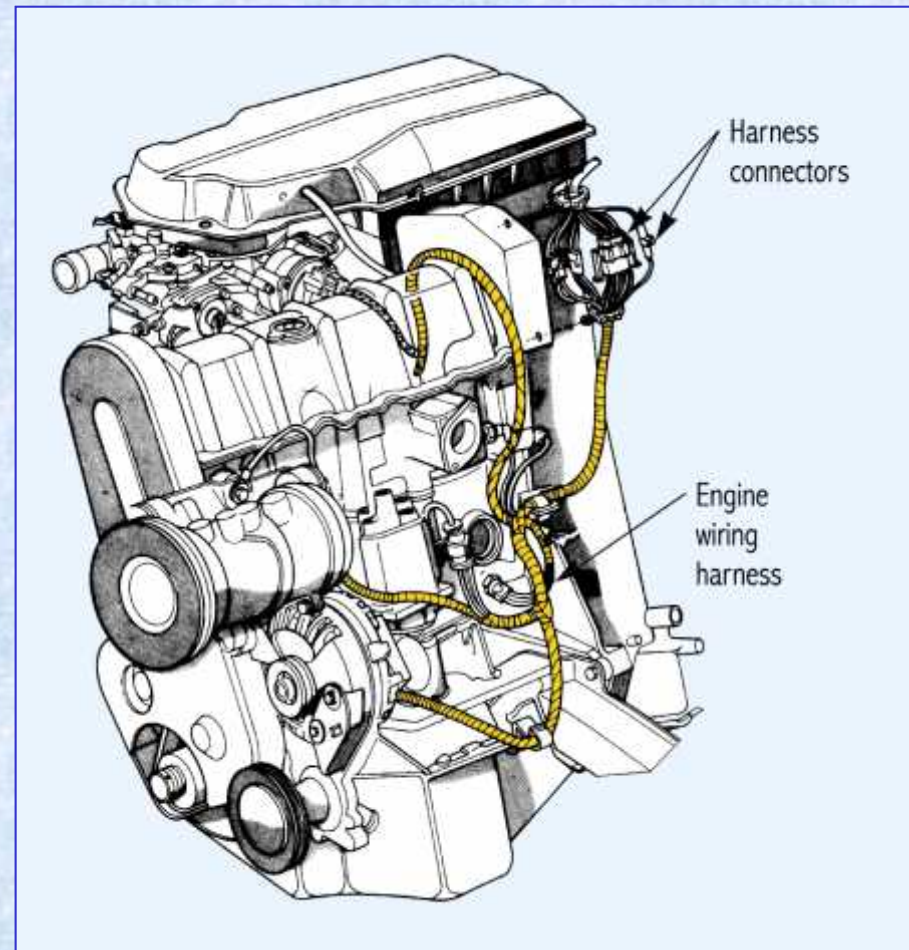
Code	Color
B	Black
Br	Brown
G	Green
Gy	Gray
L	Blue
Lb	Light blue
Lg	Light green
O	Orange
R	Red
W	White
Y	Yellow





# 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)

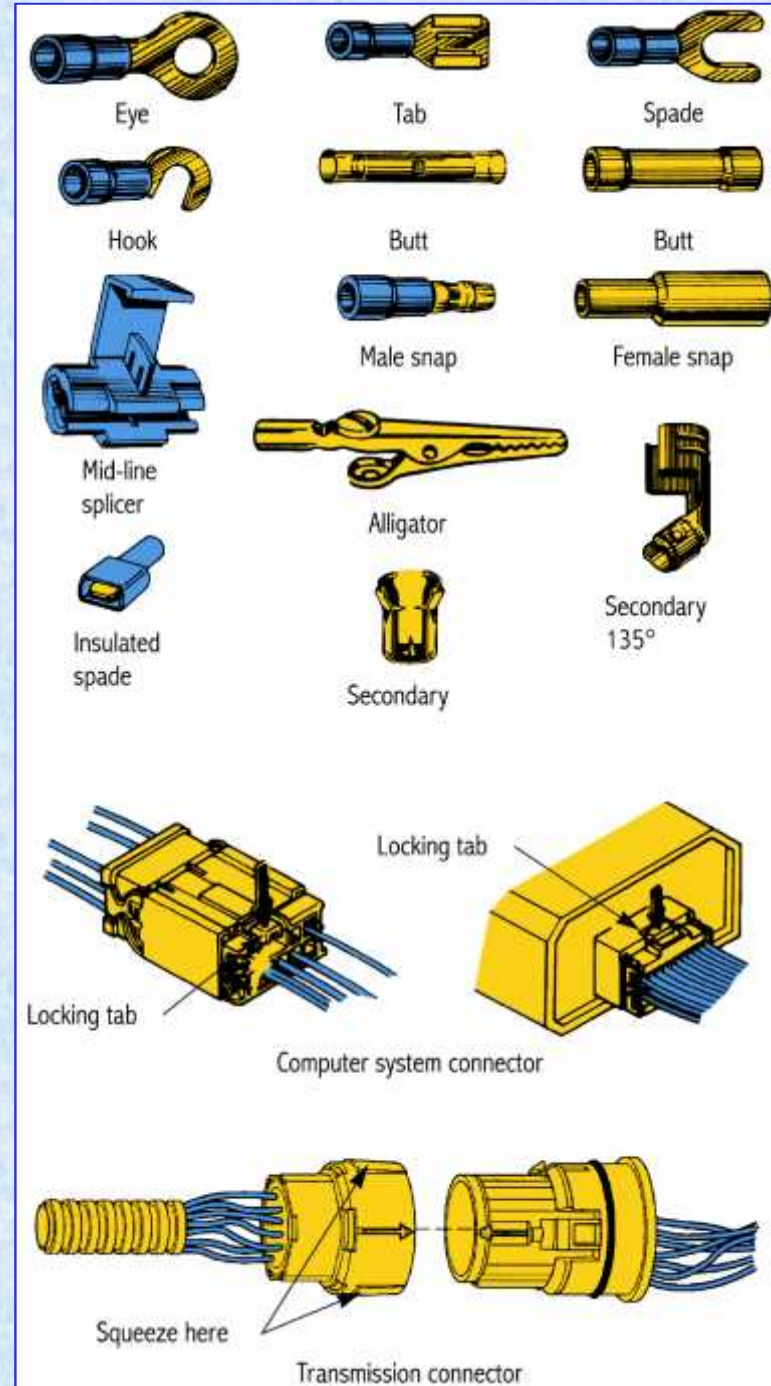
- ❑ Connect electrical components to the chassis or ground of the car
- ❑ Insulation may not be used on these wires



# 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



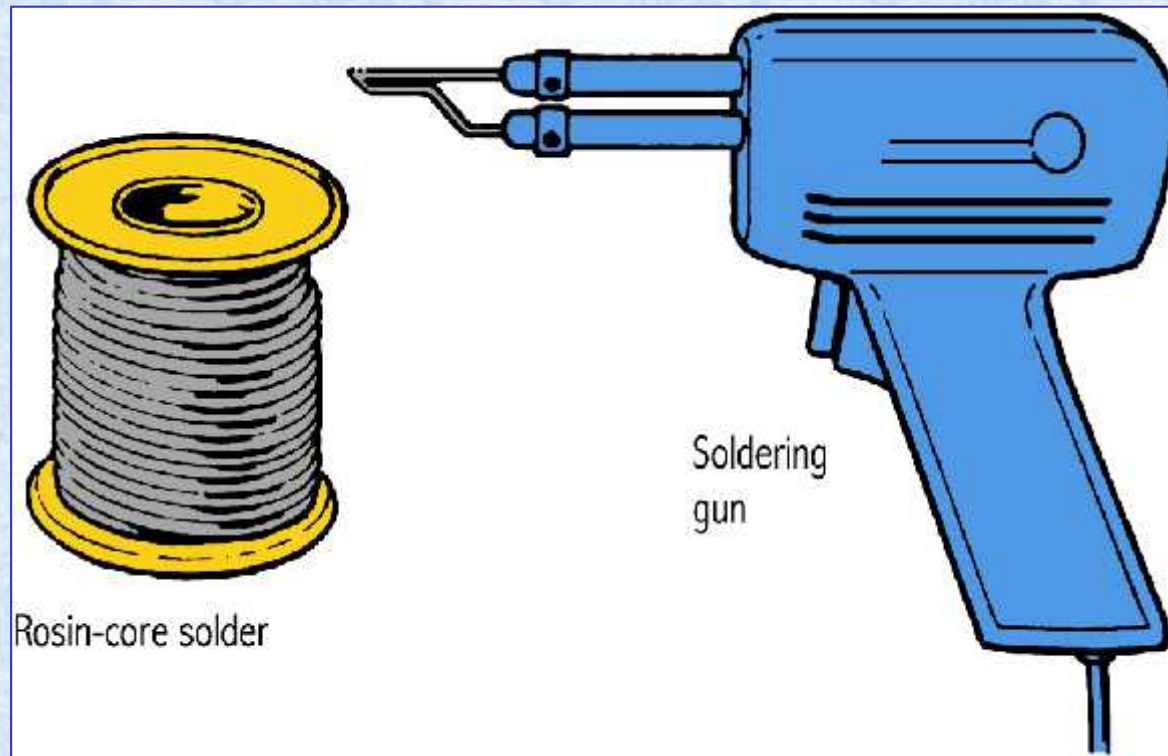
The crimping jaw was used to form this connector around the wire



# 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

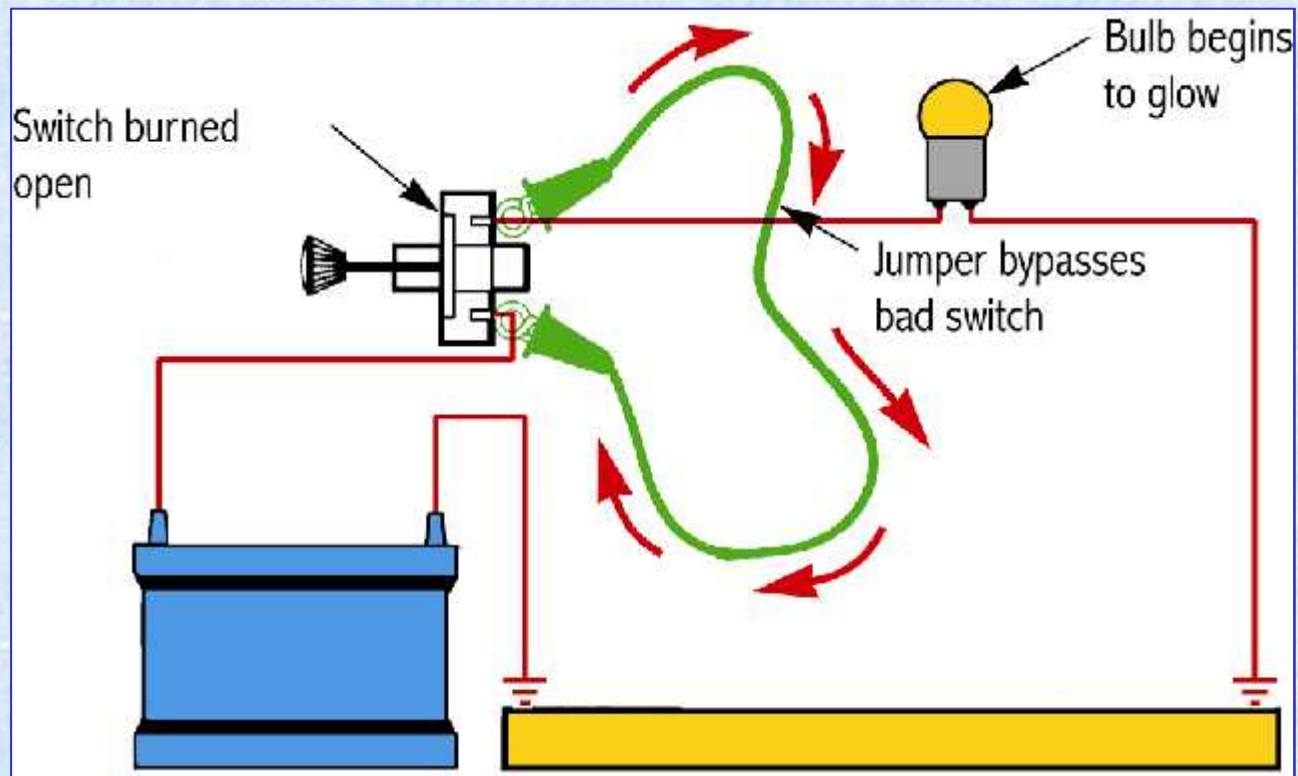
Various electrical tests and testing devices  
are used by an automotive technician

# 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

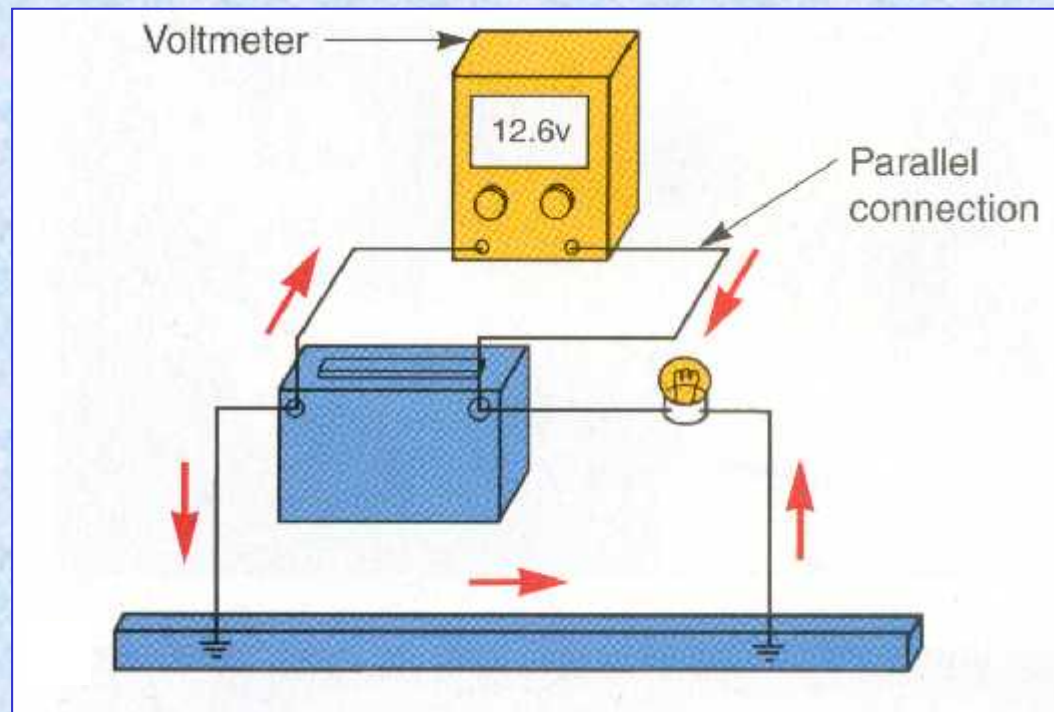
- ❑ Used to check for a complete electrical path
- ❑ To use a self-powered test light:
  - disconnect the circuit power source
  - connect the test light leads across the desired part of the circuit
  - if the light illuminates, the circuit or part has continuity



# 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

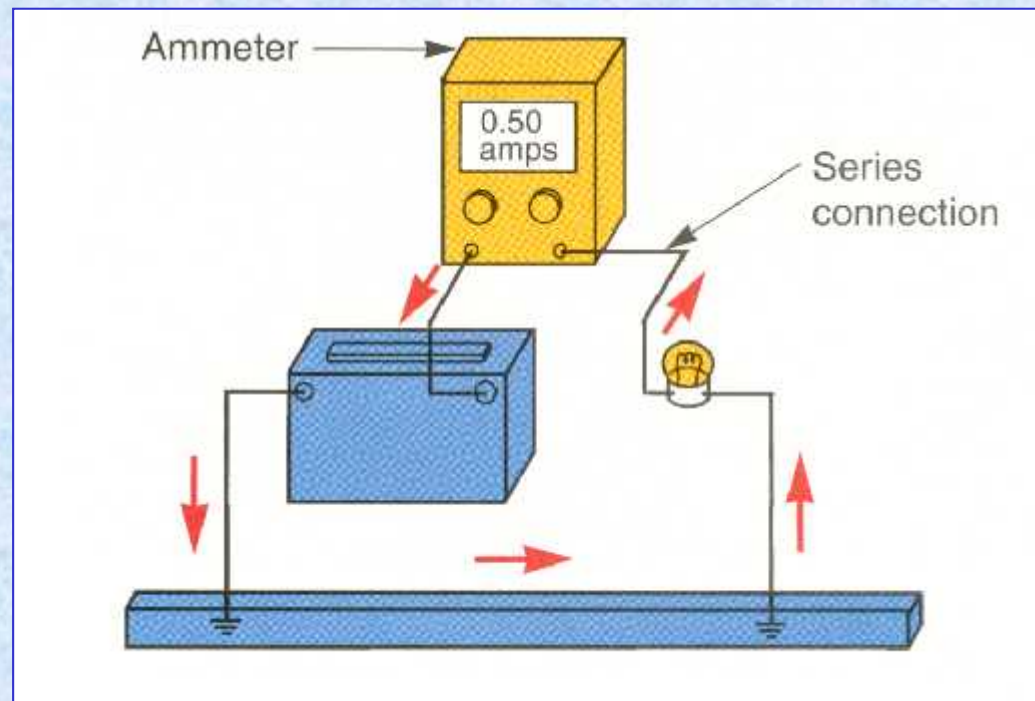




# Ammeter

- ❑ 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

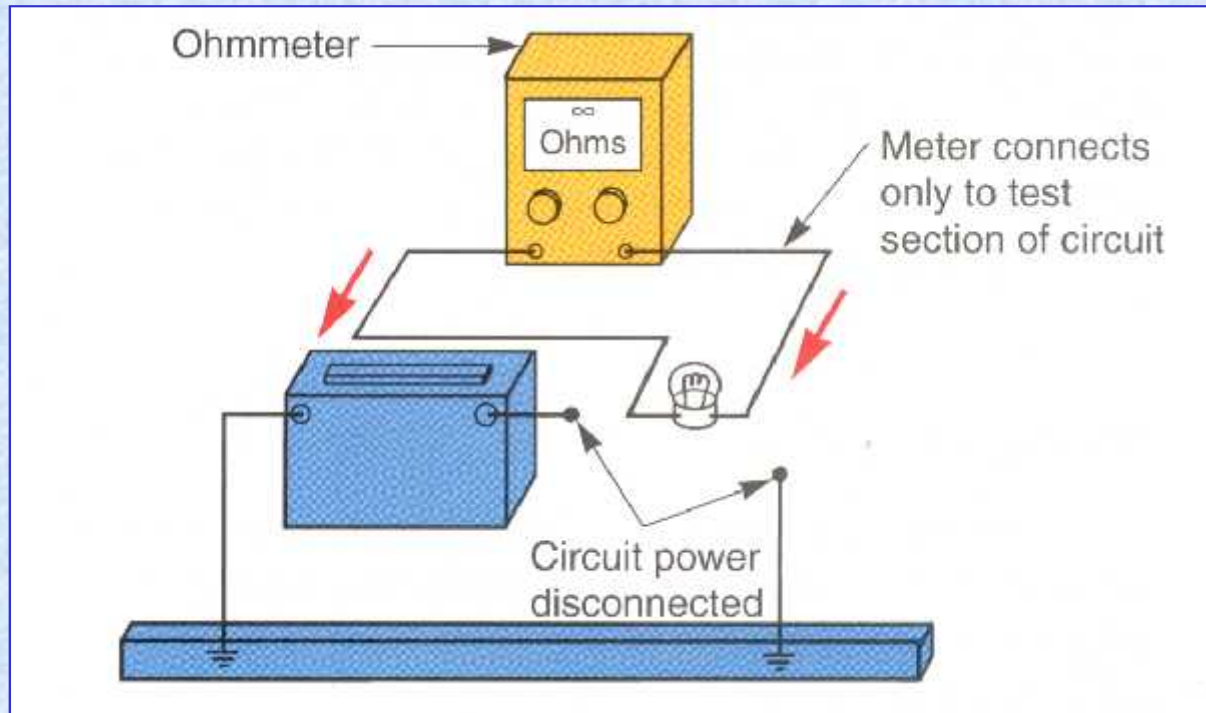




# Ohmmeter

- ❑ 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



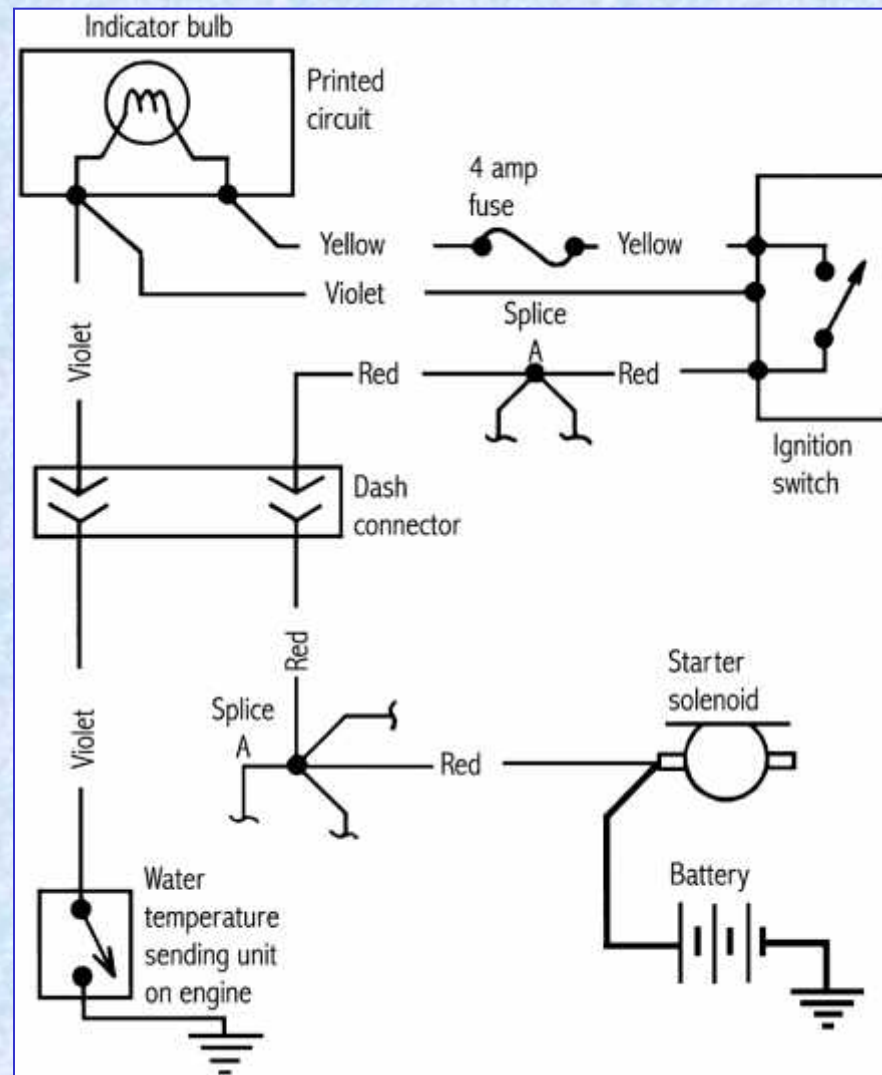
Digital display on a modern multimeter



# 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

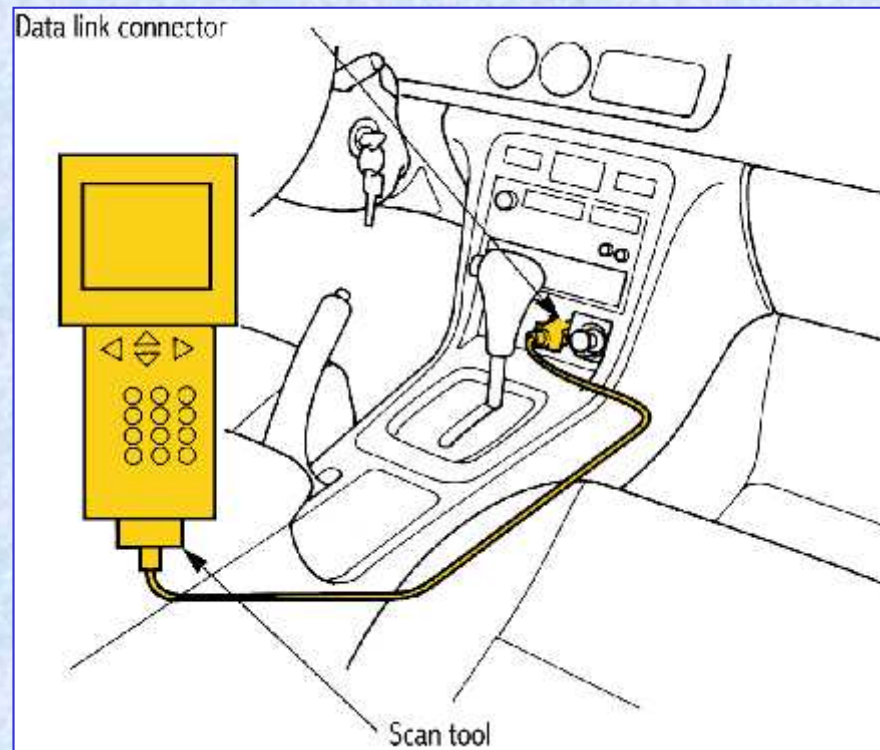
- ❑ Diagnostic tools that help find and diagnose vehicle problems
- ❑ Plug into the vehicle's diagnostic connector
- ❑ Communicate with the vehicle's control modules to read diagnostic trouble codes, display input and output data, and perform special tests

# Scan Tool Kit





# Scan Tool Connection



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