

Module 3: Battery, Charging, Electrical Systems

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Battery, Charging, Electrical Systems

- ▶ Does anyone have any Questions/Concerns?
- ▶ What are you hoping to gain from this module?

Basic Electrical Intro

Powertrain Electrical Components

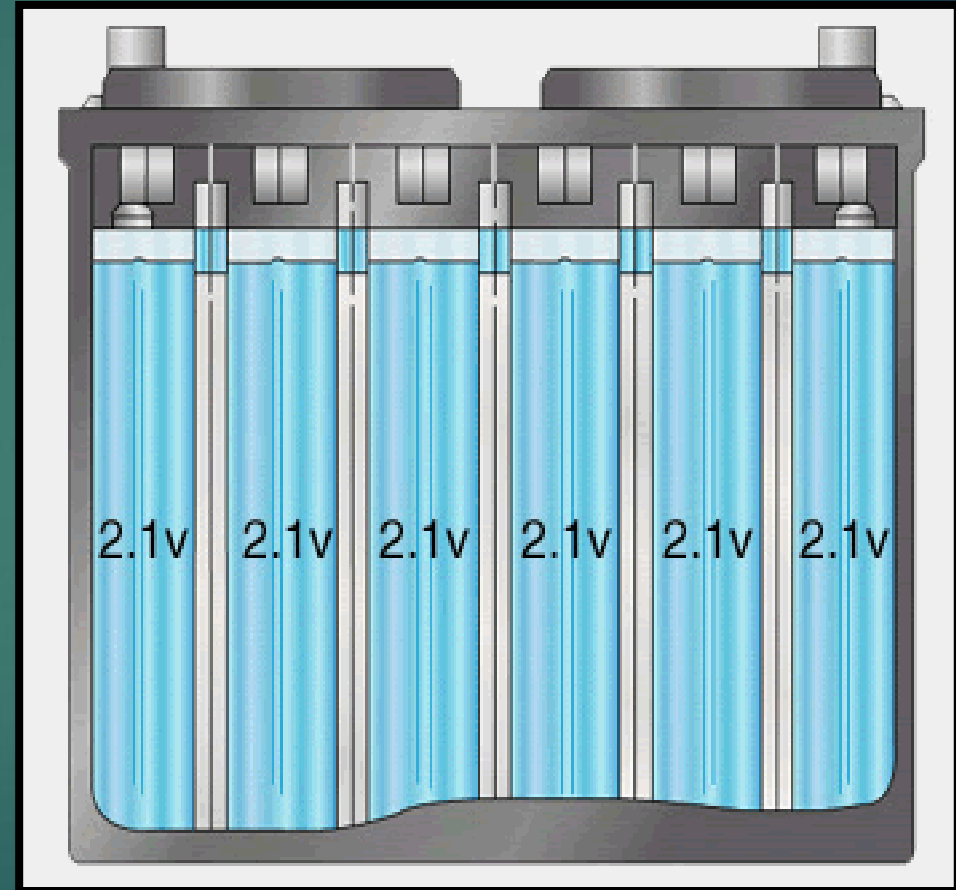
- ▶ Battery
 - ▶ Used to power the Starter Motor
- ▶ Starter Motor
 - ▶ Cranks the engine
- ▶ Alternator
 - ▶ Recharges the battery after Starting
 - ▶ Powers the Ignition system and electrical accessories
- ▶ Ignition System
 - ▶ Ignites the air/fuel mixture at the proper time

BATTERIES

- ▶ 2 dis-similar metals in an electrolyte
 - ▶ Lead (Negative Plates) - Pb
 - ▶ Lead Dioxide (Positive Plates) – PbO₂
 - ▶ Sulfuric Acid/deionized water - *Not tap water!*
- ▶ Why do car batteries use sulfuric acid?
 - ▶ Low Freeze Point
 - ▶ High Resistance to boiling

Battery

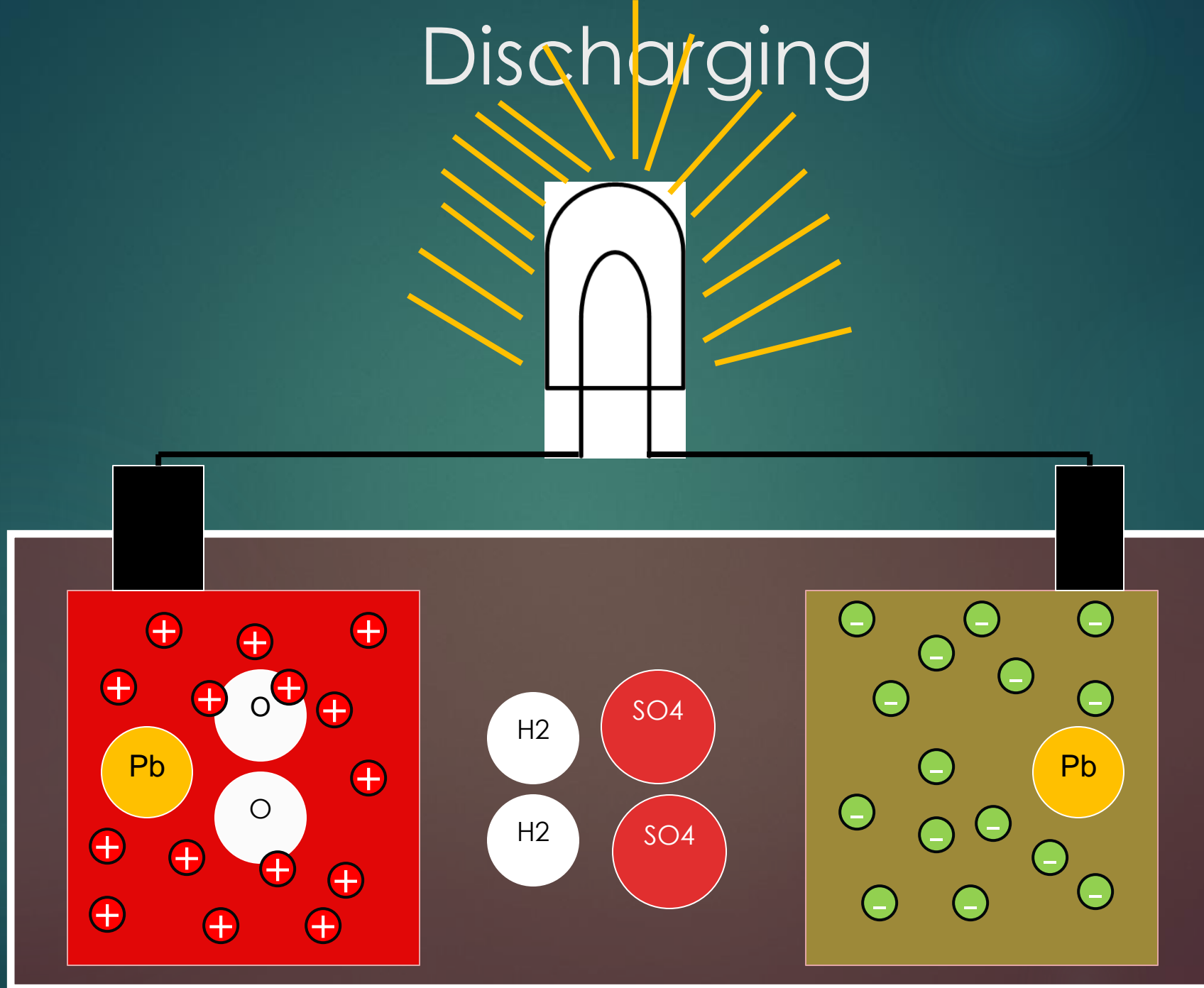
- ▶ Electro-chemical Device
- ▶ Stores Electrical Power
- ▶ 6 cells
- ▶ Each cell is 2.1 volt each
- ▶ 12.6 volts total (Fully Charged)
- ▶ Not all batteries are equal



Battery Discharge Cycle

- ▶ Positive and Negative Plates become Lead Sulfate
 - ▶ Plates become sulfated if left discharged for a long period of time
- ▶ The specific gravity of the Electrolyte decreases.
- ▶ Water level increases

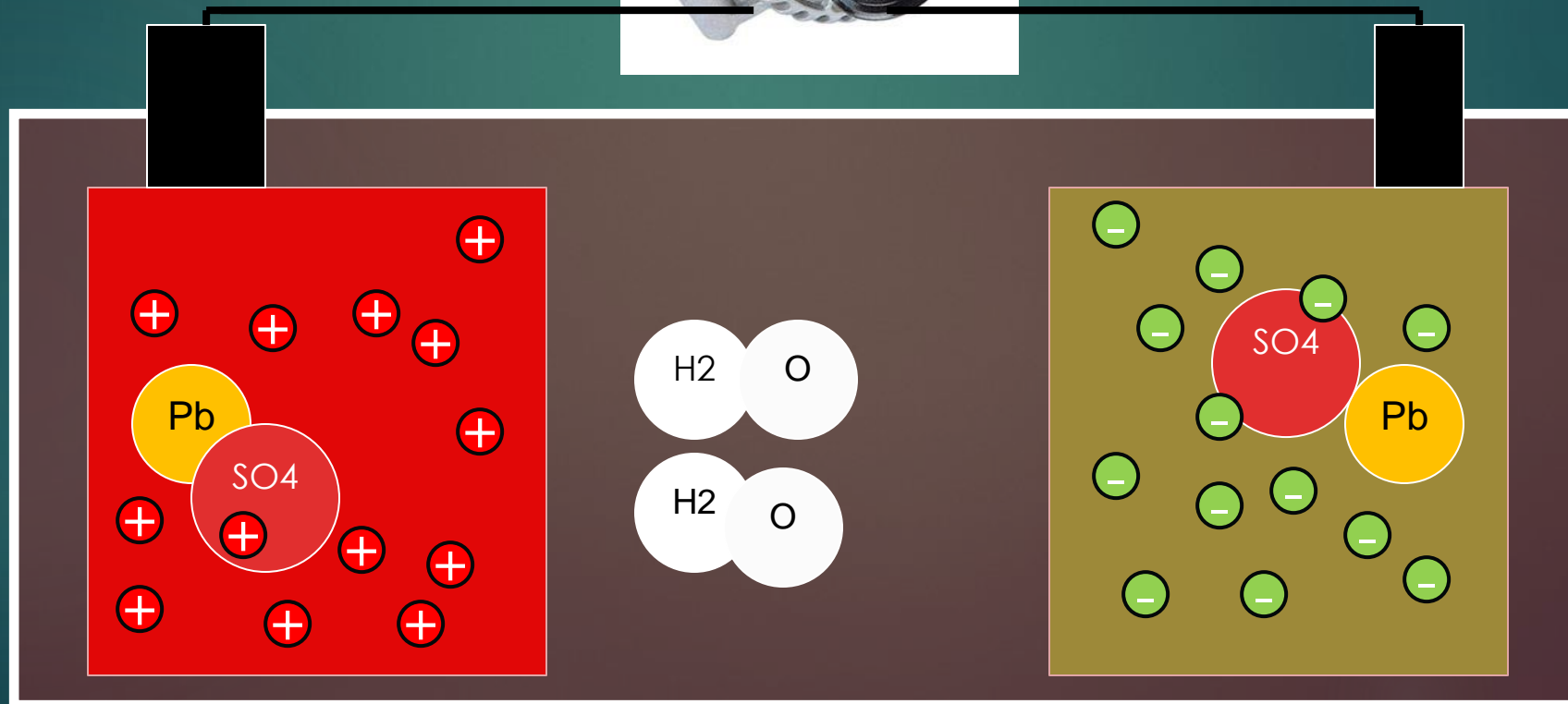
Discharging



BATTERY RECHARGE CYCLE (CHARGING)

- ▶ Positive plates become PbO_2
- ▶ Negative Plates become Pb
- ▶ The specific gravity of the Electrolyte increases
- ▶ Acid level increases

Charging

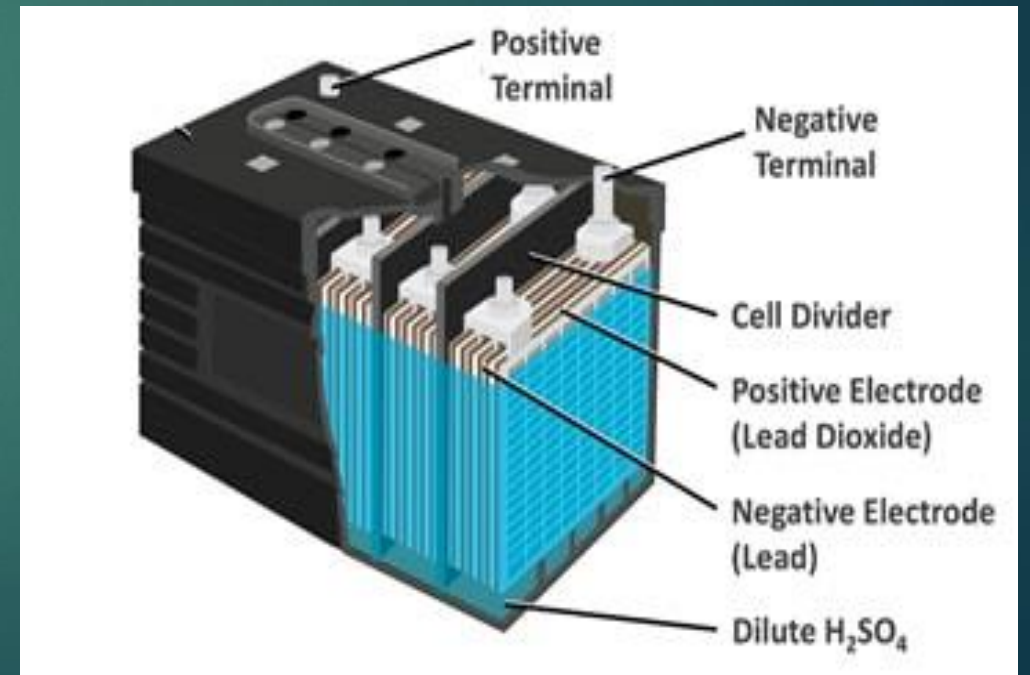


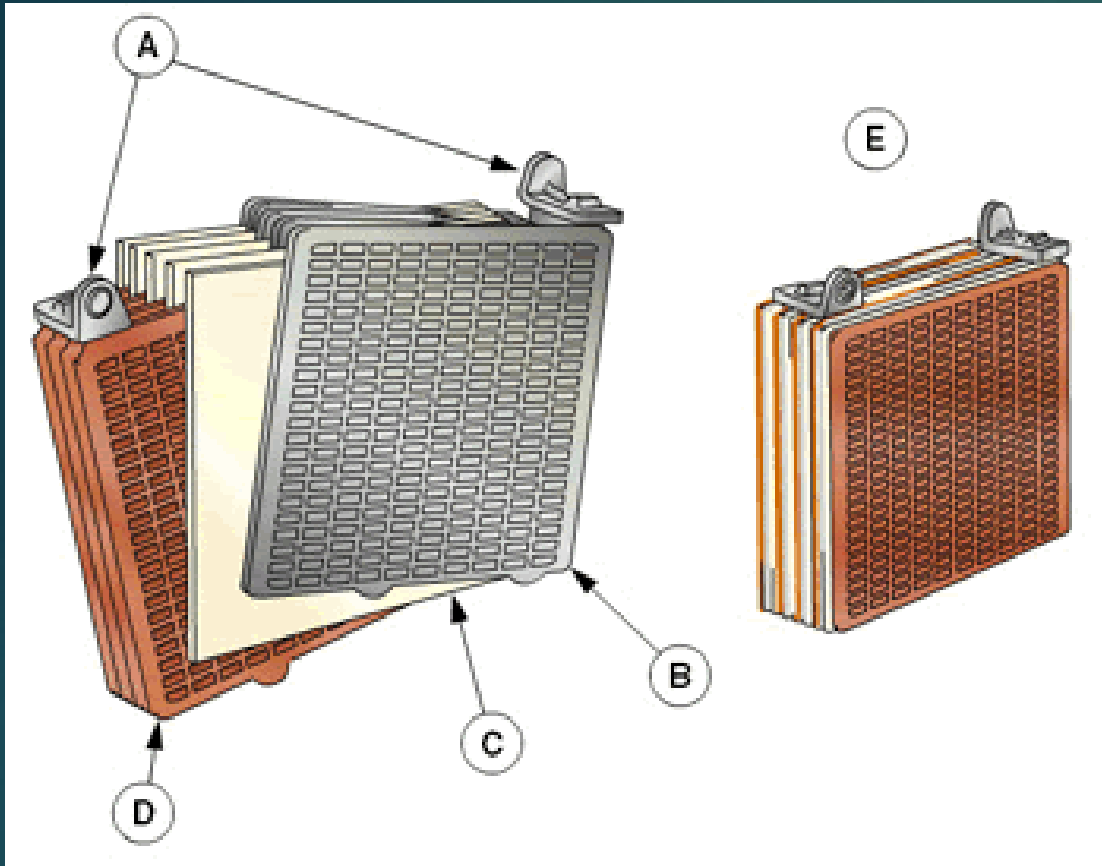
Types of Batteries

- ▶ Standard Flooded Lead Acid Battery
- ▶ Enhanced Flooded Lead Acid Battery
- ▶ AGM
- ▶ Gel battery

Flooded Lead Acid Battery

- ▶ SLI - Starting, Lighting, and Ignition
 - ▶ Traditional Automotive battery
 - ▶ Has a wet acid solution bath
 - ▶ Contains vent caps to add water

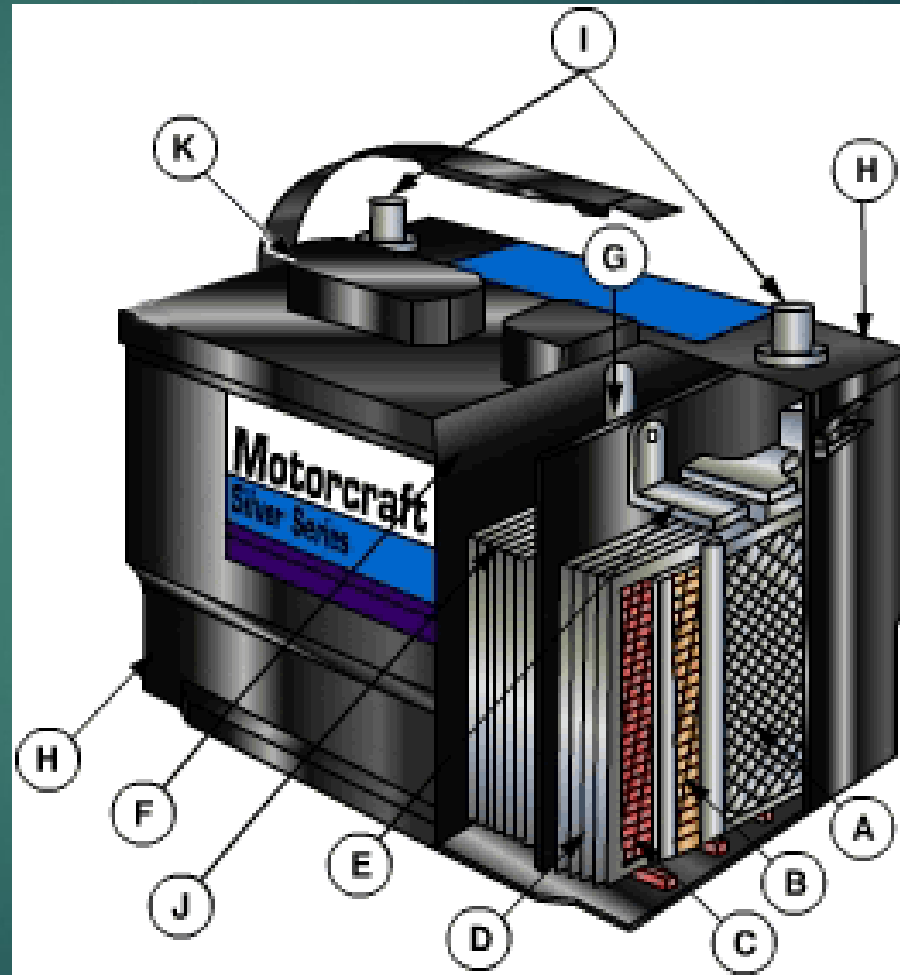




- A. Plate Straps
- B. Negative Plates
- C. Separators
- D. Positive Plates
- E. Cell

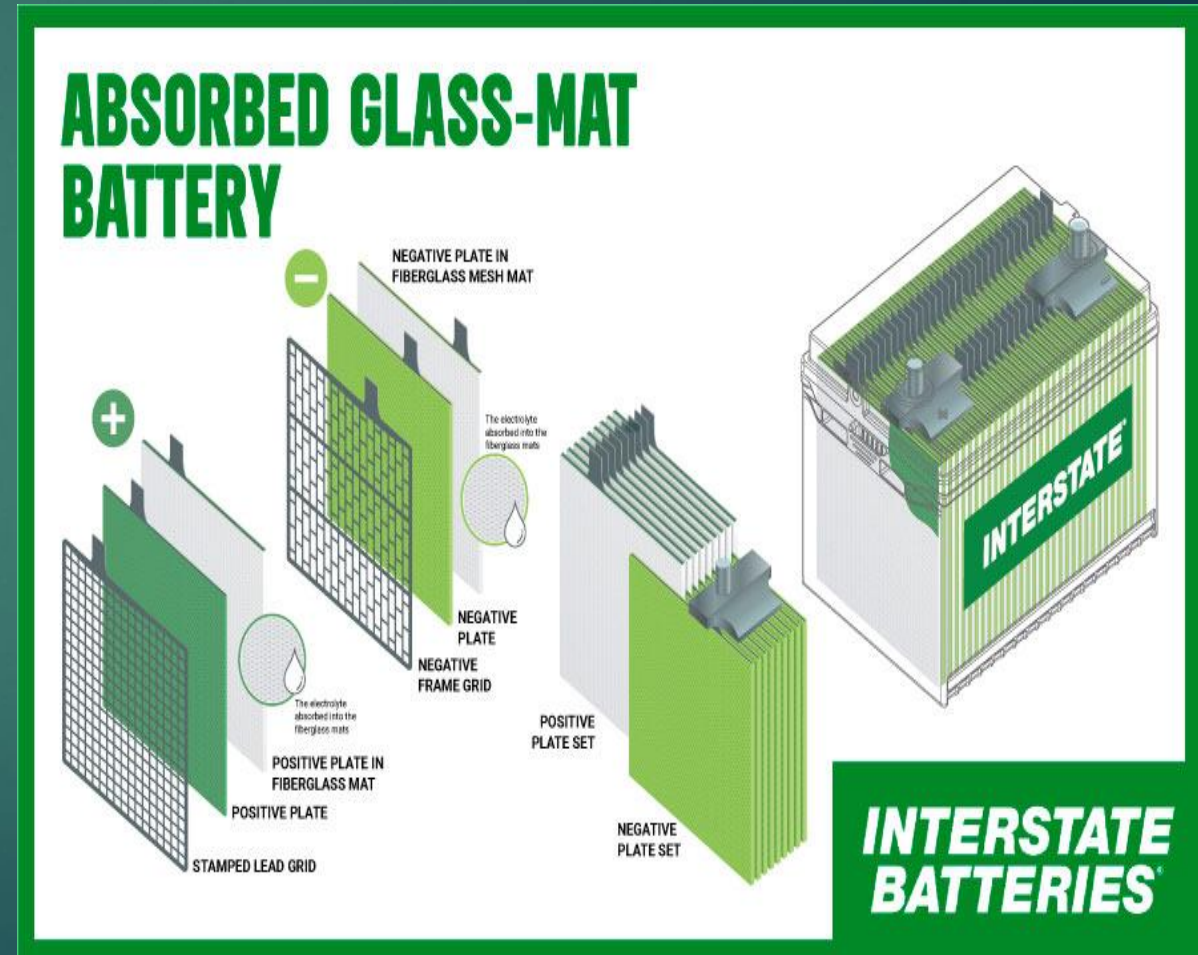
Lead Acid Battery

- a) Grid
- b) Plates
- c) Separators
- d) Plate groups
- e) Assembled elements
- f) Battery cell
- g) Thru-partition cell connectors
- h) Container and cover
- i) Terminals
- j) Electrolyte
- k) Vent caps



Absorbed Glass Mat Battery (AGM)

- ▶ Sealed Battery
 - ▶ Acid is totally absorbed into the separator
 - ▶ Cell is compressed 20%
 - ▶ Reduced damage by vibration
 - ▶ May be OEM
- ▶ Gelled Electrolyte
 - ▶ Silica added
 - ▶ Electrolyte becomes similar to gelatin



Absorbed Glass Mat Battery (AGM)

Not all AGMs are the same:

Pure Lead AGM Batteries

- ▶ 99.9% pure lead
- ▶ Up to 2x battery cycle life vs. flooded batteries
- ▶ Fastest recharge times
- ▶ Slowest self-discharge/shelf life
- ▶ Sealed - zero water loss



Alloy AGM Batteries

- ▶ Recycled lead + alloy metal
- ▶ Similar to pure lead AGM, but not as powerful
- ▶ Less expensive than pure lead AGM



Enhanced Flooded Lead Acid (EFB)

▶ Benefits:

- ▶ Enhanced Durability
- ▶ Better Energy storage
- ▶ Longer Battery life
- ▶ Weatherproof
- ▶ Start-stop friendly
- ▶ More affordable than AGM



Lithium-ion Battery

- ▶ Typically used in EV's, Also available as Starter Batteries
- ▶ Largely limited to expensive optional offerings in high-end sports cars
 - ▶ *Porsche & McLaren*
- ▶ Cost around 3-4 times as much as a good lead-acid battery
- ▶ Very high charge density relative to mass
- ▶ Higher cranking amps
- ▶ Sleep mode



Deep Cycle Batteries

- ▶ Deep cycling means to almost fully discharge
 - ▶ Golf carts
 - ▶ Marine trolling motors
 - ▶ Recreational Vehicles
- ▶ Specially designed (thicker) plates to resist heat warpage
- ▶ Can be Lead Acid, AGM or Lithium



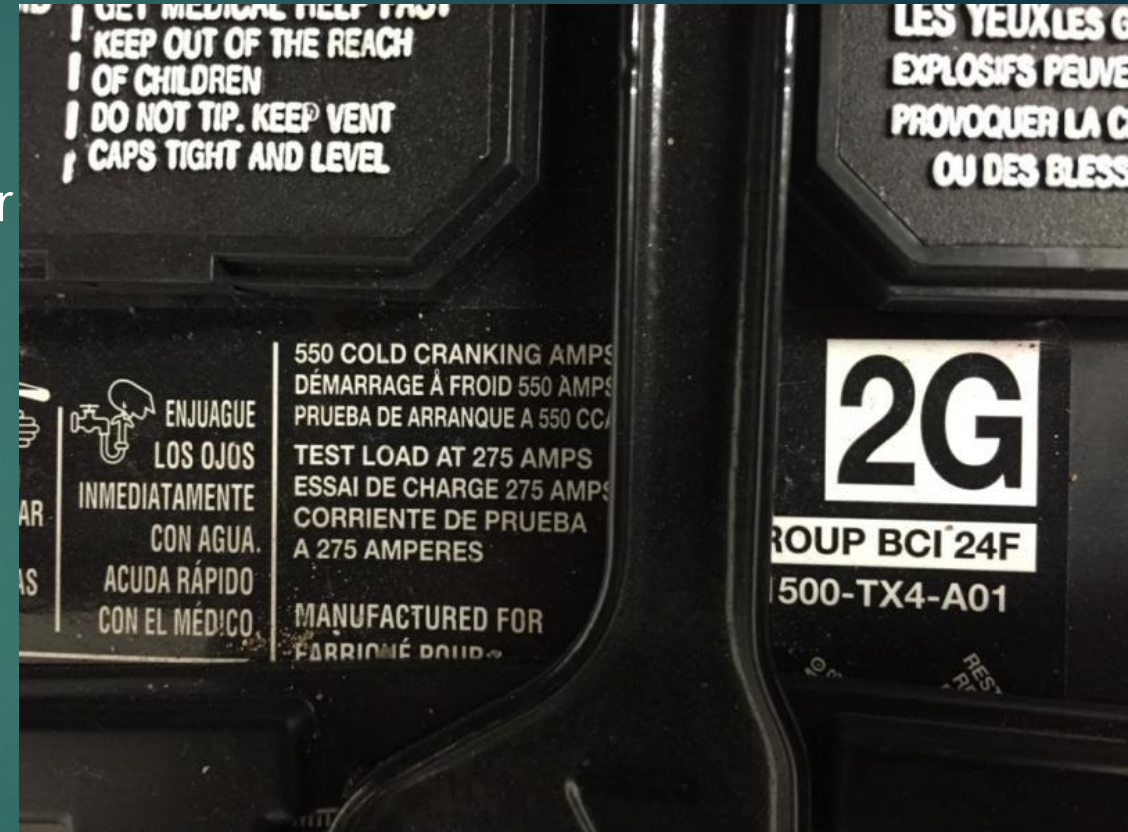
Battery Ratings

- ▶ Most automotive batteries have a CCA rating
- ▶ CCA = COLD CRANKING AMPS **0° F**
 - ▶ # Amps during a heavy load for 30 sec while staying above 7.2 Volts
- ▶ CA = CRANKING AMPS **32° F**
 - ▶ # Amps during a heavy load for 30 sec while staying above 7.2 Volts
- ▶ ALL Vehicles have a minimum CCA required to start by each model
 - ▶ Not same battery to crank a small 4 cylinder as a large 8 cylinder or a Diesel engine

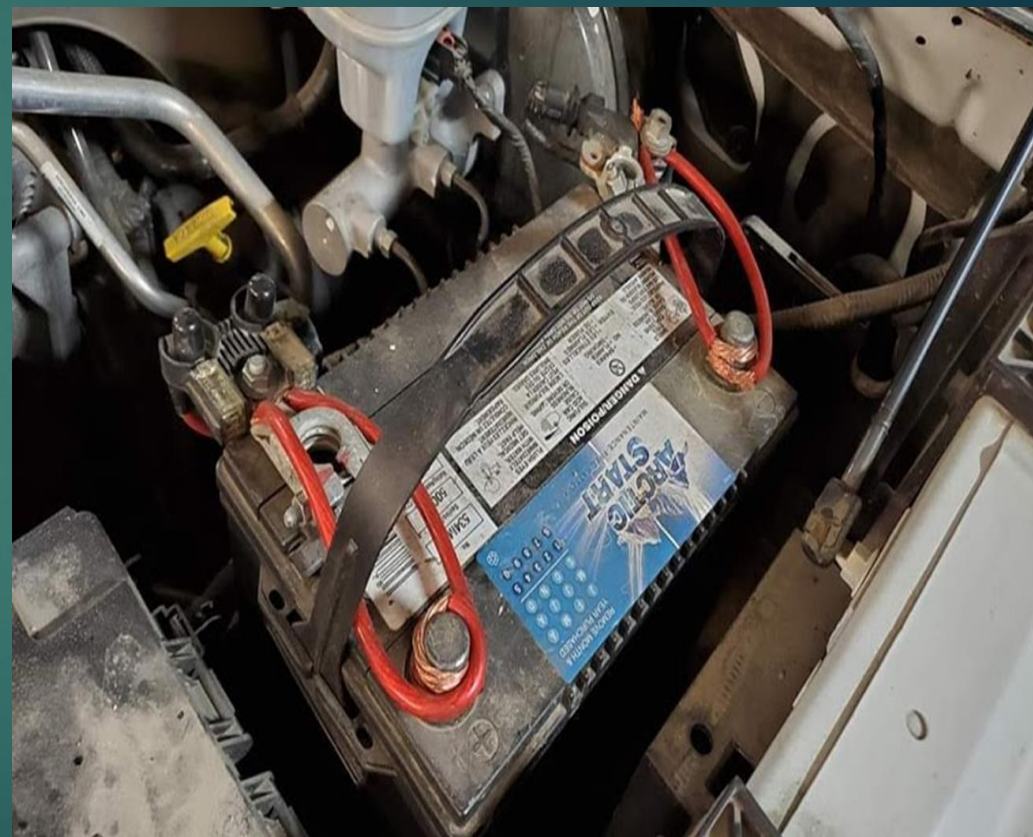


Battery “Group”

- ▶ Designated by the Battery Council International (BCI) to standardize
- ▶ Categorize batteries by dimensions for proper fitment
- ▶ Dimensional specifications include length, width, height, and polarity
- ▶ Terminal location
 - ▶ side post
 - ▶ top post
 - ▶ positive on left or right



Examples of the Wrong Battery Group

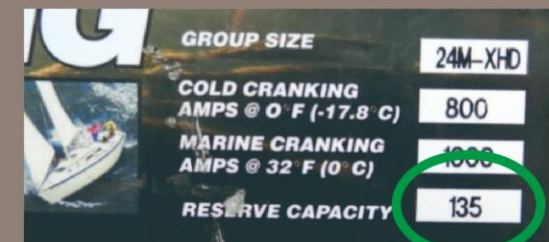


Reserve Capacity (RC)

- ▶ # Minutes the battery can produce 25 amps
- ▶ Maintain 10.5volts
- ▶ 80 ° F



Reserve Capacity (RC)



How does temperature affect Battery Life?

Lower Temperature

- ▶ Decrease in battery **Performance**
 - ▶ 10% for every 10 degree drop in temperature

Higher Temperature

- ▶ Decrease in Battery **Life**
 - ▶ Every 15° F increase in temperature will reduce the battery life by 50 %

77° F Perfect

Normal Charging Voltage 13.5 volts to 15.5 volts

(Some vehicles may charge at 12.5 volts at times)

Overcharging:

- ▶ Warp Plates
- ▶ Boil out water
- ▶ Crack case

Undercharging:

- ▶ Battery can sulfate
- ▶ Not have enough power
- ▶ Never fully charged

State of Charge

Specific Gravity	State of Charge	Voltage
▶ 1.265	▶ Fully Charged	▶ 12.6
▶ 1.225	▶ 50%	▶ 12.4
▶ 1.155	▶ 25%	▶ 12.0
▶ <1.120	▶ Discharged	▶ 11.9 or lower

▶ Difference: 0.7
Volts

Safety Considerations

- ▶ Eye protection
- ▶ Acid
 - ▶ Rinse spills
 - ▶ Neutralize
- ▶ Prevent accidental arcing
 - ▶ Disconnect negative terminal
 - ▶ Don't use battery as tool tray
- ▶ Never smoke or have near open flame



BATTERY TESTING

Load Testing

- ▶ Simulates an actual starting event
- ▶ Pass/fail test
- ▶ Can only test when fully charged

Conductance Testing

- ▶ All electronic calculation
- ▶ Safer to use
- ▶ Can test a partially dead battery
- ▶ Most common in shops today
- ▶ Estimates battery ability by:
 - ▶ STATE OF HEALTH
 - ▶ STATE OF CHARGE
 - ▶ HELP DETECT EARLY BATTERY FAILURES



What is a Parasitic Drain?

- ▶ A parasitic drain is a type of electrical current drain that occurs in a vehicle when the ignition is turned off. It is called a parasitic drain because it continues to drain power from the vehicle's battery, even though the vehicle is not in use.
 - ▶ A faulty component or wiring issue
 - ▶ A short circuit
 - ▶ A stuck relay



How long does a battery last?

- ▶ Depends - Just like oil changes and oil quality
- ▶ Does every battery have a warranty in months?
- ▶ What kind of charging conditions? (smart charge, computer controlled)
- ▶ What kind of operating conditions? (temp)
- ▶ Is it used regularly?
- ▶ What extra work-load demands have been added?
 - ▶ Radios
 - ▶ Lights
 - ▶ Inverters
 - ▶ Power supplies
 - ▶ Etc....

Temperature	Battery Life
77°F (25°C)	5 Years
92°F (33°C)	2½ Years
107°F (42°C)	~1 Year

Replace battery without losing ADAPTIVE MEMORY

- ▶ Adaptive memory
 - ▶ Radio station, memory seat, clock/time,
 - ▶ Shift patterns, ignition timing, fuel adaptive
 - ▶ Computer strategy and programming
- ▶ Procedures
 - ▶ Install another battery in parallel
 - ▶ Use the Diagnostic Link
 - ▶ Use the Auxiliary Power Point



Current
2011
Ford
F-150
XLT 3.5
BODY CONTROL / TPMS
/ PATS



SPECIAL TESTS

Menu

- ALL TESTS
- BATTERY MONITOR SYSTEM
- LAMP TESTS
- OTHER TESTS
- PATS TESTS
- RELAY TESTS
- SPECIAL FUNCTIONS

All Special Tests

Search All Special Tests 

Battery Monitor System

Battery Monitor System Reset

Lamp Tests

Central High Mounted Stop Lamp

Courtesy Lamps



Battery charging

- ▶ Slow charge when possible (5 amps)
- ▶ May take 8 hours or more
- ▶ Never charge a frozen battery
 - ▶ (electrolyte in discharged batteries will freeze)



Charging Rates and Times

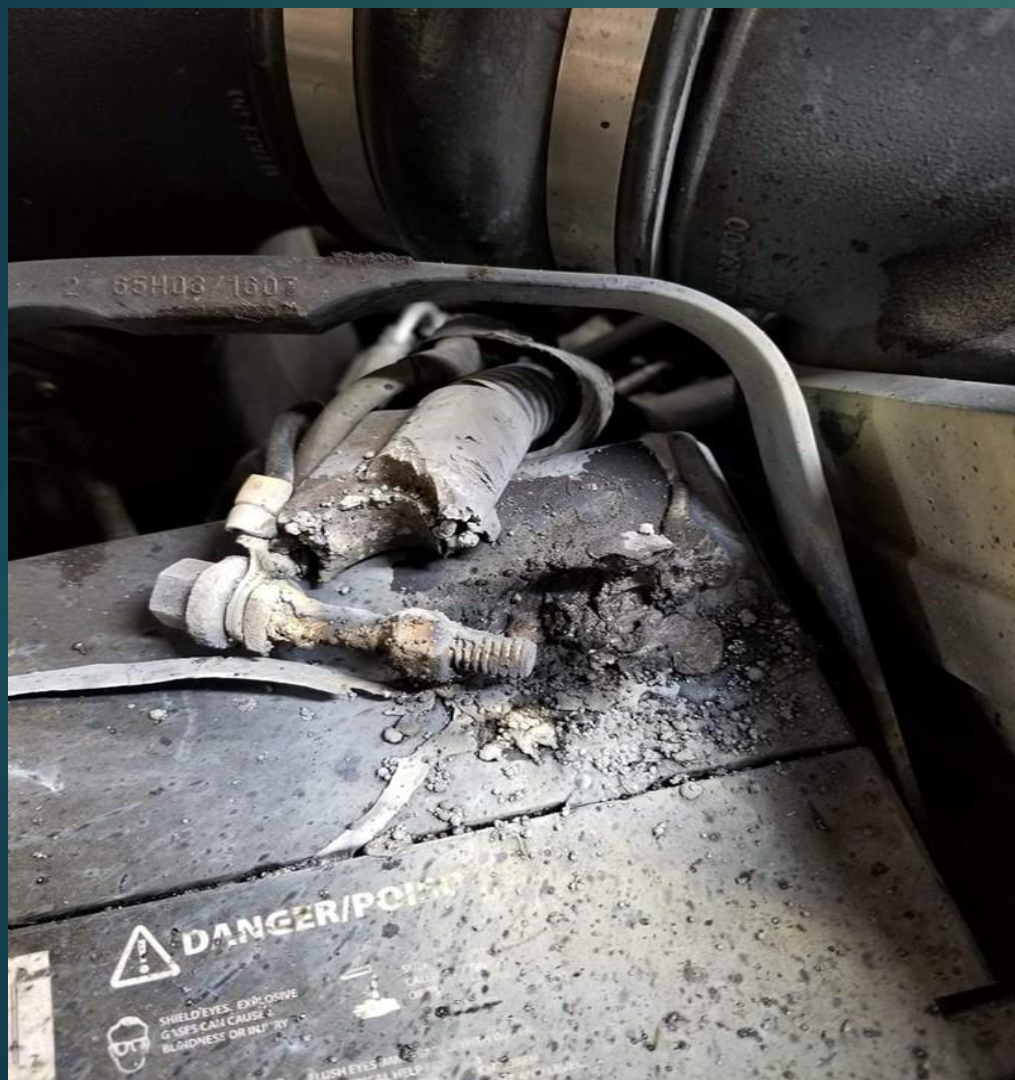
Discharged Partially Charged Fully Charged

ACID CONTENT

Open Circuit Voltage	CCA	5 Amp Charge Rate (in hours)	10 Amp Charge Rate (in hours)	30 Amp Charge Rate (in hours)
		Below 11.85	200-300 300-400 400-500 500-600 600-700	8 10 12 14 16
11.85 - 12.00	200-300 300-400 400-500 500-600 600-700	5 7 9 11 13	2.5 3.5 4.5 5.5 6.5	1.25 1.75 2.25 2.75 3.25
12.00 - 12.10	200-300 300-400 400-500 500-600 600-700	3 5 7 9 11	1.5 2.5 3.5 4.5 5.5	0.75 1.25 1.75 2.25 2.75
12.10 - 12.25	200-300 300-400 400-500 500-600 600-700	2 4 5 7 9	1 2 2.5 3.5 4.5	0.5 1 1.25 1.75 2.25
12.25 - 12.35	200-300 300-400 400-500 500-600 600-700	1 2 3 5 7	0.5 1 1.5 2.5 3.55	-- 0.5 0.75 1.25 1.75
Above 12.35	200-300 300-400 400-500 500-600 600-700	0.5 1 1.5 2.5 3.5	-- 0.5 0.75 1.25 1.75	-- -- -- 0.75 1









STARTING SYSTEM

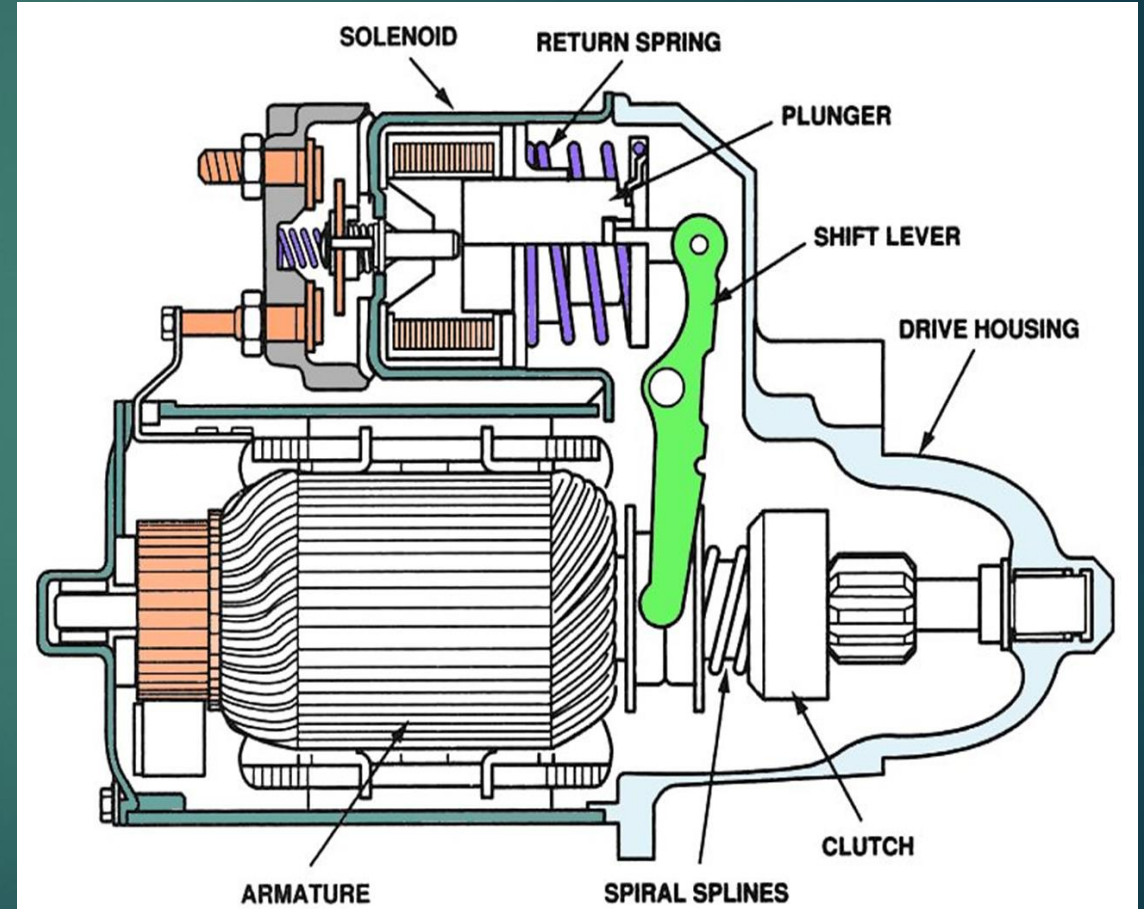
- ▶ Electrical motor for cranking engine
- ▶ High torque
- ▶ High amperage load
- ▶ Turns flywheel with gear drive
- ▶ Used to crank engine over until its fast enough that engine can run (300 rpm)

Has internal parts that wear out over time !



Normal Starter Operation

- ▶ One heavy Gauge wire connected from the Battery to the Starter
- ▶ One smaller wire activates the Solenoid
- ▶ Contact disc connects the two large starter terminals
- ▶ Pivot arm engages the pinion gear with the flywheel teeth



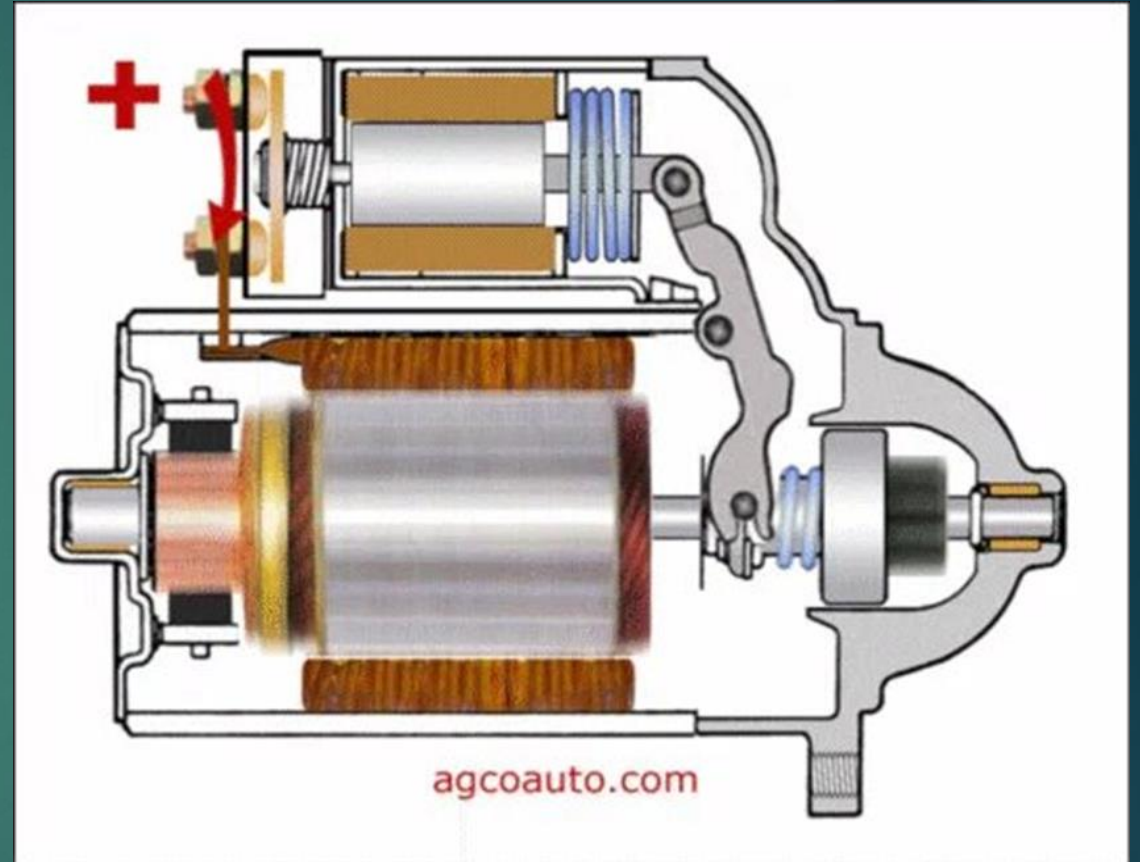
Starter Current Draw

- ▶ Four-cylinder engines
70 to 120 amperes
- ▶ Six-cylinder engines
100 to 200 amperes
- ▶ Eight-cylinder engines
185 to 250 amperes



Excessive Starter Current

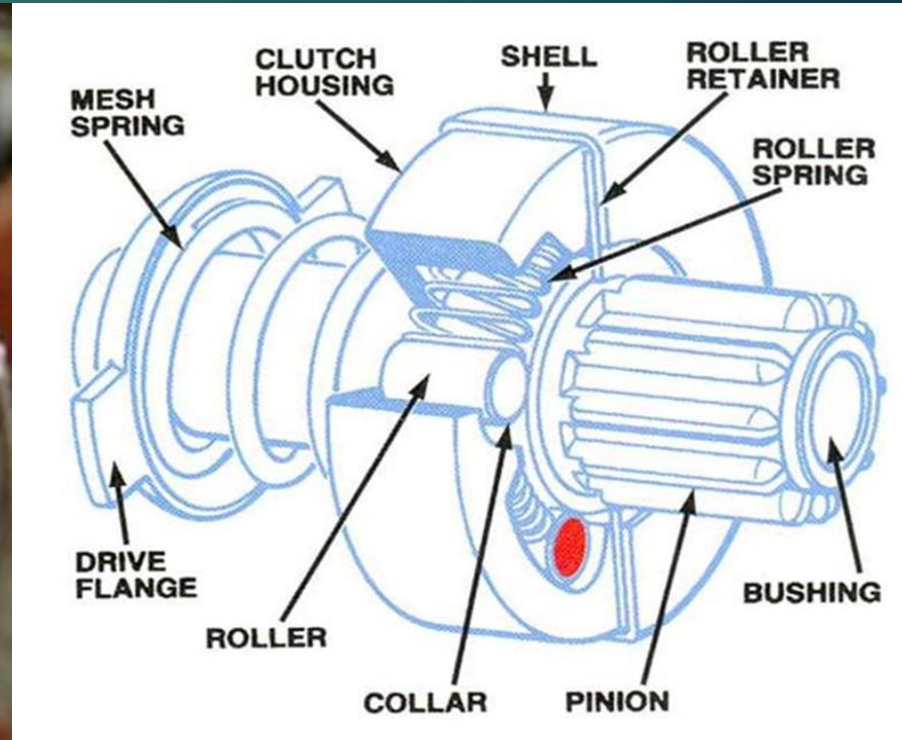
- ▶ Starter motor
 - shorted windings
 - binding armature (worn bushings)
- ▶ Seized engine



Starter Noise

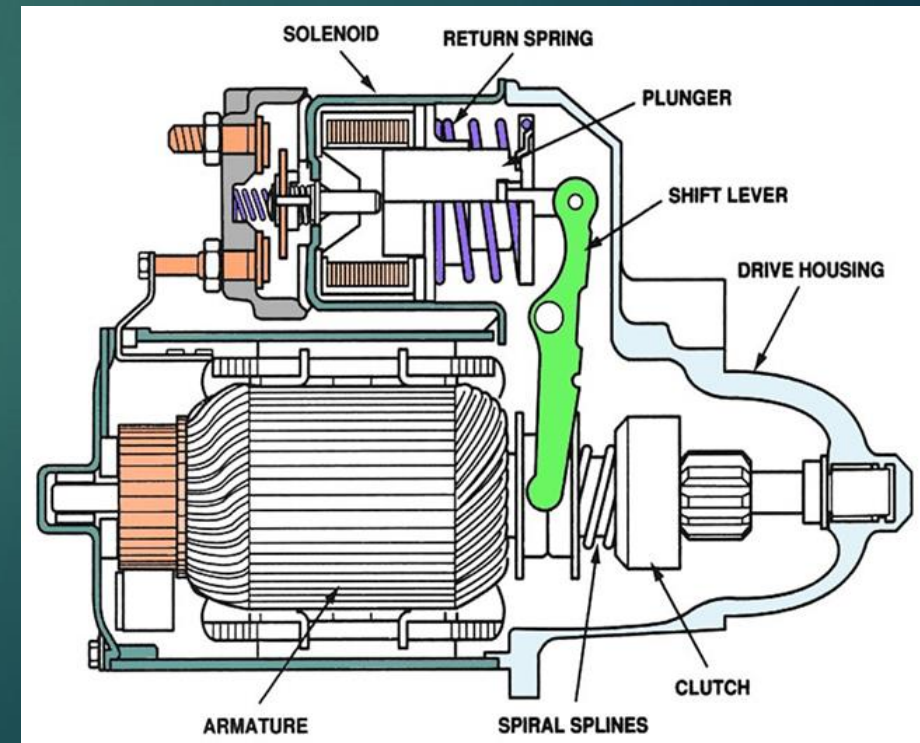
Improper starter clearance

- ▶ Excessive Clearance: Whine During cranking
- ▶ Insufficient Clearance: Whine After cranking
 - ▶ Bad Starter Drive



Starter Solenoid Noise

- ▶ Clicks - No contact between B and M
- ▶ Rapidly Clicking - Low Battery Voltage



Stop-Start Technology

- ▶ Engine shuts off at stops
- ▶ Sometimes may not be obvious
 - ▶ Maybe important to know if working on car with a disabled start/stop function
- ▶ Auto start stop icon on dash cluster
- ▶ Aux. battery in trunk
- ▶ Battery switch module on battery
- ▶ Disable button (not on early GM)
- ▶ Can't always identify by starter visual inspection



Stop-Start

- ▶ Conventional starter designed to withstand 35,000 starts for durability testing.
- ▶ Start/Stop starter motor designed to withstand 350,000 to 400,000 starts.
- ▶ The number of starts is logged and a “replace starter motor warning indicator” alerts the driver when close to the end of life expectancy
 - this must be reset with a scan tool when starter is replaced

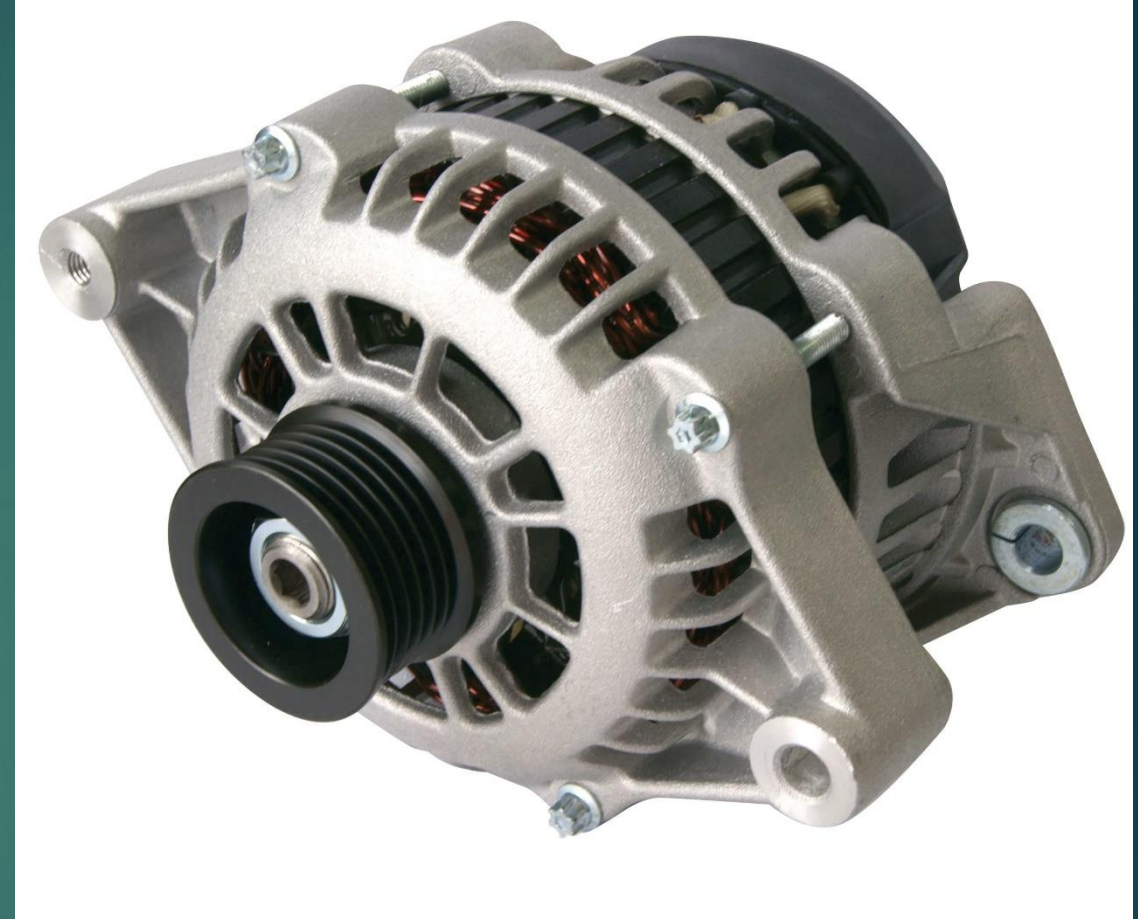
Aux Battery

- ▶ Small AGM battery located in trunk similar in size to motorcycle but much different in function
- ▶ Uses this battery for accessories when engine is shut down & then isolates the main battery to keep it from dischargingsince it will be needed for engine restart



CHARGING SYSTEM

- ▶ Alternator
- ▶ Belt driven from engine
- ▶ Recharges battery after starting
- ▶ Powers all accessories after start up
- ▶ Some have de-coupler pulley (NOISE)
- ▶ Symptoms of failure
 - ▶ Battery Light on
 - ▶ Dead Battery
 - ▶ Excessive Noise
- ▶ Has internal parts that wear out over time !



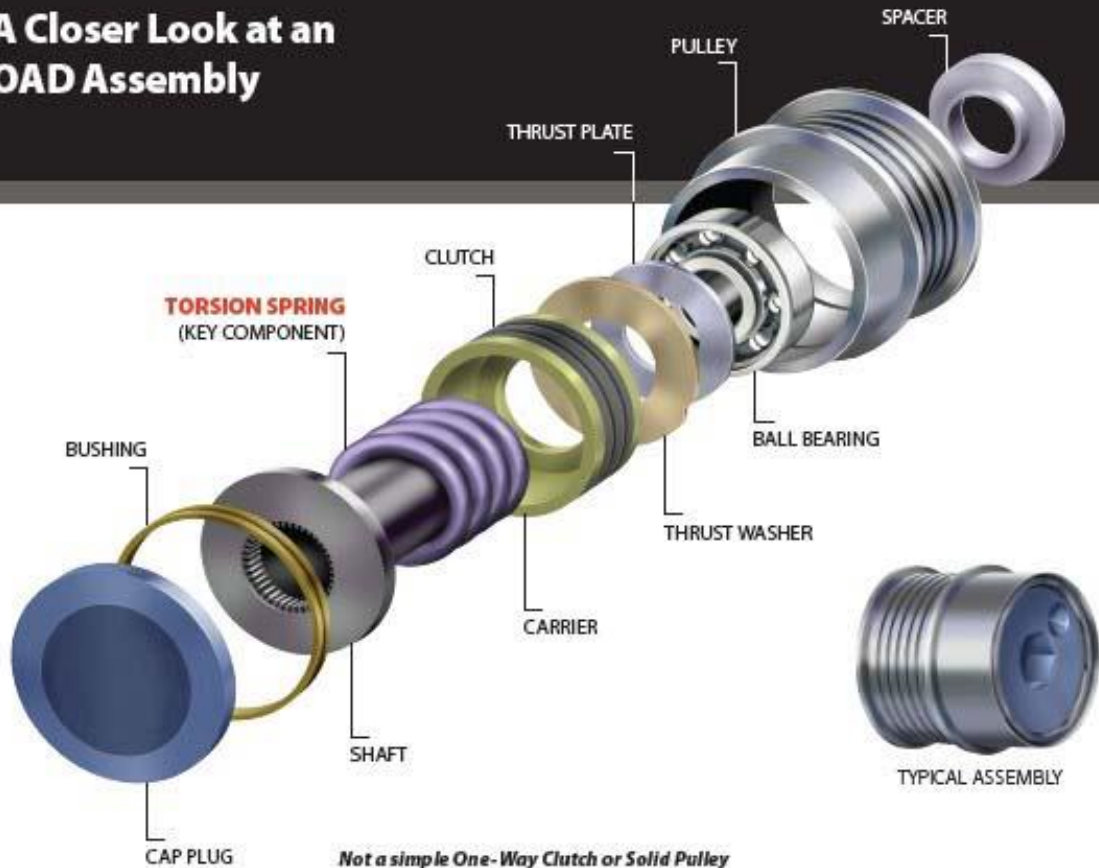
Charging System Faults

- ▶ Undercharging leads to low battery voltage
- ▶ Overcharging leads to battery and/or component damage
- ▶ Both problems can be caused by voltage regulation

Alternator De-coupler Pulley

- ▶ OAP (Overrunning Alternator Pulley)
- ▶ OAD (Alternator Decoupler Pulley)

A Closer Look at an OAD Assembly





Alternator De-coupler Pulley

Signs of a failing OAP (Overrunning Alternator Pulley) or OAD (Alternator Decoupler Pulley)

- Unusual Belt Noises (Serpentine belt)
- Unusual Vehicle Vibrations
- Undercharging
- Pulley Spins in both directions



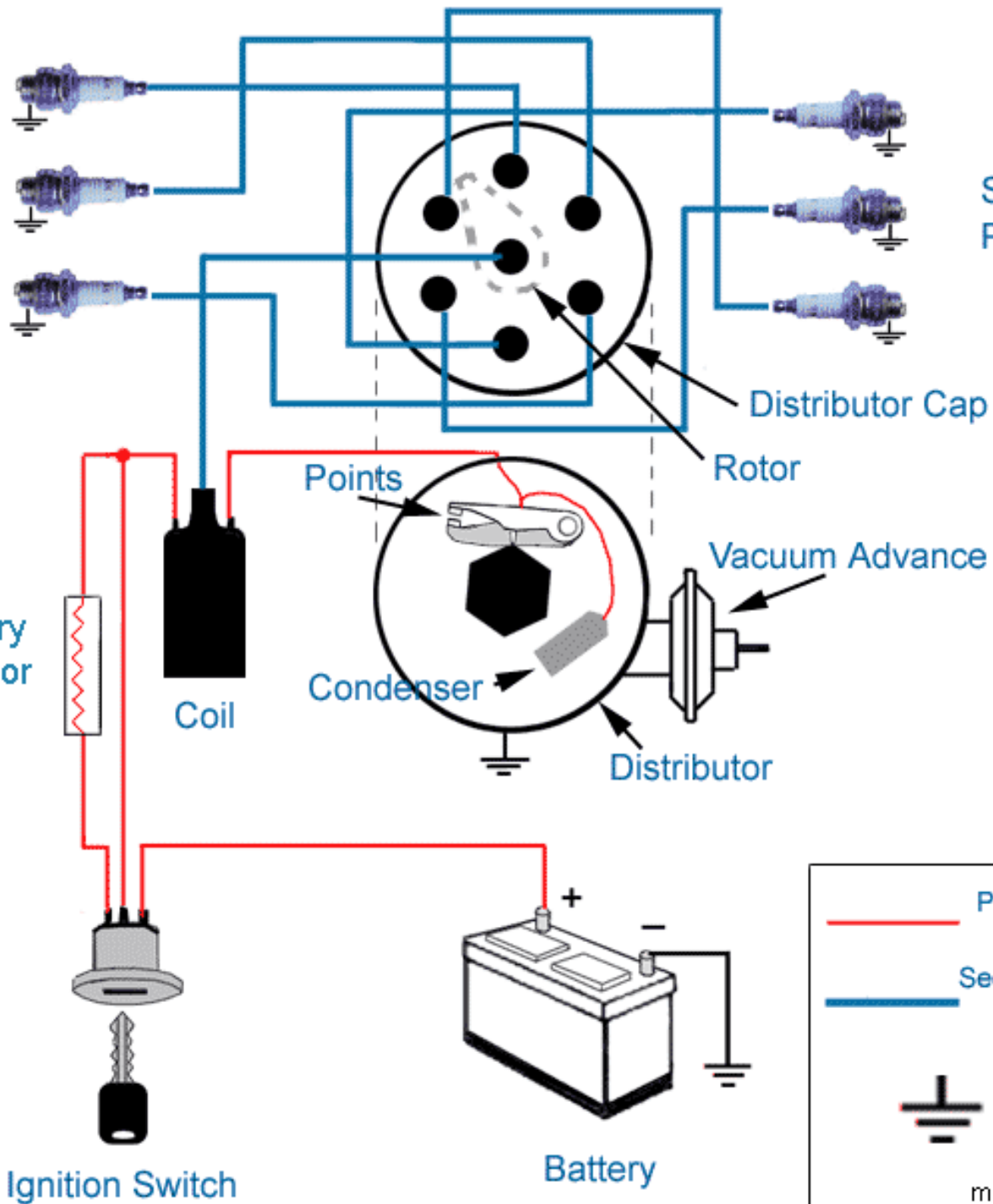
IGNITION SYSTEM

- ▶ Ignites the air/fuel mixture for combustion
- ▶ Must be timed to ignite on compression stroke of engine
- ▶ High voltage to jump spark plug gap
- ▶ Ramps up voltage with use of a transformer called an **Ignition Coil**
- ▶ Uses several engine sensors to determine proper timing



Spark
Plugs

Spark
Plugs



Primary
Resistor

Coil

Points

Condenser

Distributor

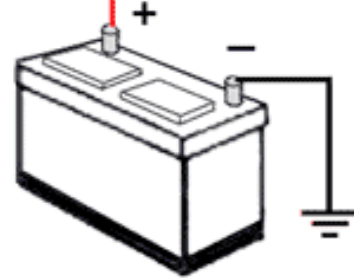
Vacuum Advance

Rotor

Distributor Cap



Ignition Switch



Battery

Primary Wiring
(Low Voltage)

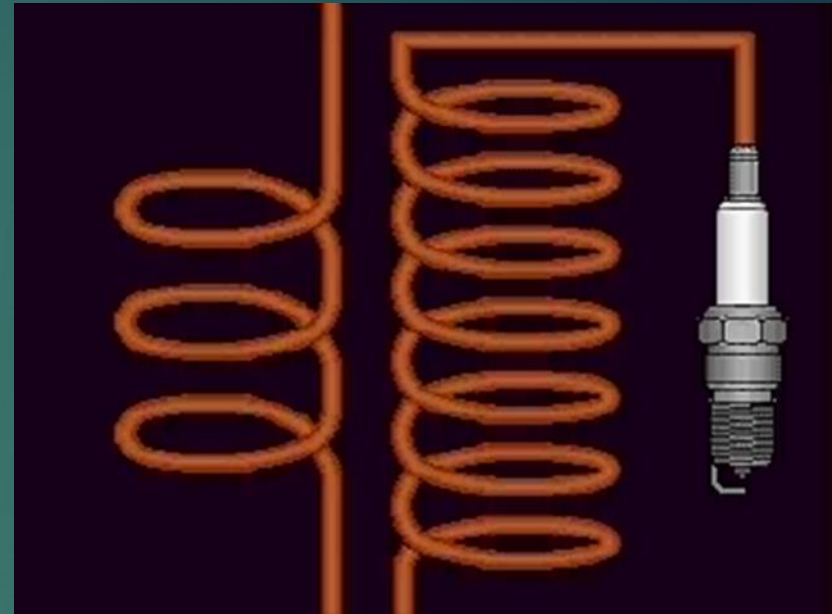
Secondary Wiring
(High Voltage)

Ground

All grounds
Connected to
metal body & frame

Parts

- ▶ Battery
- ▶ Ignition Coil / Coil Pack / Coil on Plug
- ▶ Spark Plugs / Wires
- ▶ Module & Sensors

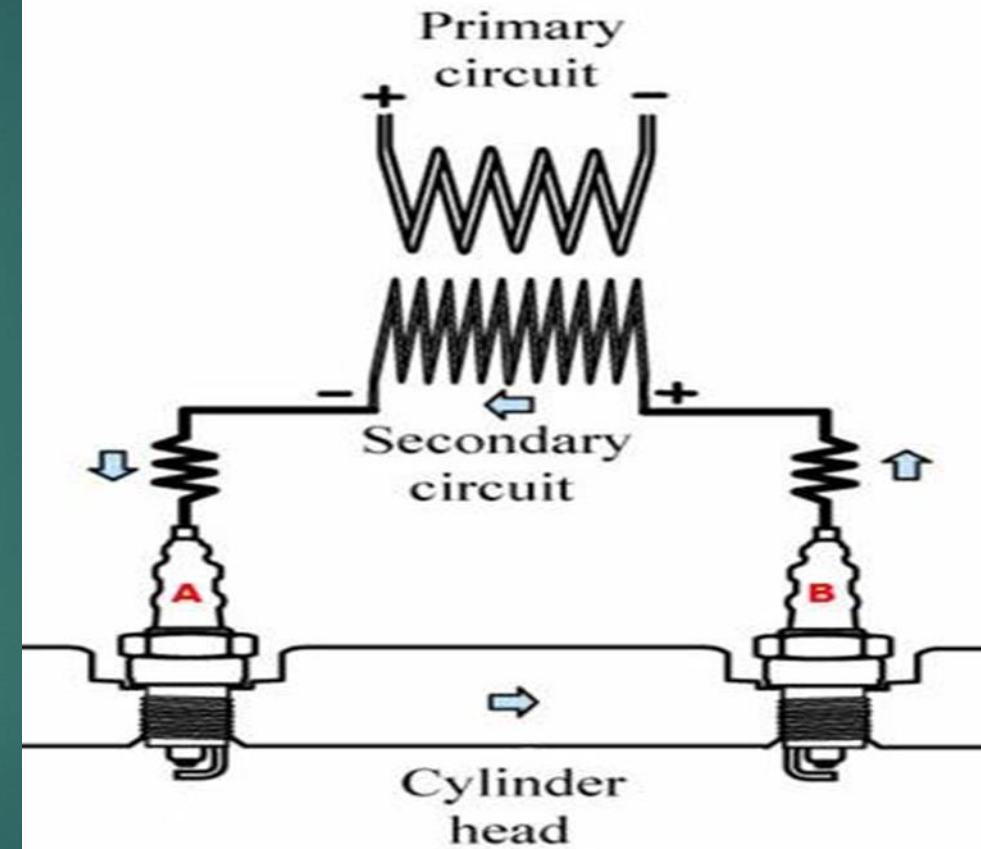
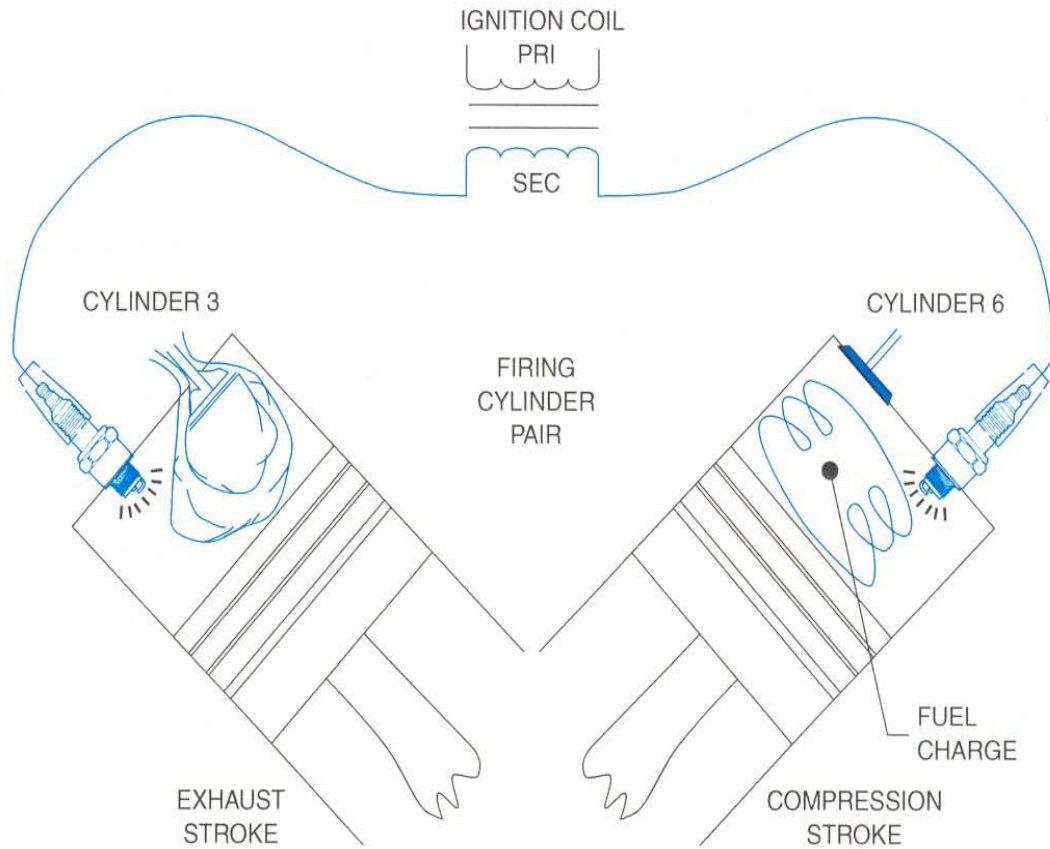


Ignition coils

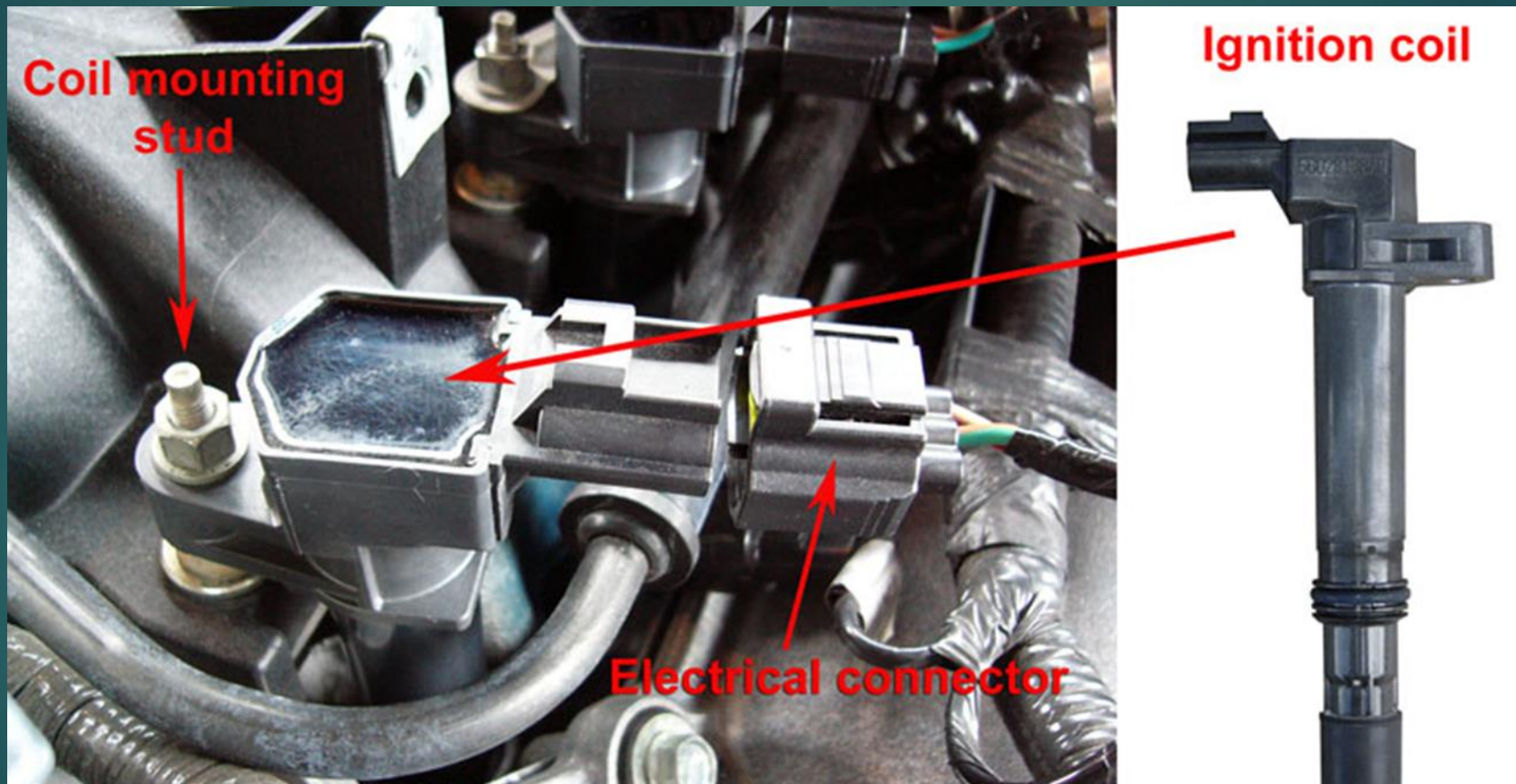
many different shapes and sizes



Waste Spark



Coil on Plug



COP / Waste Spark

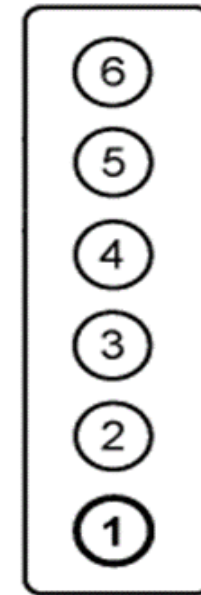


Firing Order

- Determined by crankshaft and camshaft design
- Cylinder numbering varies per manufacturer



Firing Order : 1-5-3-6-2-4



(Coil-on-plug)

Front of Vehicle

Ignition System Maintenance

- ▶ Spark plugs will wear over time
- ▶ Spark plug wires fail with age
- ▶ Ignition coils – Fail intermittently
- ▶ Misfires can cause engine performance issues & Check Engine lights



Types of Spark Plugs

- ▶ Copper
 - ▶ 20-30k Miles
- ▶ Silver
- ▶ Platinum (Double)
 - ▶ Single 60k Miles
 - ▶ Double 100K Miles
- ▶ Iridium
 - ▶ 100k-120K Miles

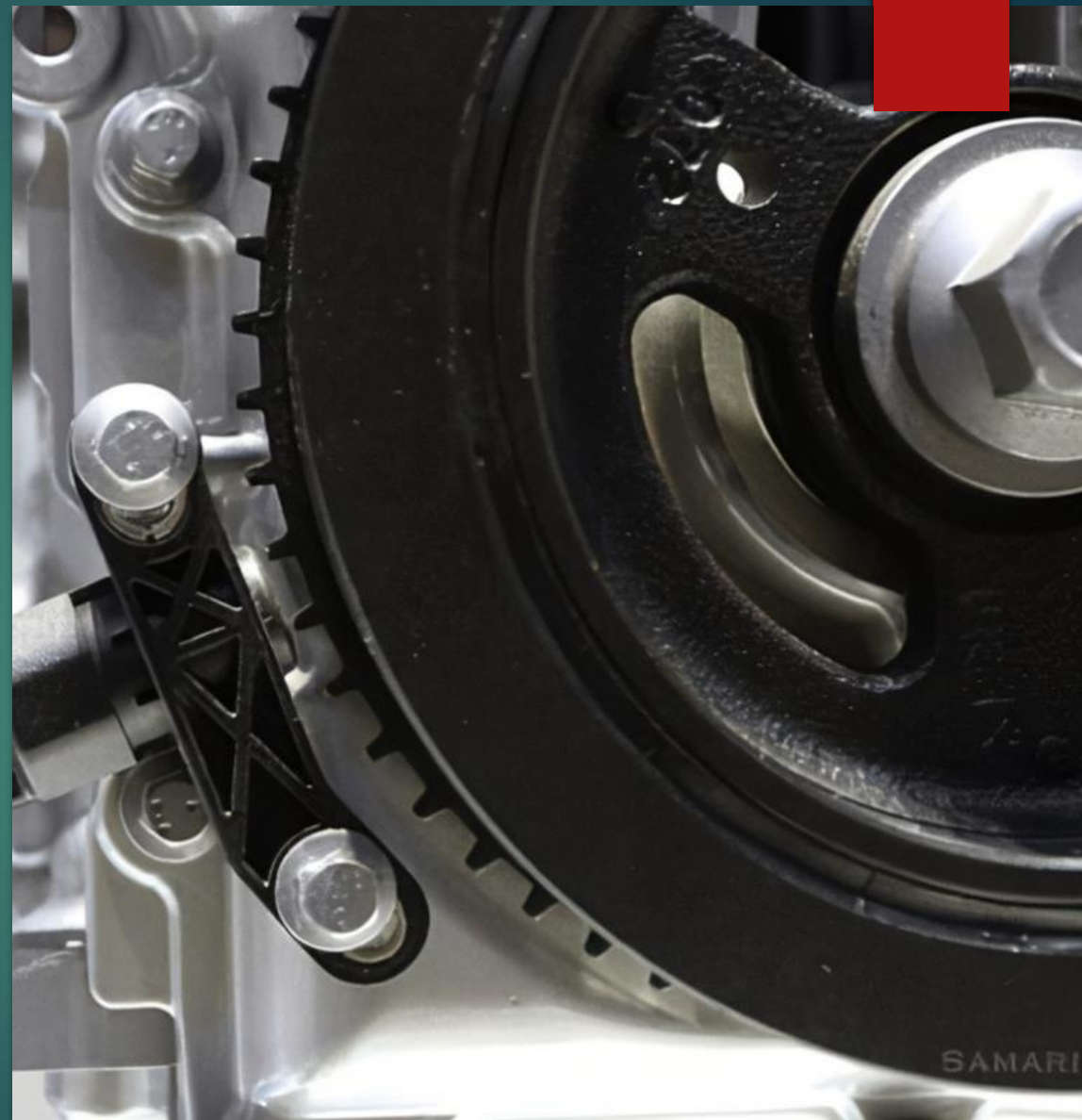


OEM may Specify 30K -120K Miles
Regardless of Spark Plug Type



Crankshaft Position Sensor

- ▶ Keeps the Engine Control Module informed of RPM and the location of each piston
- ▶ The engine will not run without the CKP signal



Camshaft Position Sensor

- ▶ Keeps the Engine Control Module informed of the location of each camshaft/valve
- ▶ The engine will usually still run without the CMP signal, but not well

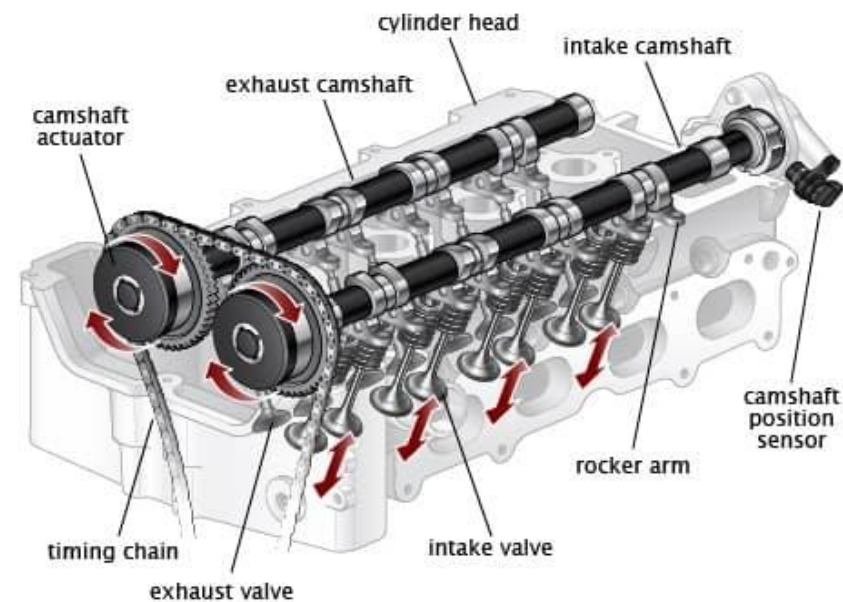
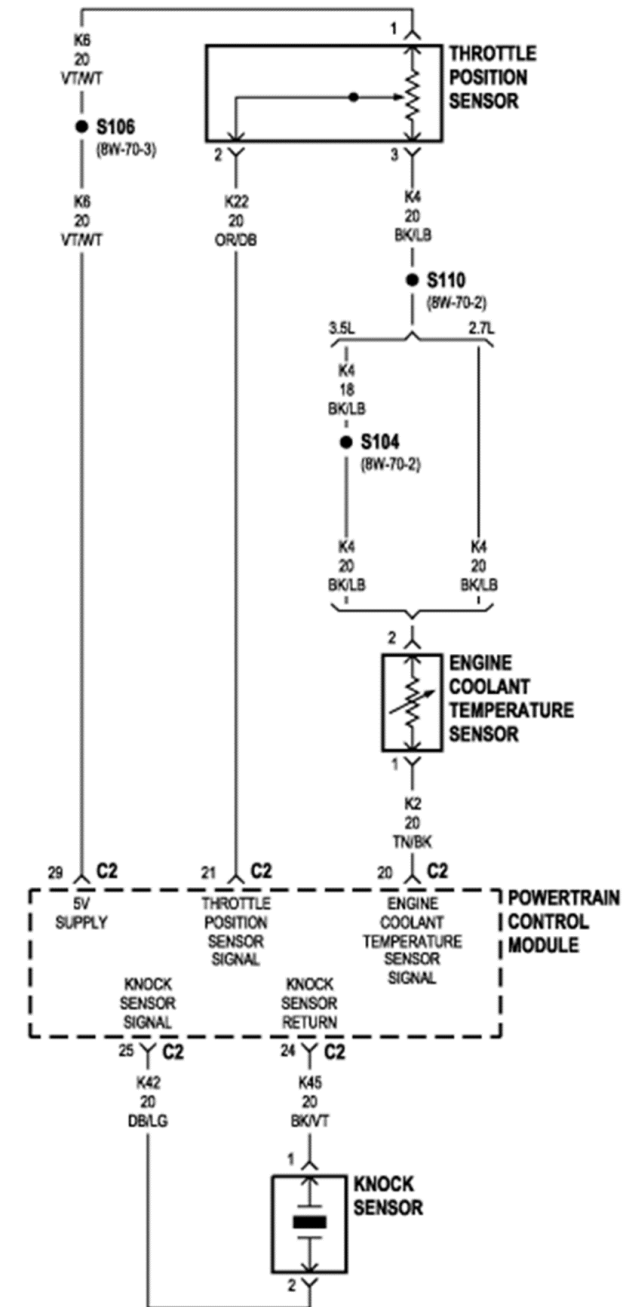


Image courtesy of ClearMechanic.com

Knock Sensor

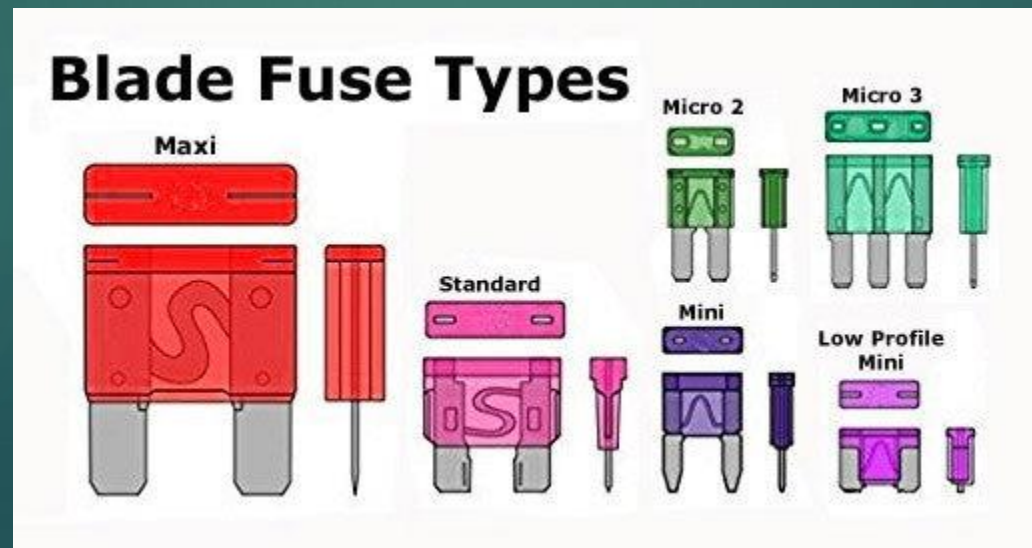
- ▶ Detects abnormal combustion
 - ▶ Ping, spark knock, or detonation.
- ▶ Abnormal combustion causes piston slap and vibration
- ▶ Knock sensor detects the vibration
- ▶ The voltage signal from the knock sensor (KS) is sent to the PCM
- ▶ PCM retards the timing under knocking conditions



CIRCUIT PROTECTION

Automotive Fuses

- ▶ Protect circuit from damage caused by excessive current flow from shorts or malfunctions
- ▶ Rated at their maximum current flow.
- ▶ The Circuit Current must be lower than the Fuse rating





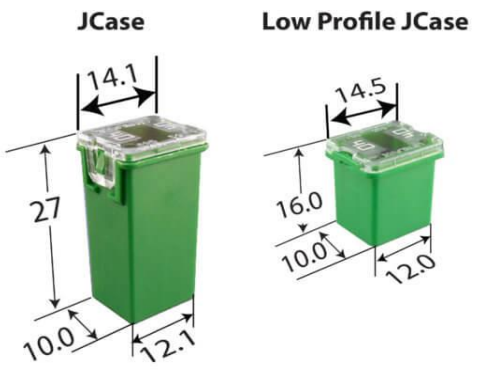
Fuse Rating by color
MAXI Fuse

Tan	70A
Red	50A
Blue	60A
Yellow	20A
Clear	80A
Green	30A
Orange	40A

Fuse Rating by color
ATO, Micro3, Micro2, Mini, and Low Profile Mini

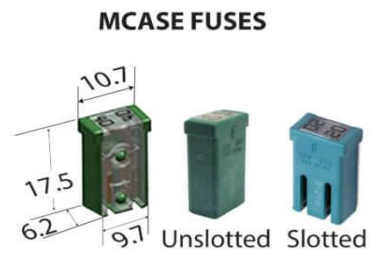
Black	1A
Gray	2A
Violet	3A
Pink	4A
Tan	5A
Red	10A
Blue	15A
Yellow	20A
Clear	25A
Green	30A

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Fuse Rating by color
JCase and Low Profile JCase

Blue	20A
White	25A
Pink	30A
Green	40A
Red	50A
Yellow	60A



Fuse Rating by color
MCASE

Color	Unslotted	Slotted
Gray	15A	15A
Blue	20A	20A
White	25A	25A
Pink	30A	30A
Green	40A	40A
Red	-----	50A
Yellow	-----	60A

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Questions?