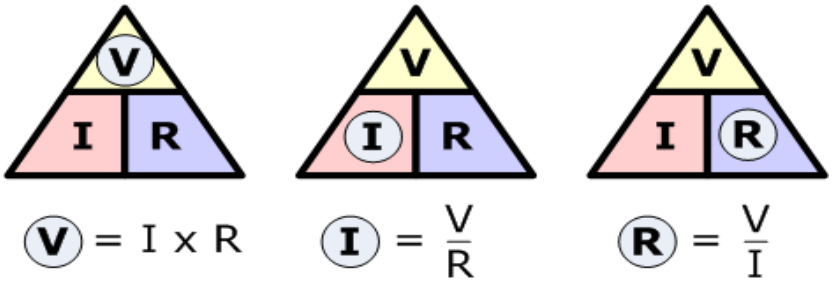
Basic theory for Mega-VET students

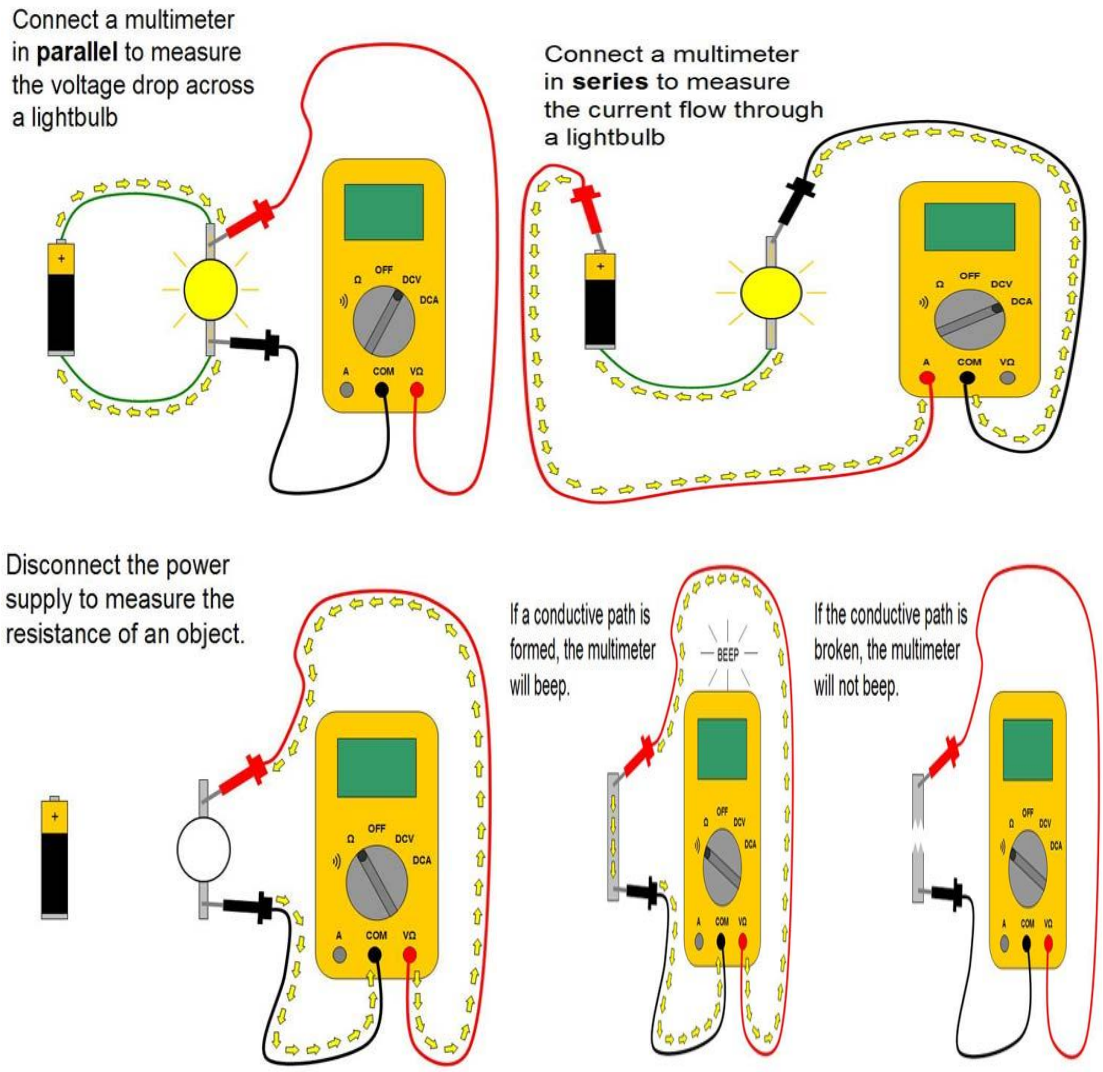
Ohm’s Law

- **Ohm's law** states that the current through a conductor between two points is directly proportional to the voltage across the two points.
- I=V/R
- ***I*** is the current through the conductor in units of **ampers**
- *V* is the voltage measured *across* the conductor in units of **volts** & *R* is the resistance of the conductor in units of **ohms**.
- More specifically, Ohm's law states that *Resistance* in this relation is constant, independent of the current.
- ***Remember the magic triangle!***



Multimeters

- Multimeter is used to make various electrical measurements, such as AC and DC voltage, AC and DC current, resistance. It is called a *multi*meter because it combines the functions of a voltmeter, ammeter, and ohmmeter. A multimeter may also have other functions, such as diodes, capacitors and **continuity** tests or special measurements like rpm, temperature etc.

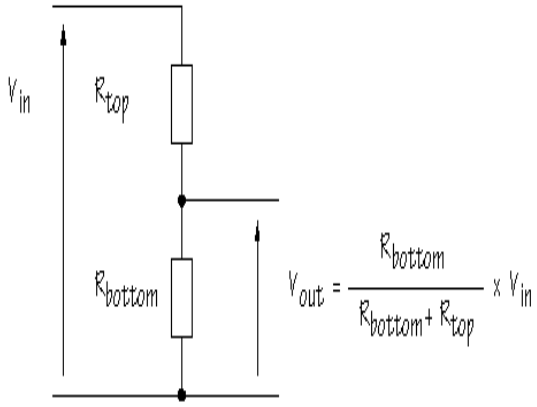


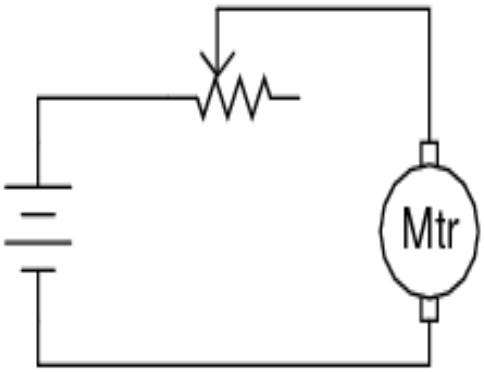
Variable Resistors

- Variable resistor is a resistor of which the electric resistance value can be adjusted. Is in essence an electro -mechanical transducer

and normally works by sliding a contact (wiper) over a resistive element.

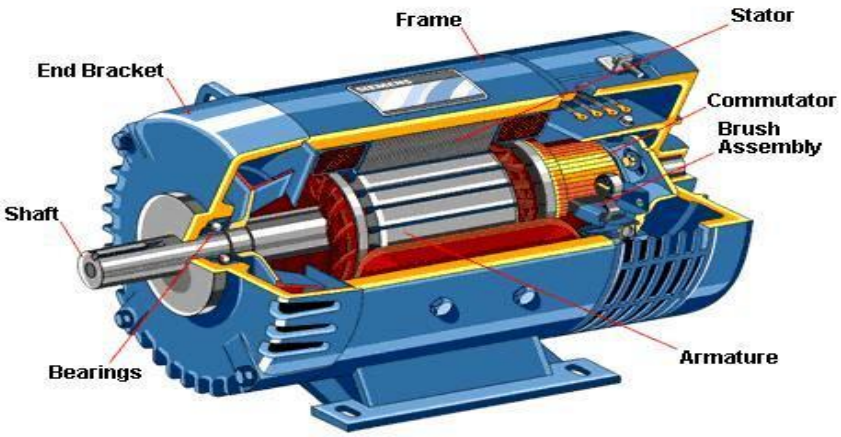
- Sometimes a variable resistor is used as a **potential divider** by using 3 terminals and is called **potentiometer.** When only two terminals are used it functions as a variable resistor and is called **rheostat**



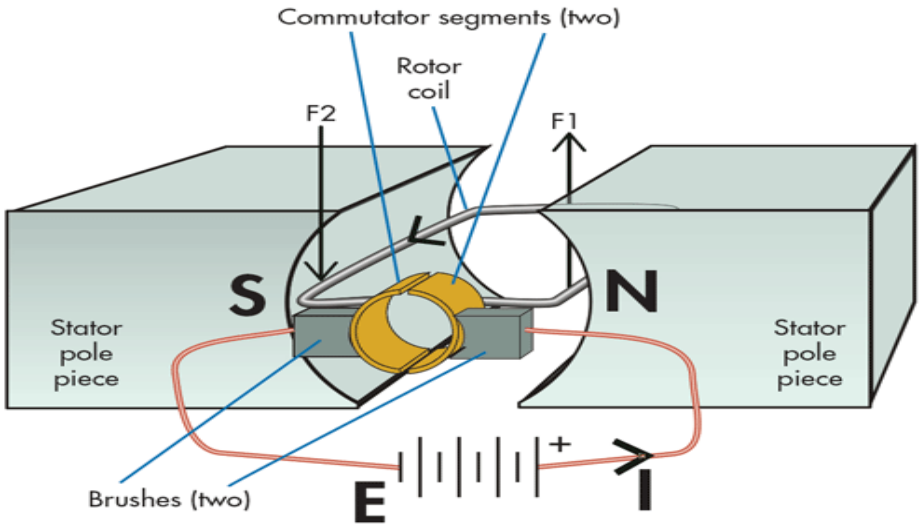


Electric Motors

- In our houses, almost every mechanical movement that you see around you is caused by an AC (alternating current) or DC (direct current) electric motor.
- A simple motor has six major parts:
- **Armature or rotor**
- **Commutator**
- **Brushes**
- **Shaft or Axle**
- **Stator or Field magnet**
- **Power supply**



- An electric motor is all about magnets and magnetism: A motor uses **magnets** to create motion. If you have ever played with magnets you know about the fundamental law of all magnets: Opposites attract and likes repel. So if you have two bar magnets with their ends marked "**north**" and "**south**," then the north end of one magnet will attract the south end of the other. On the other hand, the north end of one magnet will repel the north end of the other (and similarly, south will repel south). Inside an electric motor, these attracting and repelling forces create **rotational motion**.

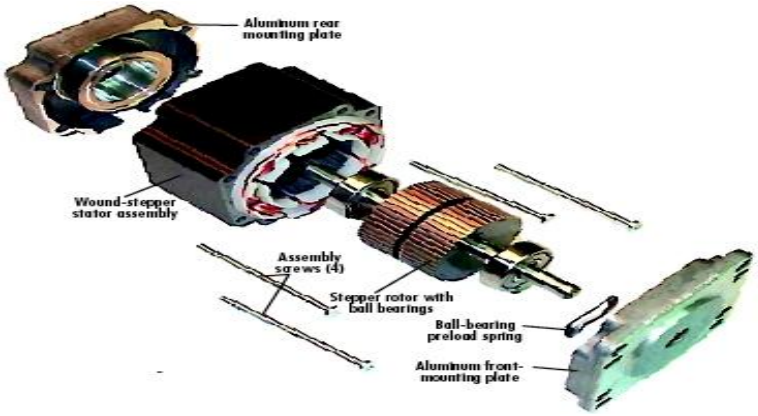


Special motors

- **1.Servo motor**

- A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors.
- Servomotors are used in applications such as robotics, CNC machinery or automated manufacturing.

- **Stepper motor**
- A stepper motor is a DC electric motor that moves in steps. It has multiple coils that organized in groups a called “phases”.
- When each phase is energizing in sequence, the motor will rotate one step at a time.
- Motors are present in cars, printers, computers, washing machines, electric razors, and much more.



Sensors

- Sensor is a device that detects and responds to an input from the physical environment. The input could be light, heat, motion,

moisture, pressure, or any one of other environmental phenomena. The output is generally a signal which we can process or we can lead it in other device

- **Thermistor**
- Is a resistor whose resistance is dependent on temperature. There are two types of Thermistor
- **NTC**, resistance ***decreases*** as temperature rises to protect against inrush *overvoltage* conditions.

  Commonly installed **parallel** in a circuit.
- **PTC**, resistance ***increases*** as temperature rises to protect against over current conditions.

  Commonly installed **series** in a circuit.
- **Inductive sensors** are widely used to measure position or speed, especially in harsh environments. However, to many engineers, inductive sensor terminology and techniques can be confusing.

  Inductive position and speed sensors come in a wide variety of shapes, sizes and designs. All inductive sensors can be said to work on transformer principles and they all use a physical phenomenon based on alternating electrical currents. This was first observed by Michael Faraday in the 1830s when he found that a first current-carrying conductor could 'induce' a current to flow in a second conductor. Faraday's discoveries went on to deliver electric motors, dynamos and, of course, inductive position and speed sensors. Such sensors include simple proximity switches, variable inductance sensors, variable reluctance sensors, synchros, resolvers etc.

Mechatronics

The definition of mechatronics has evolved since the original definition by the YasakawaElectric Company. In trademark application documents, Yasakawadefined mechatronics in this way: The word, mechatronics, is composed of "**mecha**" from mechanism and the "**tronics**" from electronics. In other words, technologies and developed products will be incorporating electronics more and more into mechanisms, intimately and organically, and making it impossible to tell where one ends and the other begins.

•The evolution of modern mechatronics can be illustrated with the example of the automobile. Until the 1960s, the radio was the only significant electronics in an automobile. All other functions were entirely mechanical or electrical, such as the starter motor and the battery charging systems. There were no "intelligent safety systems.

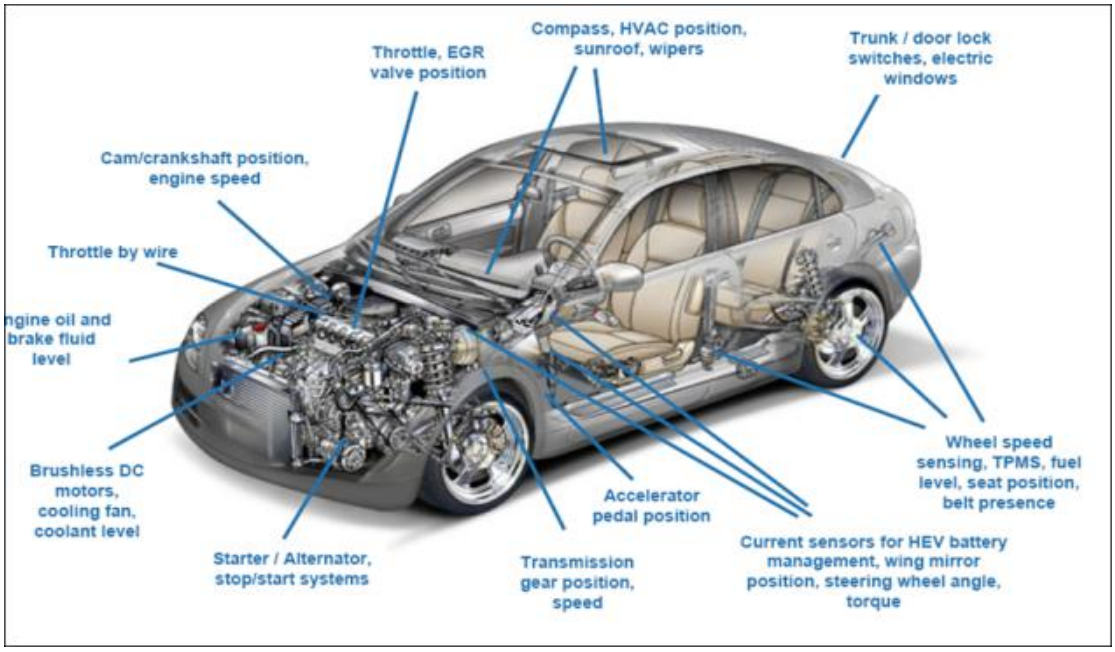
Mechatronics Apps in Automotive
•Before the introduction of sensors and microcontrollers, a mechanical distributor was used to select the specific spark plug to fire when the fuel–air mixture was compressed. The timing of the ignition was the control variable. The mechanically controlled combustion process was not optimal in terms of fuel efficiency.

•The electronic ignition system was one of the first mechatronic systems to be introduced in the automobile in the late 1970s. The electronic ignition system consists of a crankshaft position sensor, camshaft position sensor, airflow rate, throttle position, rate of throttle position change sensors and a dedicated microcontroller determining the timing of the spark plug firings. Early implementations involved only a Hall effect sensor to sense the position of the rotor in the distributor accurately.
The ABS works by sensing lockup of any of the wheels and then modulating the hydraulic pressure as needed to minimize or eliminate sliding.

•In some cases, the ABS is used to slow down the vehicle to achieve desired control. In automobiles today, typically, 8, 16, or 32-bit CPUs are used for implementation of the various control systems. The microcontroller or Electronic Control Unit (ECU) has onboard memory (EEPROM/EPROM), digital and analog inputs, A/D converters, pulse width modulation (PWM), timer functions, such as event counting and pulse width measurement, prioritized inputs, and in some cases digital signal processing. The 32-bit processor is used for engine management, transmission control, and airbags; the 16-bit processor is used for the ABS, instrument cluster, and air conditioning systems; the 8-bit processor is used for seat, mirror control, and window lift systems.

Sensors

- Computer controlled systems monitor the operating condition of today vechicles.
- Through sensors computer receives vital information about many conditions of the engine sensors are the computer's eyes as they convert physical signals (e.g tempreture,pressure) into digital or analog electrical signals.
- There are three main categories of sensors used in automobiles:
- **Resistive sensors**
- **Voltage generating sensors**
- **Switch sensors**



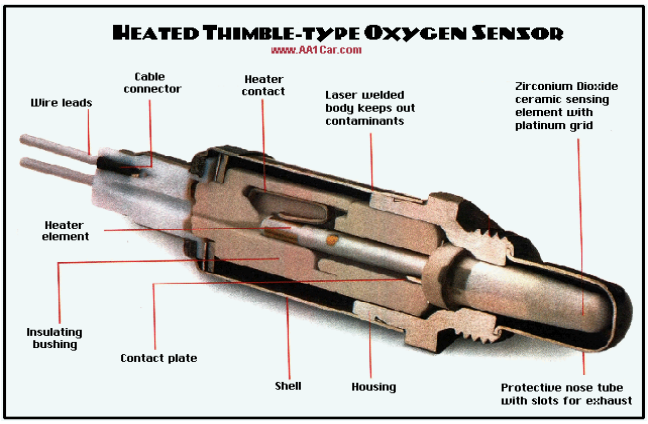
- **Manifold Absolute Pressure (MAP) Sensor**
- The manifold absolute pressure sensor is a **variable resistor** used to monitor the difference in pressure between the intake manifold at outside atmosphere. This information is used by the engine computer to monitor engine load (vacuum drops when the engine is under load or at wide open throttle). When the engine is under load, the computer may alter spark timing and the fuel mixture to improve performance and emissions.

Coolant Temperature (CTS) Sensor

- A Coolant Temperature sensor is a simple sensor that it's fitted in the engine's block or cylinder head and determines the temperature of the engine coolant. Basically is a **thermistor** that can change its resistance with engine coolant temperature changes, usually a NTC type –Negative Temperature Coefficient. The resistance reading by the ECM can be used to change the air/fuel ratio and the ignition timing, to activate emission control or turn the cooling fan on.

- **Knock sensor**
- Engine knock is characteristic of an uncontrolled combustion process and can cause engine damage. That is prevented by a knock sensor, a noise sensor near the engine. The Knock Sensor is a **Piezo Electric** device that when you stress it, a voltage is produced. It senses knock and transmits information to the electronic engine management control unit. This influences process control in the engine, for example timing and fuel injection until knock is eliminated. Knock is frequently caused by fuel that does not comply with the required minimum quality.

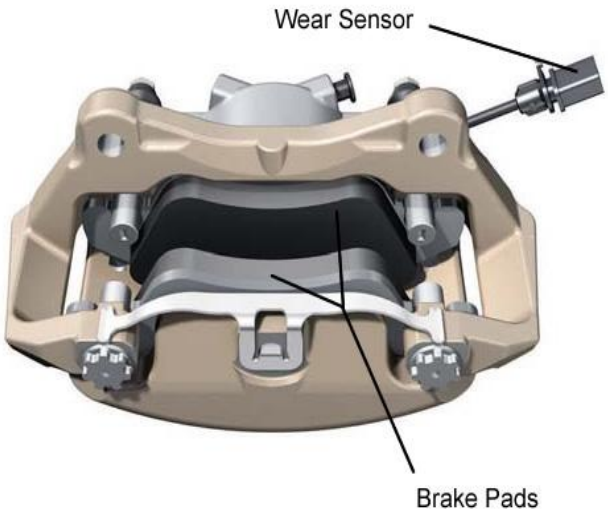
- **λ or oxygen sensor**
- An Oxygen sensor is a chemical generator. It is constantly making a comparison between the Oxygen inside the exhaust manifold and air outside the engine. If this comparison shows little or no Oxygen in the exhaust manifold, a voltage is generated. The output of the sensor is usually between 0 and 1.1 volts.



- **Throttle position (TPS) sensor**

- The TPS is a potentiometer attached to the throttle shaft. A voltage signal is supplied to the sensor, and a variable voltage is returned. The voltage increases as the throttle is opened. This signal and the MAP output determines how much air goes into the engine) so the computer can respond quickly to changes, increasing or decreasing the fuel rate as necessary.

- **Brake sensors**
- Brake sensors are used in vehicle applications such as travel sensor for brake master cylinder position detection (optional redundant); travel sensor for rear axle steering to support advanced **ESP**; rotary sensor for brake pedal position detection (optional redundant); hall brake light switch and wheel speed sensor. We also provide pressure sensors such as the vacuum brake booster sensor.



Actuators

- **Actuators** are the devices uses energy to provide motion (e.g electric motors, step motors, valves).
- We could say that actuators complete the control process by carrying out the computer's instuctions. An actuator can adjust engine idle speed or regulate the fuel metered into the engine, start the windscreen wipers, relief a pressure etc.
- Actuators are divided into the following areas:
- **Electric & Stepper motors**
- **Solenoids**

Electric Motors

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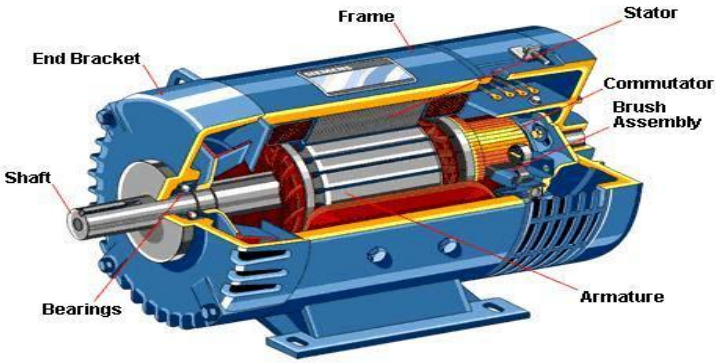
- **Armature or rotor**
- **Commutator**
- **Brushes**
- **Axle**
- **Field magnet**
- **DC power supply**



- **Digital Linear Actuator – Stepper motor**
- **Idle Air Control Valve** in the gasoline engine vehicles equipped with mechanical throttle body. The valve allows accurate and precise air flow during idle phase. Accurate and precise linear positioning against external load.

The Idle Air Control Valve offers:

- Accurate and stable idle air contro
- Various gas (air) flow curve can be achieved
- High accuracy under severe conditions
- Proven reliability and long durability

- High resolution linear positioning against load

- **Injectors**
- **Fuel Injectors** are solenoids valves. Usually, the injector have two pins. One pin is connected to the battery through the ignition relay and the other pin goes to the ECU. The ECU sends a pulsing ground to the injector, which closes the circuit, providing the injector's solenoid with current. The magnet on top of the plunger is attracted to the solenoid's magnetic field, opening the valve. Since there is high pressure in the rail, opening the valve sends fuel at a high velocity through the injector's spray tip.