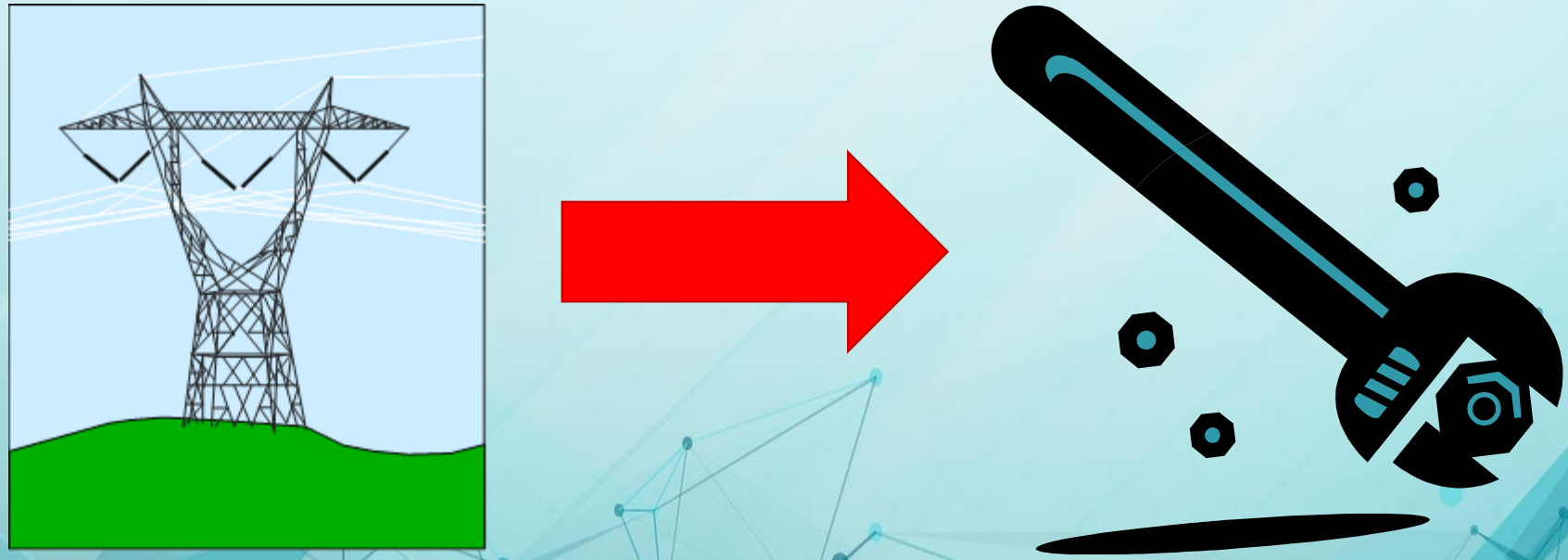
Fundamentals of Electric Motors

- Overview/Objectives:
  - Basic motor function
  - Basic motor components
  - Basic motor application and performance

Fundamentals of Electric Motors

What is a Motor?

An Electric Motor Converts Electrical Power to Mechanical Power

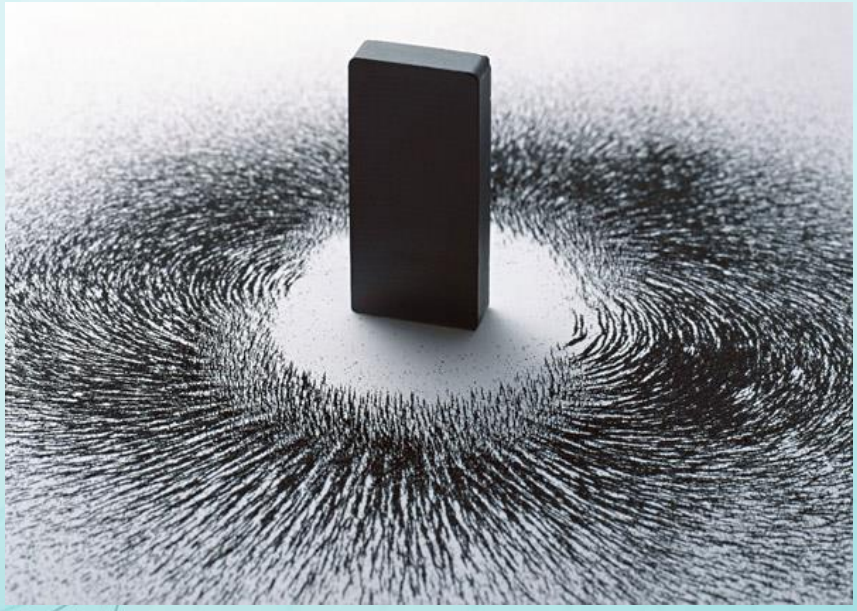


How an Induction Motor Operates

Magnetism is the force used by motors to create rotation

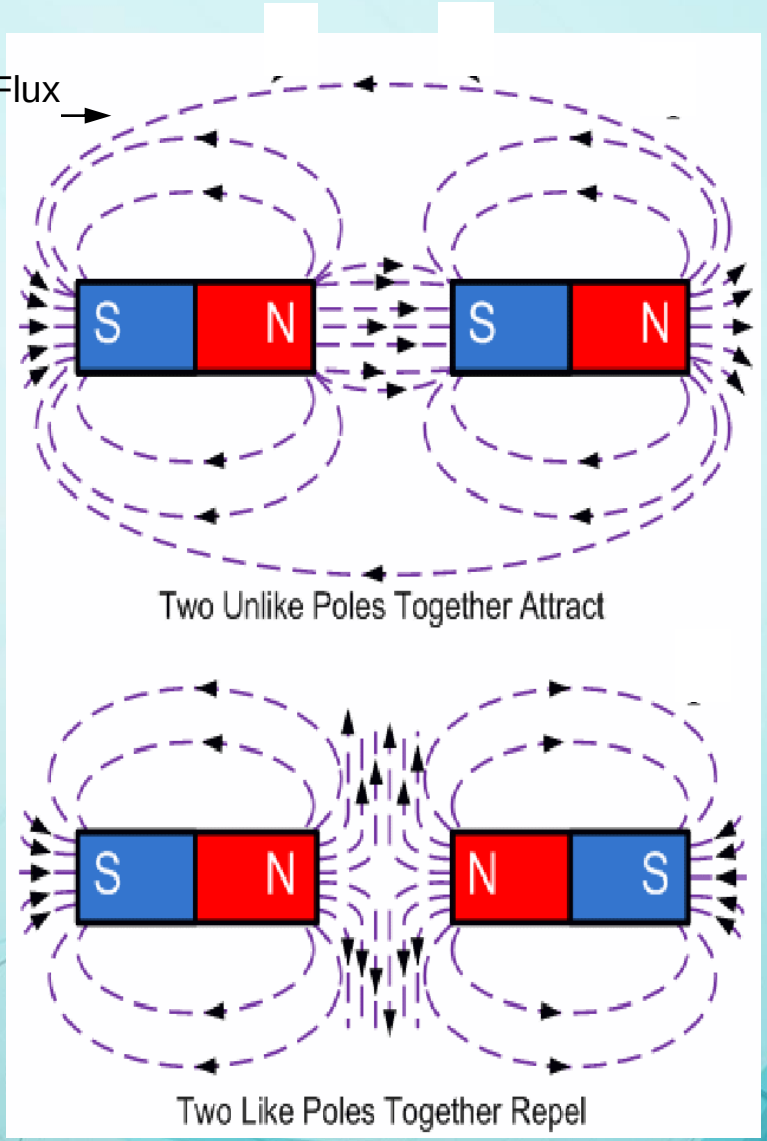
On What Principle Does it Operate?

- Induced Magnetism



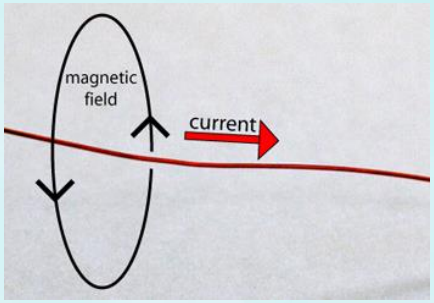
Permanent Magnet Basics

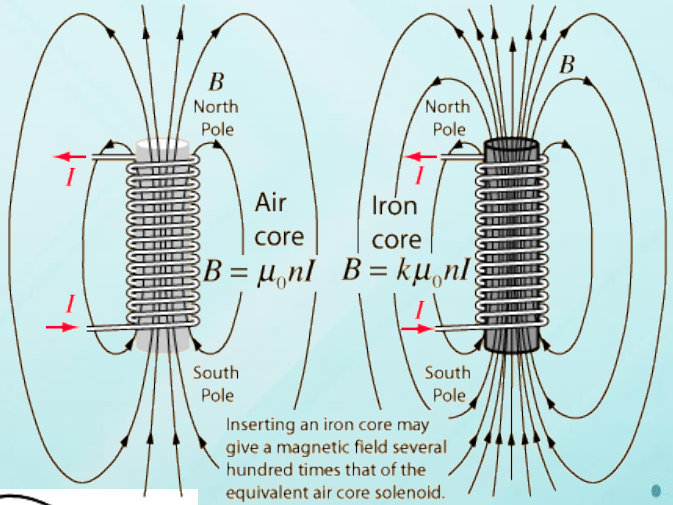
- Any magnet has a North and a South Pole
- “Opposite” poles of a magnet attract each other
- “Like” poles of a magnet repel each other.
- Motors use this principle of attraction and repulsion to rotate

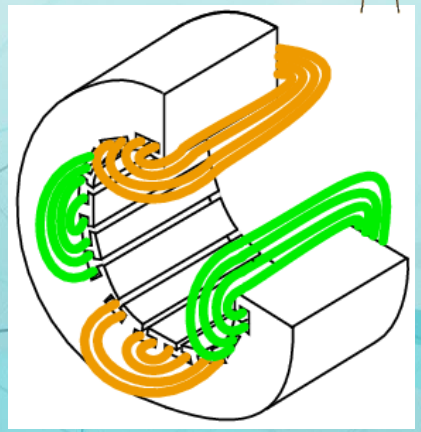


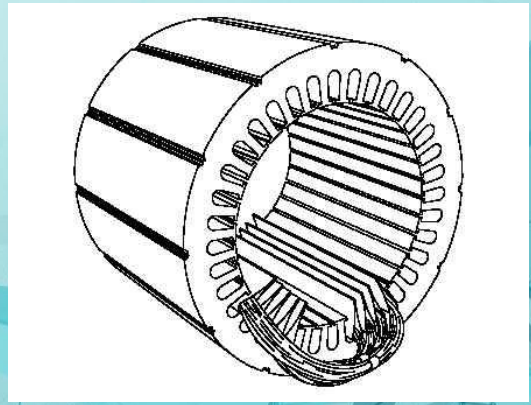
Induced Magnetic Fields

- A magnetic field (B) is produced any time an electric current is passed through a wire.
- The magnetic field around a singular straight wire is not very strong.
- A stronger field can be created by coiling the wire
- An even stronger field can be produced by coiling wire around a piece of **special** steel called “electrical steel”. This is called an Electromagnet.
- Coil “groups” laid in slots in electromagnetic material forms the stator of the motor

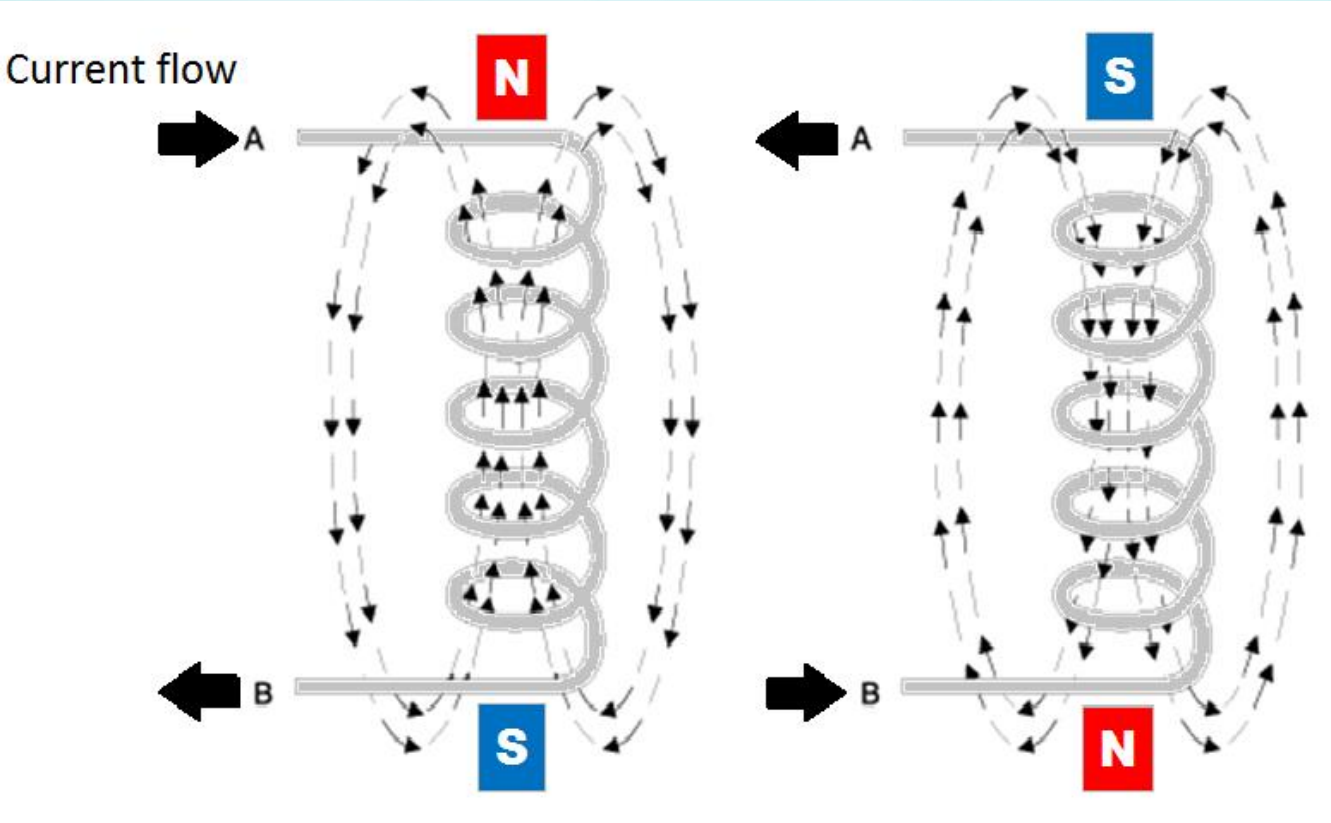








Alternating Current



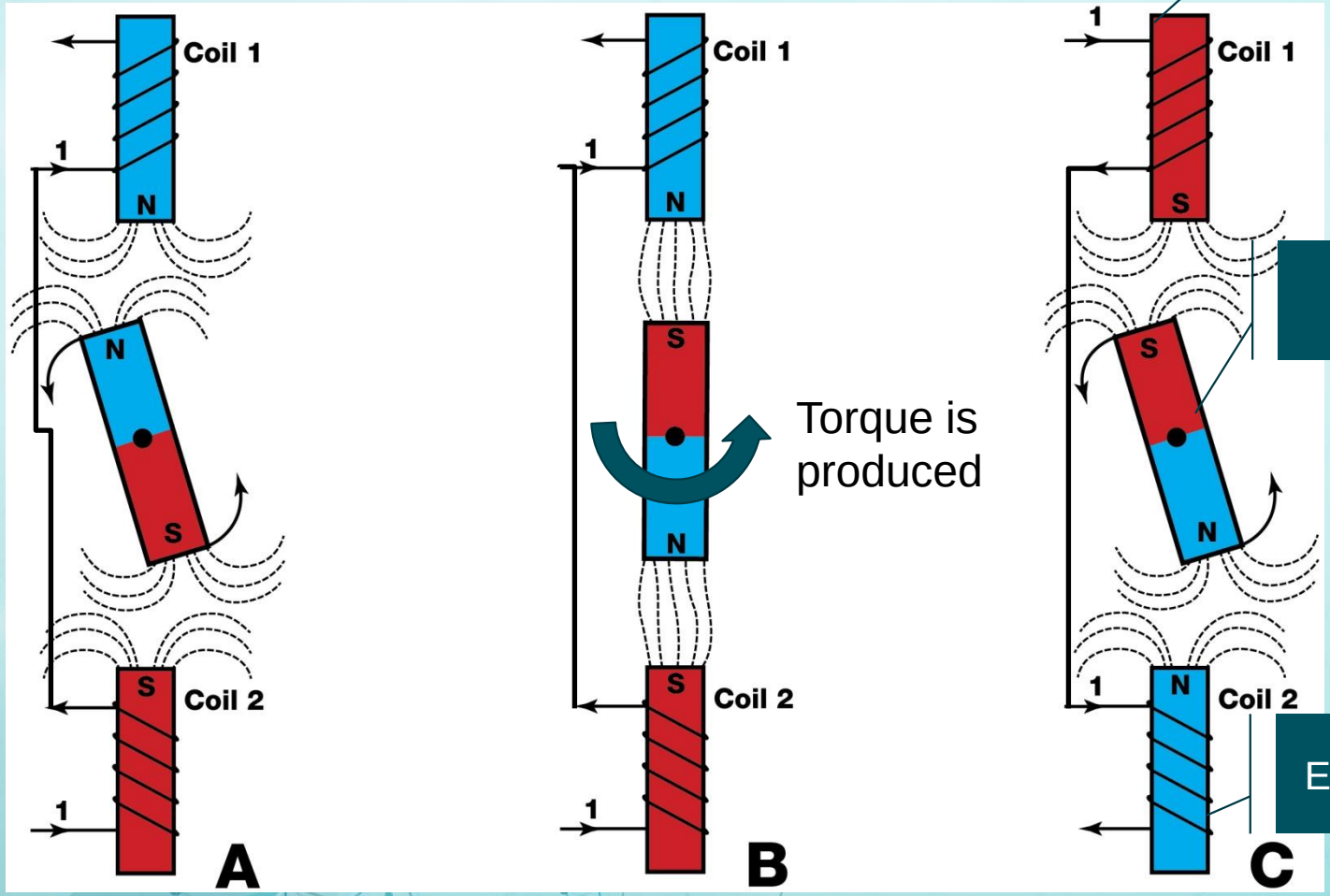
- The poles of an electro-magnetic coil change polarity when the direction of current flow changes.

Magnetic Propulsion

Stator

Rotor

Stator



Electromagnet

Permanent Magnet

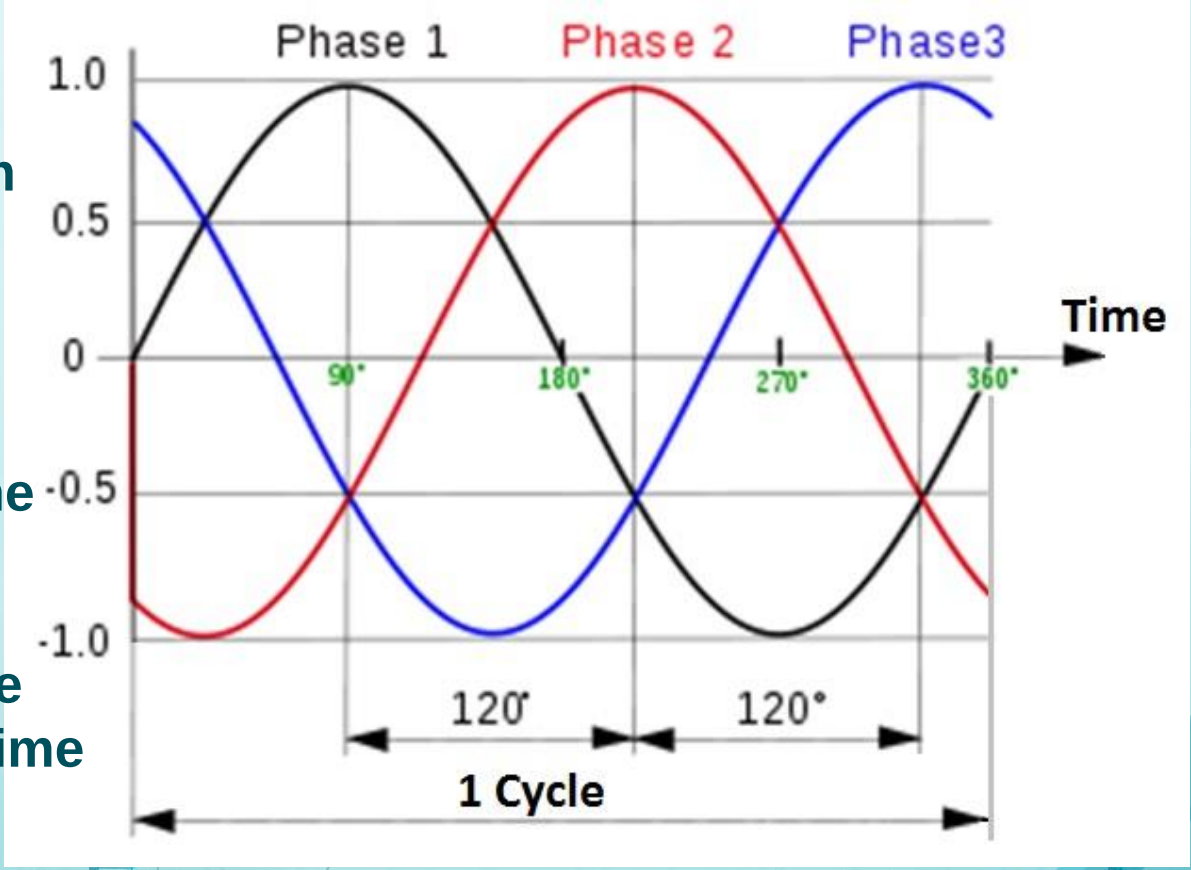
Electromagnet

The principle of an induction motor is to induce magnetic forces into the rotor of the motor. A new generation of motors has permanent magnets imbedded in the rotor

Three Phase AC Power

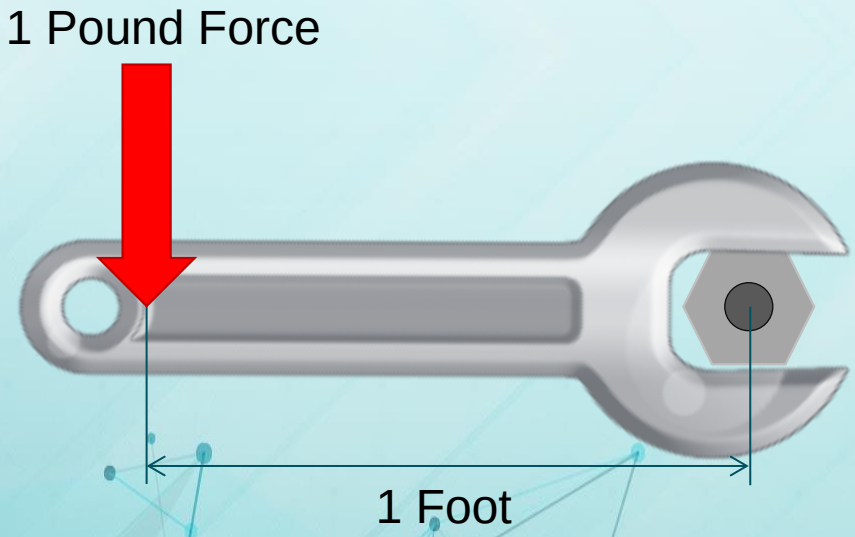
Why 3 phases?

- **It allows the most power transfer with the minimum number of conductors**
- **Three times the power transfer of a single phase system by adding only one conductor**
- **The sum of all three phase voltage at any instant of time is zero**



What is Torque?

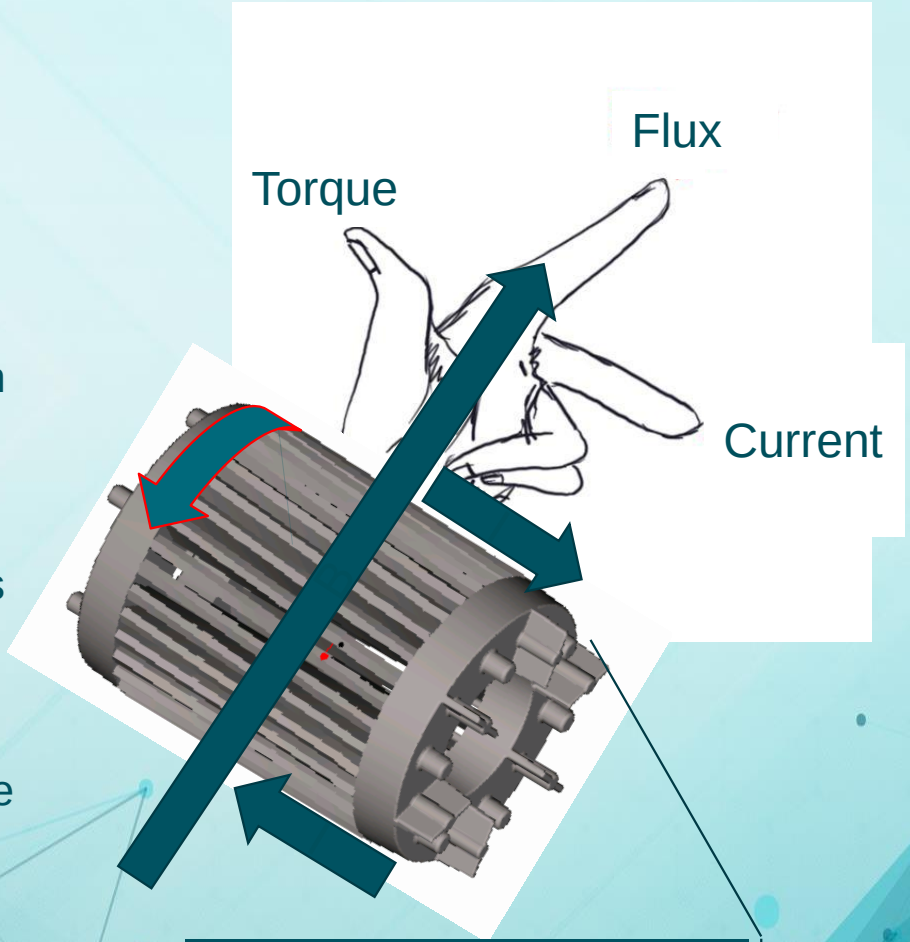
- Torque is a force applied at a distance from and perpendicular to an axis.



Torque = 1 Ft X 1 Lb = 1 Ft-Lb

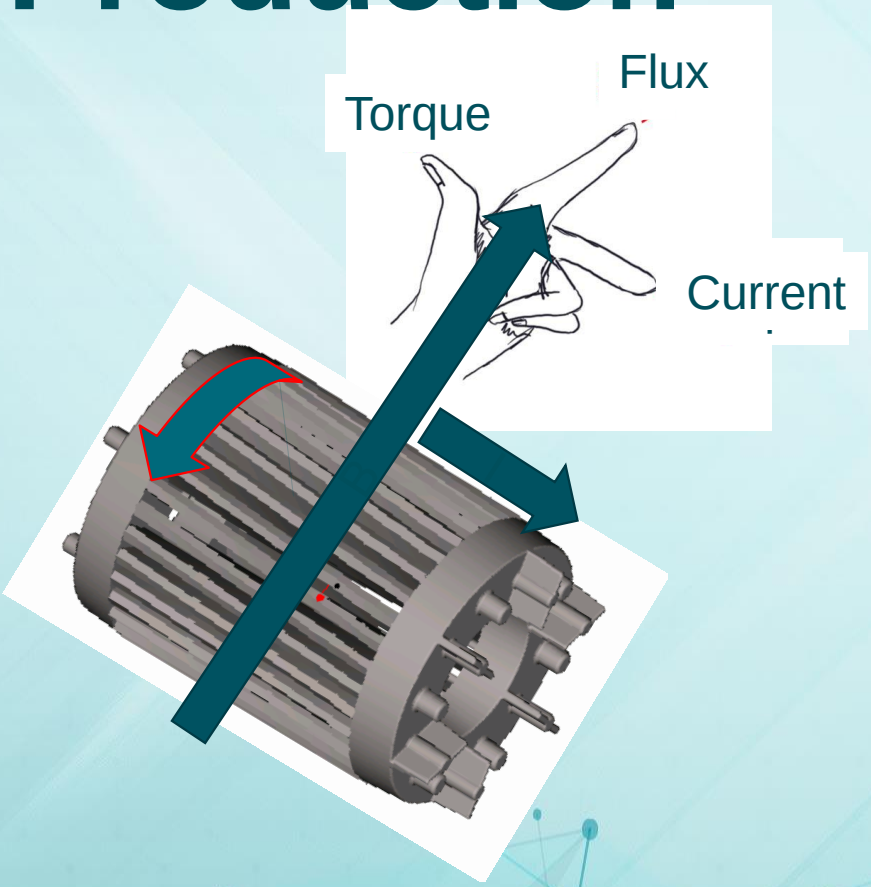
How is Torque Produced in the Rotor?

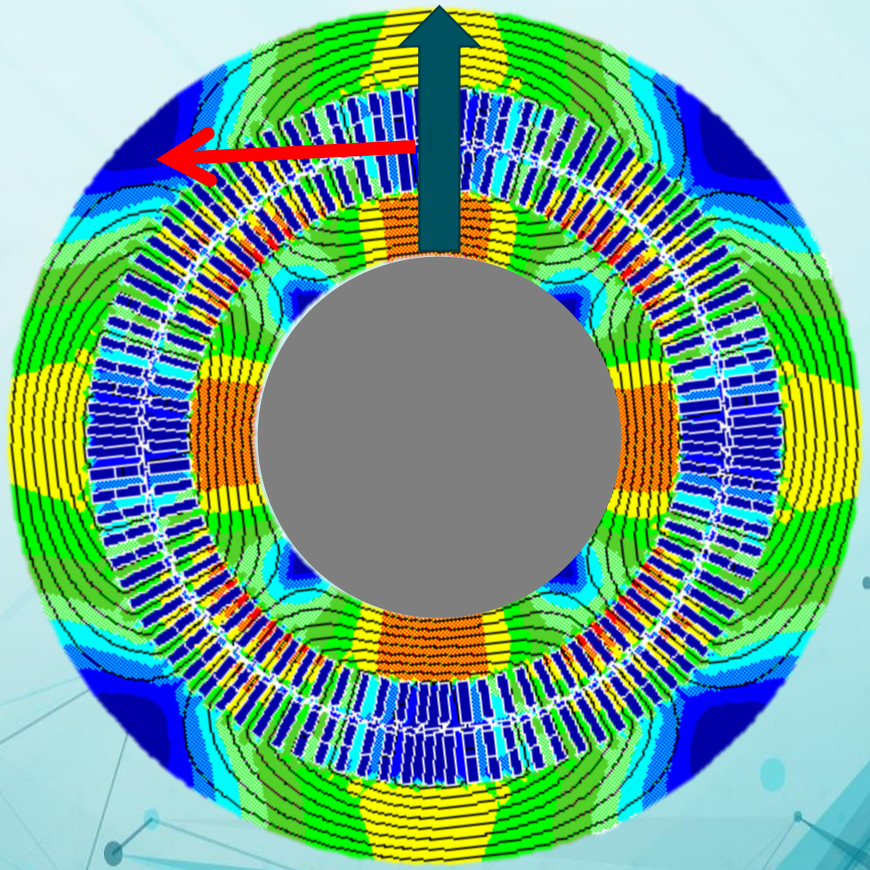
- Follows “Left Hand Rule”
- Rotating stator flux (B) sweeps through air gap
- The rotating magnetic field from the stator “cuts” through the rotor bars and induces current in them. The current flows through the bars to one of the end rings, through the bar on the opposite side of the rotor then returns through the other end ring etc.
- The current flowing through the rotor bar creates a magnetic field in the rotor that follows the stator’s magnetic field.
- The difference in speed between the rotor and the stator’s rotating magnetic field determines how many lines of magnetic flux cut through the rotor bar.
- The greater the difference in speed between rotor and stator, the more current that is induced in rotor and greater the force



Thrust is the radial force that produces torque

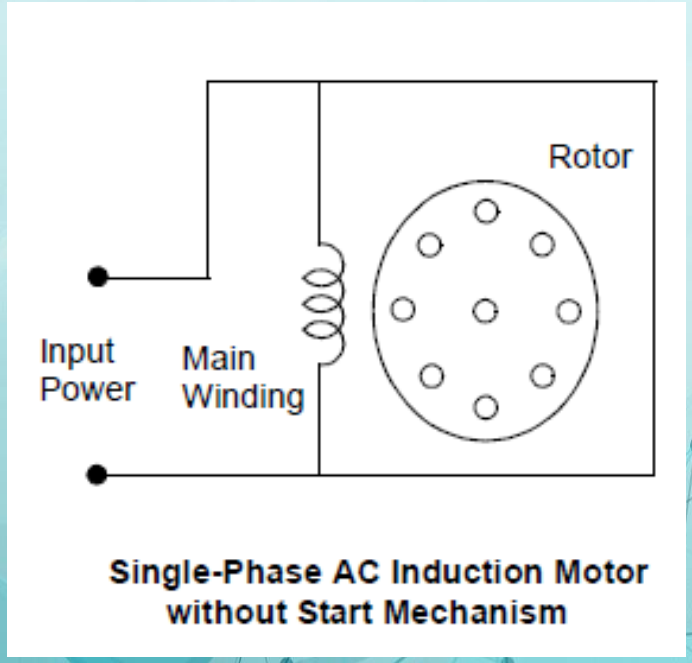
Four Pole Motor Torque Production



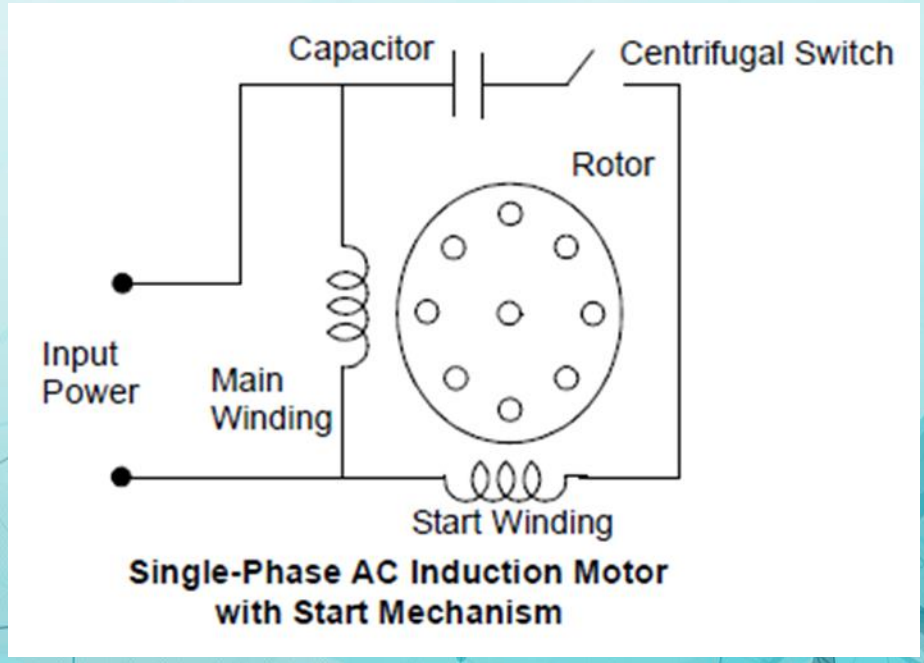


Single Phase Motors

- Single Phase induction motors cannot self start because they lack a rotating magnetic field.
- The starting mechanism is mainly an additional stator winding (start/Auxiliary winding)
- Up to 10hp

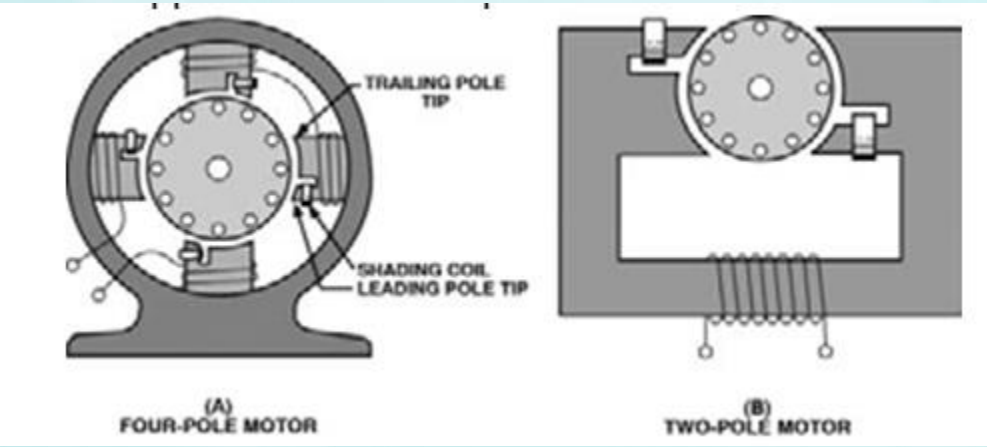


Single-Phase AC Induction Motor without Start Mechanism

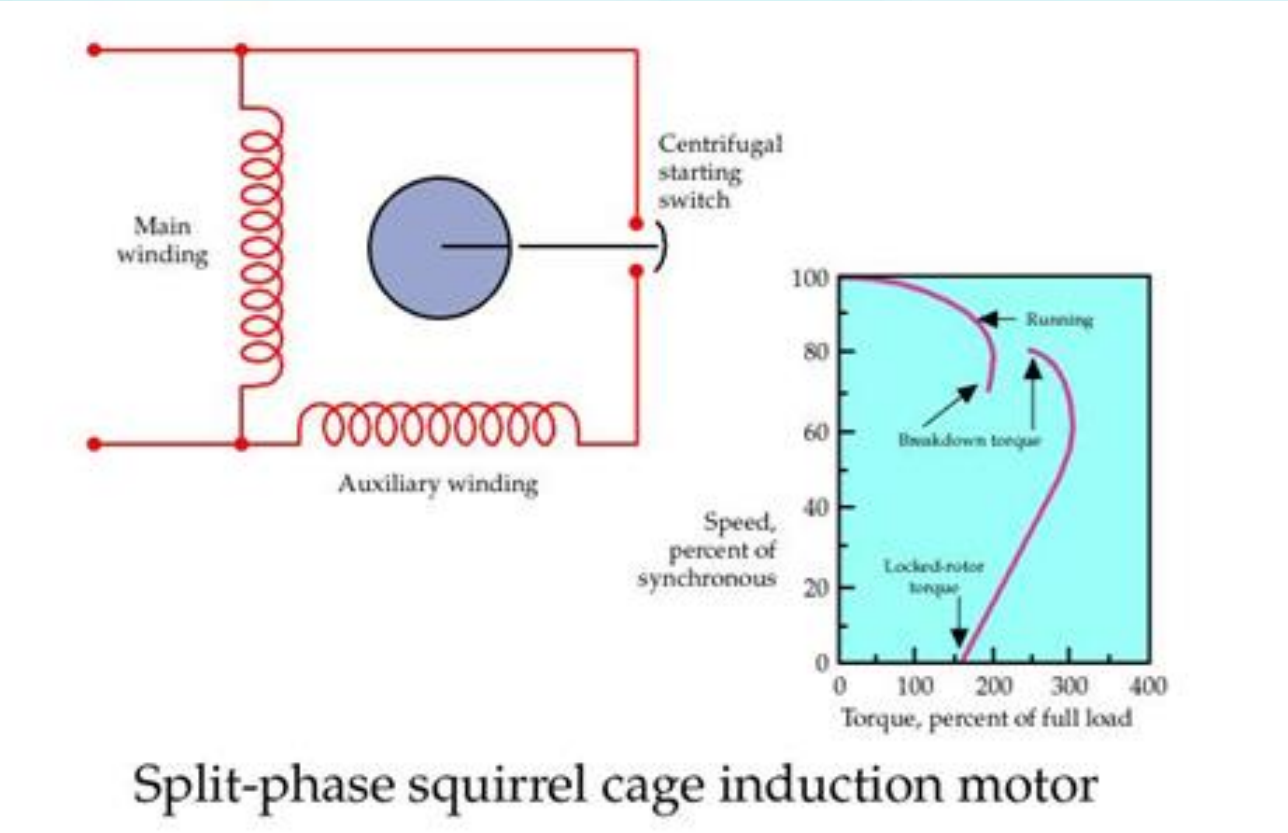


Single-Phase AC Induction Motor with Start Mechanism

Single Phase Motors

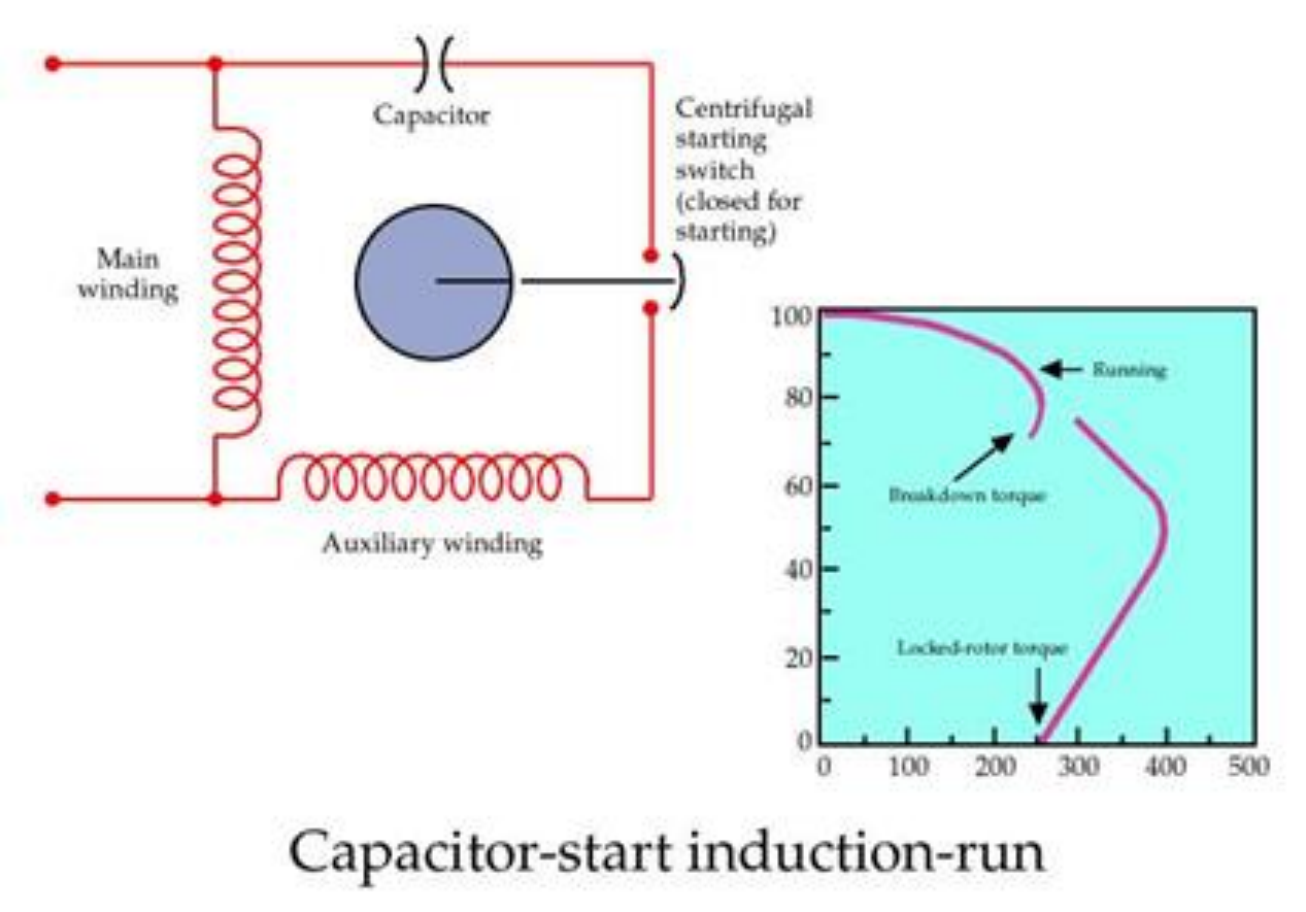


Single Phase Motors

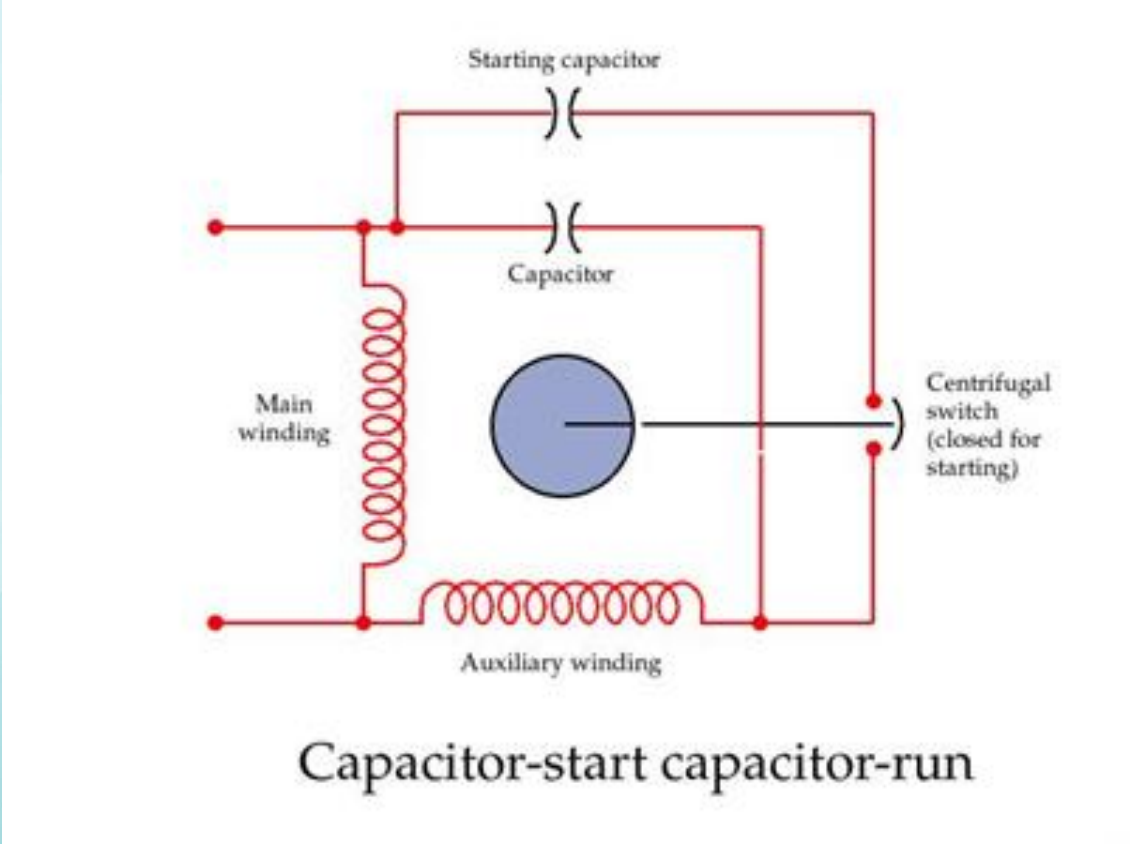


Split-phase squirrel cage induction motor

Single Phase Motors

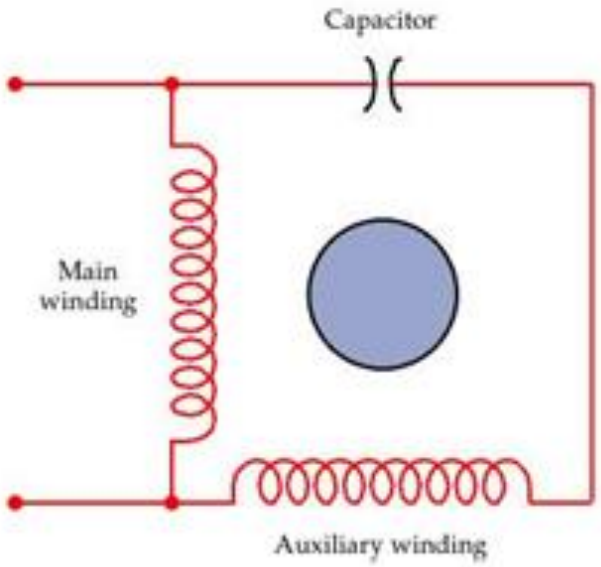


Single Phase Motors



Capacitor-start capacitor-run

Single Phase Motors



Permanent split-capacitor

Single-Phase Motors

Motor Type	Starting Ability (Torque)	Starting Current	Size HP	Voltage	RPM	REV?	Relative Cost	Notes	Uses
Shaded-pole Induction	Very Low, 0.5 – 1 x rt	Low	1/50 to 1/4	115	900, 1200 1800, 3600	NO	Very Low	Light duty, Low efficiency	Small fans, freezer blowers, arc welder blower, hair dryers
Split-Phase	Low, 1 – 1.5 x rt	High, 6 – 8 x rc	1/20 to 3/4	115 or 230	900, 1200, 1800, 3600	YES	Low	Simple construction	Fans, furnace blowers, lathes, small shop tools, jet pumps, small compressors
Permanent-Split, Capacitor-Induction	Very Low, 0.5 – 1 x rt	Low, 2 – r x rc	1/20 to 2	115 or 230	Variable 900 to 1800	YES	Low to Mid	Often custom designed	Fans, furnace blowers, air handling
Capacitor-Start, Induction-Run	High, 3 – 4 x rt	Medium, 3 – 6 x rc	1/6 to 10	115 or 230	900, 1200, 1800,3600	YES	Mid	Long service, easy care	Water systems, air compressors, ventilating fans, grinders, blowers, conveyors
Repulsion-Start, Induction-Run	High, 4 x rt	Low, 2.5 – 3 x rc	1/2 to 15	115 or 230	1200, 1800, 3600	YES	Mid	Handles big load changes well	Grinders, deep well pumps, silo unloaders, grain elevators, barn cleaners
Capacitor-Start, Capacitor-Run	High, 3.5 – 4 x rt	Medium, 3 – 5 x rc	1/2 to 15	115 or 230	900, 1200, 1800, 3600	YES	Mid	Good starting ability, efficiency	Pumps, air compressors, drying fans, large conveyors, feed mills

rc = Running Current

rt = Running Torque

Quiz

- What are the two essential parts to a motor?
- How are single phase motors “started” typically?
- What two major kinds of materials are used to make stators?

- Rotor and Stator
- “Starting” Capacitors
- Permanent Magnets or Coils of Wire