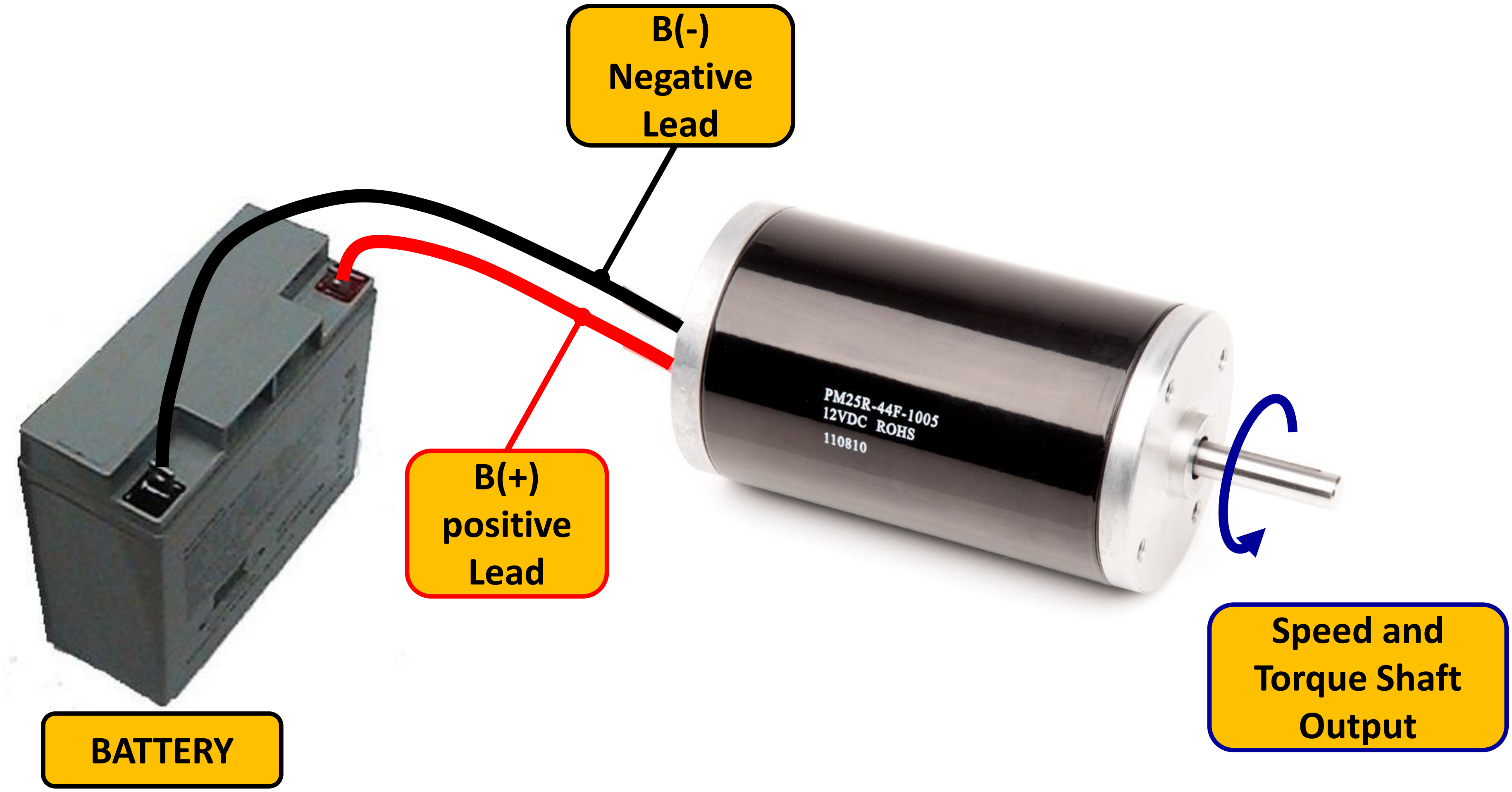
ADAMBOTS

Team 245

ELECTRIC MOTORS

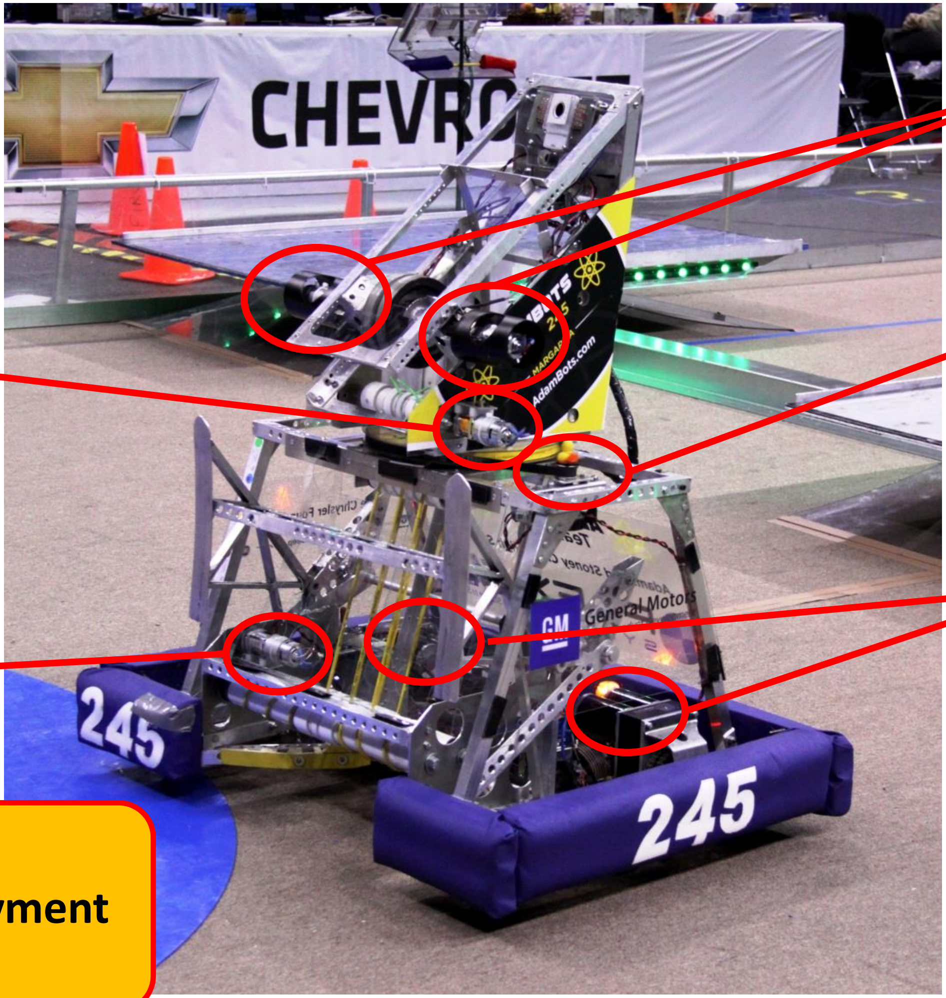
ELECTRIC MOTORS: What Do They Do?

- Convert electrical energy into mechanical power



ELECTRIC MOTORS: How Are They Used?

- **Anything that turns on the Robot uses a motor**

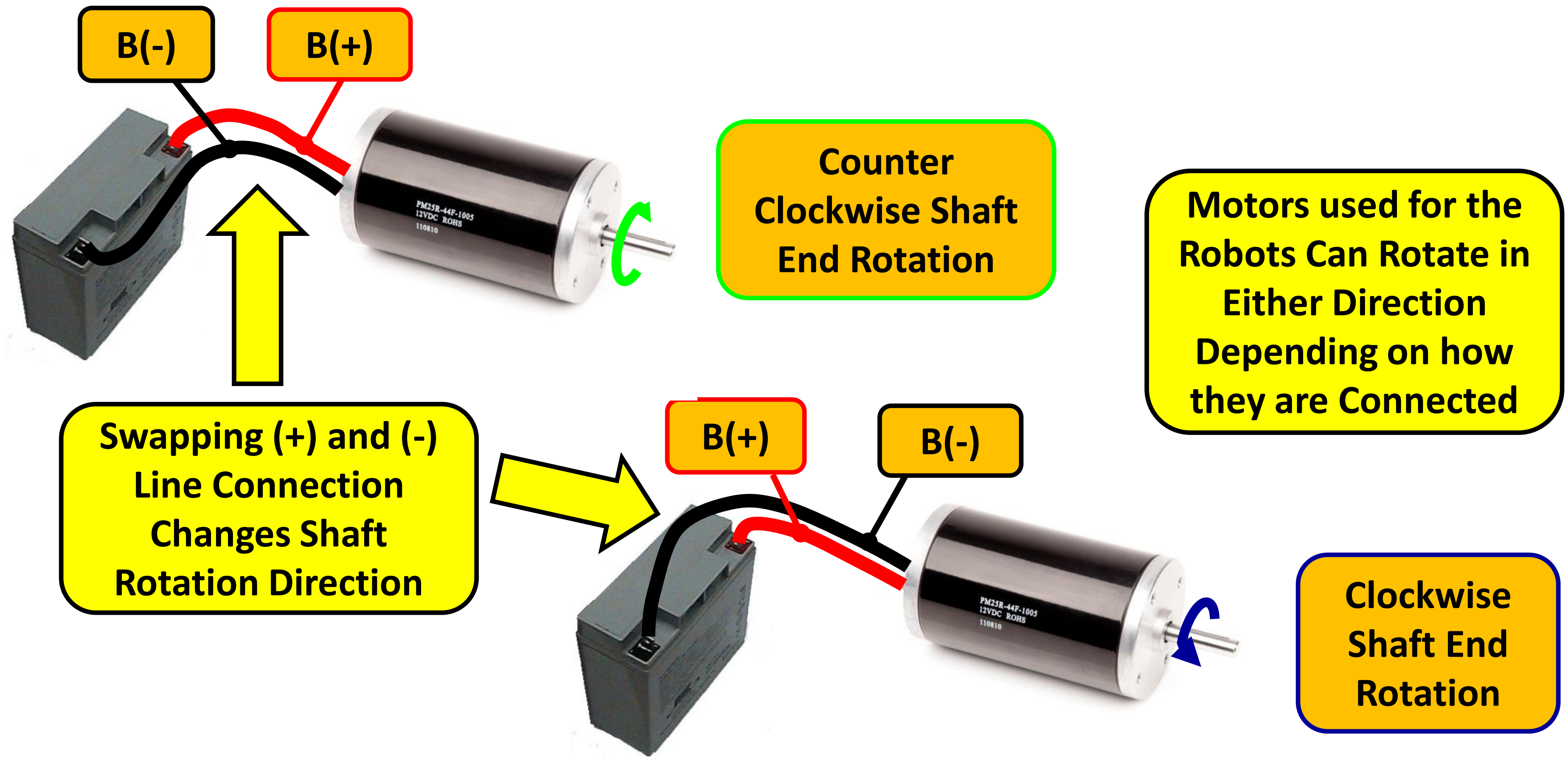


11 Motors used on Margarita

Not Visible:
- Bridge Arm Deployment
- Ball Feed Roller

ELECTRIC MOTORS: Shaft Rotation Direction

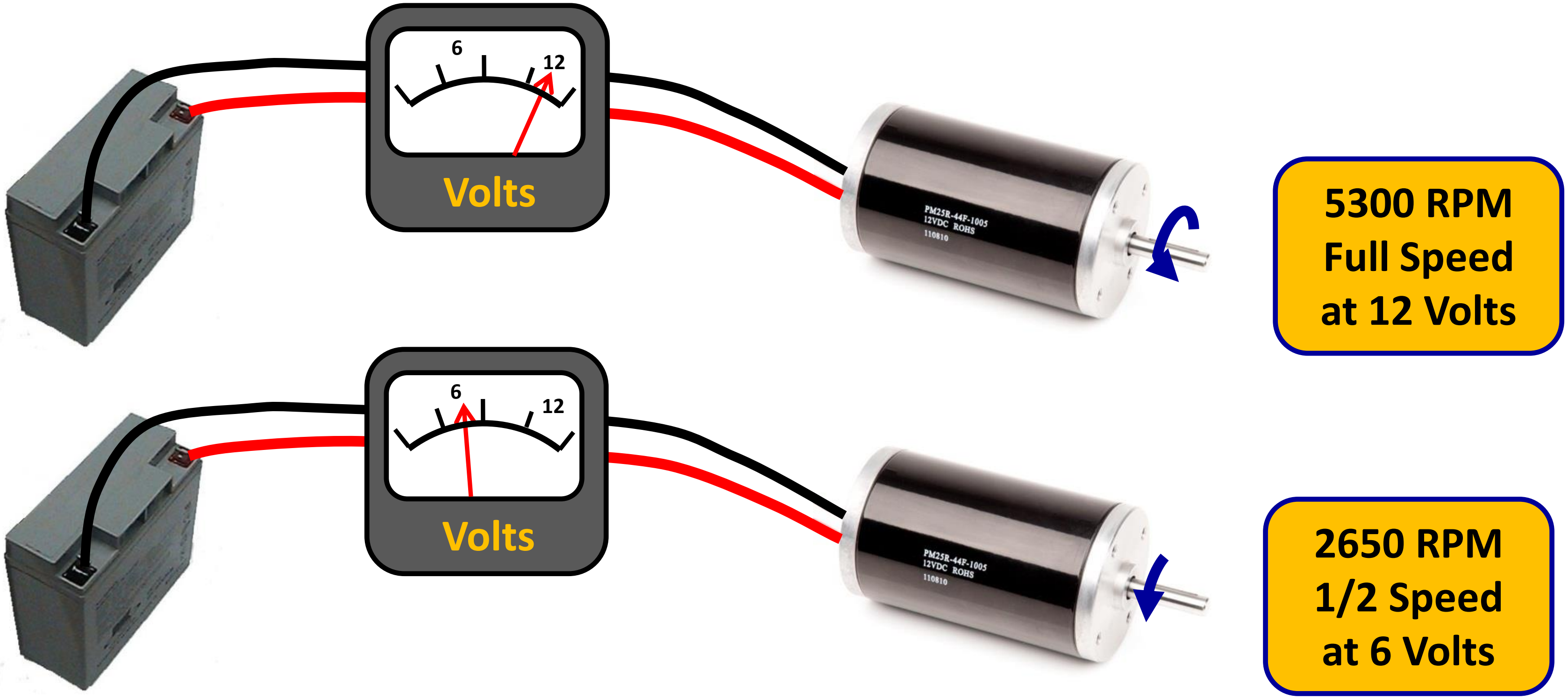
- Shaft rotation direction depends on how (+) and (-) leads are connected to motor



ELECTRIC MOTORS: Speed with Voltage

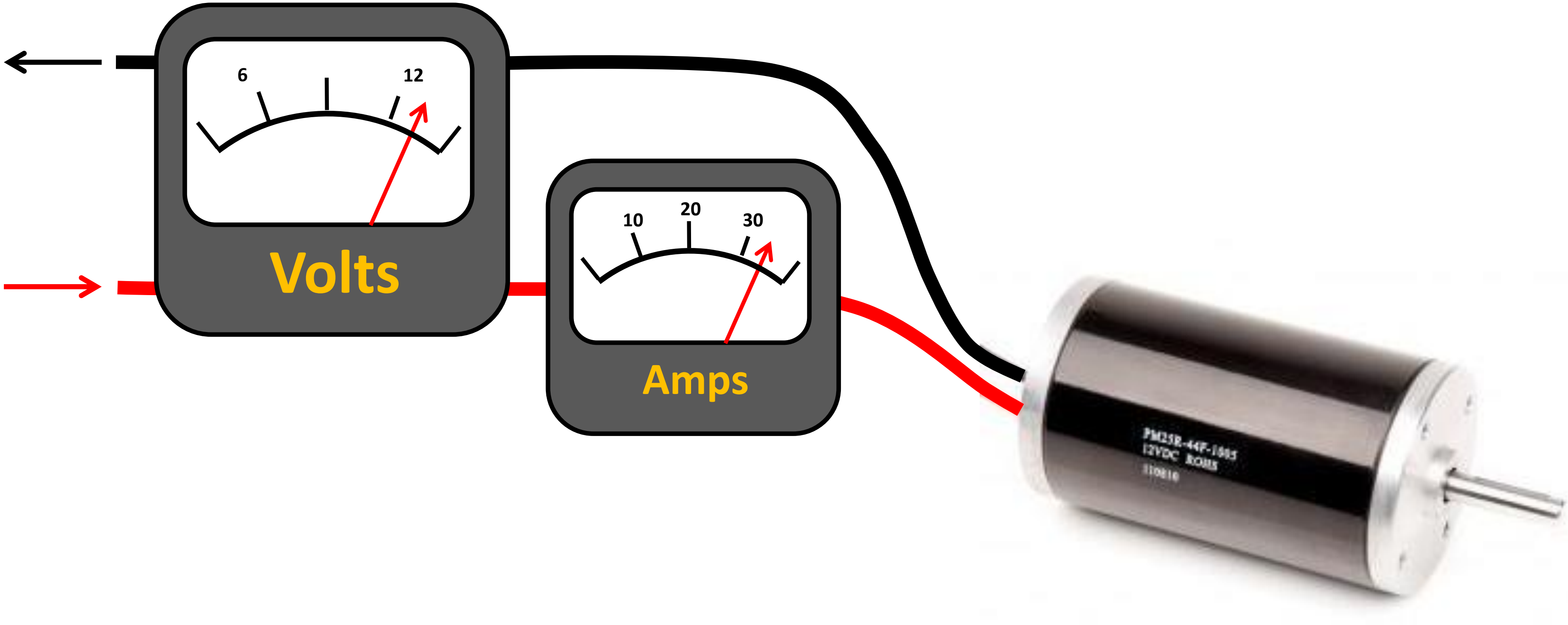
Motor speed varies with input voltage

- 12V = Full Speed (5300 Revolutions per Minute (No Load))
- 6V = ½ Speed (2650 Revolutions per Minute (No Load))



ELECTRIC MOTORS: Input Power

- **Electrical Power is the product of Volts x Current = Watts (Watts = Joules/Second)**
  - Current is measured with units of Amps



ELECTRIC MOTORS: Output Power

- Mechanical Power is the product of Shaft Speed x Torque = Watts

Shaft Speed Typically Measured with units of Revolutions per Minute

Power is combination of operating speed and torque

Torque at shaft is expressed as units of Force x Distance (Ounce-Inch, Foot-Pounds, or Newton-Meter)

ELECTRIC MOTORS: Efficiency

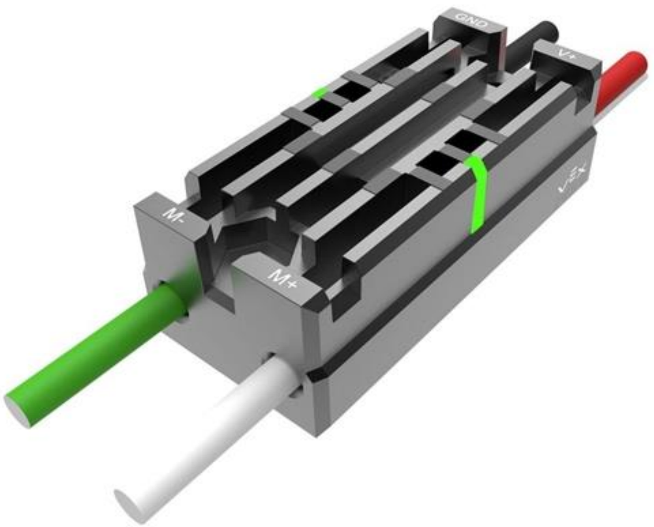
- **Motors are not 100% Efficient**
  - 65% of Power Goes out the shaft (Typical)
  - 35% of Power Goes into Waste Heat

ELECTRIC MOTORS: Speed Controllers

- **Motors need to run at different speeds to work properly on the robot**
  - Main drive wheel motors need variable speed
  - Manipulator arm motors need for variable speed

Typical Motor Speed Control

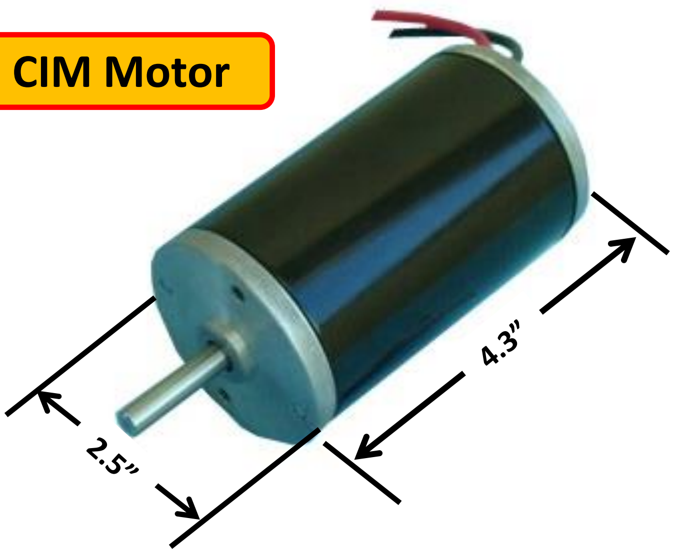
- **Variable speed achieved by changing voltage seen by the motor based on command input issued by the control system**
- **Speed controller generates its own waste heat**



ELECTRIC MOTORS: Power Capability

Power Capability Depends on Size & Weight

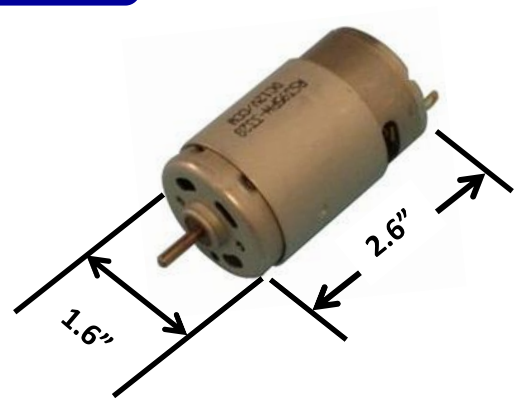
CIM Motor



Normal 12V Load Point

- 4,320 RPM
- 205 Watts out
- 2.4 Lbm

Bane Bots

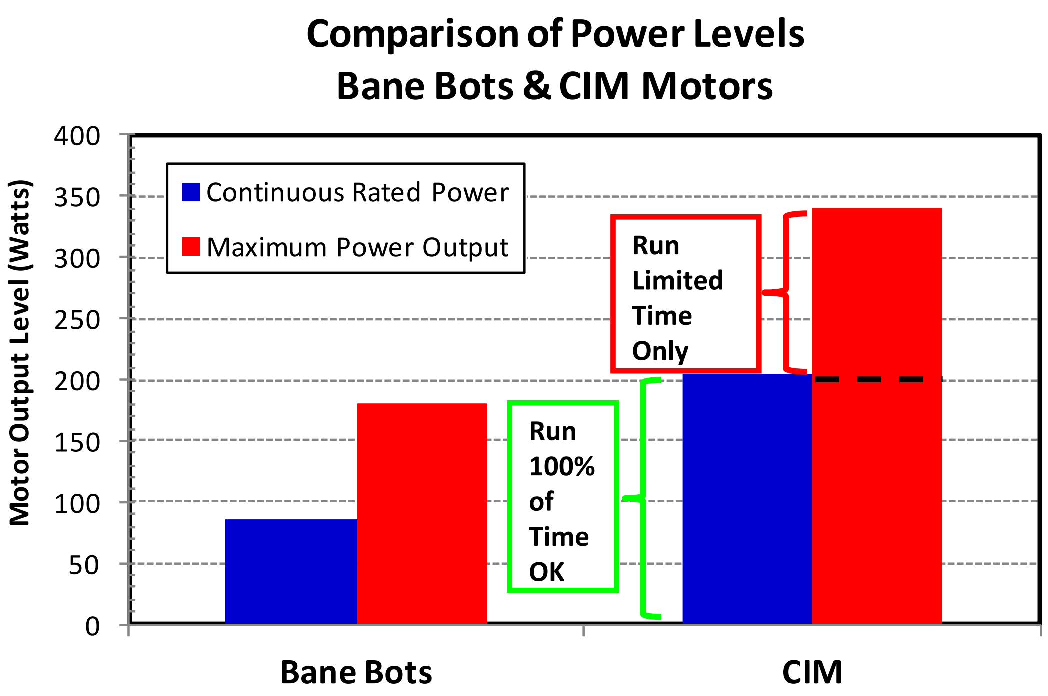


Normal 12V Load Point

- 13,800 RPM
- 85 Watts out
- 0.87 Lbm

ELECTRIC MOTORS: Max & Continuous Power

- **All motors have a power limit where they can run 100% of the time without harming the motor**
  - This is the Maximum Continuous rated power level
- **Motors also have a Maximum power output capability**
  - This is the Maximum power the motor can generate
- **Motors can run a limited amount of time at power levels above the continuous rated power level**
  - You have essentially "Lit the Fuse" when you start running the motor at power levels above the continuous rated level
  - Motor will eventually overheat and generate "Blue Smoke" if run too long at these power levels

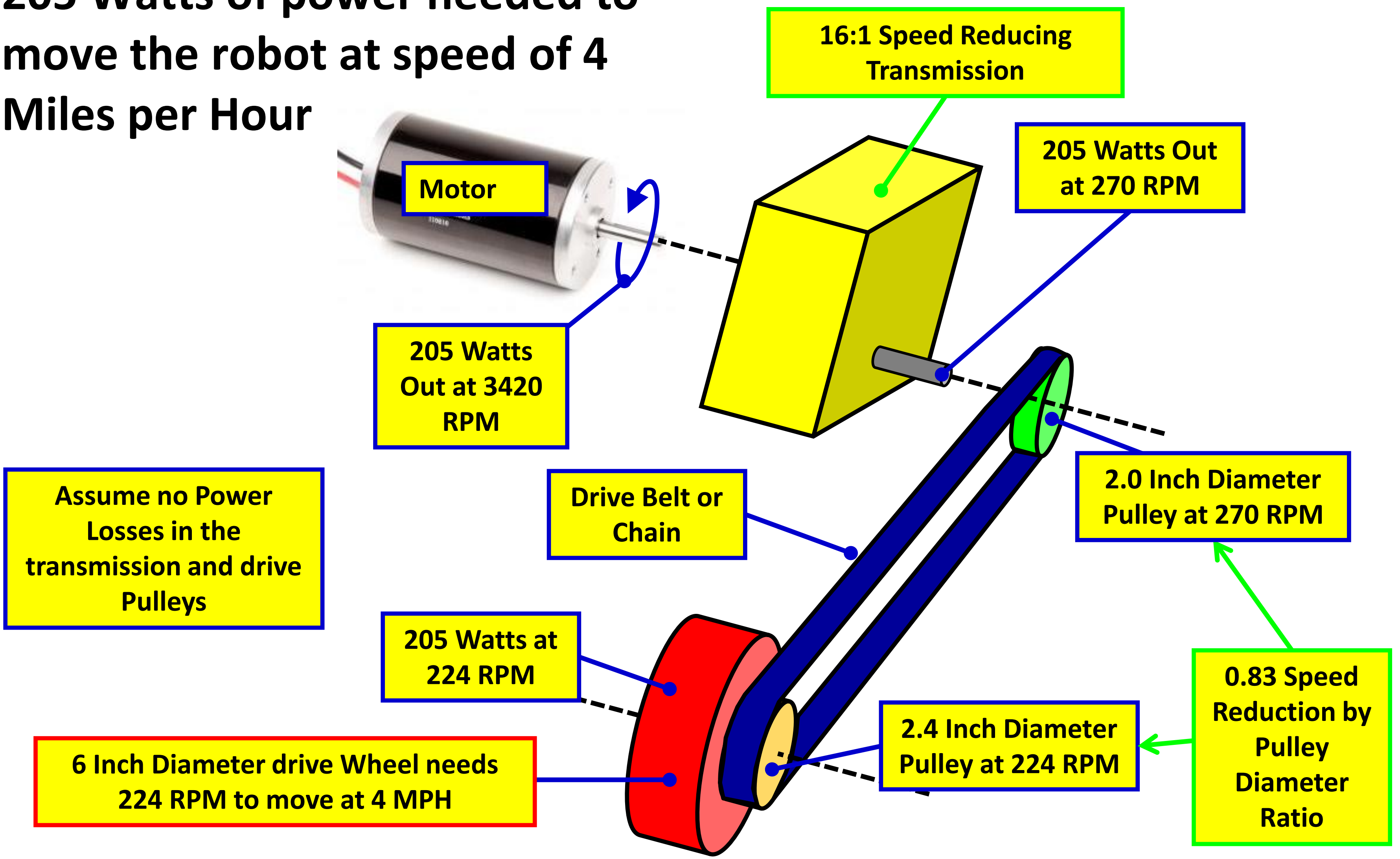


ELECTRIC MOTORS: Overheating

- **What would cause a motor to overheat?**
  - A pushing match with another robot
  - Damage from a collision sends a feature out of alignment and significantly increases load on the motor
  - Failure of another component that jams a feature
  - Back to back matches with not enough time to cool motors down
  - Motor is not big enough for the job and overheats during “Normal” operation

ELECTRIC MOTORS: Speed Reduction

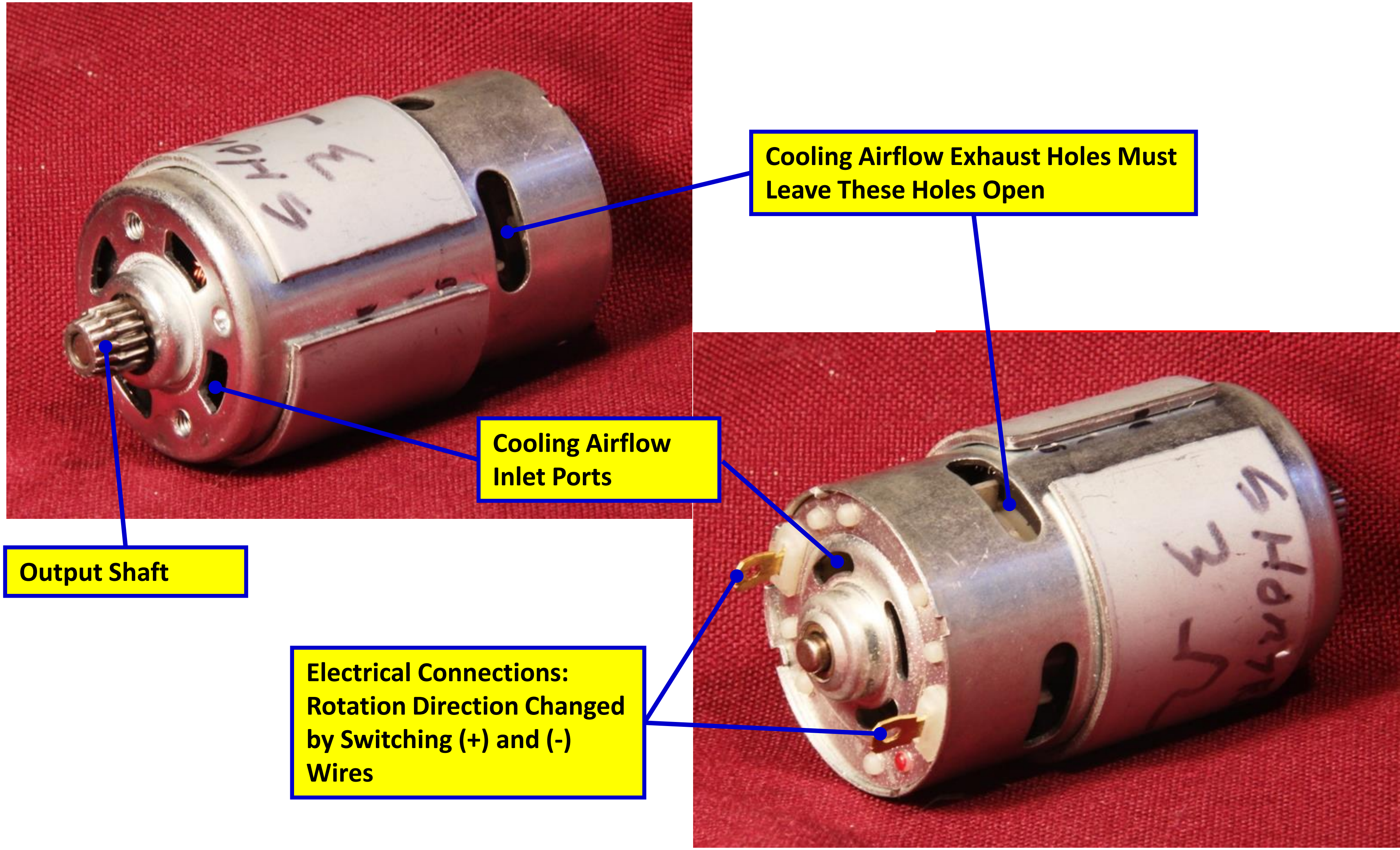
- 205 Watts of power needed to move the robot at speed of 4 Miles per Hour



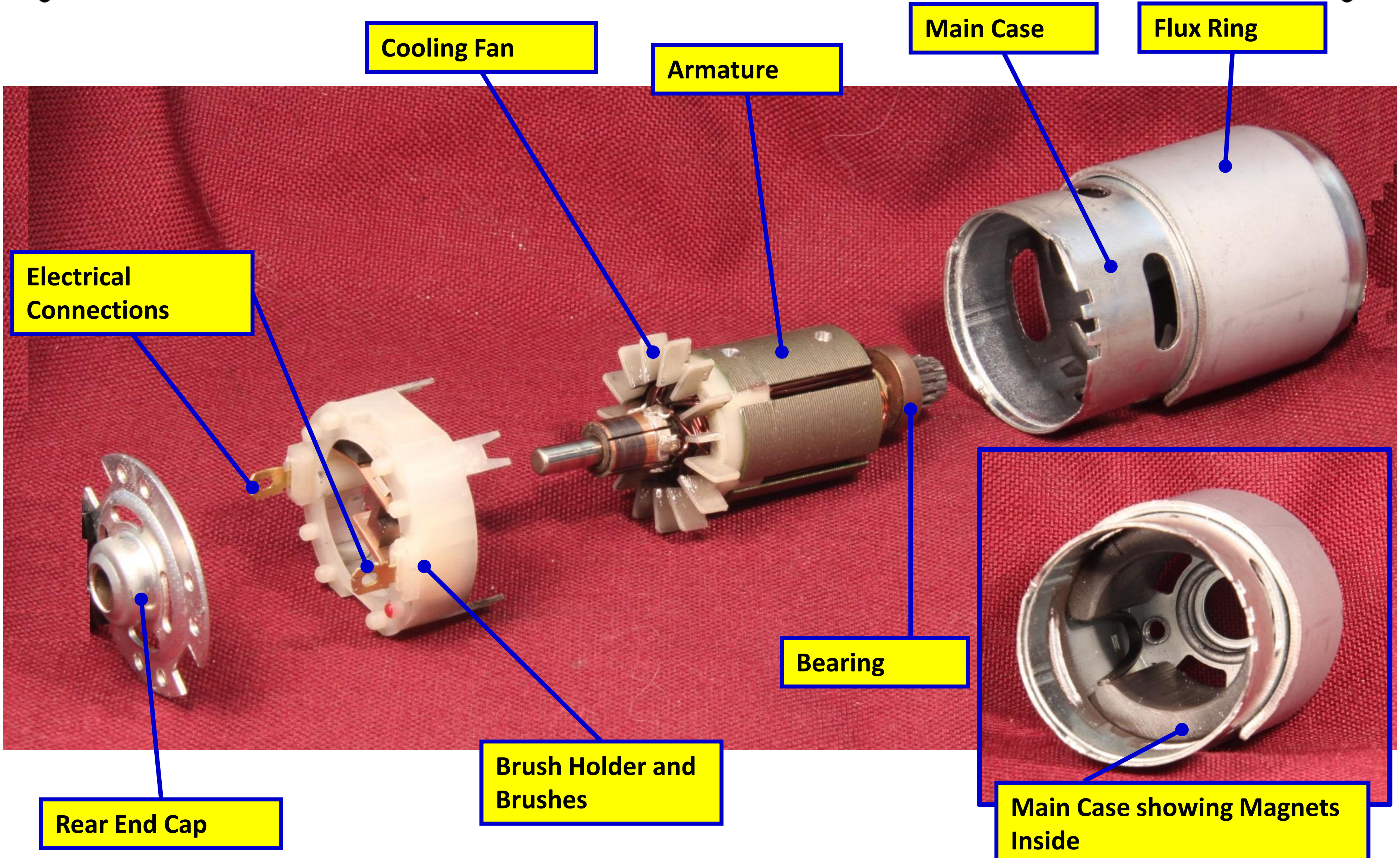
ELECTRIC MOTORS: Pneumatics or Motors?

- **Pneumatic actuators are good to control devices that need only discrete positions**
  - Fully extended or Fully retracted or fixed intermediate position
  - Open or Closed
  - Need quick travel from Stop to Stop
- **Motors are best for devices that need either variable speed or variable positions**
  - Main drive wheels
  - Shooting drives that need variable speed
  - Variable positioning requirements

ELECTRIC MOTORS: Outside Features



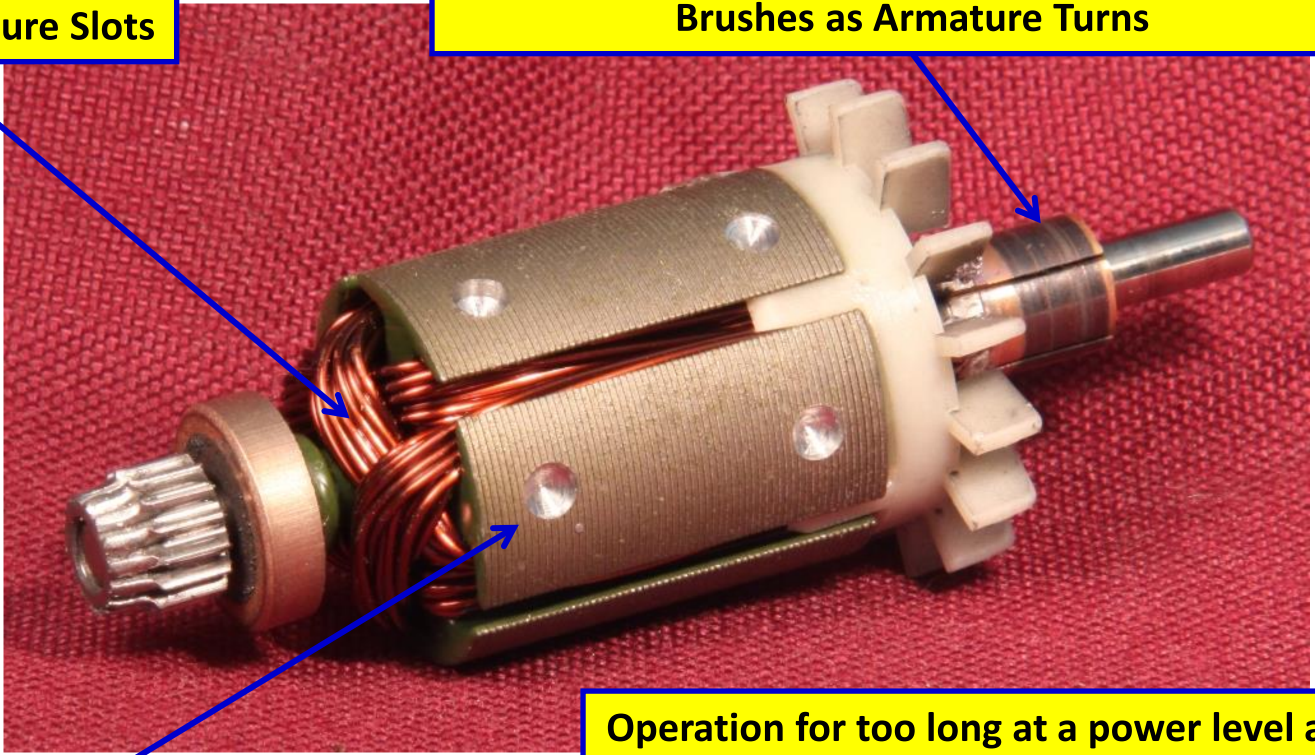
ELECTRIC MOTORS: Inside Features



Where Does the "Blue Smoke" Come From?

Multiple Individual Coils Within the Armature Slots

Commutator Bars Connected to Each Wend of the Wire Coils Maintain Electrical Connection with the Brushes as Armature Turns



These "Circles" are to correct unbalance of the armature

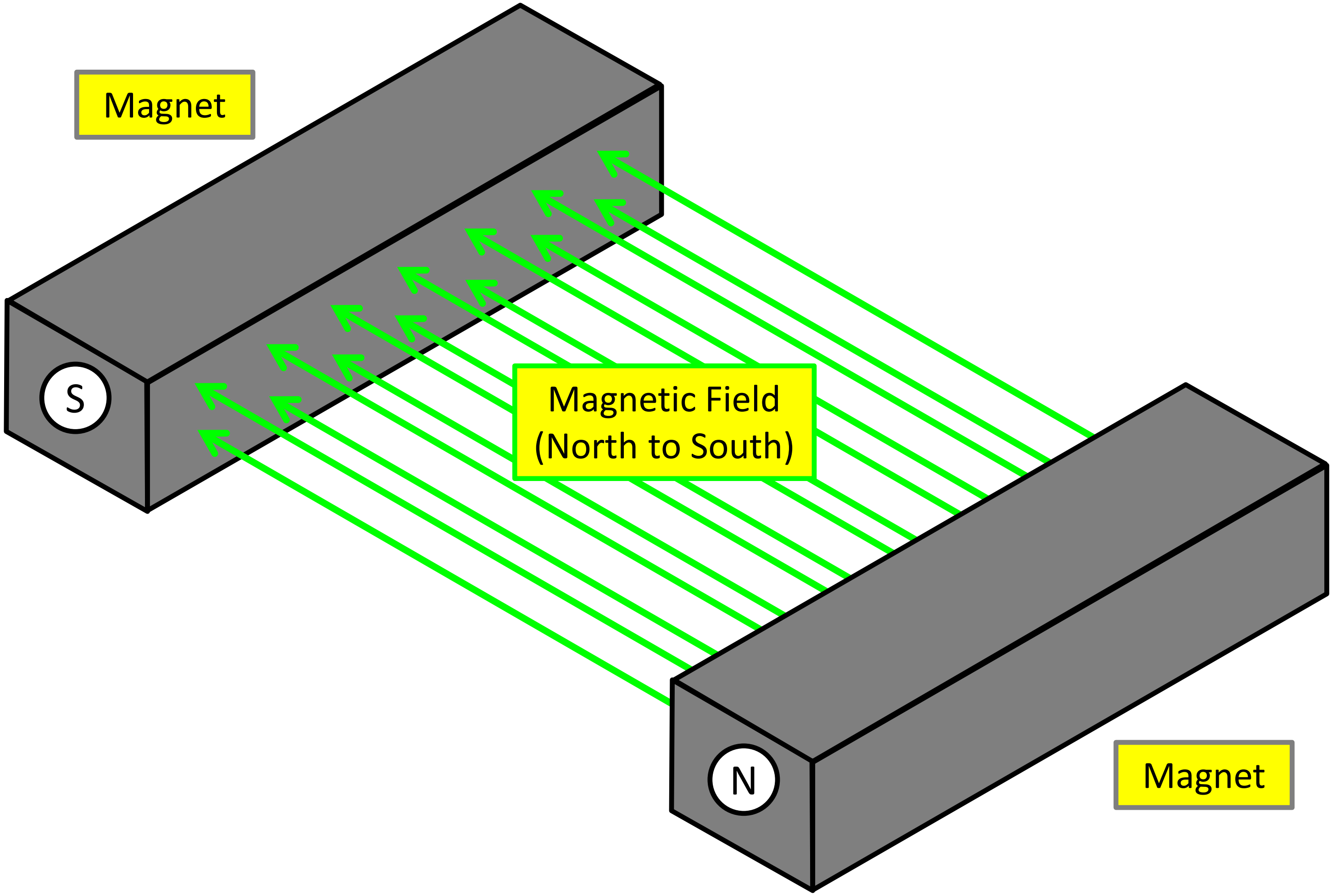
Operation for too long at a power level above the continuous rated point will increase temperatures inside the motor to a level where insulation on the copper wire begins to smoke

Motor can "Smoke" for some time before it is permanently damaged

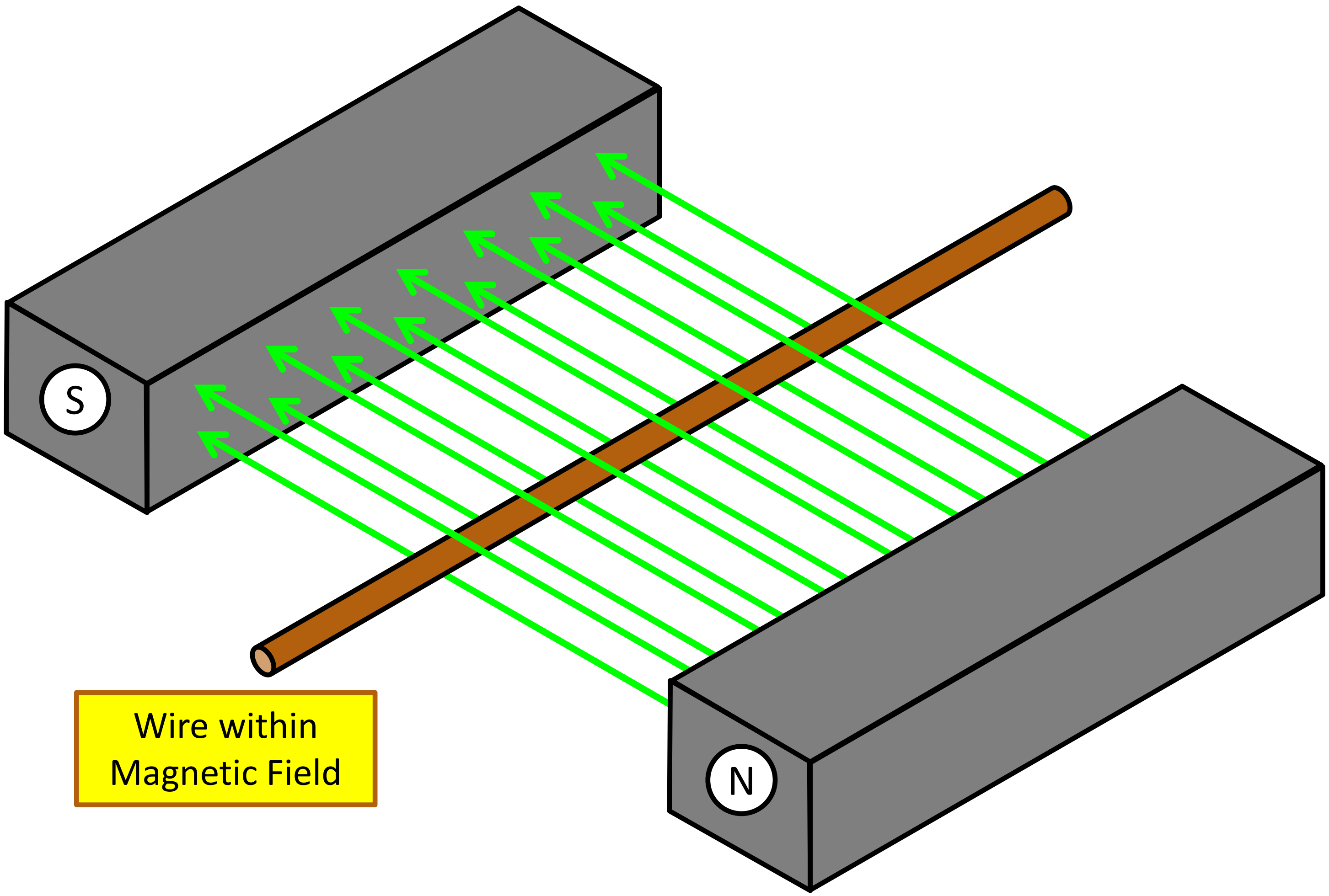
How Does a Motor Work:

Electro Magnetic Theory

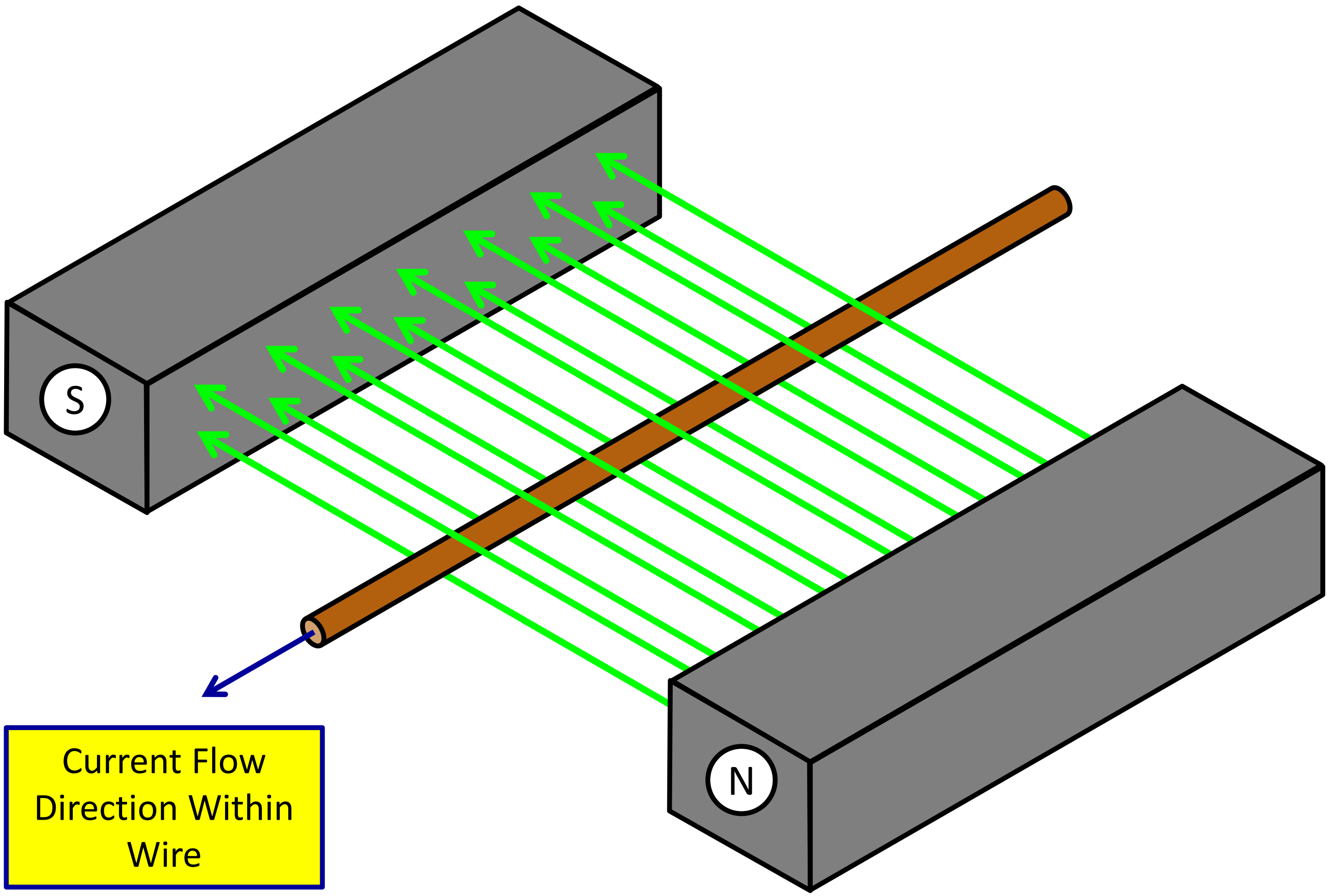
Magnetic Field



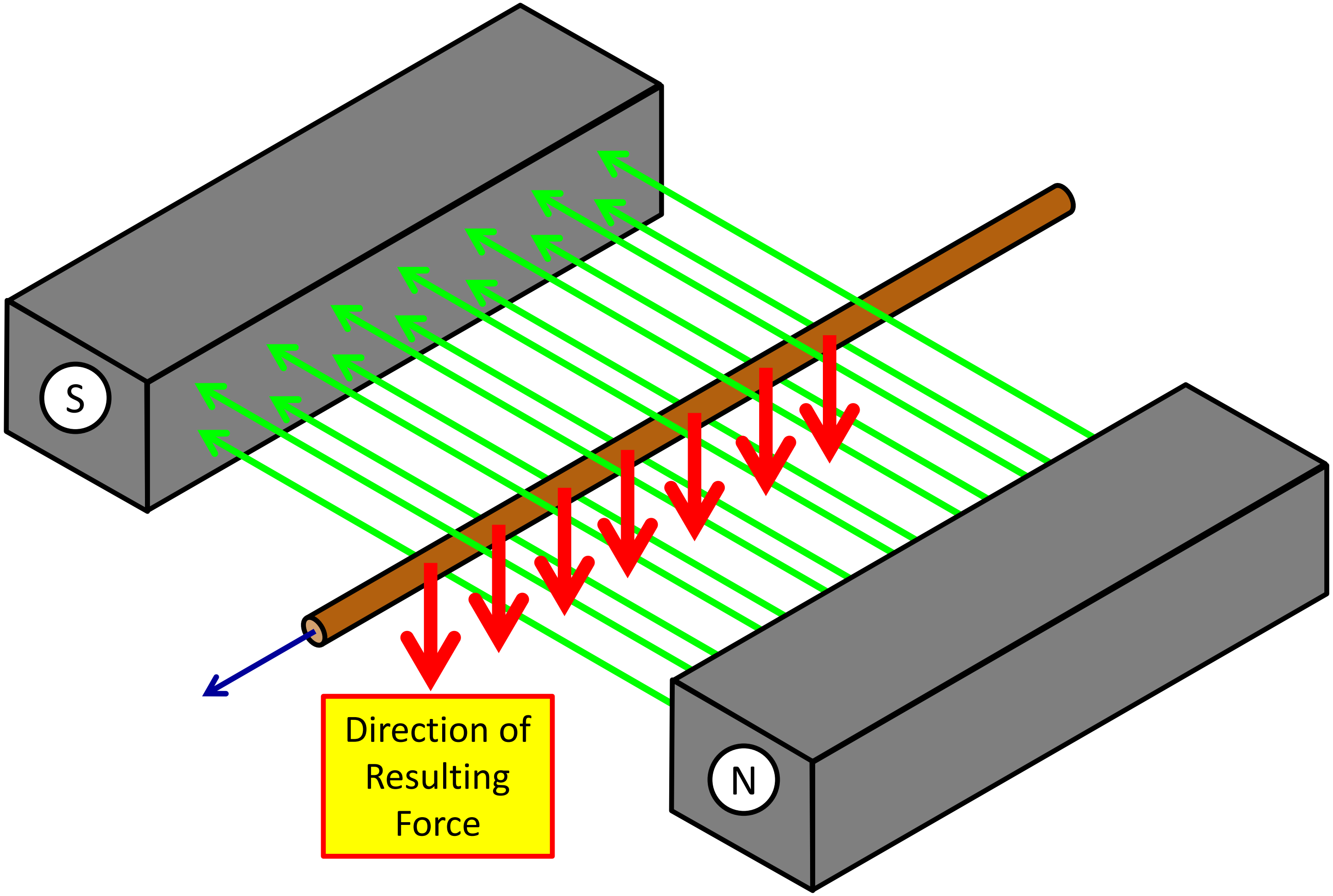
Wire Within Magnetic Field



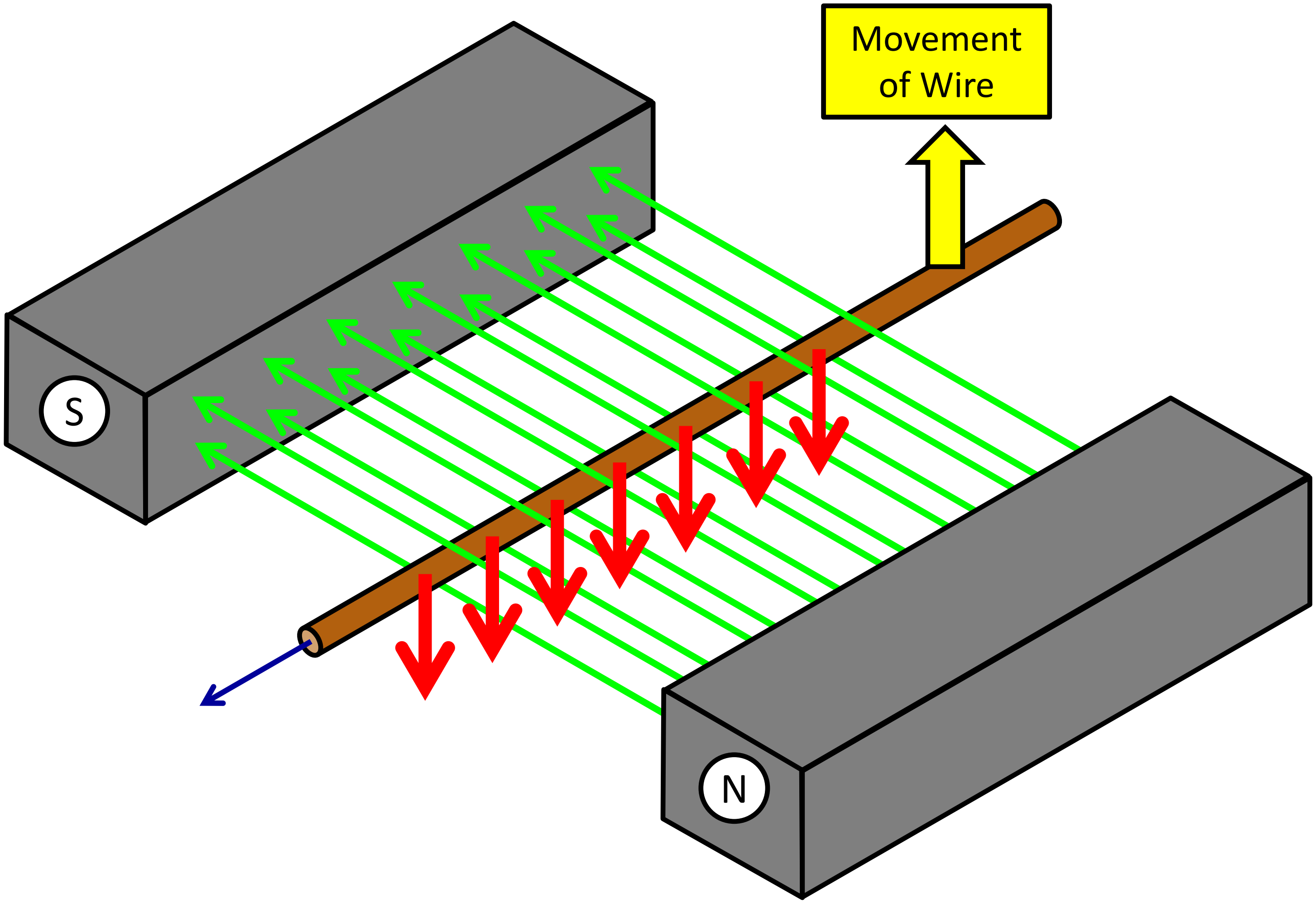
Current Flow Through Wire



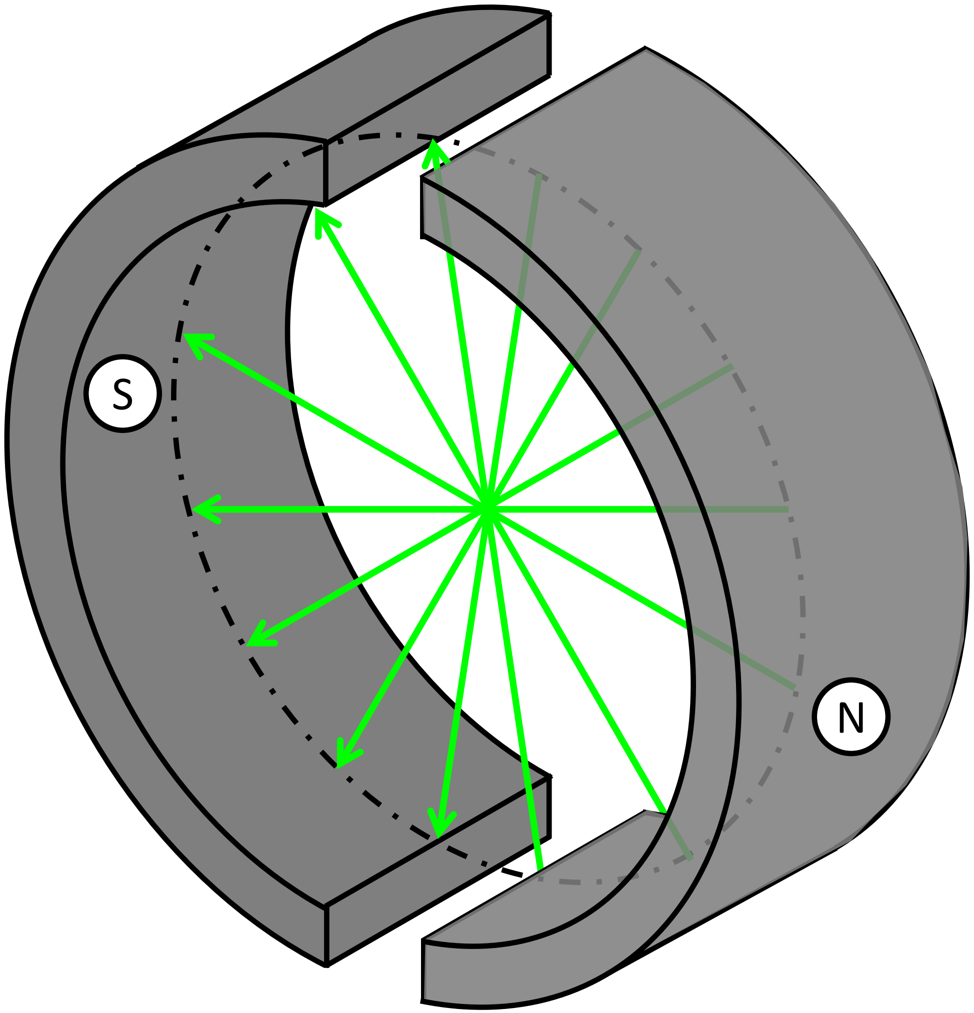
Interaction Between Current Flow Through Wire in Magnetic Field Generates Force



Force Generates Motion

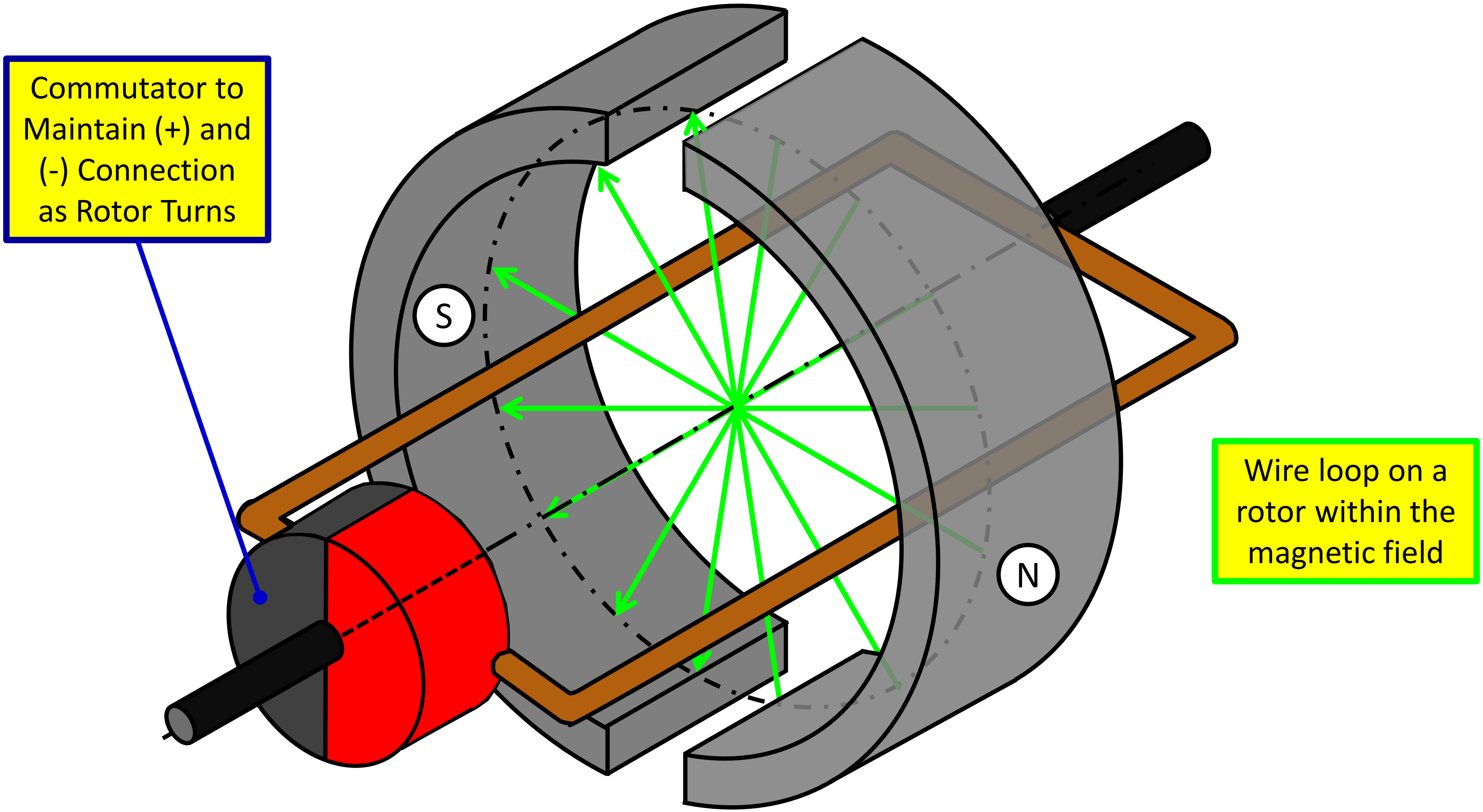


Motor Electro-Magnetic Configuration



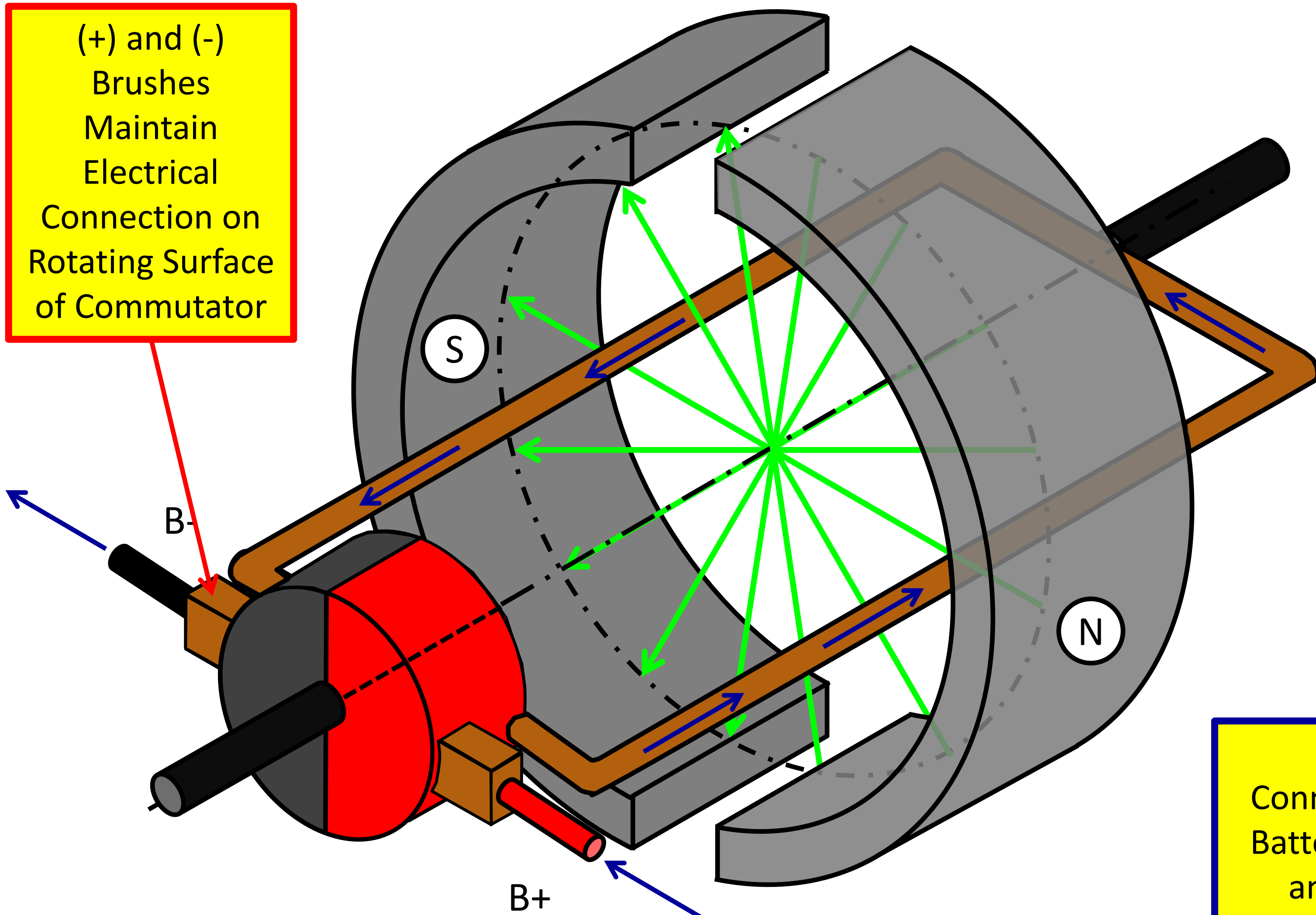
Magnetic Field (Running North to South Around the Magnet Arc)

Motor Electro-Magnetic Configuration



Motor Electro-Magnetic Configuration

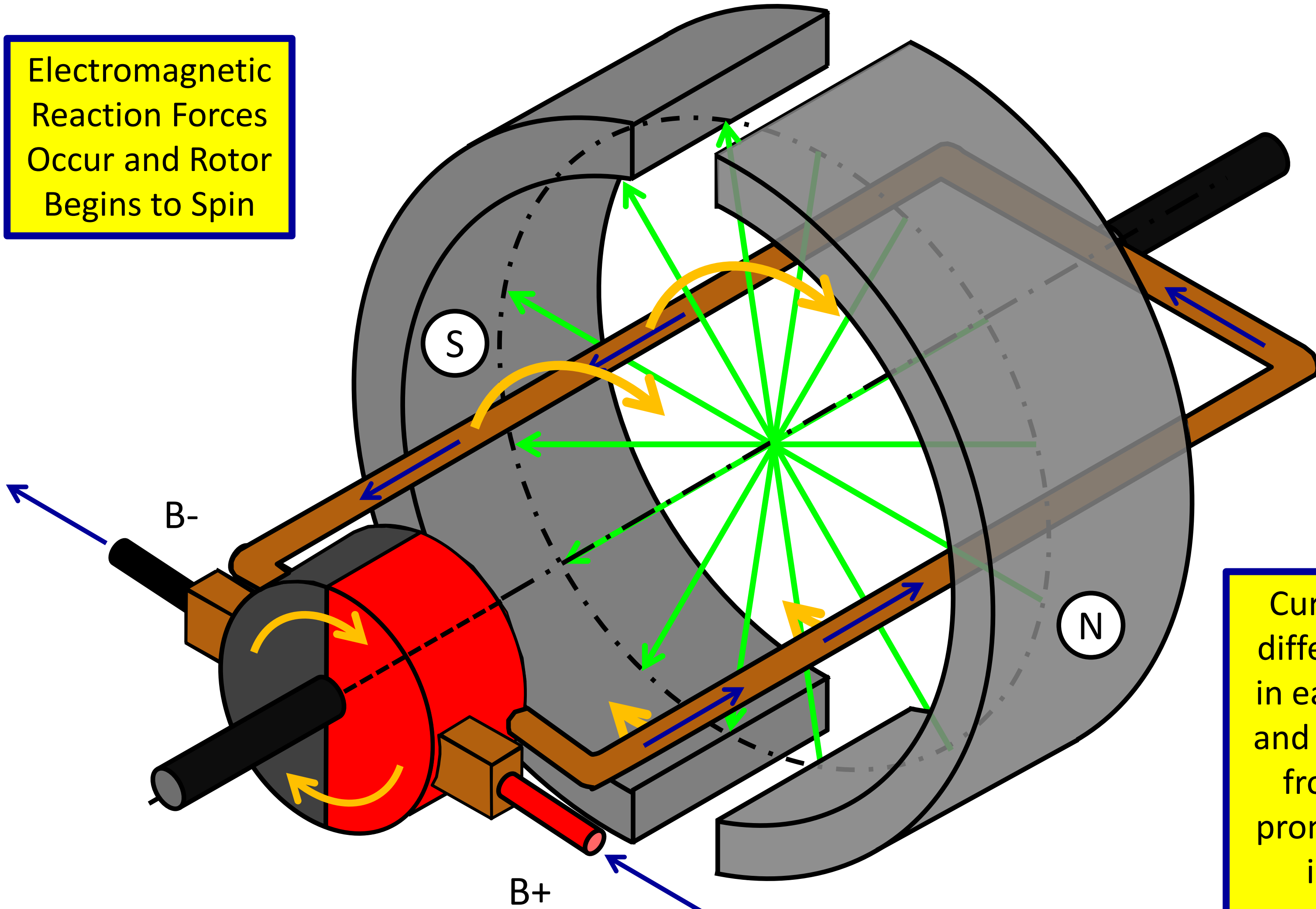
(+) and (-) Brushes Maintain Electrical Connection on Rotating Surface of Commutator



Make Connection to Battery Power and Start Current Flow

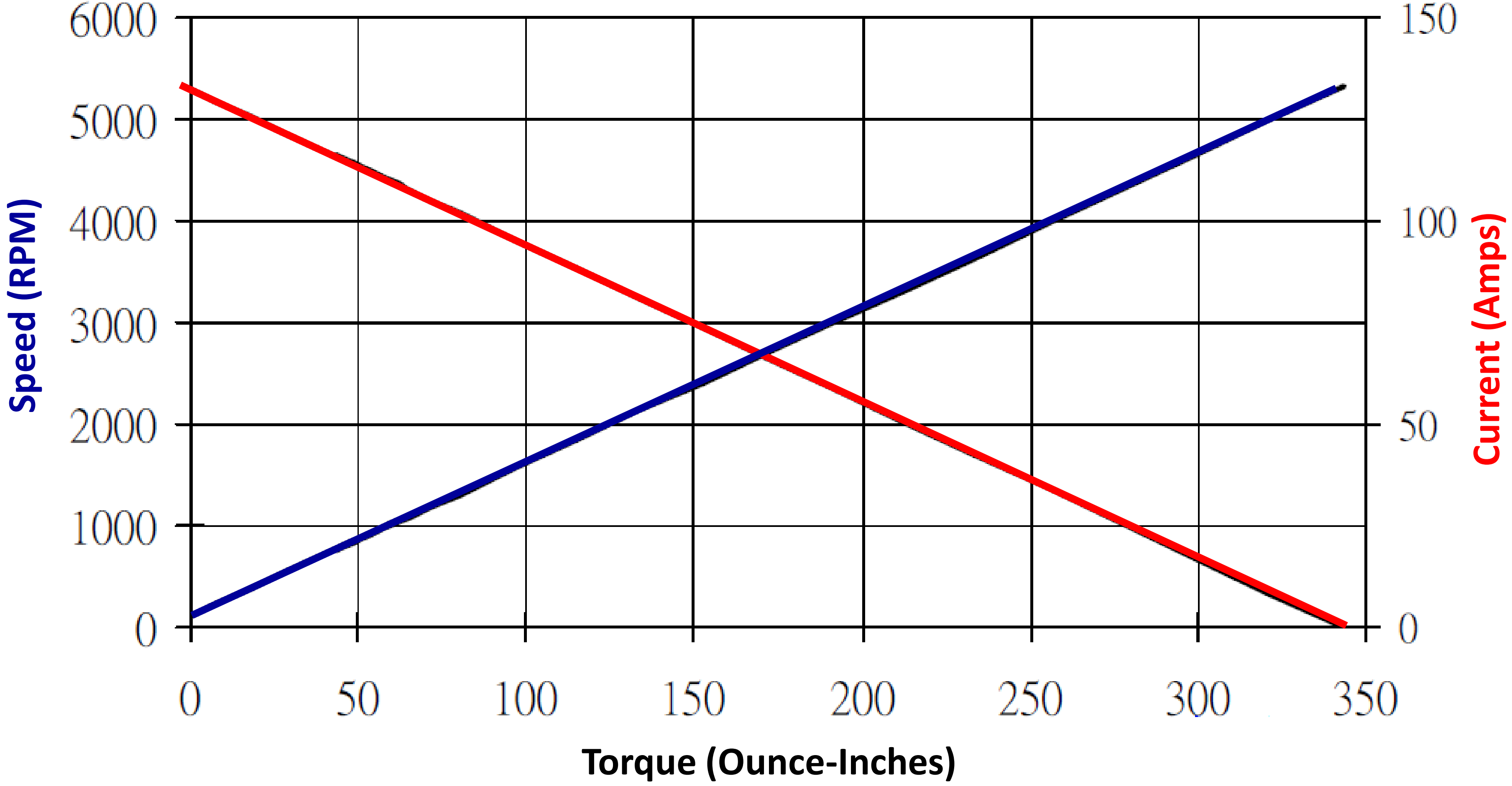
Motor Electro-Magnetic Configuration

Electromagnetic Reaction Forces Occur and Rotor Begins to Spin

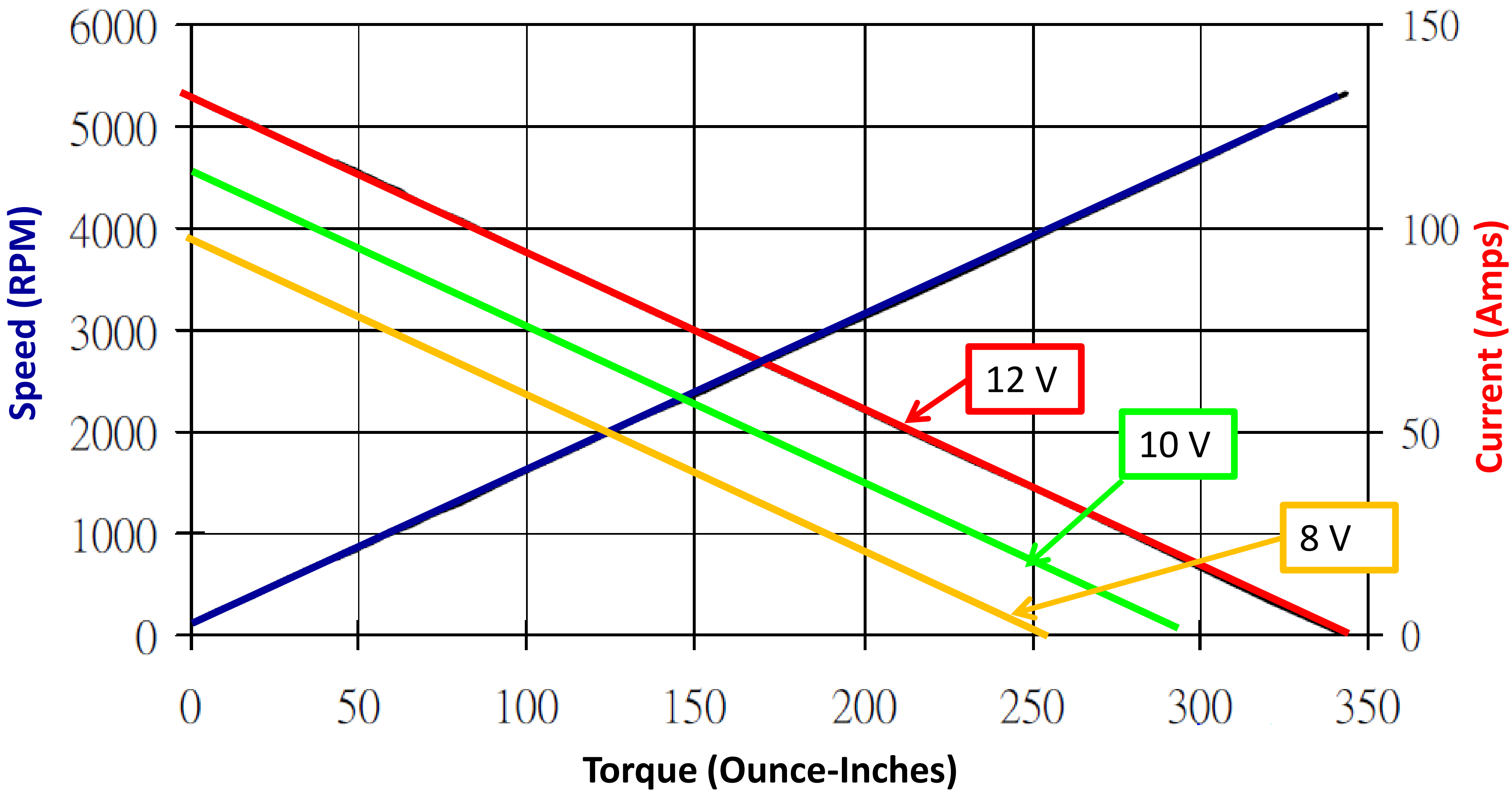


Current flow has different direction in each side of coil and resulting force from each side promotes rotation in the same direction

Motor Performance Curves
Full Size CIM Motor at 12.0 Volts



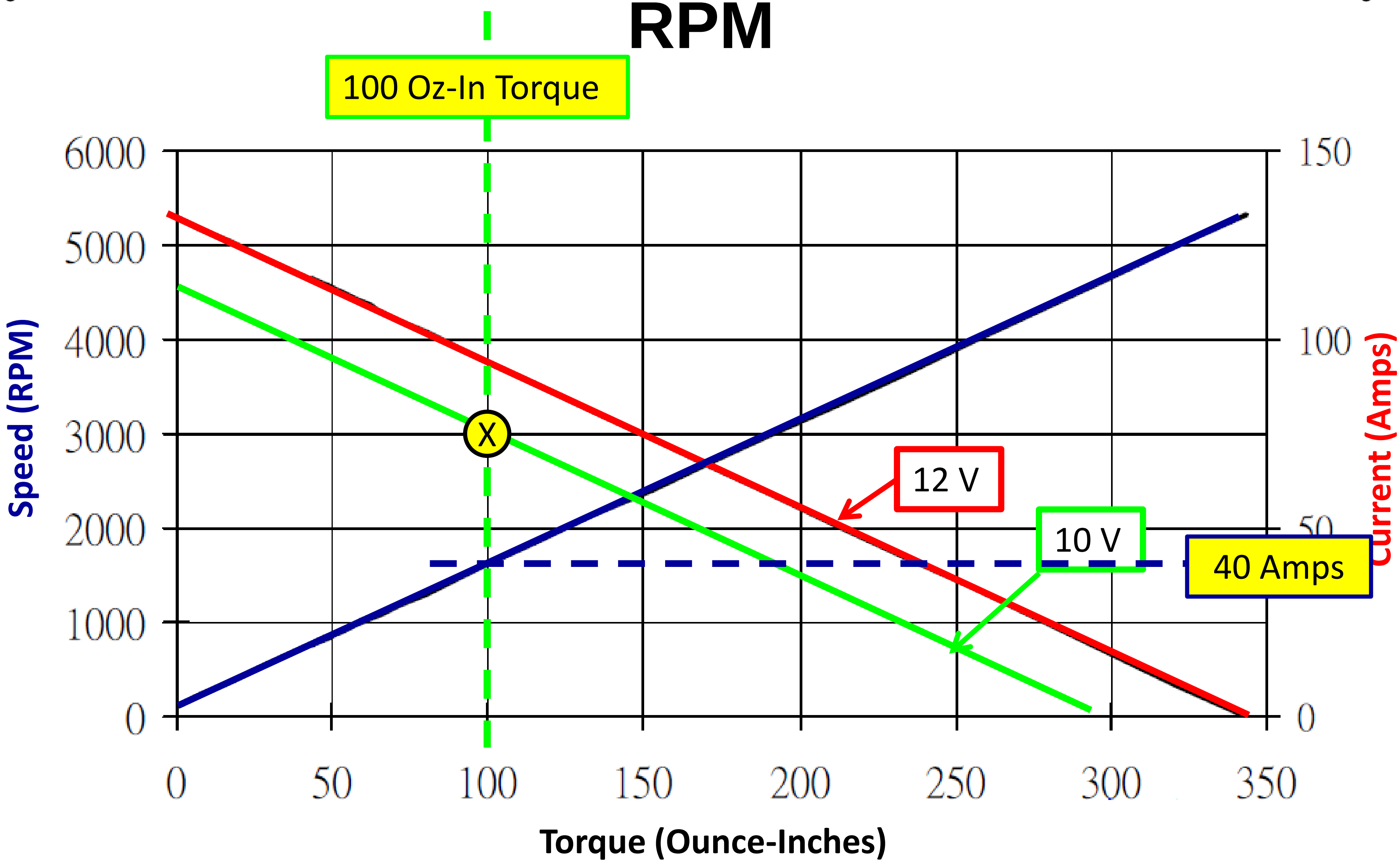
Motor Performance Curves
Full Size CIM Motor at Different Voltages
Speed Changes with Voltage
Current Does Not Change with Voltage



Motor Operating Point

- **Determine motor operating point information for motor running at 10 Volts and 3000 RPM**
  - Look at Motor curve for 3000 RPM and 10 Volt operation

Motor Operating Point: 10V and 3000 RPM



ADAMBOTS
Team 245

Motor Operating Point

- **10 Volts, 3000 RPM, 40 Amps, 100 Oz-In Torque**
  - Power Input: 10 x 40 = 400 Watts
  - Power Out: 100 x 3000 / 1351.74 = 222 Watts
  - Efficiency: 222 / 400 x 100 = 55.5%
  - Efficiency Losses: 400 – 222 – 178 Watts (into heat)

Motor Performance Curves
Maximum Operating Point for Continuous Operation