EE 1291

Electrical Engg & control System

PART A

ELECTRICAL ENGG

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LECT / EEE

UNIT 3

DC MACHINES

UNIT 3

DC MACHINES

UNIT 3 – DC MACHINES

TYPES OF DC MACHINES:

- ✓ DC MOTOR
- ✓ DC GENERATOR

DC MOTORS

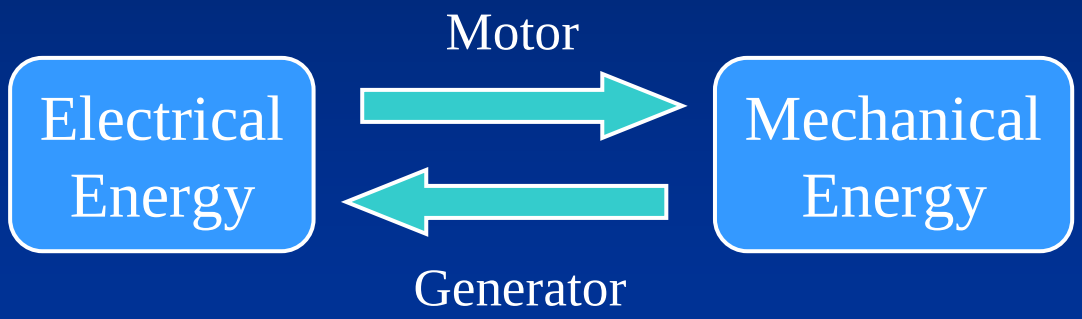
- ✓ Principle of working
- ✓ characteristics
- ✓ starting methods

+

- ✓ Types of dc motor
- ✓ voltage, torque & speed expression

WHAT IS DC MOTOR?

Converting Energy



An electric motor is a machine which converts electrical energy into mechanical energy.

DIRECT CURRENT (DC) MACHINES Fundamentals

- **Generator action:** An emf (voltage) is induced in a conductor if it moves through a magnetic field.
- **Motor action:** A force is induced in a conductor that has a current going through it and placed in a magnetic field
- Any DC machine can act either as a generator or as a motor.

Dc motor


Nylon
end cap
Axle
Steel can
Lead wires
to battery
Dime
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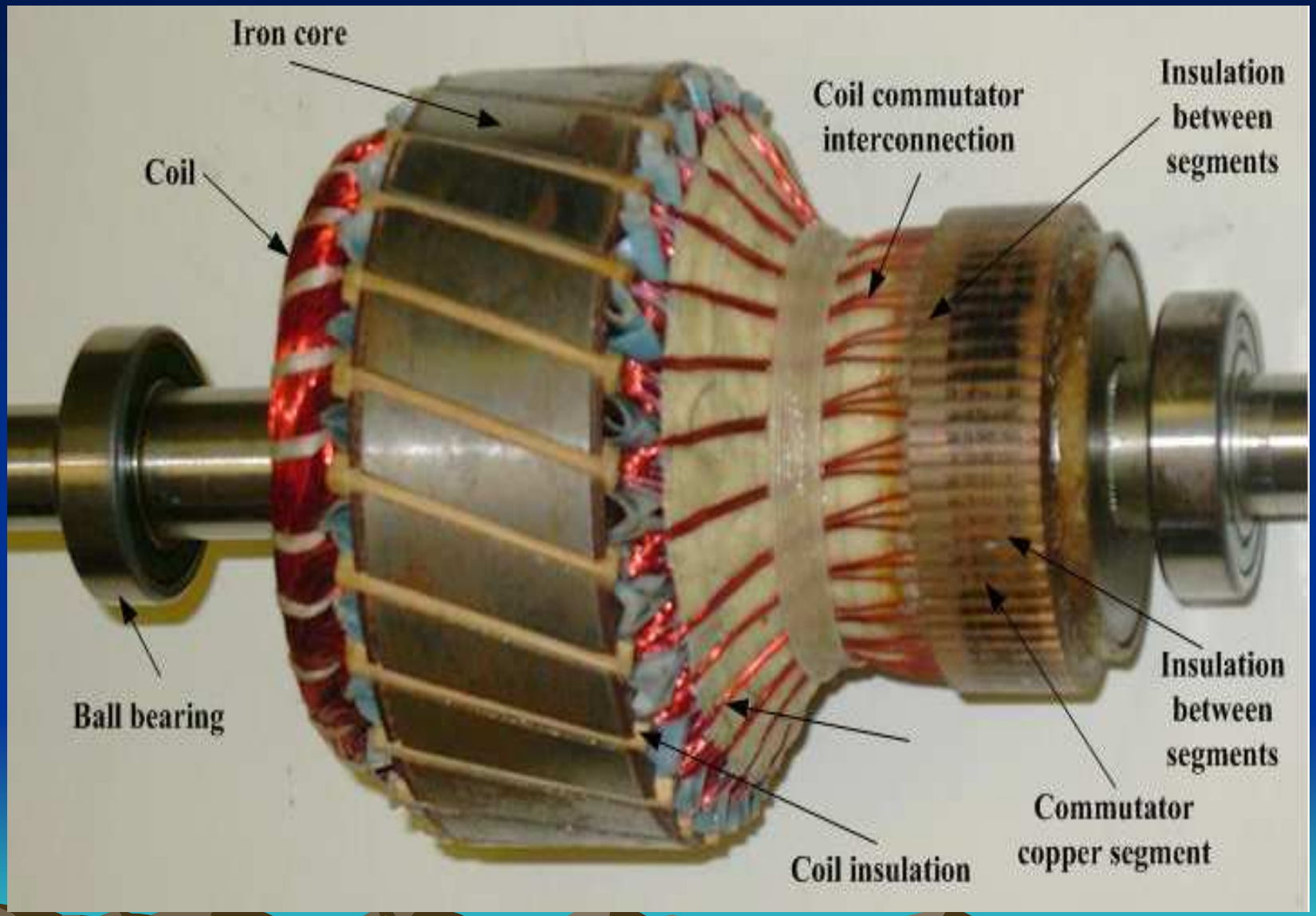
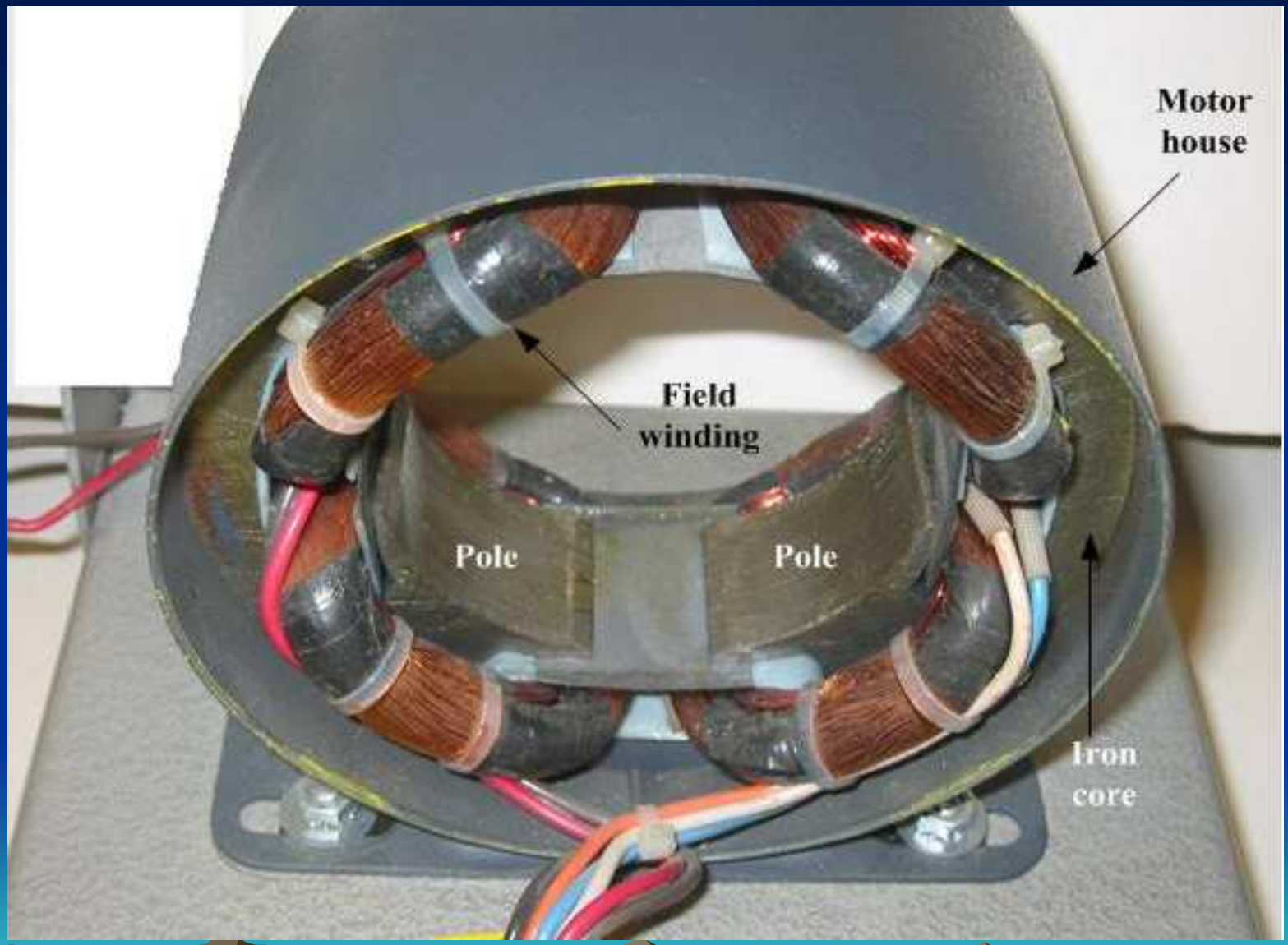

Iron core
Coil
Coil commutator interconnection
Insulation between segments
Ball bearing
Insulation between segments
Commutator copper segment
Coil insulation


Motor
house
Field
winding
Pole
Pole
Iron
core

WORKING PRINCIPLE

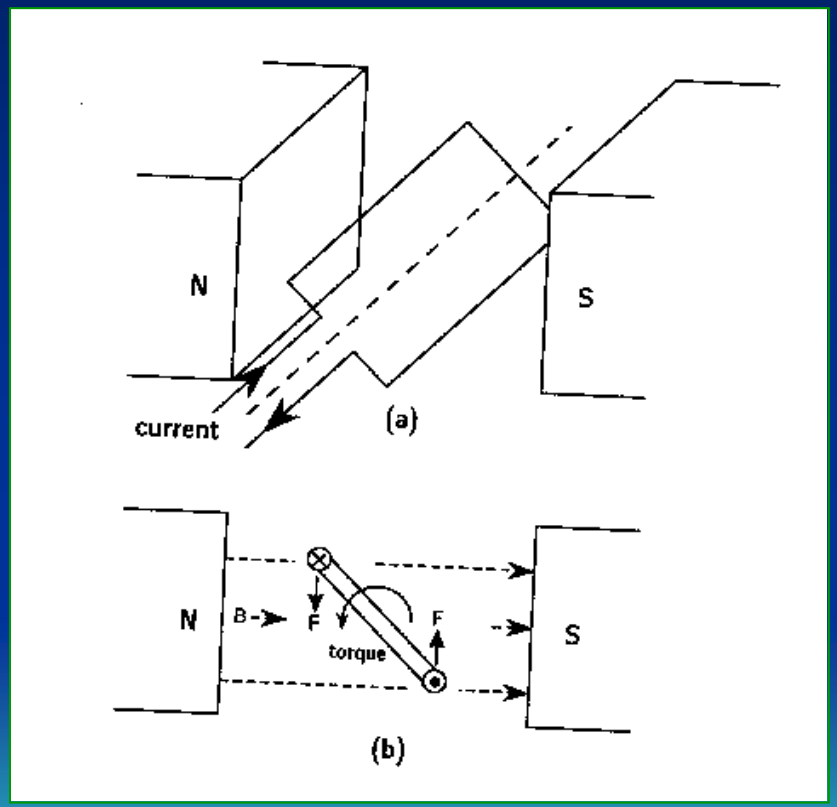
DC MOTOR

CONST..

- Field
- Armature

Principle:

Current carrying conductor placed in a mag field ⟶ F



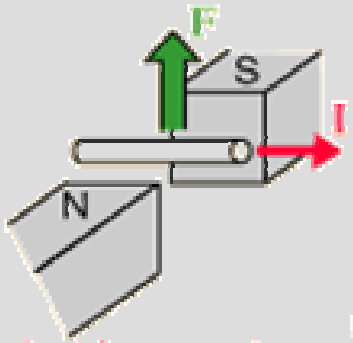
- It is based on the principle that when a current-carrying conductor is placed in a magnetic field, it experiences a mechanical force whose direction is given by Fleming's Left-hand rule and whose magnitude is given by

Force, **F = B I l** newton

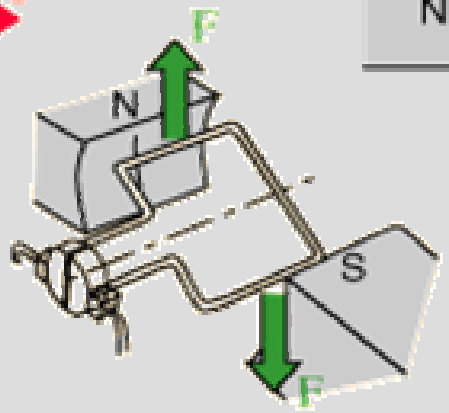
Where B is the magnetic field in weber/m2.

I is the current in amperes and

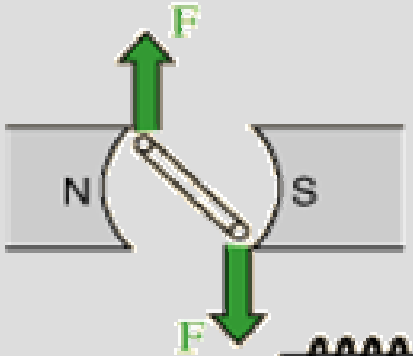
l is the length of the coil in meter.



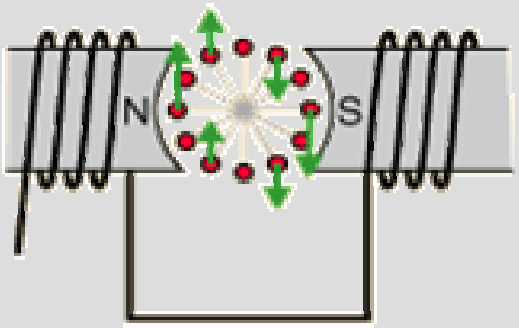
An electric current in a magnetic field will experience a force.



If the current-carrying wire is bent into a loop, then the two sides of the loop which are at right angles to the magnetic field will experience forces in opposite directions.



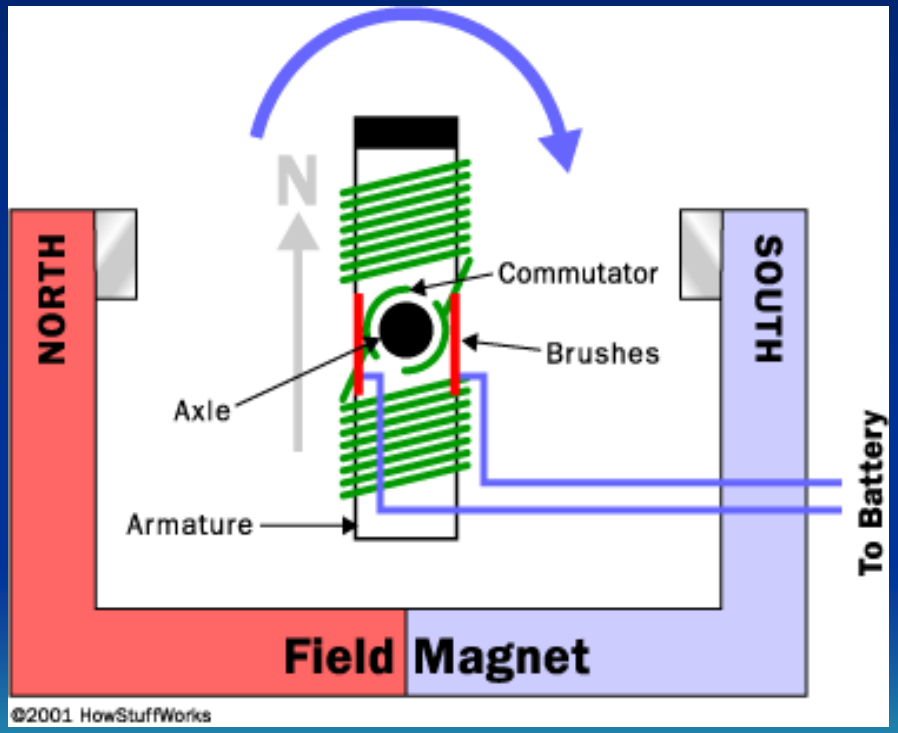
The pair of forces creates a turning influence or torque to rotate the coil.



Practical motors have several loops on an armature to provide a more uniform torque and the magnetic field is produced by an electromagnet arrangement called the field coils.

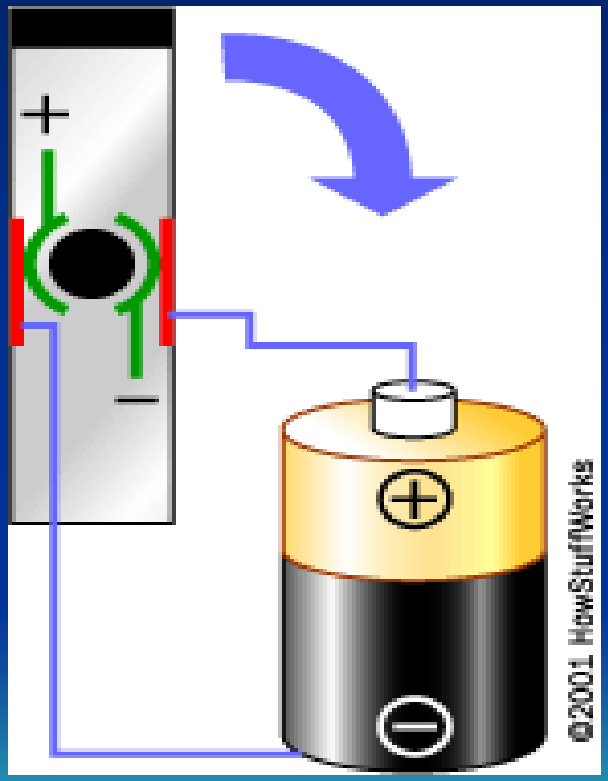
WORKING

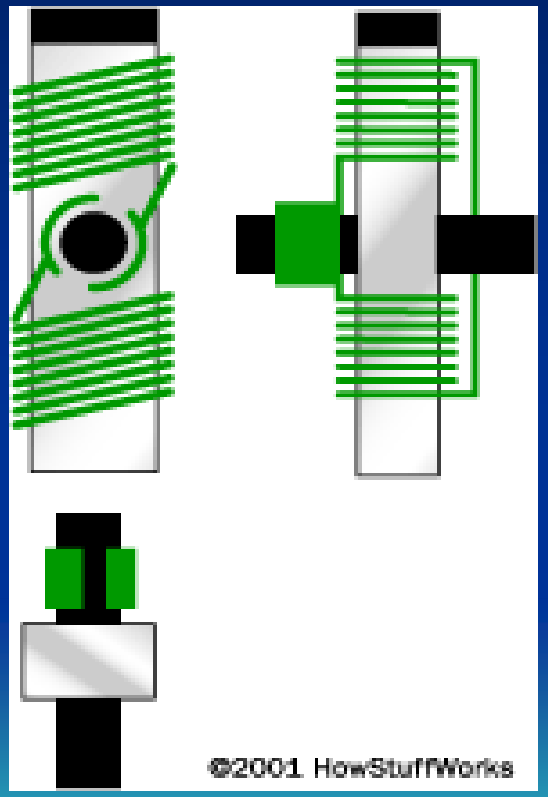
- Fig shows simple **two-pole DC electric motor**. A simple motor has six parts

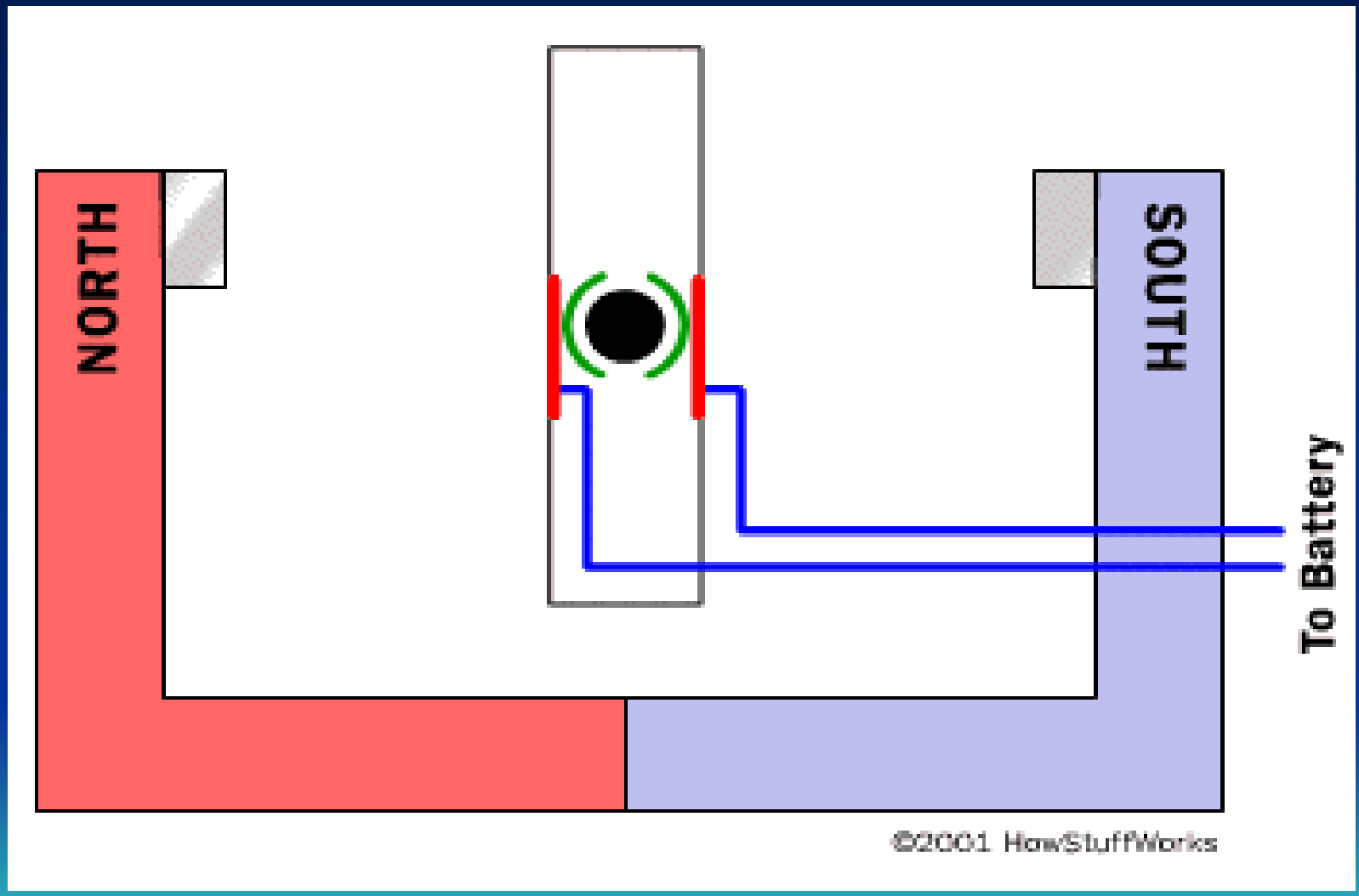


- ✓**Armature or rotor**
- ✓**Commutator**
- ✓**Brushes**
- ✓**Axle**
- ✓**Field magnet**
- ✓**DC power supply**

Armature, Commutator and Brushes






NORTH
SOUTH
To Battery
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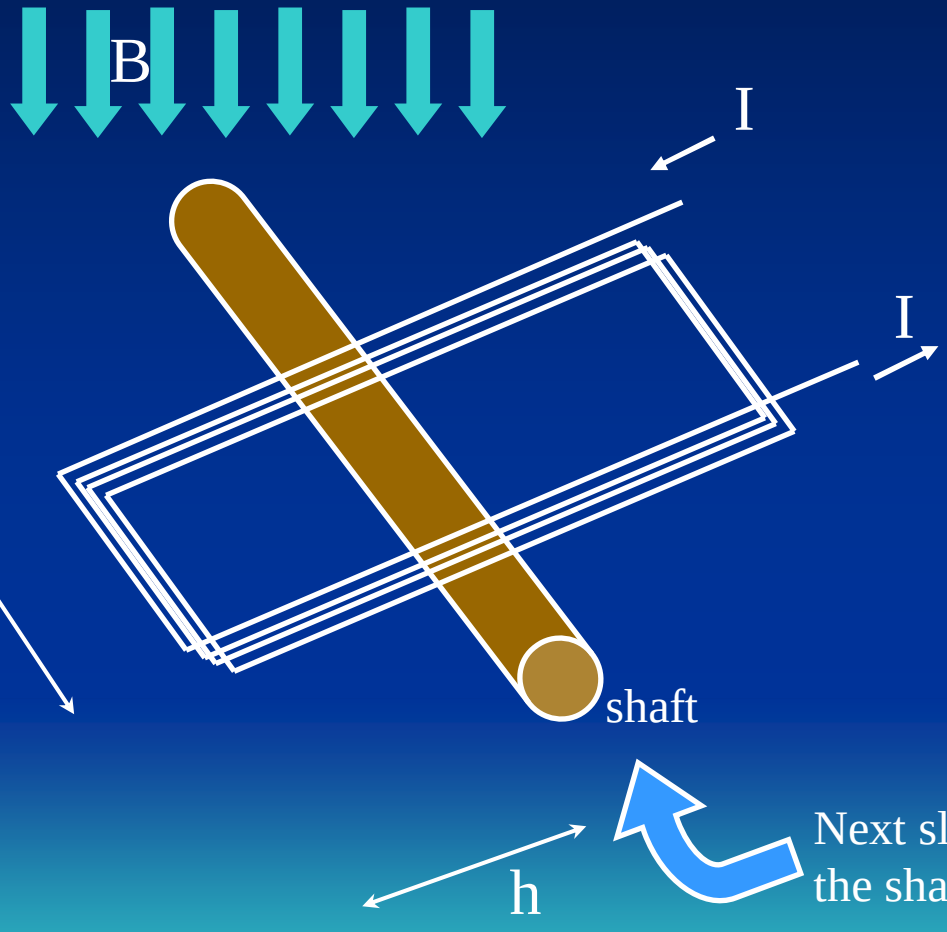
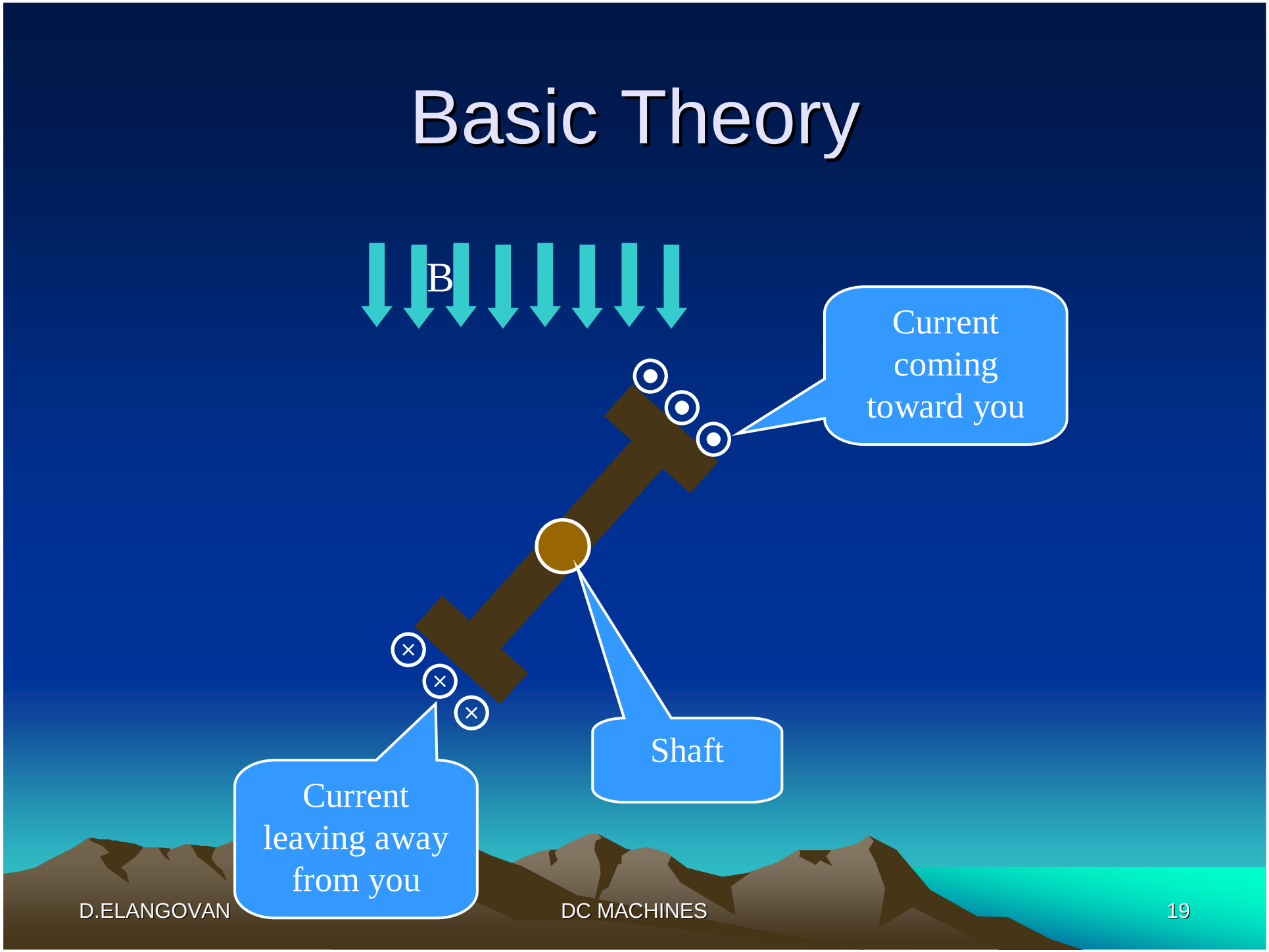
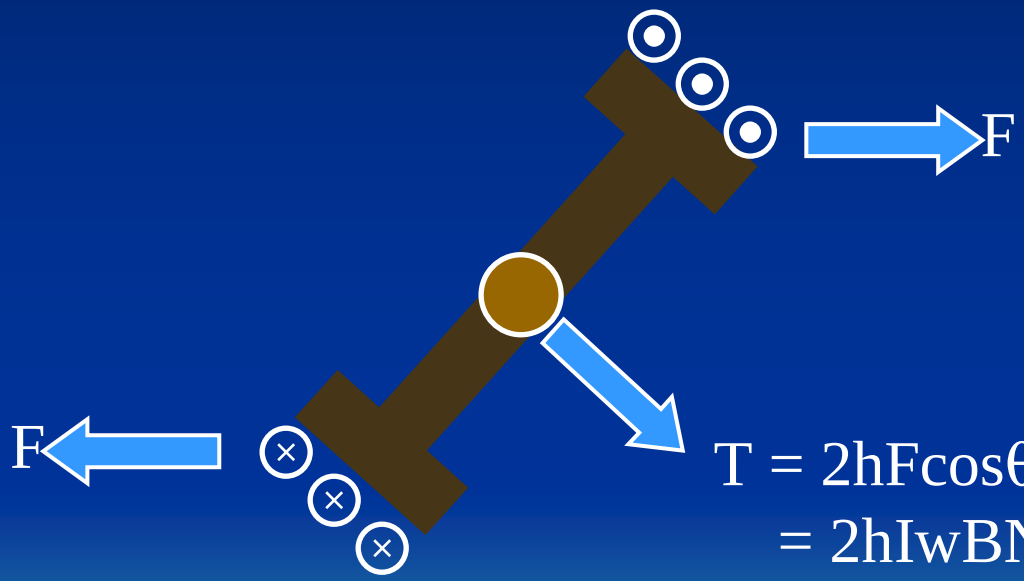
Basic Theory



Basic Theory

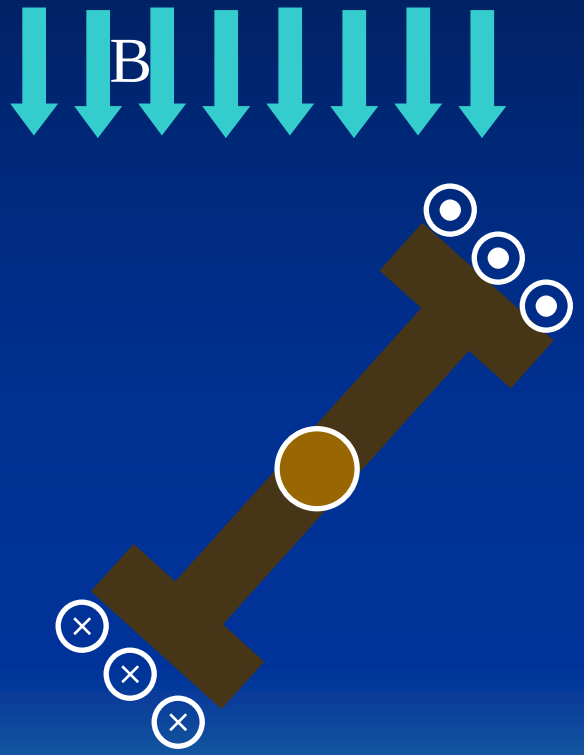


Basic Theory

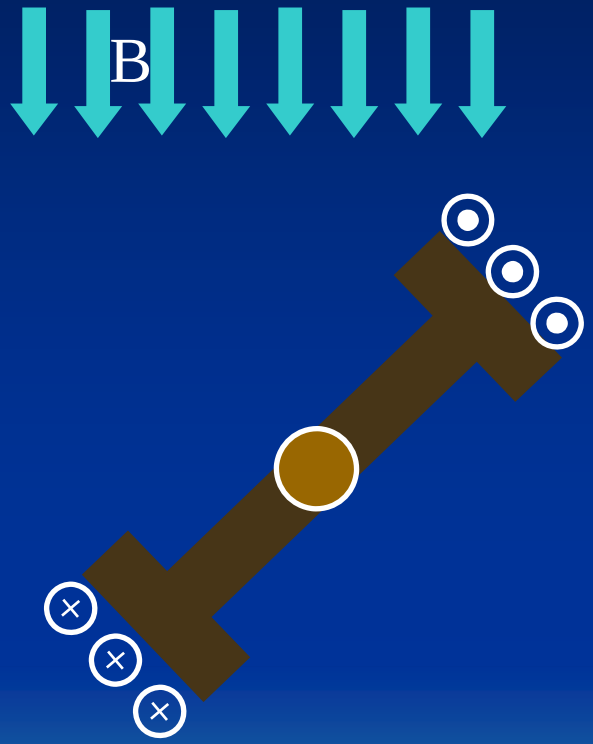


$$T = 2hF\cos\theta$$
$$= 2hIwBN\cos\theta$$

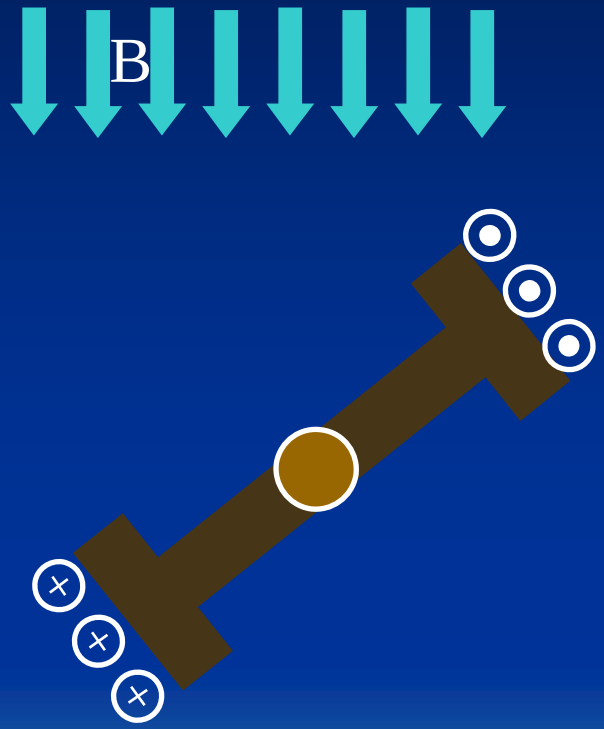
Basic Theory



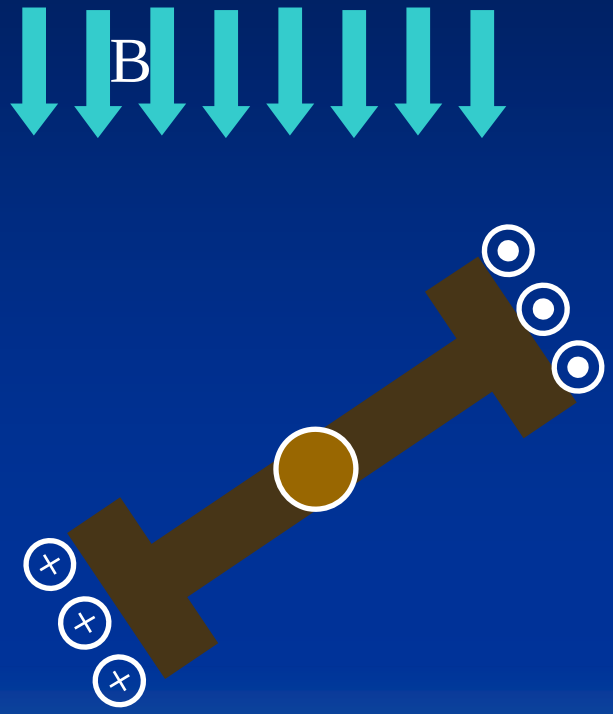
Basic Theory



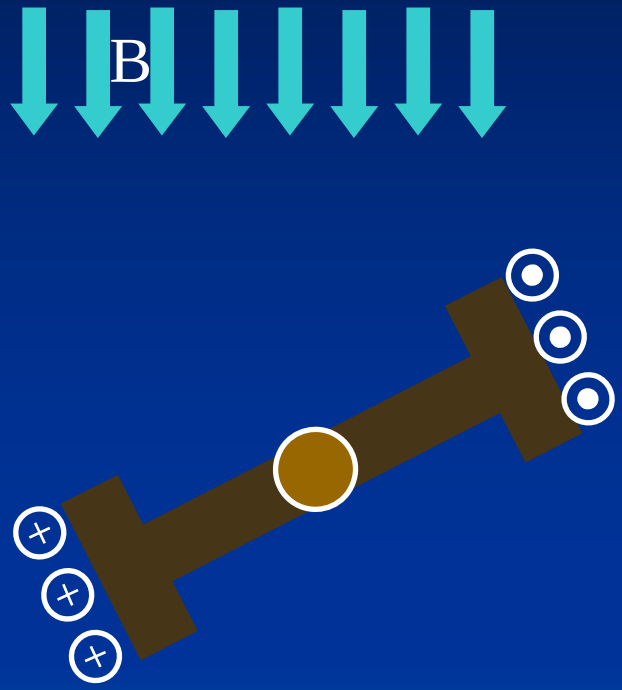
Basic Theory



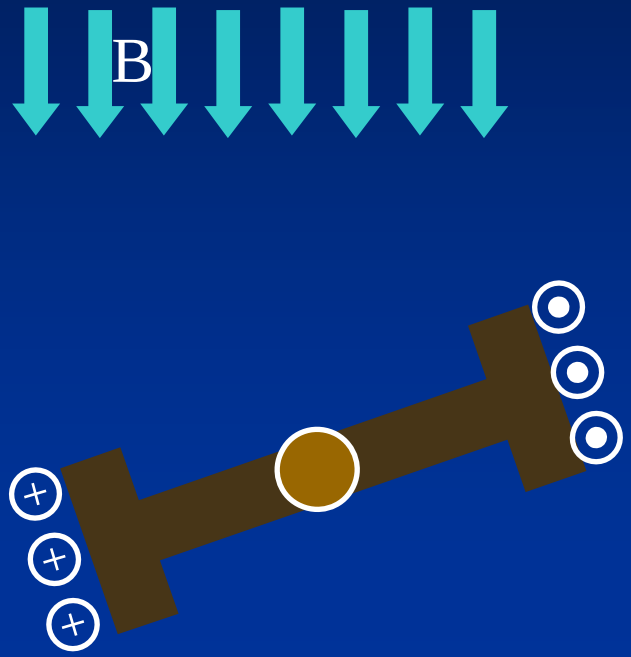
Basic Theory



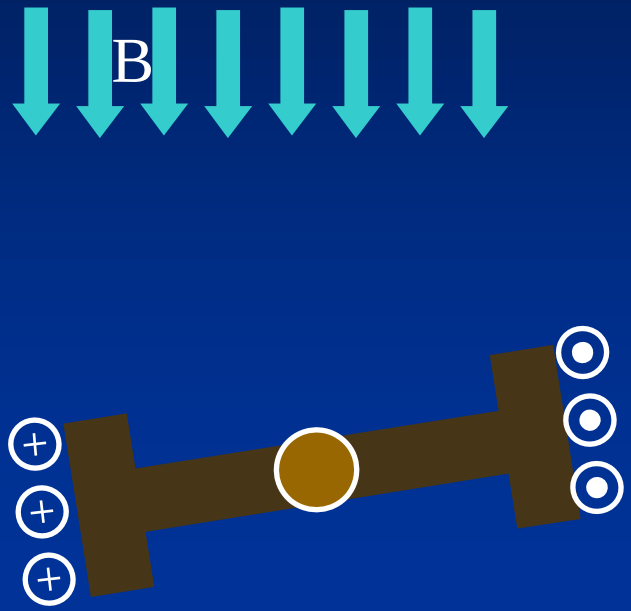
Basic Theory



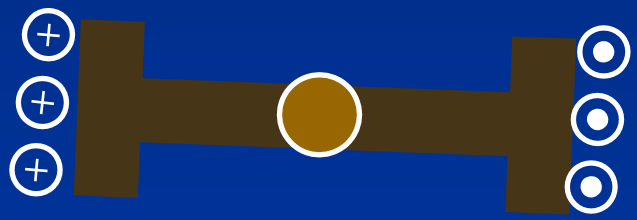
Basic Theory



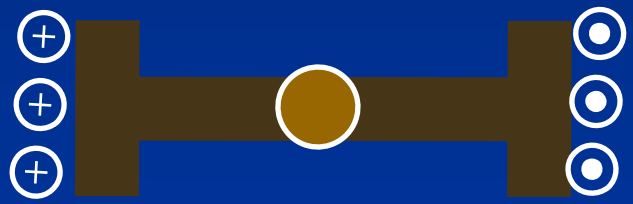
Basic Theory



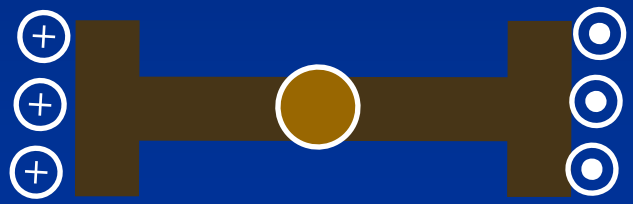
Basic Theory



Basic Theory



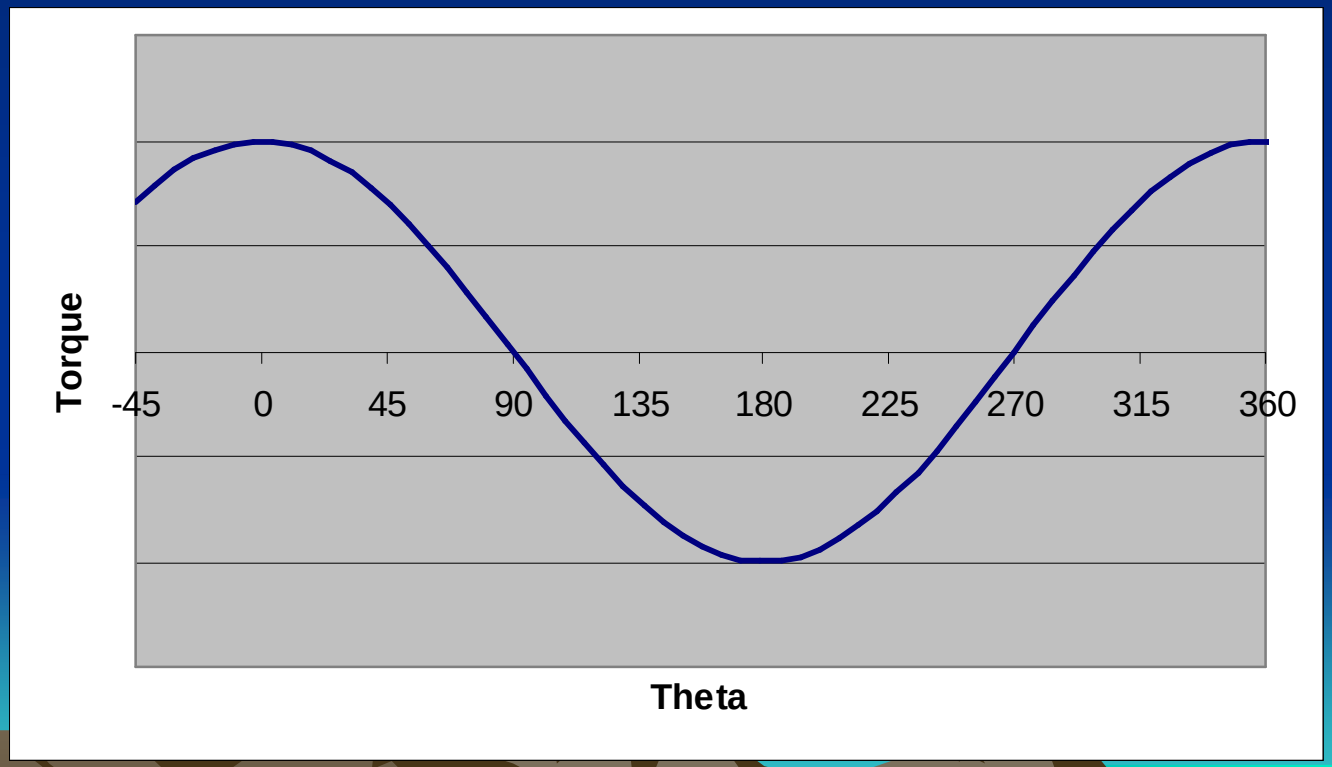
Basic Theory



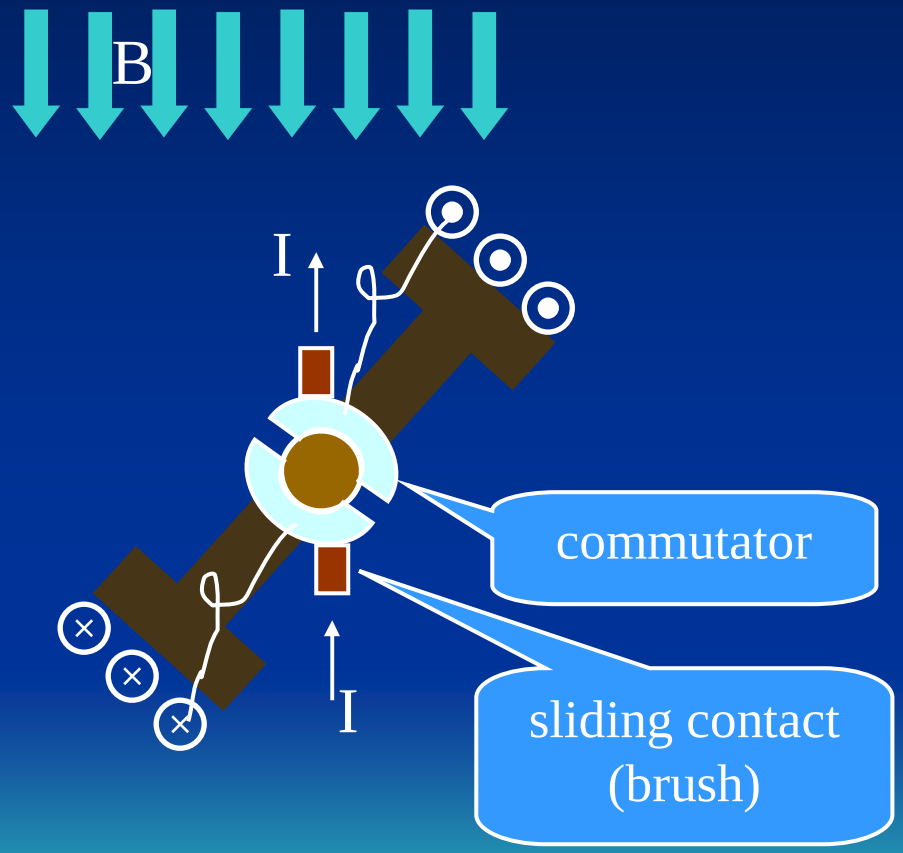
Oops – We're stuck. T=0, because θ=90°

Basic Theory

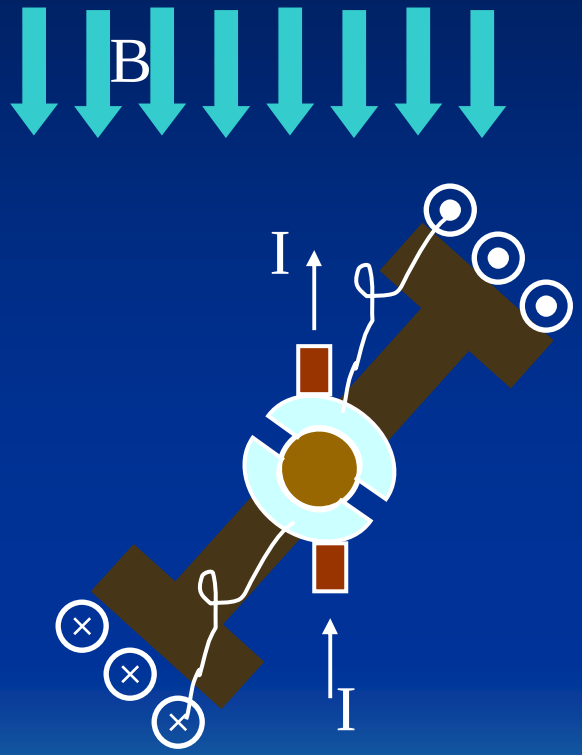
- Stable point at 90° -- need to reverse polarity



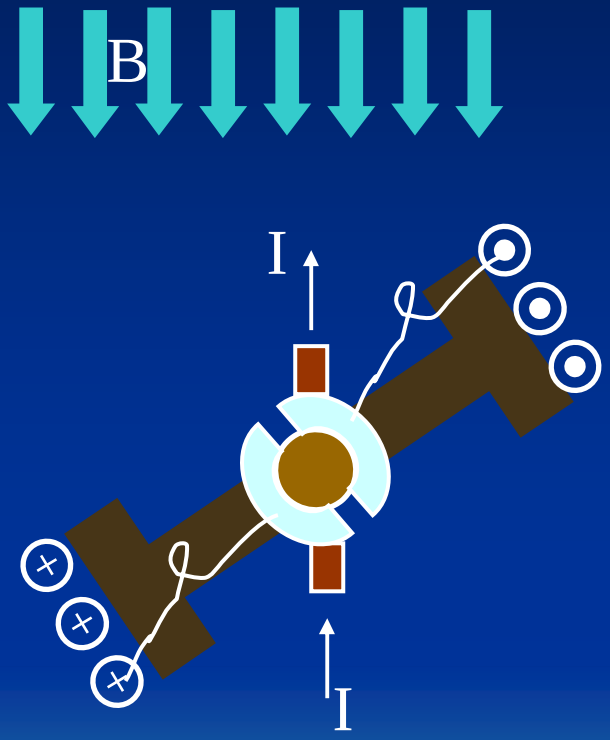
Improved Design



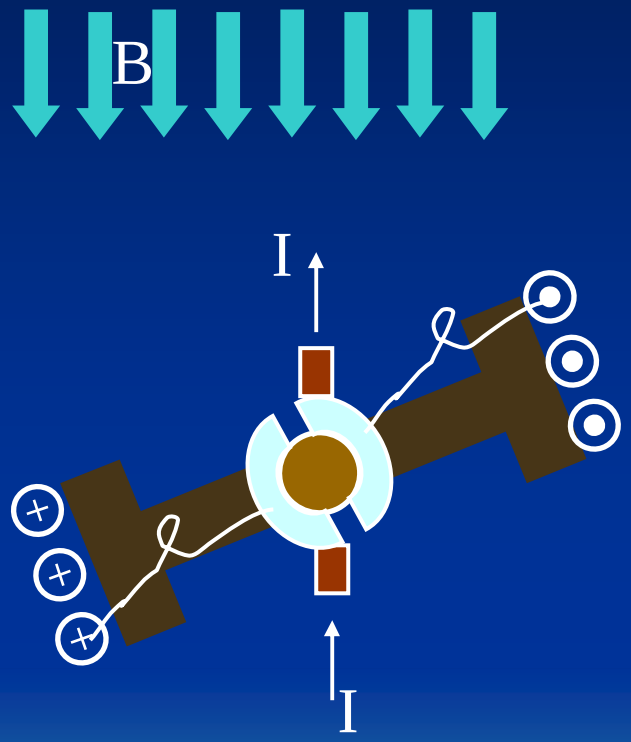
Improved Design



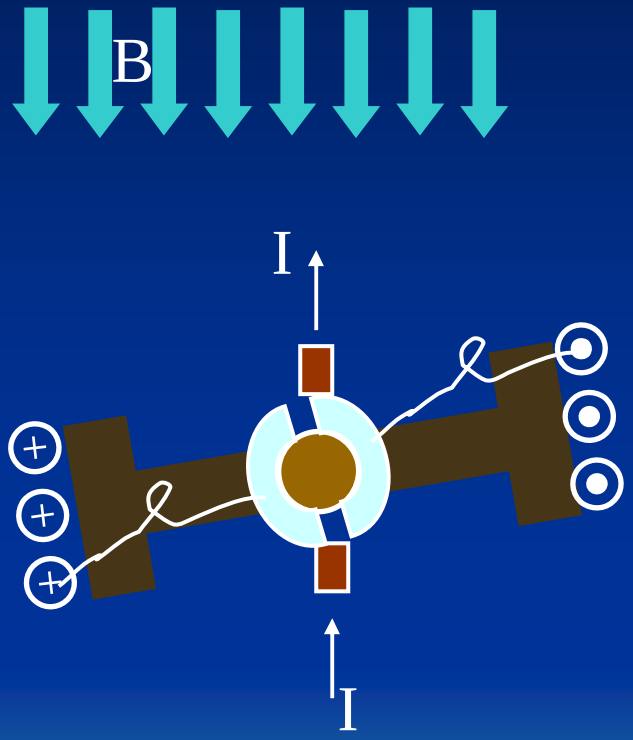
Improved Design



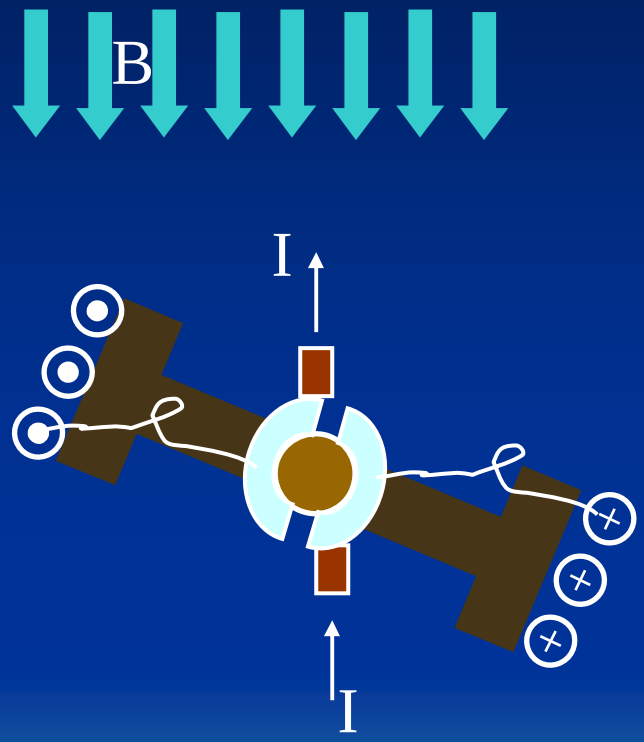
Improved Design



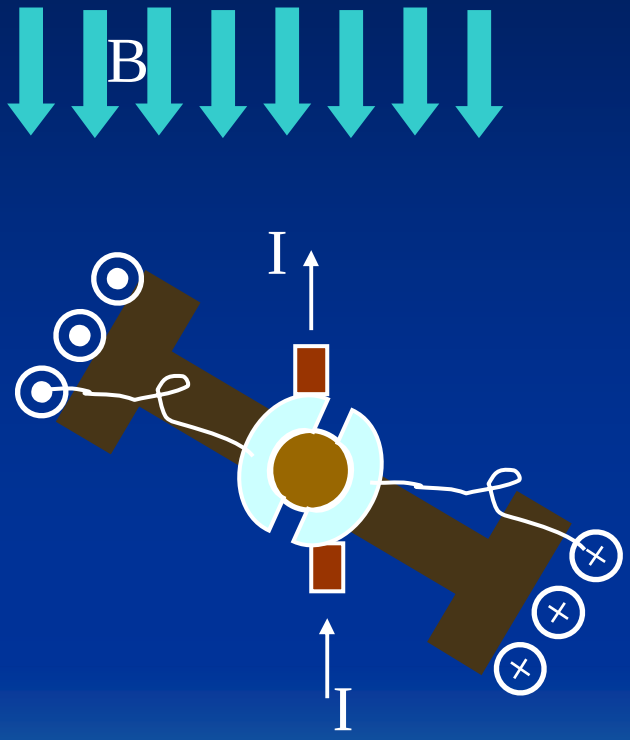
Improved Design



Improved Design

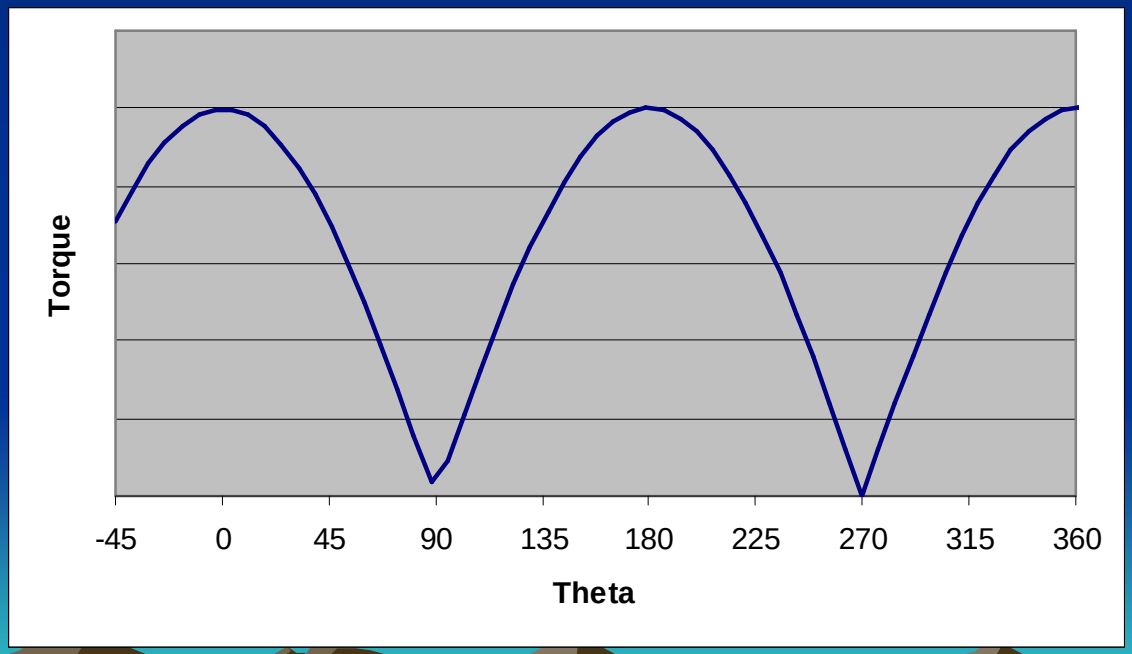


Improved Design



Improved Design

Still have trouble at 90°:



Principle of working

- Both armature & field windings are supplied DC supply
- Field winding produce magnetic field
- Now current carrying armature conductor placed in a static magnetic field.
- The field due to current carrying armature conductors interacts with main field winding
- Armature experience a mechanical force

Working….

- The commutator periodically reverses the direction of current flow through the armature
- Hence armature will have continuous rotation

BACK EMF

- ✓ When armature rotates, we have conductors in stationary magnetic field
- ✓ conductor experience a change in flux
- ✓ according to faradays law Emf is induced in armature conductors
- ✓ as per lenzs law, this emf opposes the applied voltage. Hence this emf is called BACK EMF

BACK EMF

$$E_b = \frac{ZP}{60a}\phi n$$

Where

Z = total number of conductors

P = total number of poles

a = P for lap winding, a = 2 for wave winding,

φ = flux,

n = speed in rpm.

Voltage equation

- Let V be the applied voltage in volts
- E_b be the back emf in volts
- R_a be the armature resistance in ohms
- Net voltage across the

  Armature is given by = $V - E_b$

  - Armature current is given by = $V-E_b / R_a$

Voltage equation

- Ia= V-Eb/Ra
- Ia Ra= V-Eb
- $V=E_b+I_aR_a$

Torque equation

- Electrical power $P_e = VI_a$
- Mechanical power Pm = P_e-losses
- $= VI_a - I_a^2 R_a$
- $= (V - I_a R_a) I_a$
- $P_m = E_b I_a$ —— (1)

- Mechanical power developed = 2πNT/60
- (2)
- Equate 1 and 2

$$\frac{2\pi NT}{60} = EbIa$$

$$T = \frac{ZP}{2\pi a}\phi I_A$$

$$T = k_m \phi I_A$$

Speed equation

END
OF
LECTURE