The Electric Motor

Lesson 6

Objectives

- explain, quantitatively, the effect of an external magnetic field on a current-carrying conductor.
- describe, qualitatively, the effects of moving a conductor in an external magnetic field, in terms of moving charges in a magnetic field.

Diploma Question Alert!

16. A proton and an alpha particle have identical circular orbits in a magnetic field. The proton has a speed of 4.4×10^5 m/s. The speed of the alpha particle is

A. 1.1×10^5 m/s

B. 2.2×10^5 m/s

C. 4.4×10^5 m/s

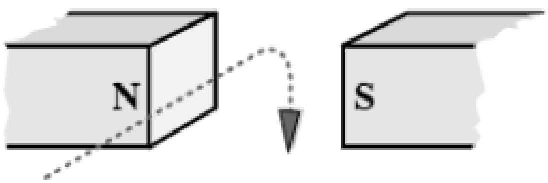
D. 8.8×10^5 m/s

Diploma Question Alert!

22. The path followed by a moving proton in an external magnetic field is shown in

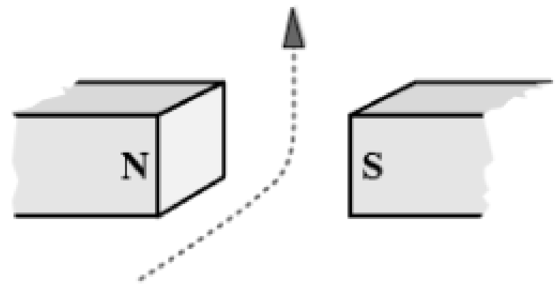
A.

vertically down



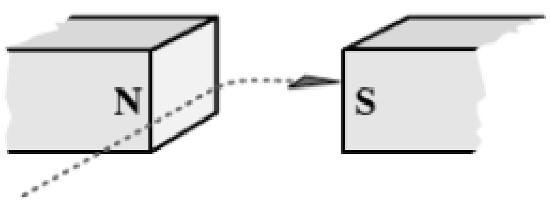
B.

vertically up



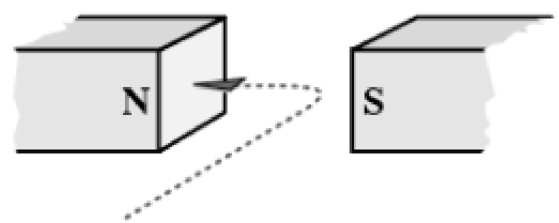
C.

horizontally right



D.

horizontally left



Diploma Question Alert!

24. The magnitude of the magnetic force exerted on a charged particle in a magnetic field will be doubled by doubling **any one** of

A. the charge of the particle, or the speed of the particle, or the mass of the particle

B. the magnitude of the field or the angle of entry of the particle

C. the speed of the particle, or the mass of the particle, or the magnitude of the field

D. the charge of the particle, or the speed of the particle, or the magnitude of the field

Diploma Question Alert!

25. One $\dfrac{N \cdot C \cdot m}{A \cdot m \cdot s}$ is the same as

A. 1 A

B. 1 N

C. 1 C

D. 1 J

Current Carrying Wires

- Recall Hans Christian Oersted's discovery:
- "A current carrying wire produces a magnetic field!"
- We can determine the direction of this B-field using the first LHR:

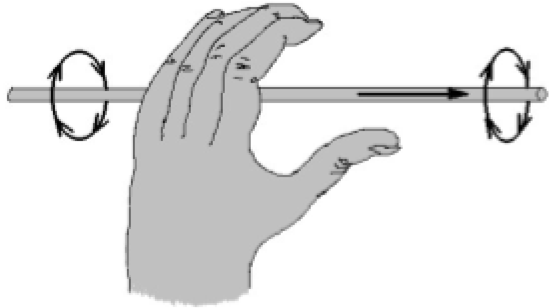


FIGURE 8: Left hand rule for current flow through a wire generating magnetic flux lines.

Force...

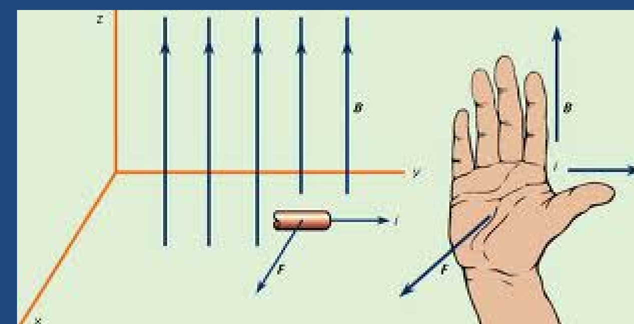
- we have also seen that charged particles placed in an external magnetic field experience a magnetic force:

$$\vec{F}_B = q\,\vec{v}\,\vec{B}_{\perp}$$

force on a charge in a B-field

Force in a Current Carrying Wire

- A current carrying wire placed in an external magnetic field experiences a magnetic force, just like a point charge.
- The direction of the force can be found by using the 3rd LHR.
- The magnitude of the force can be found using the equation:



$$\vec{F}_B = \vec{B}_{\perp} IL$$

where:
I = current (A)
L = length of wire (m)

The discovery of this force led to many important inventions such as:

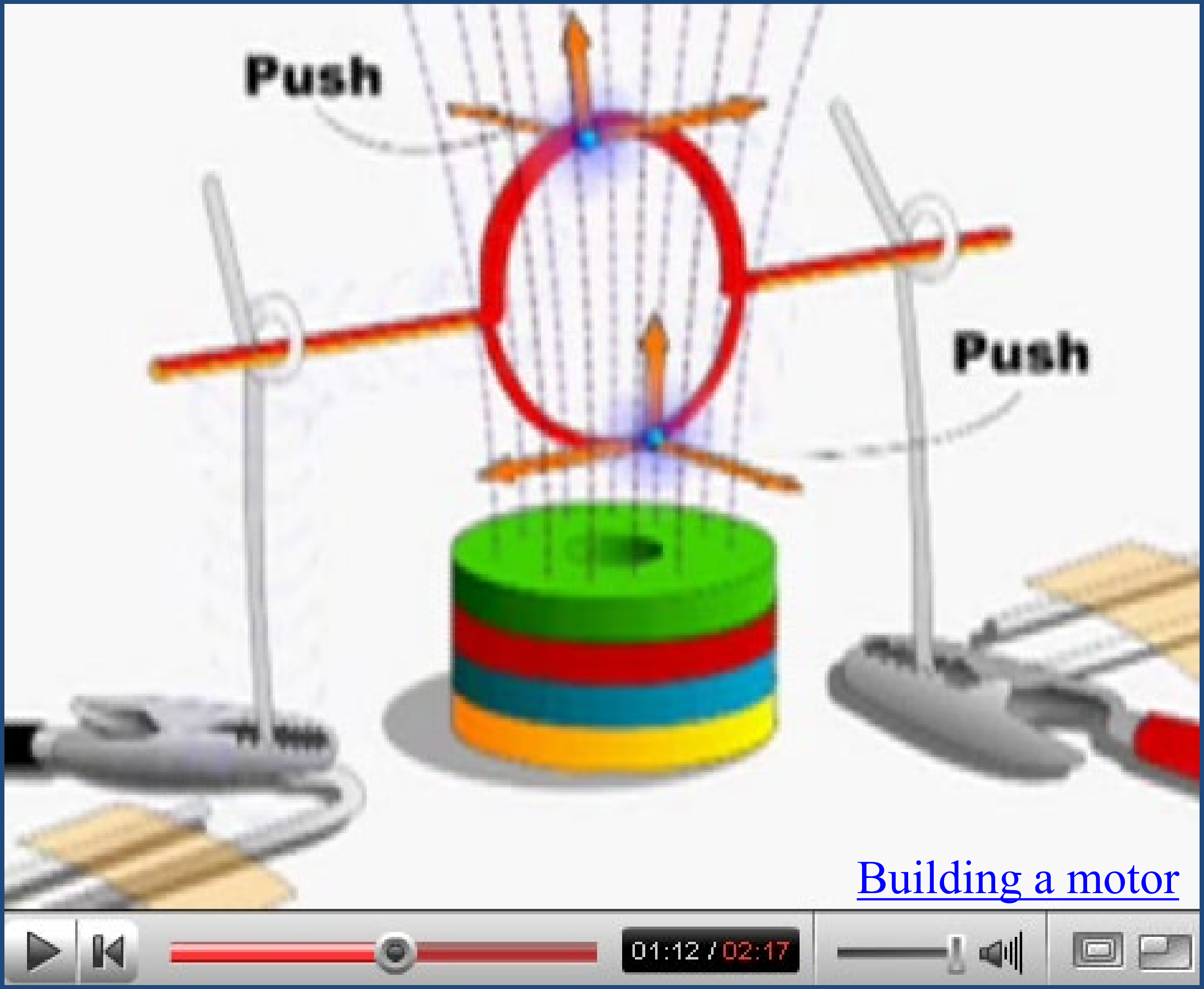
- **The Electric Motor**

- **The Galvanometer**

The Electric Motor

- Oersted's discovery that a current carrying wire can experience a force in a B-field interested another giant in the world of science: Michael Faraday.
- Faraday built a simple motor out of a current carrying wire suspended in a pool of mercury containing a magnet
- This acted as a forerunner for other modern electric motors

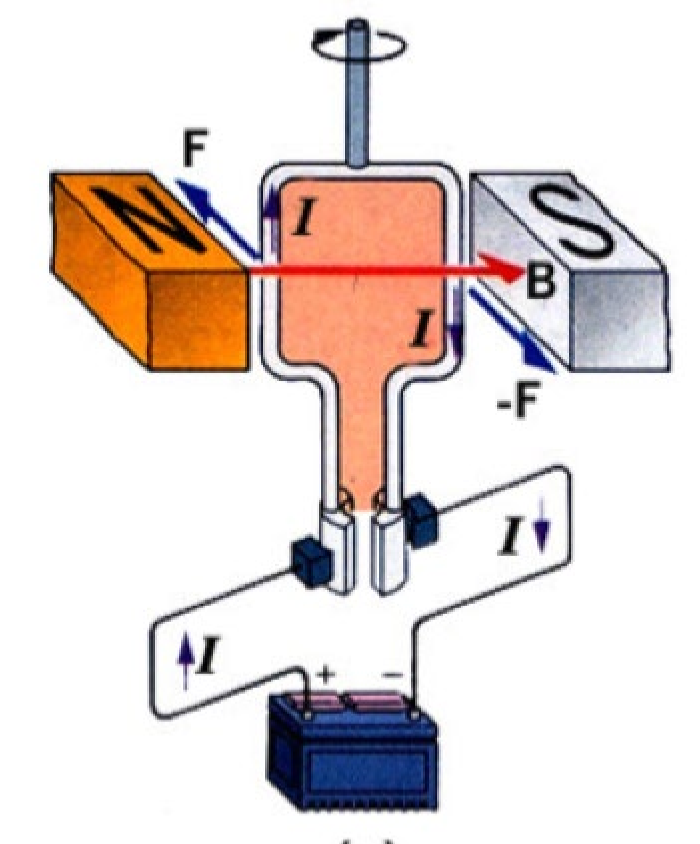
Building a Simple Motor



Building a motor

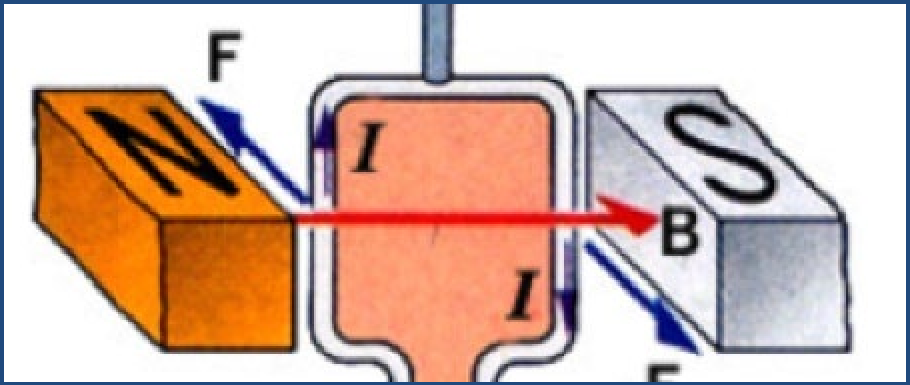
Workings of an Electric (DC) Motor

- Made of 4 main parts:
- 1. Magnetic Field
- 2. Armature/Rotor
- 3. Brushes
- 4. Split Ring/Commutator
- *Note: this diagram uses conventional current, so you will need to use your 3rd RHR to analyze it.



(a)

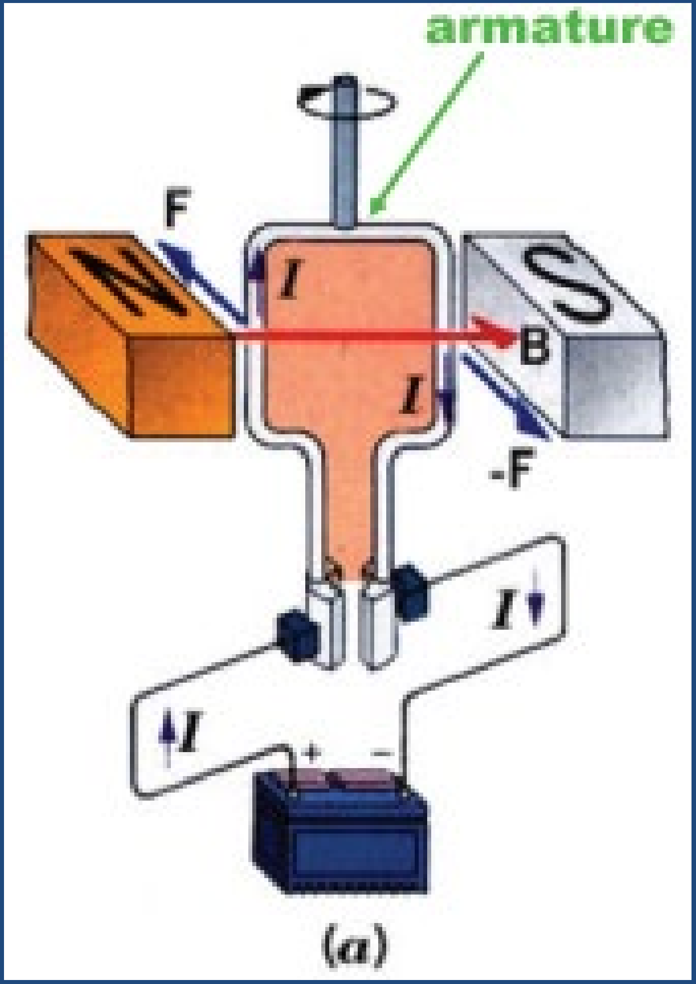
1. The Magnetic Field



- All electric motors need an external magnetic field provided by a permanent magnet
- The magnet and the apparatus holding it is sometimes called the stator

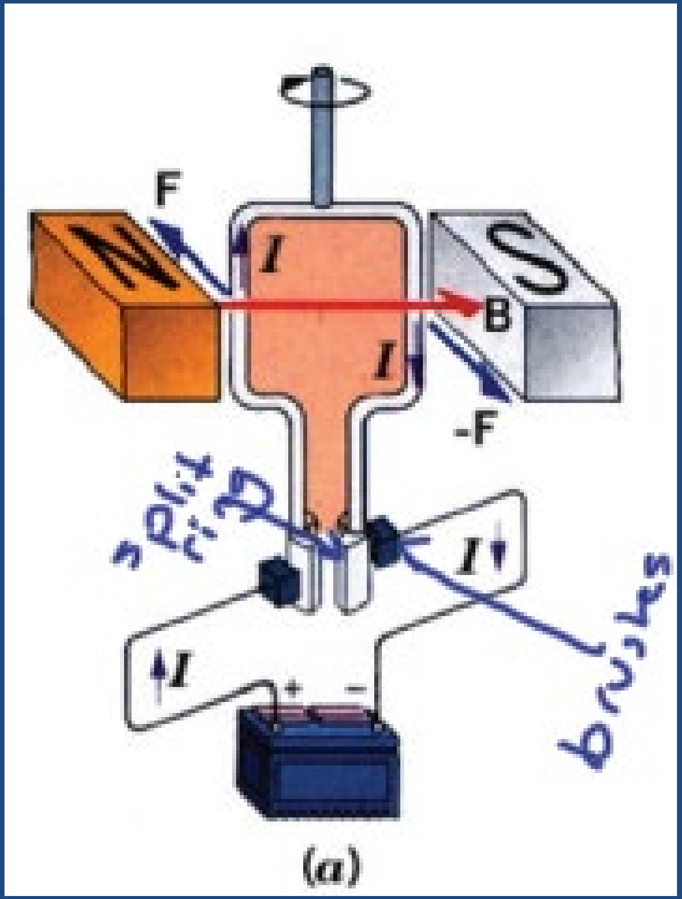
2. The Armature/Rotor

- A loop of current carrying wire
- often more than one loop to increase the overall force
- The direction of the force can be found using the 3rd *HR
- The loop is attached to the payload (what you want to spin...)



3. Brushes and
4. Split Ring/Commutator

- In order for the motor to keep spinning, the current must experience a break every half-rotation
- The split ring contains a gap that momentarily breaks the circuit, instead of allowing current to reverse
- The brushes provide a contact point between the armature and the split ring

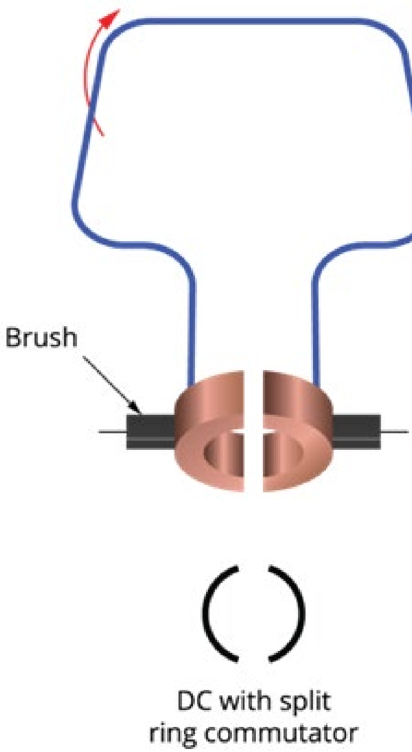


Split – ring vs. Slip - ring

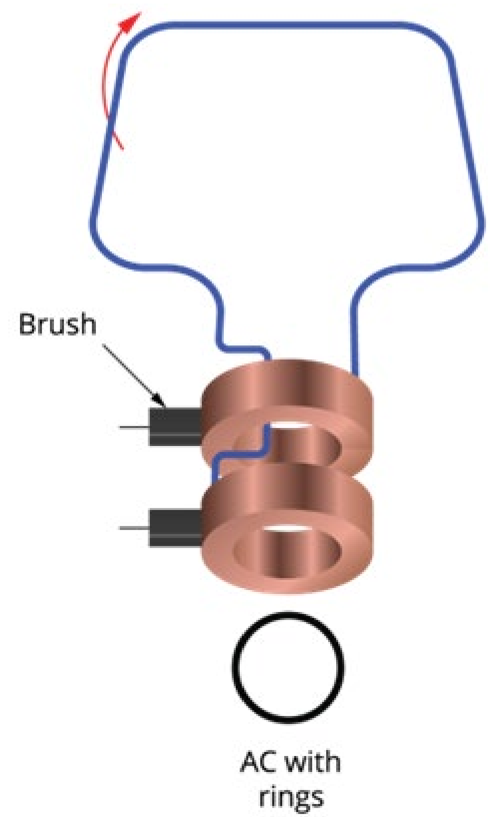
- A slip-ring is used in an **AC** generator or motor
- It supplies a continuous current to transfer power or signals from a **fixed** part to a **rotating** part.
- In a **DC** motor, the split-ring commutator is used **to switch the current direction in the armature** and to maintain continuous rotation in the same direction.

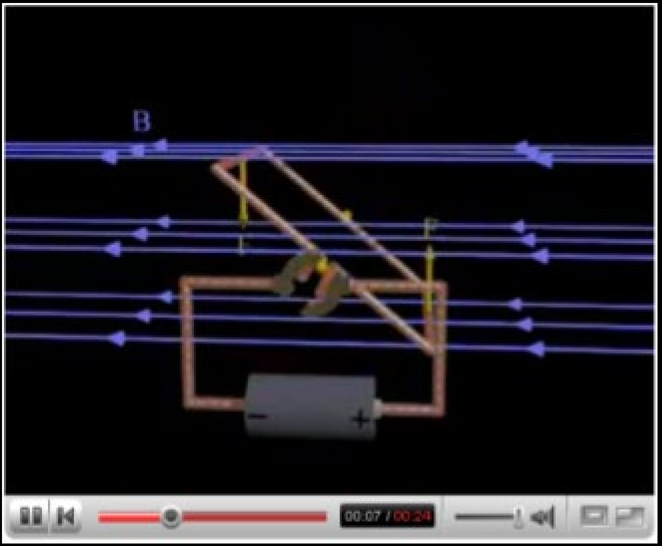
Split – ring vs. Slip - ring

Split - ring

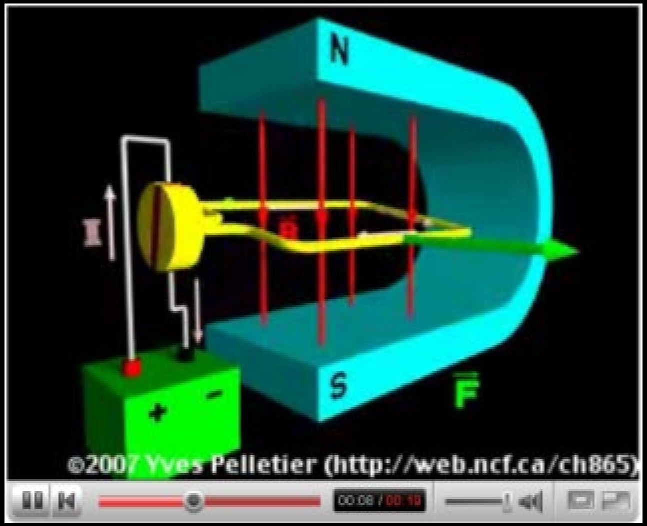


Slip - ring





http://www.youtube.com/watch?v=FjNnRyLexNM&feature=related



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