

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!

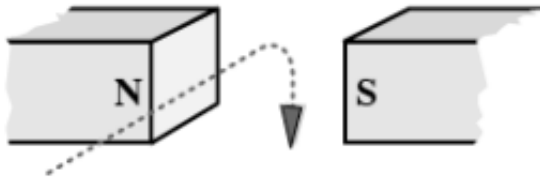
16. A proton and an alpha particle have identical circular orbits in a magnetic field. The proton has a speed of 4.4×10^5 m/s. The speed of the alpha particle is
- A. 1.1×10^5 m/s
 - B. 2.2×10^5 m/s
 - C. 4.4×10^5 m/s
 - D. 8.8×10^5 m/s

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

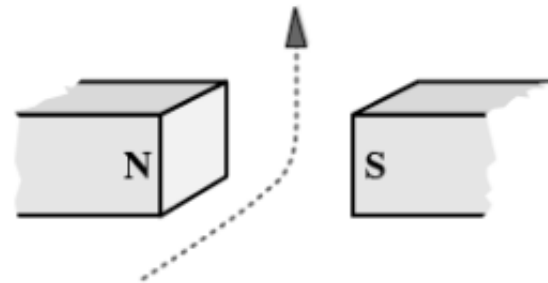
A.

vertically down



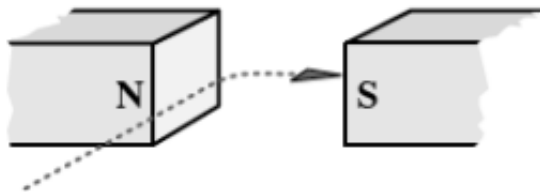
B.

vertically up



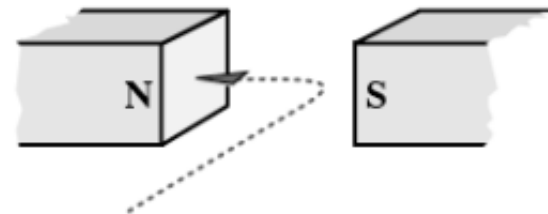
C.

horizontally right



D.

horizontally left



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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

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

A. 1 A

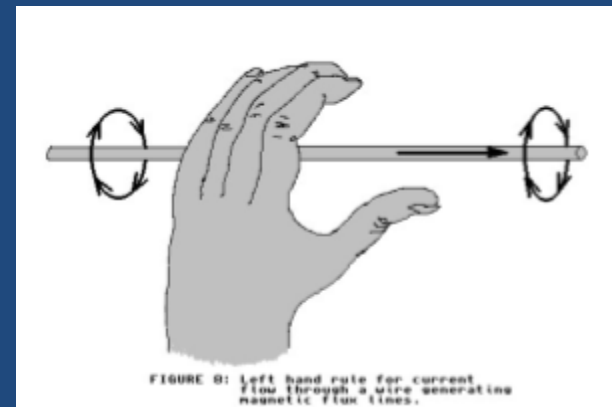
B. 1 N

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:



Force...

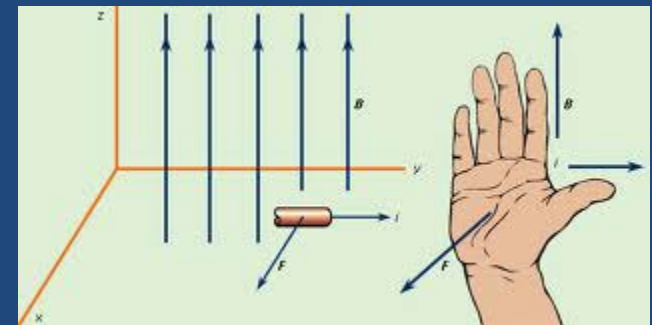
- we have also seen that charged particles placed in an external magnetic field experience a magnetic force:

$$\vec{F}_B = q \vec{v} \times \vec{B}$$

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:



$$\vec{F}_B = \vec{B} \perp I L$$

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

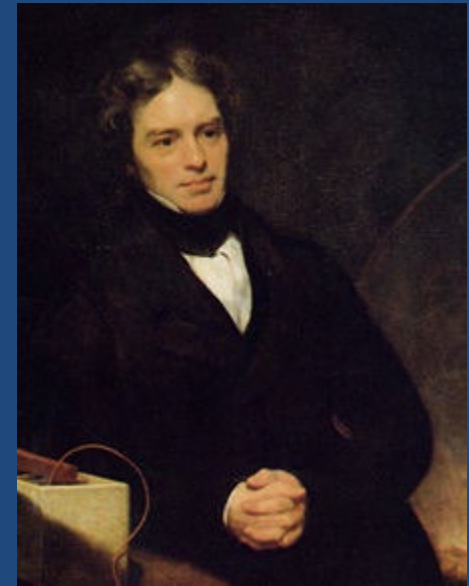
The discovery of this force led to many important inventions such as:

- **The Electric Motor**

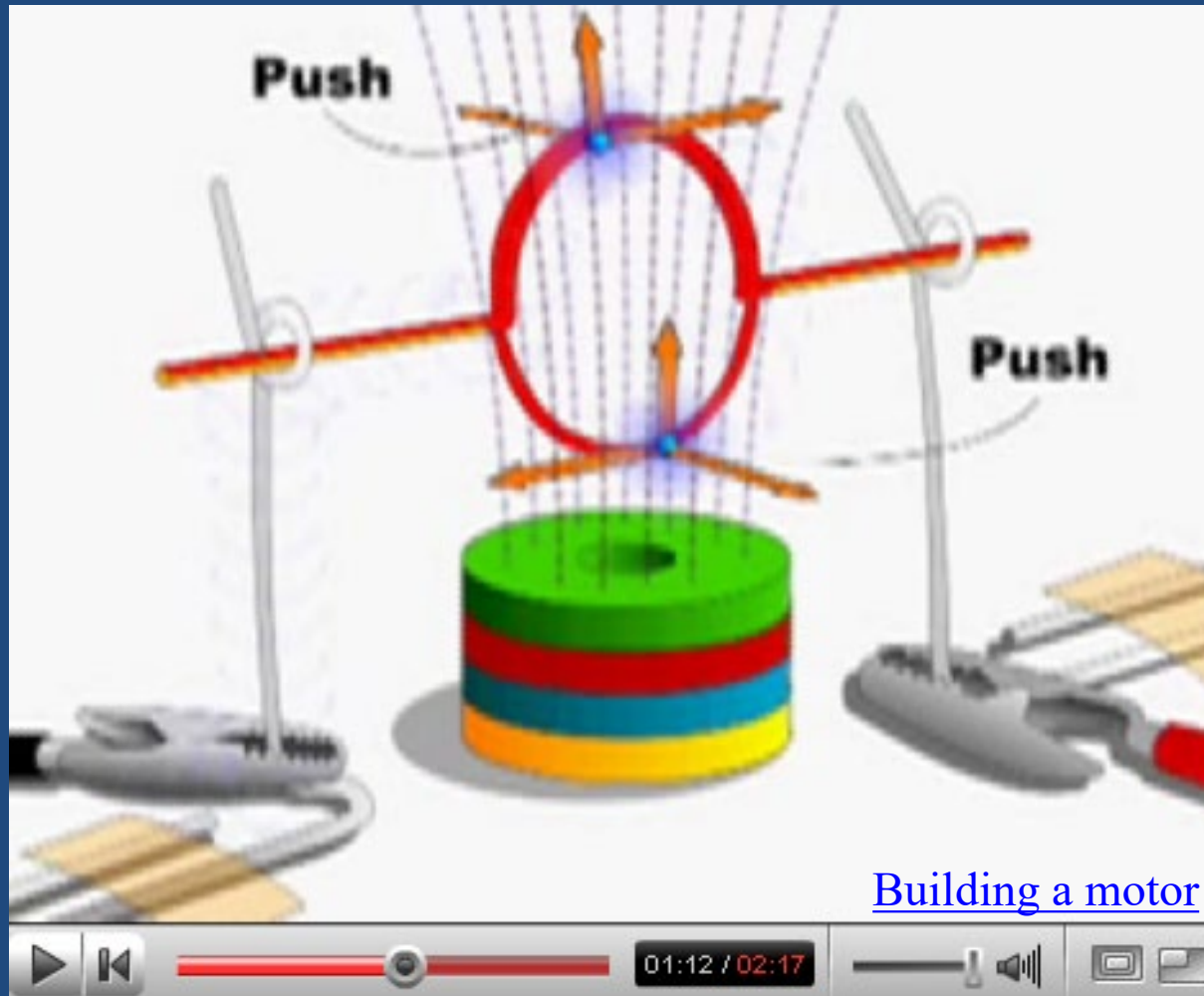
- **The Galvanometer**

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

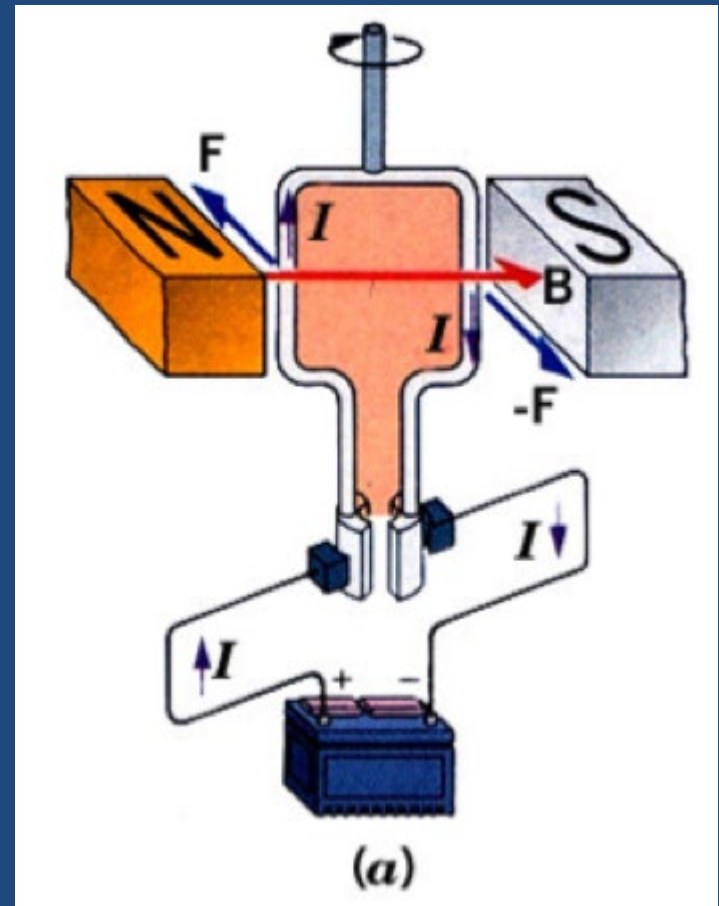


Building a Simple Motor

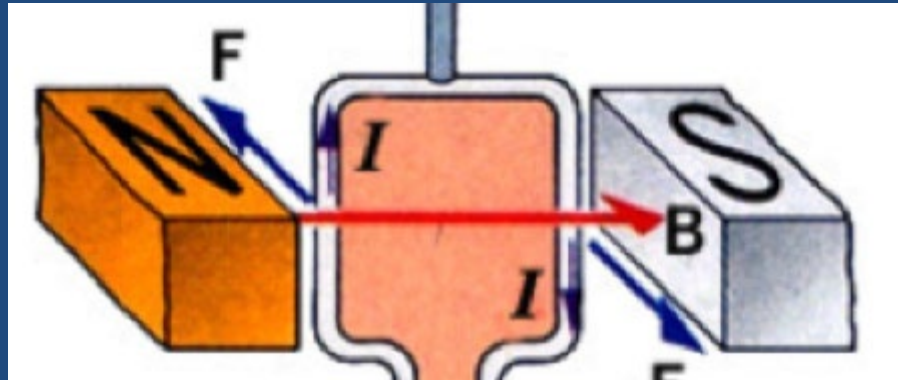


Workings of an Electric Motor

- 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.



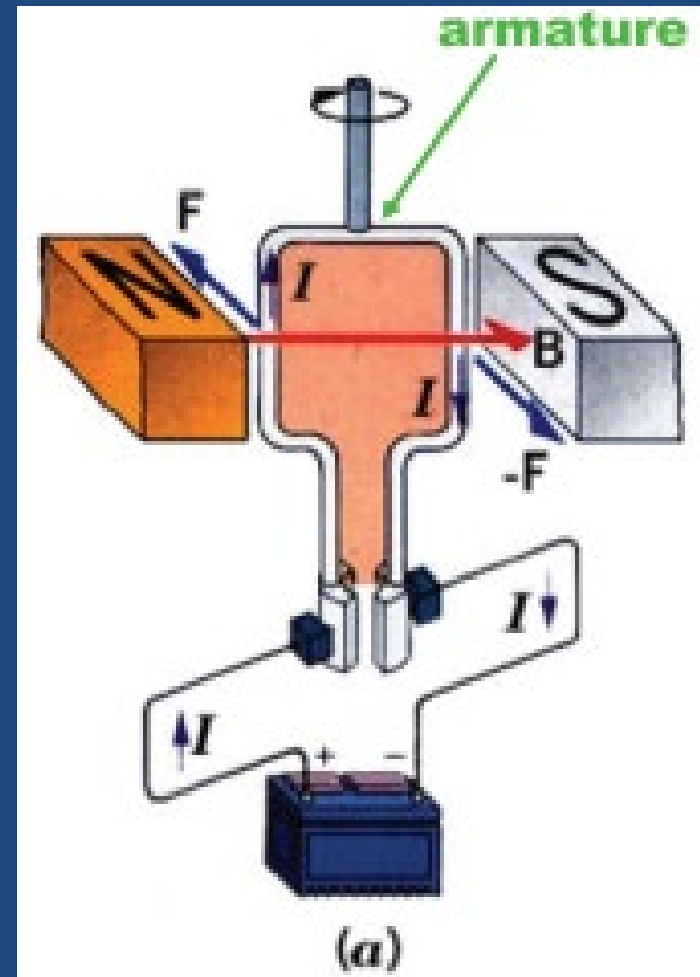
1. The Magnetic Field



- 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**

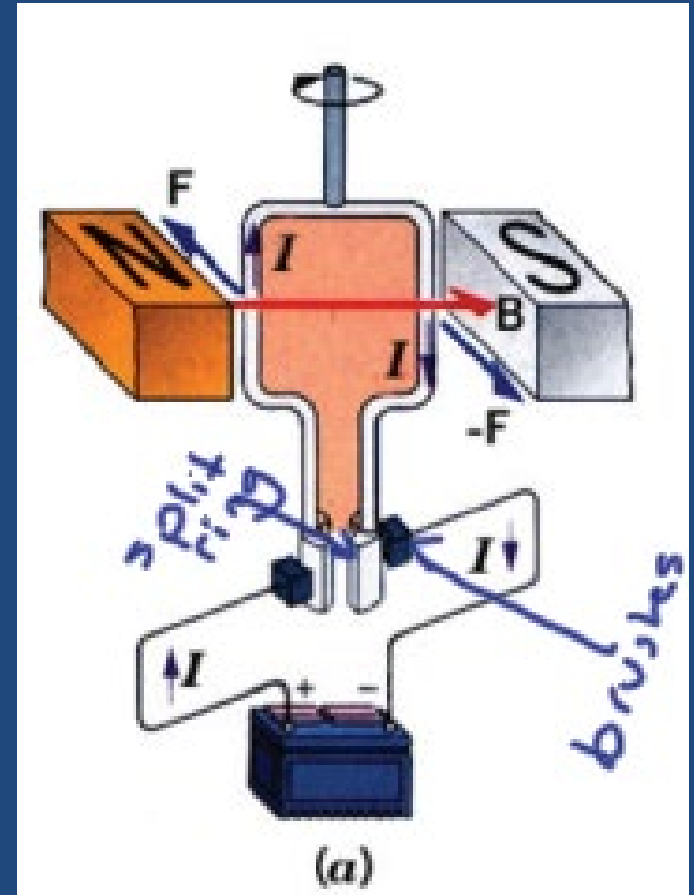
2. The Armature/Rotor

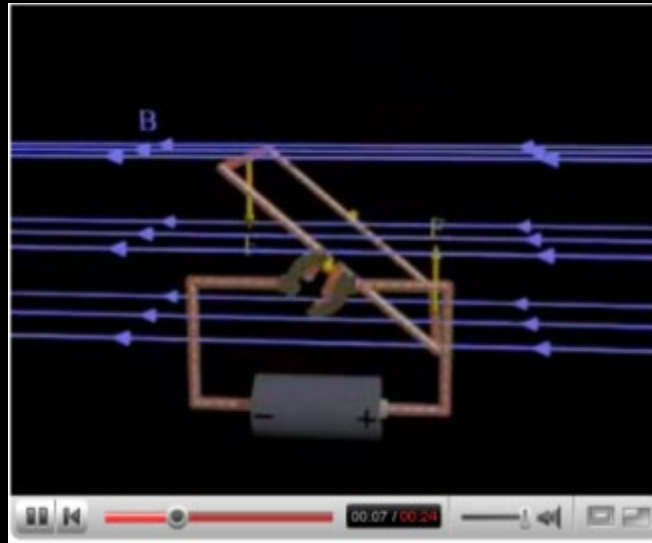
- A loop of current carrying wire
- often more than one loop to increase the overall force
- The direction of the force can be found using the 3rd *HR
- The loop is attached to the payload (what you want to spin...)



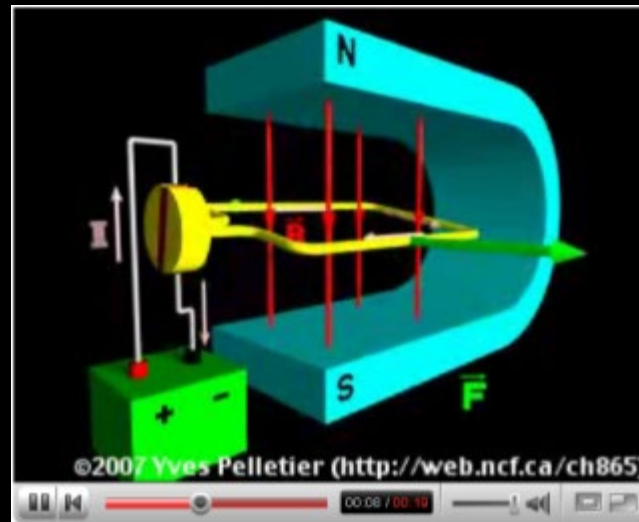
3. Brushes and 4. Split Ring/Commutator

- 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





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



<http://www.youtube.com/watch?v=Xi7o8cMPI0E&NR=1>