Magnetically Levitated Trains

Question:

Suppose you have a long bar magnet with a north pole at one end and a south pole at the other. If you break it in half, will the two new ends:

1. Attract
2. Repel
3. Neither

Observations About Maglev Trains

- Ordinary trains rattle on their rails
- Magnetic suspension would be nice and soft
- Repelling magnets tend to fall off one another
- Attracting magnets tend to leap at each other

Magnetic Poles

- Two types: north & south
- Like poles repel, opposites attract
  - Forces consist of a matched pair
  - Forces increase with decreasing separation
- Analogous to electric charges EXCEPT:
  - No isolated magnetic poles ever found!
  - Net pole on an object is always zero!

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Magnetic Fields

- A magnetic field is a structure in space that pushes on magnetic pole
- The magnitude of the field is proportional to the magnitude of the force on a test pole
- The direction of the field is the direction of the force on a north test pole

Electromagnetism 1

- Electric fields
  - Push only on electric charges
  - Produced by electric charges
  - Can be produced by *changing* magnetism
- Magnetic fields
  - Push only on magnetic poles
  - Produced by magnetic poles
  - Can be produced by *changing* electricity

Electromagnetism 2

- Magnetism created by
  - Poles (but isolated poles don't seem to exist)
  - Moving electric charges
  - Changing electric fields
- Electricity created by
  - Charges
  - Moving magnetic poles
  - Changing magnetic fields

Current

- Current measures the electric charge passing through a region per unit of time
- Current is measured in coulombs/second or amperes (amps)
- Electric fields cause currents to flow
- Currents are magnetic

Equilibrium

- Stable equilibrium
  - Zero net force at equilibrium
  - Accelerates toward equilibrium when disturbed
- Unstable equilibrium
  - Zero net force at equilibrium
  - accelerates away from equilibrium when disturbed
- Neutral equilibrium
  - Zero net force at or near equilibrium

Levitation & Stability

- Unstable Levitation Schemes
  - Static permanent magnets
- Stable Levitation Schemes
  - Permanent magnets and contact
  - Dynamic stabilization with permanent magnets
  - Electromagnets and Feedback

Electromagnetic Induction

- Changing magnetic field → electric field
- Electric field in conductor → current
- Current → magnetic field
- Induced magnetic field opposes the original magnetic field change (Lenz's law)

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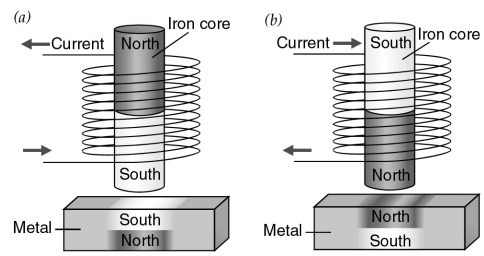
Alternating Current Levitation



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  - Electrodynamic Levitation

Electrodynamic Levitation