EECE 370 Handout 1

Introduction to Machinery Principles – Chapter 1

Electrical devices:

- Electrical machine: generator / motor
- Transformer

The Magnetic Field

Four basic principles describe how magnetic fields are used in electric devices:

1. A current-carrying conductor produces a magnetic field in the area around it.

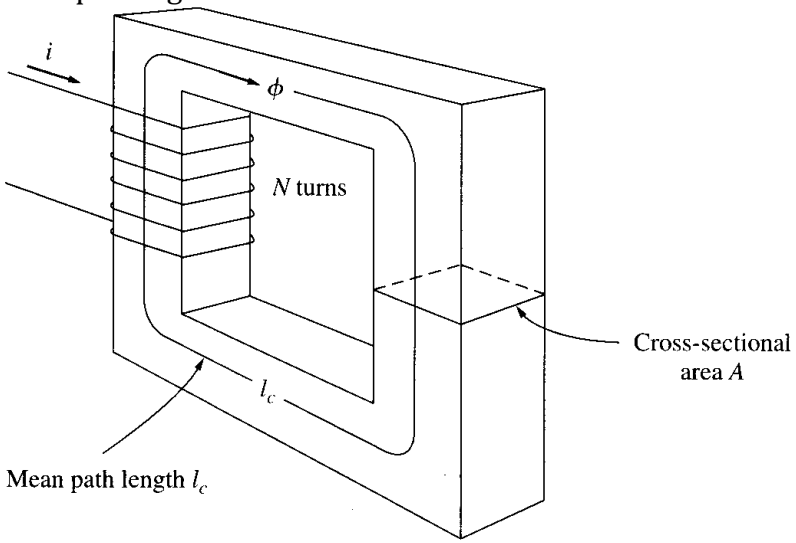
2. A time-changing magnetic field induces a voltage in a coil of wire if it passes through that coil.

3. A current-carrying wire in the presence of a magnetic field has a force induced on it.

4. A moving wire in the presence of a magnetic field has a voltage induced in it.

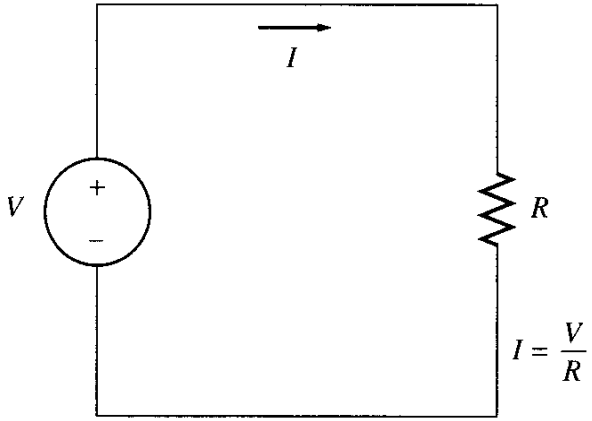
**Production of a Magnetic Field*

A simple magnetic core

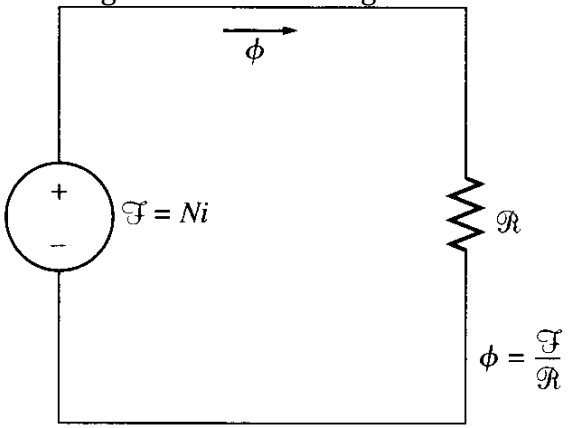


**Magnetic Circuits*

A simple electric circuit



The magnetic circuit analog to a transformer core



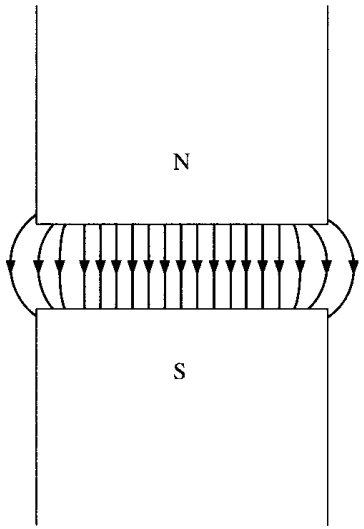
Calculations of the flux in a core performed by using magnetic circuit computations are always approximations because:

1.

2.

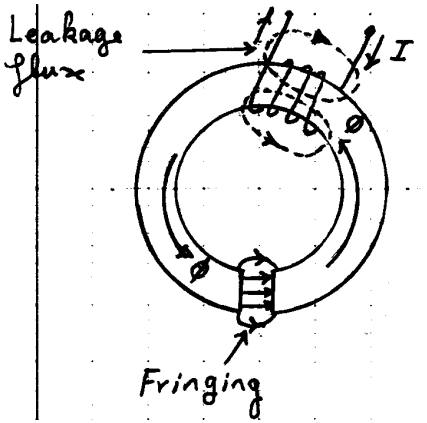
3.

4.



Example:

An electromagnet with square cross-section

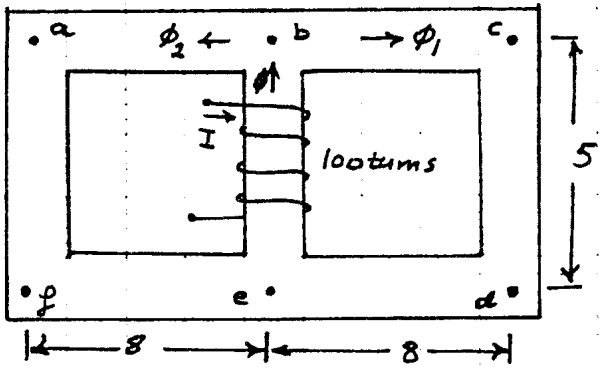


Number of turns = 1500
Inner radius = 10 cm
Outer radius = 12 cm
Air-gap length = 1 cm
I = 4 A
μ_r=1200
Neglect fringing

Determine the flux density in the magnetic circuit.

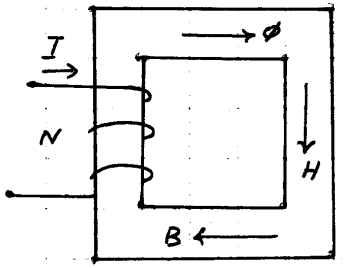
Example:

Dimensions are in cm
Cross-sectional area = 6 cm^2
μ_r=2000

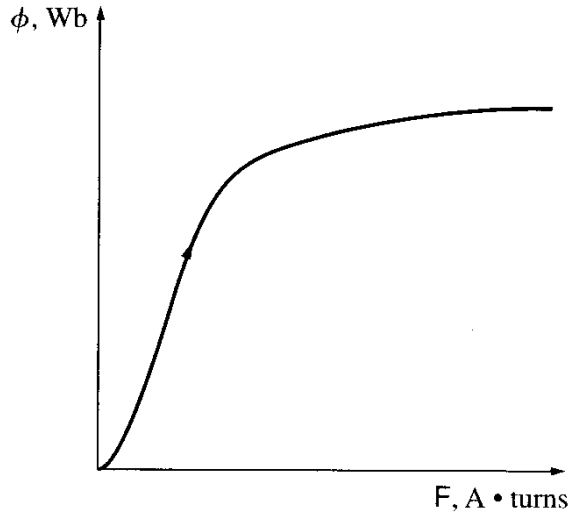


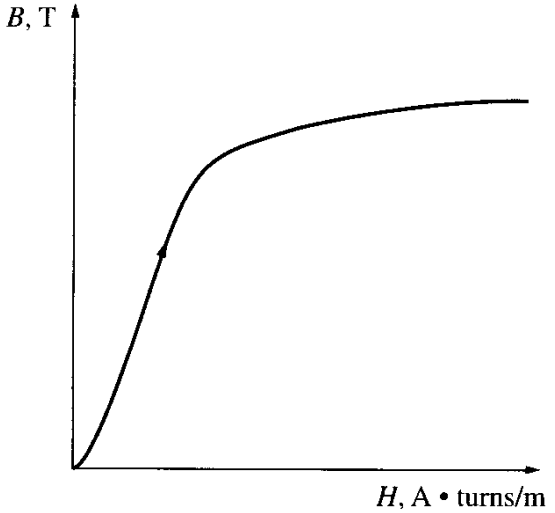
Determine *I* to establish $\phi_1 = 4\times10^{-4}$ Wb.

**Magnetic Behavior of Ferromagnetic Materials*



saturation curve or dc magnetization curve → BH curve

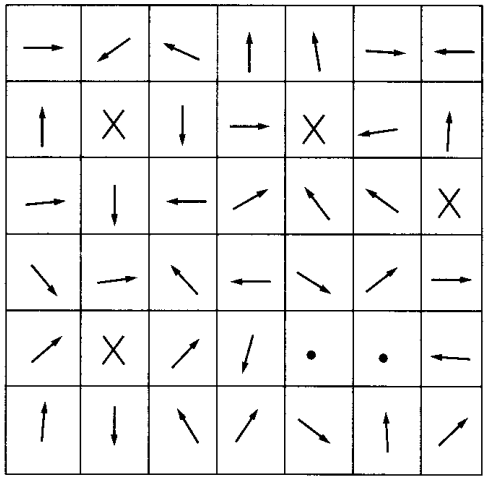




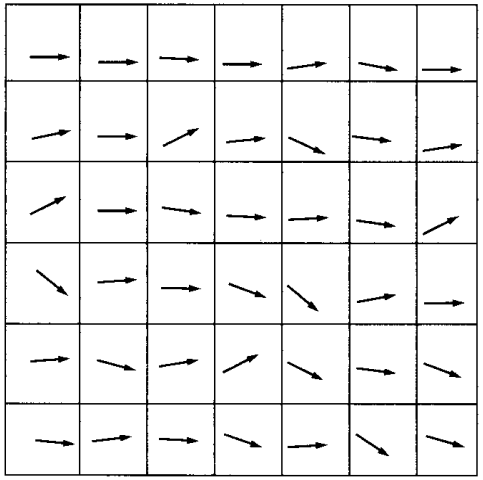
*_Why does ferromagnetic material saturate?_

The behavior of magnetic material can be explained in terms of magnetic domains.

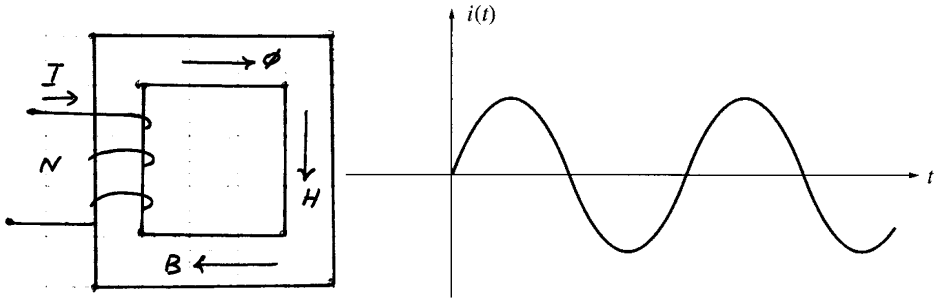
Magnetic domains are randomly oriented



$\vec{H}$-field is applied



**The Hysteresis Loop*



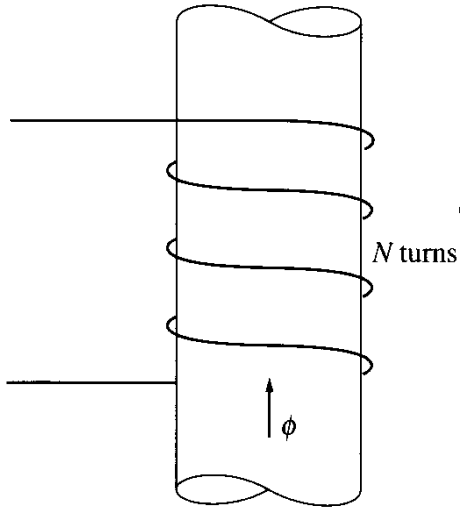
Hysteresis Loss:

Core losses = hysteresis loss + eddy current loss

Faraday's Law – Induced Voltage from a Time-Changing Magnetic Field

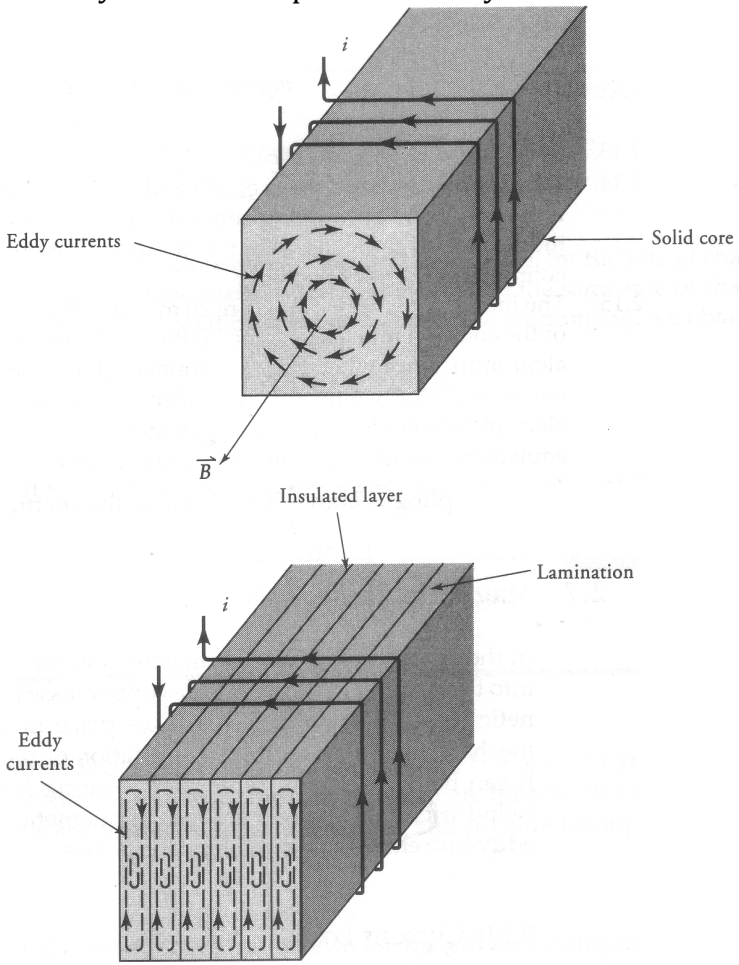
Faraday's Law

Lenz's Law: The direction of the voltage buildup in the coil is such that if the coil ends were short circuited, it would produce current that would cause a flux opposing the original flux change.



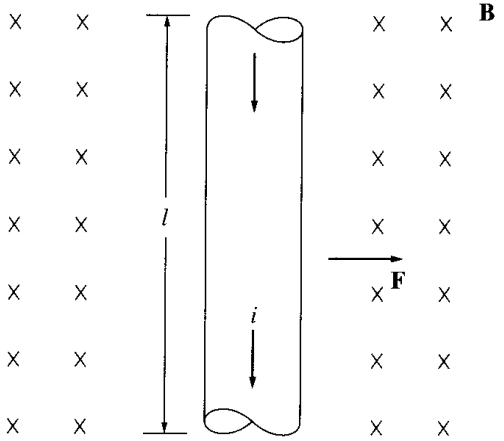
What is the expression of e_{ind} if leakage is high or high accuracy is required?

Faraday's law also explains the eddy current loss



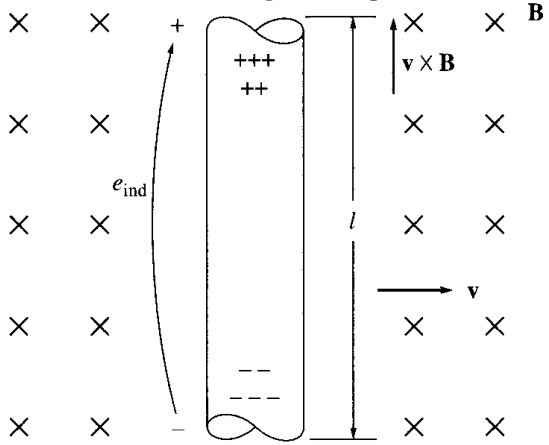
Production of Induced Force on a Wire

A current-carrying wire in the presence of a magnetic field

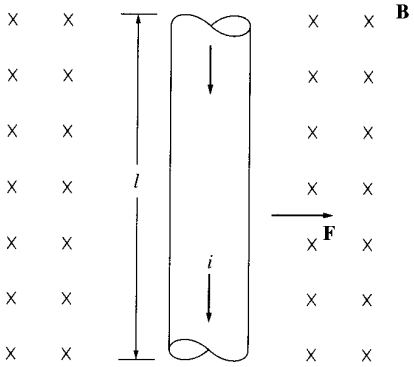


Induced Voltage on a Conductor Moving in a Magnetic Field

A conductor moving in the presence of a magnetic field



Example:
The magnetic flux density is 0.25 T, directed into the page.
The wire is 1 m long and carries 0.5 A of current in the direction from the top of the page to the bottom of the page.
What are the magnitude and direction of the force induced on the wire?



Example:
The conductor is moving with a velocity of 10 m/s to the right in a magnetic field.
The flux density is 0.5 T, out of the page, and the wire is 1 m in length.
What are the magnitude and polarity of the resulting induced voltage?