Topics for Today:

- Announcements
  - Matlab to be incorporated in upcoming Hwks.
  - Office hrs: 1:30-2:30pm Tues; 2:30-3:30pm Thurs
  - Office: EERC 623. Phone: 906.487.2857
  - Recommended problems from Ch.4,5 solutions posted
  - Next: Transmission Line C Parameters, Chapter 6

Chapter 5 - Series Inductance of Transmission Lines

- Self-inductance of a conductor - recap
- Review of mutual inductance concepts - recap
- Mutual inductance between 2 conductors
- Inductance matrix for group of conductors
- Geometric mean "averaging" of effective radius and phase spacing. Single-circuit, double-circuit.
- Use of tables - standard 1-foot phase spacing.
As a simple example, an ideal single-winding magnetic circuit will be used. The magnetic core in this case is assumed to have no magnetic saturation, even at high levels of flux density.

Some of the basic parameters which physically define this circuit are:

- \( A \): Cross-sectional area of core
- \( N \): Number of turns of the winding
- \( \lambda \): Mean (average) path length of core (dashed line)
- \( \mu \): Magnetic permeability of the core. \( \mu \) depends on the type of core material. (\( \mu = \mu_r \mu_0 \))

Some other important magnetic circuit quantities are defined as follows:

- **Reluctance of magnetic core**:
  \[
  R = \frac{l}{\mu A} \, \text{H}^{-1}
  \]

- **Magnetomotive Force**:
  \[
  \text{MMF} = N I \, \text{Amp-Turns}
  \]

- **Magnetic Flux**:
  \[
  \phi = \frac{\text{MMF}}{R} = \frac{N I}{R} \, \text{Webers}
  \]
  (Direction given by "right-hand rule").

- **Magnetic Field Intensity**:
  \[
  H = \frac{\text{MMF}}{\lambda} \, \frac{\text{Amp-Turns}}{m}
  \]

- **Magnetic Flux Density**
  \[
  B = \frac{\phi}{A} \, \text{Webers/m}^2 \quad \text{or Tesla}
  \]

\[\mu = \mu_r \mu_0 \]
\[\mu_0 = 4\pi \times 10^{-7} \, \text{H/m}\]
Flux Linkage
\[ \lambda = N \Phi = NAB \text{ Weber-Turns (or Volt-sec)} \]

Inductance
\[ L = \frac{\lambda}{I} = \frac{N^2}{R} = \frac{N^2 \mu A}{\lambda} \text{ Wb-Turns Amp} \text{ or Henries} \]

Induced Voltage
\[ v(t) = \frac{d\lambda}{dt} = N \frac{d\Phi}{dt} = L \frac{di}{dt} \text{ Volts} \]

Note that in this case, the induced voltage \( v(t) \) is zero, since the current and flux do not change with time.

USE OF VARIOUS UNITS OF MEASUREMENT

Manufacturer's test reports for various magnetic materials may give parameters in several different units of measurement. The following is a clarification of these different units:

Flux Density (B)

Standard Unit: Tesla = Weber/m²
Other Unit: Maxwell's (lines/inch²) = Tesla x 64500
Other Unit: Gauss = Tesla x 10⁴

Field Intensity (H)

Standard Unit: Ampere-Turns/m or Amps/m or Amps/cm
Other Unit: Oersteds = Ampere-Turns/m x 0.01257

* Note that "Turns" is not really a dimensional unit

Magnetomotive Force (MMF)

Standard Unit: Ampere-Turns
Other Unit: Gilberts = Ampere Turns x 0.4π
End view

$A \quad \bar{H}_2$ due to $I_2$, links cond A.

$B \quad \bar{H}_1$ due to $I_1$, links to cond B.
Static Wires (Shield Wires)

EE5220

- Grounded at each structure
- Insulators, grounded periodically
- Segmented ground
Self-Inductance

\[ L = 0.05 \text{ mH/m} \]

Continue w/ posted hand notes on Inductance.