Topics for Today:

• Announcements
  • EE5200-L@mtu.edu is soon up and working. Use it.
  • Web page: http://www.ece.mtu.edu/faculty/bamork/ee5200/
  • Bring calculator to lectures, for in-class sample calculations.
  • Buy a 3-ring binder for course materials, print 2/page 2-sided.
  • Office hrs: initially set for M,W,F 2-3pm Eastern Time
  • Office: EERC 614. Phone: 906.487.2857
  • Ch.1 Solutions posted on web page, finish review Sept. 13th.
  • First set of graded exercises is posted, due Mon Sept 11th.
  • Ch.2 material - aggressively review it, Ch.2 solutions posted.

• Coverage for Review:
  • Chapter 2 problems (phasors, 3 phase analysis)
  • Click on Pre-Req Mat’ls - Euler’s Identity, EE3120 Review
  • Matlab quickstart tutorial, will be using Matlab starting Week 3.
  • Plan on initiating a survey to get a handle on your skill levels.
Prerequisite Material, Useful References (see course web page)

- Euler's Identity - The foundation of phasor analysis, as well as hyperbolic functions (used for long transmission lines)
- Basic Circuit Analysis, Thevenizing, Phasor Analysis, Impedance, P,Q,S, etc.: EE3120 pre-req practice problems | Solutions
- Basic 3-Phase Phasor Analysis - Review problem from EE3120
- Magnetic Circuits - quick review and introduction of how a transformer works
- Mutual Inductance - concept handout from EE3120 (refer to Section 2.2 of your text)
- Transformers 101 - Everything you wanted (or suddenly need to know) about transformers but were afraid to ask...
- Delta-Wye Transformer - detailed example with solution from EE3120
- EE 4221 Pre-Req Course Description
- EE 4222 Pre-Req Course Description
- Pre-Req Review Videos with Notes (from 2003 Archives)
  - Basic Circuit Analysis, Phasors, Three Phase Phasors: Lect 1 (skip first 12 mins) | Lect 1 Notes
  - Phasor Diagrams, Ideal Transformers, Nodal Analysis: Lect 2 (skip first 6:20) | Lect 2 Notes
  - Nodal Analysis, 3-phase circuits, Deltas and Wyes, Per Unit System: Lect 3 (skip first 3 mins) | Lect 3 Notes
  - Active & Passive Sign Convention for power flow, Per Unit, Transformers, Symmetrical Components: Lect 4 (skip first 2 mins) | Lect 4 Notes
  - Transformers, Induced Voltage & Polarity Marks, Phase Shift: Lect 5 (skip 3:45 - 5:20) | Lect 5 Notes
  - Phase Shift in Transformers, Phasor Diagrams, Application of Symmetrical Components: Lect 6 (skip first 3 mins) | Lect 6 Notes
  - Sample .m files from above tutorials: | for_ex.m | r2p.m | for_if_ex.m | while_ex.m | ft.m |
- Symmetrical Components - the basics.
Transformers -

\[ P_{\text{loss}} \propto i^2 R_{\text{line}} \]

\[ Z_c = 300 \Omega \]

\[ \frac{n^2}{1} = \frac{50}{300} = \frac{1}{6} \]

\[ n^2 = \frac{1}{6} \implies n = \frac{1}{\sqrt{6}} \]
Non-Ideal

- Flux Leakage
- Winding Resistance
- Magnetic Saturation
- Core Losses (Eddy Currents, Hysteresis)
\[ R = \frac{x}{mAC} \]

Laminations:

\[ P_E = \frac{1}{2} \]

\[ 4\pi \times 10^7 \]

\[ \mu = \mu_r \mu_0 \]

\[ R_1 \quad L_1 \]

\[ R_2 \quad L_2 \]

\[ R_c \quad \sqrt{L_M} \]
Lenz's Law

- Induced voltage causes a current, if coil is shorted, that produces a flux which cancels the \( \frac{d\phi}{dt} \) that induced the voltage in first place.
\[ e_{\text{ind}} = N \frac{d\phi}{dt} = -\frac{dt}{dt} \]

Faraday

Lenz
Mutual Inductance

\[ L_{12} = \frac{N_2 \Phi_{12}}{i_2} = \frac{N_2}{i_2} \]

Self-Inductance

\[ L_{11} = \frac{N_1 \Phi_{11}}{i_1} = \frac{N_1}{i_1} \]

Fundamental definition of inductance: \( L = \frac{\Phi}{i} \)

Mutual Inductance

\[ L_{22} = \frac{N_2 \Phi_{22}}{i_2} = \frac{N_2}{i_2} \]

Self-Inductance

\[ L_{21} = \frac{N_2 \Phi_{21}}{i_1} = \frac{N_2}{i_1} \]

Section 4.4 in text, pp. 73-77. See also handout on Basic Magnetic Circuits.
Some thing.

\[ M_{12} \text{ and } M_{21}. \]

Mutual inducances, they are called.

In some texts, since \( L_{21} \text{ and } L_{22} \) are.

Also of note:

\[ \begin{bmatrix} I_1^2 \\ I_2 \end{bmatrix} \begin{bmatrix} \sqrt{M_{12}^2 + M_{22}^2} & \sqrt{M_{12} M_{22}} \\ -\sqrt{M_{12} M_{22}} & \sqrt{M_{12}^2 + M_{22}^2} \end{bmatrix} = \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} \]

**In phasor domain:**

\[ \begin{bmatrix} V_1^2 \\ V_2 \end{bmatrix} = \begin{bmatrix} V_{12} L_{22} + L_{11} V_{21} \\ L_{12} V_{11} + V_{22} L_{21} \end{bmatrix} \]

**In time domain:**

Note: Reference of voltage at (+) side into terminals is current direction of device.

How to use the concept of mutual inductance.
Shell-form

core form.
Next: Ampere's Law

\[ NI = \Phi R \]

**Electrical** / **Magnetic**

**MMF**
a)

b)

Pri  Sec
Ampere's Law

\[ NI = \Phi \]

\[ \vec{H} = \frac{I_{\text{ENCLOSED}}}{2\pi r} \]

\[ I_{\text{ENCLOSED}} = \int \vec{H} \cdot d\ell \]

Clamp-on ammeter or current probe.