ECE430
Exam #1
Fall 2005

Name Solution
(Print Name)

Section: **(Circle One)** **10 MWF** **2:00 MWF**

Problem 1 ______ **Problem 2** ______ **Problem 3** ______ **Problem 4** ______

TOTAL: ______

USEFUL INFORMATION

$\sin x = \cos(x - 90°)$ $\quad \bar{Z}_Y = \frac{1}{3}\bar{Z}_\Delta$ $\quad \bar{S}_{3\phi} = \sqrt{3} V_L I_L \angle\theta$

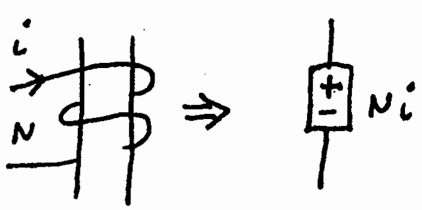
$\bar{V} = \bar{Z}\bar{I}$ $\quad \bar{S} = \bar{V}\bar{I}^*$ $\quad 1HP = 746W$ $\quad 0 \le \theta \le 180°$ Lag

$-180° \le \theta \le 0$ Lead

$\oint_C \underline{H} \cdot d\underline{l} = \int_S \underline{J} \cdot \underline{n}\, da$ $\quad \oint_C \underline{E} \cdot d\underline{l} = -\frac{d}{dt}\int_S \underline{B} \cdot \underline{n}\, da$ $\quad I_L = \sqrt{3} I_\phi$ (delta)

$\oint_S \underline{B} \cdot \underline{n}\, da = 0$ $\quad \mathcal{R} = \frac{l}{\mu A}$ $\quad mmf = Ni = \phi\mathcal{R}$

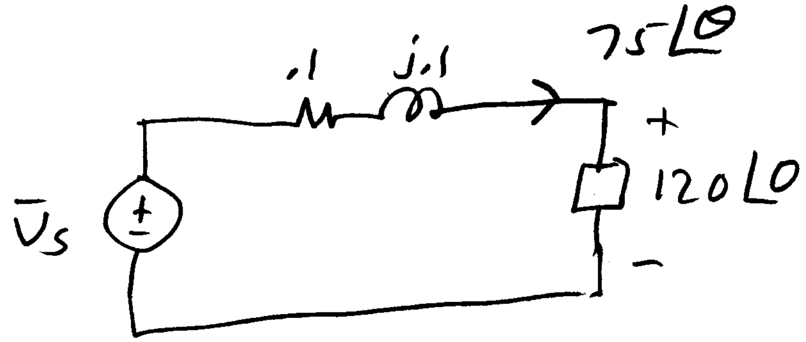
$\lambda = N\phi = Li$ $\quad \mu_0 = 4\pi \times 10^{-7}$ H/m $\quad k = \frac{M}{\sqrt{L_1 L_2}}$



$\phi = BA$

Problem 1 (25 pts.)

A single-phase source is supplying passive loads through a 0.1 + j 0.1 Ohm feeder (a feeder is another name for a line). The feeder current is 75 Amps (RMS). What is the range of source voltages that you need to keep 120 Volts (RMS) at the load for all possible load power factors?



pf angle = −θ

$$\bar{V}_s = (.1 + j.1)\,75\angle\theta + 120\angle 0 = 120 + 10.6\angle\theta + 45^\circ$$

θ can vary between −90° and +90°

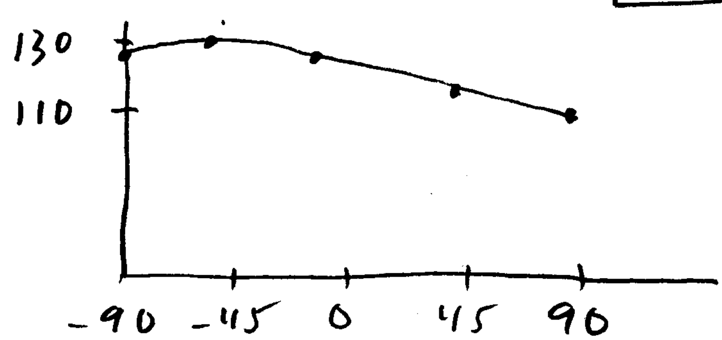
$\theta = -90^\circ$ $|\bar{V}_s| = |120 + 10.6\angle -45^\circ| = 128\,V$

$\theta = -45^\circ$ $|\bar{V}_s| = |120 + 10.6| =$ **131 V (This is max)**

$\theta = 0$ $|\bar{V}_s| = |120 + 10.6\angle 45| = 128\,V$

$\theta = 45^\circ$ $|\bar{V}_s| = |120 + 10.6\angle 90^\circ| = 121\,V$

$\theta = 90^\circ$ $|\bar{V}_s| = |120 + 10.6\angle 135^\circ| =$ **113 V (This is min)**



Problem 2 (25 pts)

Three loads are connected in parallel across a 60Hz, 3-phase source at 208 Volts (line-line).

Load #1: Delta-connected load with 12 Amps phase current at 0.9 power factor lag
Load #2: Wye-connected load with 20 Ohms per phase pure resistance
Load #3: Delta-connected load with 3,000 Watts plus 1,500 Vars of power (3-phase)

a) Find the total complex power consumed by these three loads.
b) Find the source current magnitude
c) Find the value of capacitive VARS (3-phase) that should be added in parallel to these three loads to make the overall power factor 0.95 lag.

a) $\bar{S} = 3 \times 12 \times 208 \angle +\cos^{-1} 0.9 + 3 \times \frac{(208/\sqrt{3})^2}{20} + 3000 + j\,1500$

$= 11,892 + j\,4,764$ VA

b) $|\bar{S}| = \sqrt{11,892^2 + 4,764^2} = 12,811 = \sqrt{3} \times 208 \times I_L$

$I_L = 36\text{ A}$

c) $\bar{S}_{new} = \frac{11892}{.95} \angle +\cos^{-1} 0.95 = 11892 + j\,3909$

$3909 = 4764 + Q_{cap}$

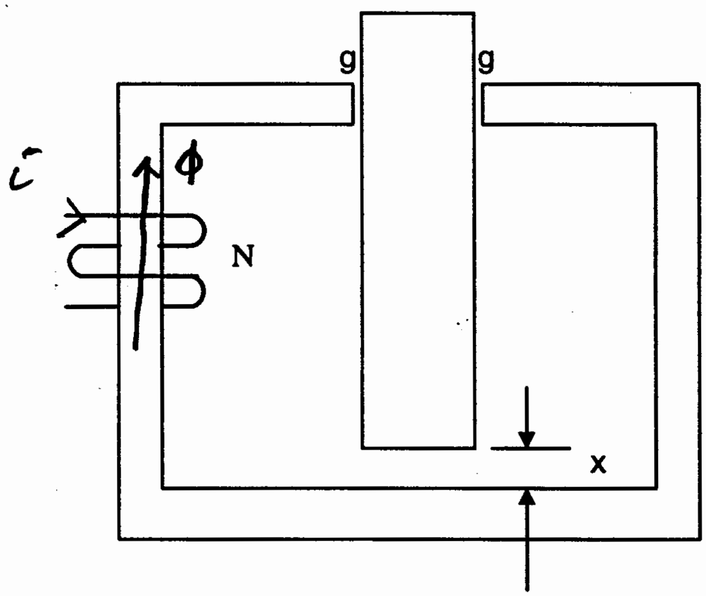
$Q_{cap} = -855$ VARS

OR

855 VARS of capacitance

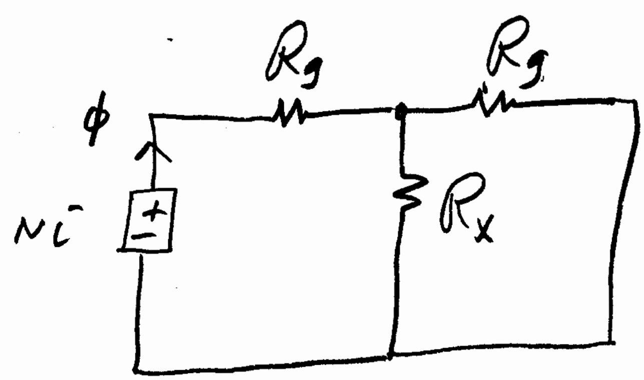
Problem 3 (25 pts)

For the electromagnetic circuit shown below, find an expression for the inductance of the coil in terms of the cross-sectional area of the external iron path (A_g), the cross sectional area of the center piece (A_x), the gap length, the permeability of free space (in the two gaps, and in the space denoted by the distance x), the number of turns N, and the distance x shown in the figure. Neglect the reluctance of the iron and neglect fringing.



$$\mathcal{R}_g = \frac{g}{\mu_0 A_g}$$

$$\mathcal{R}_x = \frac{x}{\mu_0 A_x}$$



$$Ni = \phi\left(\mathcal{R}_g + \frac{\mathcal{R}_g \mathcal{R}_x}{\mathcal{R}_g + \mathcal{R}_x}\right)$$

$$\phi = \frac{Ni}{\mathcal{R}_g + \frac{\mathcal{R}_g \mathcal{R}_x}{\mathcal{R}_g + \mathcal{R}_x}}$$

$$\lambda = \left(\frac{N^2}{\mathcal{R}_g + \frac{\mathcal{R}_g \mathcal{R}_x}{\mathcal{R}_g + \mathcal{R}_x}}\right) i$$

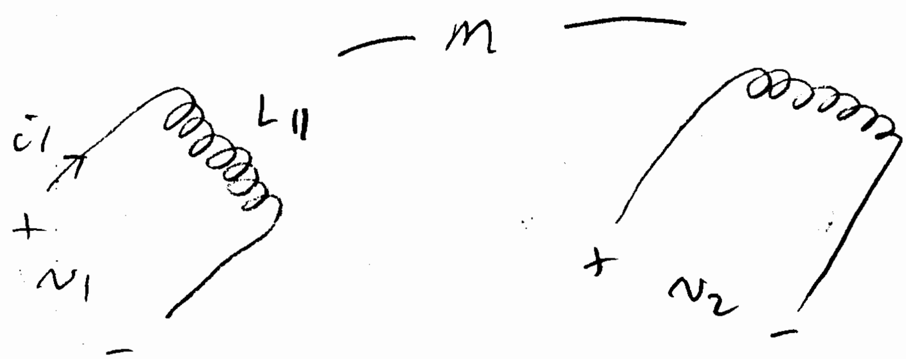
$$= L$$

Problem 4 (25 pts)

Two coils (each with zero resistance) are located near each other. Coil #2 is open circuited. When a 60Hz sinusoidal voltage of 120 Volts (RMS) is applied to coil #1, the coil #1 current is 5 Amps (RMS) and the voltage measured on the open-circuited coil #2 is 70 Volts (RMS).

a) What is the self inductance of coil #1?

b) What is the magnitude of the mutual inductance between coil #1 and coil #2?



a) $v_1 = 120\sqrt{2}\cos(2\pi 60 t) = L_{11}\frac{di_1}{dT} + 0$

$i_1 = \left(\frac{120\sqrt{2}}{L_{11} 2\pi 60}\right)\sin 2\pi 60 t$

$\frac{120\sqrt{2}}{L_{11} 2\pi 60} = 5\sqrt{2}$

$\frac{120}{L_{11} 2\pi 60} = 5$

$L_{11} = 0.064\ H$

b) $v_2 = L_{21}\frac{di_1}{dt} + 0 = \left(L_{21}\frac{120\sqrt{2}}{0.064}\right)\cos(2\pi 60 t)$

$L_{21}\frac{120\sqrt{2}}{0.064} = 70\sqrt{2}$

$\frac{120 L_{21}}{0.064} = 70$

$L_{21} = 0.037$