ECE430
Exam #1
Fall 2006

Name Nick
(Print Name)

Section: (Circle One) 2 MWF 3 MWF

Problem 1 _______ **Problem 2** _______ **Problem 3** _______

TOTAL: _______

USEFUL INFORMATION

$\sin(x) = \cos(x - 90^\circ)$ $\overline{V} = \overline{ZI}$ $\overline{S} = \overline{VI}^*$ $\overline{S}_{3\phi} = \sqrt{3} V_L I_L \angle \theta$

$0 < \theta < 180^\circ$ (lag)
$-180^\circ < \theta < 0$ (lead)

$I_L = \sqrt{3} I_\phi$ (delta)
$V_L = \sqrt{3} V_\phi$ (wye)

1 hp = 746 W

$$\int_C \mathbf{H} \cdot \mathbf{dl} = \int_S \mathbf{J} \cdot \mathbf{n} da$$

$$\int_C \mathbf{E} \cdot \mathbf{dl} = -\frac{\partial}{\partial t} \int_S \mathbf{B} \cdot \mathbf{n} da$$

$\Re = \dfrac{l}{\mu A}$ $\mu_0 = 4\pi \cdot 10^{-7}$ H/m $MMF = Ni = \phi \Re$

$\lambda = Li = N\phi$ $\phi = BA$ $k = \dfrac{M}{\sqrt{L_1 L_2}}$

Problem 1 (30 pts.)

A single-phase, 60 Hz, sinusoidal source is supplying two loads at 120Volts (RMS). When load number one is connected all by itself, the source current is 5 Amps (RMS) and the load consumes 550 Watts. When load number 2 is connected all by itself, the source current is 7 Amps (RMS) and the load consumes 750 Watts. Find two different possible values of the source line current when both loads are connected at the same time.

$$|S_1| = 120(5) = 600$$

$$P_1 = 550\,W \rightarrow Q_1 = \pm\sqrt{600^2 - 550^2} = \pm 239.8\,VAR$$

$$|S_2| = 120(7) = 840$$

$$P_2 = 750 \qquad Q_2 = \pm\sqrt{840^2 - 750^2} = \pm 378\,VAR$$

4 possible loads

2 possible current magnitudes

Both negative

$$S_T = 1300 - j618 \qquad |S_T| = 1439\,VA$$

$$\boxed{|I| = 12A}$$

Q_1 neg $\quad Q_2$ pos

$$S_T = 1300 + j138 \qquad |S_T| = 1307\,VA$$

$$\boxed{|I| = 10.9A}$$

Problem 2 (30 pts)

A balanced 3-phase, 208 Volt (line-line), Wye-connected source serves a balanced, 3-phase, Wye-connected, passive load. A variable 3-phase capacitor bank is connected across the load in a Delta configuration. Measurements of the source line current for various values of capacitor Vars (3-phase) give:

Capacitor Vars (3-phase):	0	200	400	600	800	1,000	1,200	1,400
Source line current:	3.75	3.43	3.17	3.00	2.92	2.95	3.07	3.29

(a) By just looking at the numbers in the table above, about how many Vars (3-phase) would you say the original load (without the capacitors) consumes?

Note: $|I| = \frac{|S|}{V} = \frac{\sqrt{P^2+Q^2}}{V}$

Put answer here: ≈ 800 Vars

P constant → Min I occurs when $Q \approx 0$

(b) Approximately how many Watts (3-phase) would you say the original load (without the capacitors) consumes?

$$P \approx 3 \cdot \left(\frac{208}{\sqrt{3}}\right)(2.92) \approx 1052 \text{ W}$$

(c) What is the exact value of the original load P + jQ (without the capacitors)?

$$|S_1| = 3.75 \cdot 3 \frac{208}{\sqrt{3}} = 1351$$

$$|S_2| = 3.43 \cdot \sqrt{3}\, 208 = 1236$$

$$|S_1|^2 - |S_2|^2 = P^2 + Q_1^2 - P^2 - Q_2^2$$

$$Q_2 = Q_1 - 200$$

$$|S_1|^2 - |S_2|^2 = Q_1^2 - (Q_1 - 200)^2 = Q_1^2 - Q_1^2 + 400Q_1 - 40000$$

$$297505 = 400Q_1 - 40000$$

$$\boxed{Q_1 = +844 \text{ VAR}}$$

$$P_1 = \sqrt{S_1^2 - Q_1^2} \longrightarrow P_1 = 1055 \text{ W}$$

$$\boxed{S_1 = 1055 + j844 \text{ VA}}$$

Problem 3 (40 points)

5 cm depth

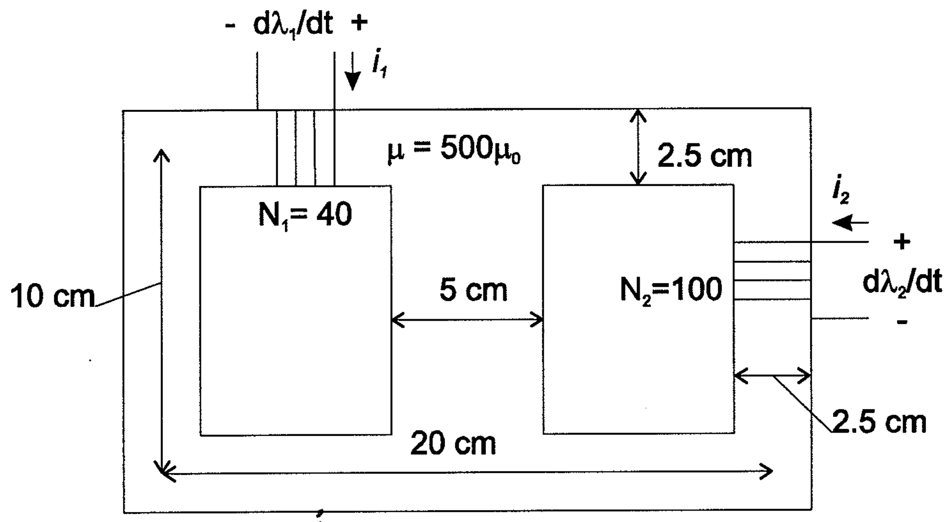
Given the magnetic device below, considering uniform flux in the iron only, calculate

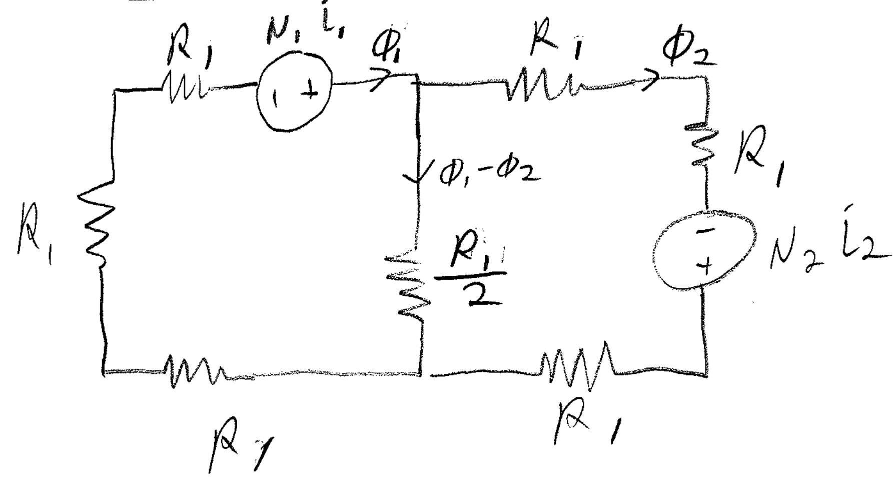
(1) The absolute value of the mutual inductance relating the current in coil #2 to the flux linkage in coil #1.

$M = 0.0013\ H$

(2) The flux linkage in coil #1 if the currents are $i_1 = 5$ A and $i_2 = -3$ A.

$\lambda_1 = 0.0144$ wb tn





$$R_1 = \frac{0.1\ m}{500\mu_0 (0.025)(0.05)} = 127\times10^3\ \frac{AT}{Wb}$$

$$N_1 i_1 = \frac{R_1}{2}(\Phi_1 - \Phi_2) + 3\Phi_1 R_1 \rightarrow \Phi_2 = \frac{2}{R_1}\left(\frac{7}{2}R_1\Phi_1 - N_1 i_1\right)$$

$$N_2 i_2 = \frac{R_1}{2}(\Phi_2 - \Phi_1) + 3\Phi_2 R_1 \rightarrow \Phi_1 = \frac{2}{R_1}\left(\frac{7}{2}R_1\Phi_2 - N_2 i_2\right)$$

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$$\Phi_1 = \frac{2}{R_1}\left(\frac{7}{2}R_1\left(\frac{2}{R_1}\left(\frac{7}{2}R_1\Phi_1 - N_1 i_1\right)\right) - N_2 i_2\right)$$

$$\Phi_1 = \frac{2}{R_1}\frac{7}{2}R_1\frac{2}{R_1}\frac{7}{2}R_1\Phi_1 - \frac{2}{R_1}\frac{7}{2}R_1\frac{2}{R_1}N_1 i_1 - \frac{2}{R_1}N_2 i_2$$

$$\Phi_1 = 49\Phi_1 - \frac{14}{R_1}N_1 i_1 - \frac{2}{R_1}N_2 i_2$$

$$48\Phi_1 = \frac{14}{R_1}N_1 i_1 + \frac{2}{R_1}N_2 i_2$$

$$\Phi_1 = \frac{14}{48R_1}N_1 i_1 + \frac{2}{48R_1}N_2 i_2$$

$$\lambda_1 = N_1\Phi_1 = \underbrace{\frac{14}{48R_1}N_1^2}_{L_1} i_1 + \underbrace{\frac{2}{48R_1}N_1 N_2}_{M} i_2$$

$$\boxed{M = 0.00131\ H} \qquad L_1 = 0.00367\ H$$

$$\lambda_1 = L_1 i_1 + M i_2$$

$$\lambda_1 = 0.00367(5) + 0.00131(-3) = \boxed{0.144\ \text{Wb Tn}}$$