ECE 430 Exam #1, Fall 2008   Name: Solution
90 Minutes

Section (Check One)   MWF _______   TTH _______

1. ________ / 25   2. ________ / 25

3. ________ / 25   4. ________ / 25   Total ________ / 100

Useful information

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

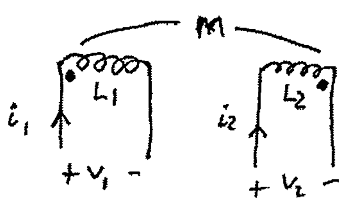
$0 < \theta < 180^\circ$ (lag)
$-180^\circ < \theta < 0$ (lead)

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

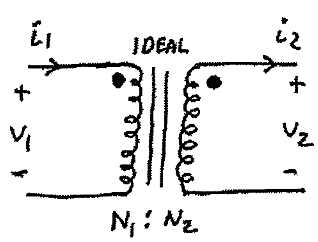
$\bar{Z}_Y = \bar{Z}_\Delta / 3$ $\mu_0 = 4\pi \cdot 10^{-7}$ H/m

$\int_C \mathbf{H} \cdot \mathbf{dl} = \int_S \mathbf{J} \cdot \mathbf{n} da$ $\int_C \mathbf{E} \cdot \mathbf{dl} = -\frac{\partial}{\partial t} \int_S \mathbf{B} \cdot \mathbf{n} da$ $\Re = \frac{l}{\mu A}$ $MMF = Ni = \phi\Re$

$\phi = BA$ $\lambda = Li = N\phi$ $k = \frac{M}{\sqrt{L_1 L_2}}$ 1 hp = 746 Watts



$v_1 = L_1 \frac{di_1}{dt} - M \frac{di_2}{dt}$



$a = \frac{N_1}{N_2}$ $N_1 i_1 = N_2 i_2$

$\frac{V_1}{V_2} = \frac{N_1}{N_2}$

1. (25 points)

A single-phase residential electric service has two lines plus one neutral (single phase, 3 wire).

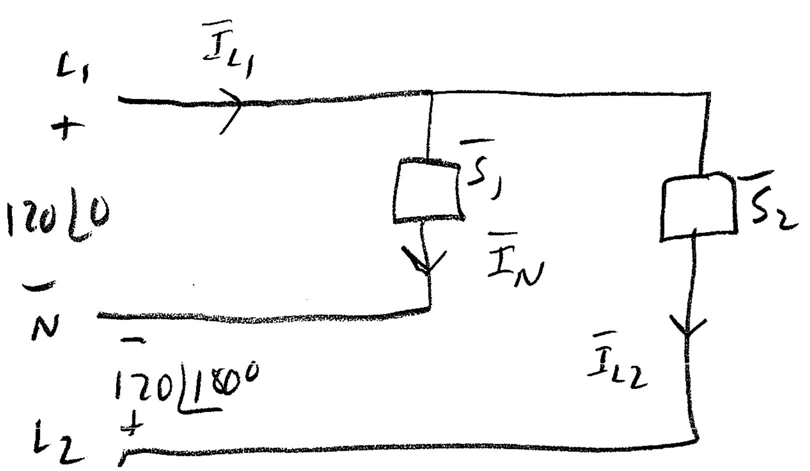
The voltage from line 1 to neutral is 120 volts angle zero.

The voltage from line 2 to neutral is 120 volts angle 180 degrees.

The voltage from line 1 to line 2 is 240 volts angle zero.

One load is connected between line 1 and neutral and draws 10 Amps at 0.9 power factor lag. A second load is connected between line 1 and line 2 and draws 15 Amps at 0.85 power factor lag.

a) Find the magnitude of the current in the line 1 conductor (call this I_{L1})
b) Find the magnitude of the current in the line 2 conductor (call this I_{L2})
c) Find the magnitude of the current in the neutral conductor (call this I_N)
d) Find the total real power consumed by both of the loads



$\bar{I}_1 = 10\angle -25.8^\circ$

$\bar{I}_{L2} = 15\angle -31.8^\circ$

$\bar{I}_{L1} = 9 - j4.35$
$+12.7 - j7.9$

$= 21.7 - j12.3$

$= 24.9\angle -29.5^\circ$

a) 24.9 A.

b) 15 A

c) 10 A

d) 4140 W

$P = 120 \times 10 \cos 25.8^\circ$
$+ 240 \times 15 \cos 31.8^\circ$

$= 4140\,W$

V_{LN} V_{LL}

volts

2. **(25 points)**

A 120/208, 3-phase, 4 wire, wye-connected, ABC sequence, 60 HZ source supplies the following 2 loads:

Load #1 10 Amps (line current) 3200 Watts (3-phase), wye-connected, lagging power factor
Load #2 8 Amps (phase current) 0.9 power factor lag, delta connected

a) What is the total line current being supplied by the source?
b) How many capacitive VARS 3-phase need to be supplied at the load to reduce the total source line current to 22 Amps?

$$|\bar{S}_1| = \sqrt{3} \times 208 \times 10 = 3603$$

$$P_1 = 3200 \text{ W}$$

$$Q_1 = +\sqrt{3603^2 - 3200^2}$$

$$= 1656 \text{ vars}$$

$$\bar{S}_2 = 3 \times 208 \times 8 \angle 25.8^\circ$$

$$= 4494 + j2173$$

$$\bar{S}_{TOT} = 7694 + j3829$$

$$= 8594 \angle 26.5^\circ$$

$$\sqrt{3} \times 208 \times I_L = 8594$$

$$I_L = 23.9\text{A}$$

$$\bar{S}_{new} = \sqrt{3} \times 208 \times 22 \angle \theta \overset{\text{must}}{=} 7694 + jQ_{new}$$

$$\sqrt{3} \times 208 \times 22 \cos\theta = 7694 \qquad \theta = 13.9^\circ$$

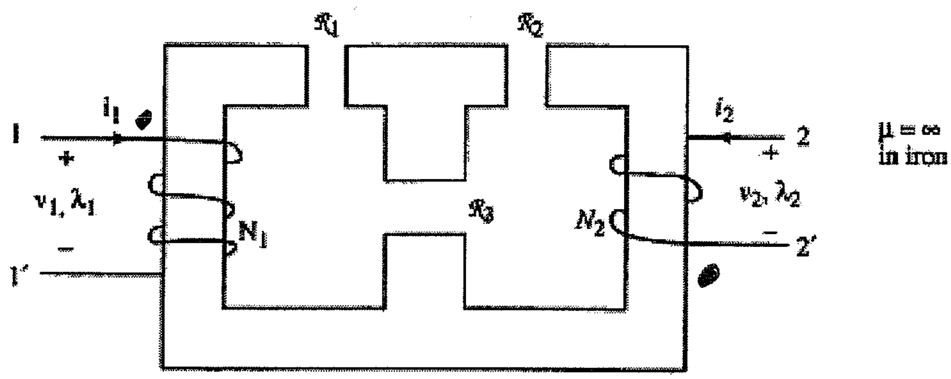
$$Q_{new} = \sqrt{3} \times 208 \times 22 \sin\theta = 1904$$

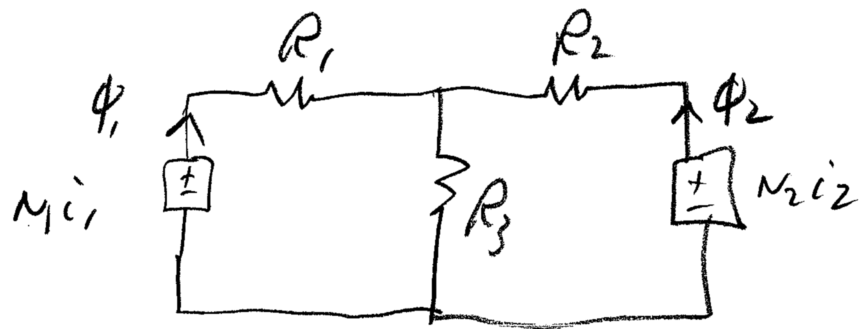
$$Q_{add} = -1925 \text{ vars}$$

3. (25 points)

Two coils are coupled through the iron of the magnetic circuit shown below.

a) Place the dots on the appropriate terminals of the two coils
b) Write all of the equations that you would need to find the two flux linkages in terms of the two currents (do not solve).





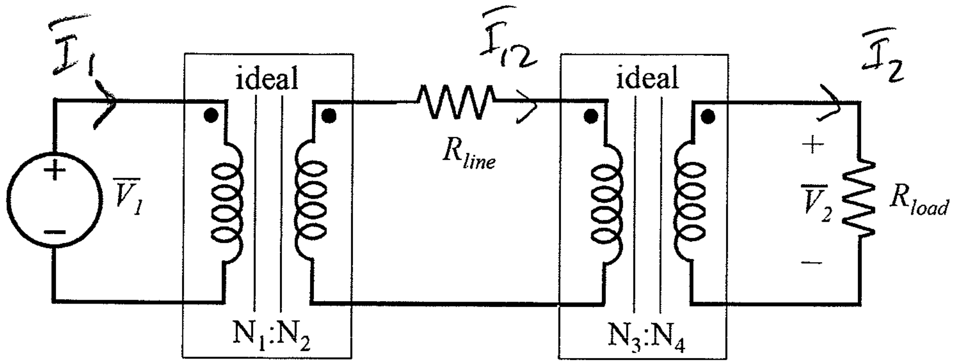
$\lambda_1 = N_1 \phi_1$

$\lambda_2 = N_2 \phi_2$

$$-N_1 i_1 + R_1 \phi_1 + R_3 (\phi_1 + \phi_2) = 0$$

$$-N_2 i_2 + R_2 \phi_2 + R_3 (\phi_1 + \phi_2) = 0$$

4. (25 points)



$$\frac{N_1}{N_2} = a \qquad \frac{N_3}{N_4} = b$$

For the circuit shown above:

a) Find the equivalent resistance as seen by the source $\overline{V_1}$

b) Find the voltage $\overline{V_2}$ as a function of $\overline{V_1}$

a) $a^2(R_{line} + b^2 R_{load})$

b) $\bar{I}_1 = \dfrac{\bar{V}_1}{a^2(R_{line} + b^2 R_{load})}$ $\qquad N_1 \bar{I}_1 = N_2 \bar{I}_{12}$

$\bar{I}_{12} = \dfrac{\cancel{a}\,\bar{V}_1}{a^{\cancel{2}}(R_{line} + b^2 R_{load})}$ $\qquad N_3 \bar{I}_{12} = N_4 \bar{I}_2$

$\bar{I}_2 = \dfrac{b\bar{V}_1}{a(R_{line} + b^2 R_{load})}$

$$\bar{V}_2 = \frac{b\bar{V}_1 R_{load}}{a(R_{line} + b^2 R_{load})}$$