

Section (Check One) MWF 10am _____ TR 12:30pm _____

1. _____ / 25 2. _____ / 25

3. _____ / 25 4. _____ / 25 Total _____ / 100

Useful information

$$\sin(x) = \cos(x - 90^\circ)$$

$$\bar{V} = \bar{ZI}$$

$$\bar{S} = \bar{VI}^*$$

$$\bar{S}_{3\phi} = \sqrt{3}V_L I_L \angle \theta$$

$$0 < \theta < 180^\circ \text{ (lag)}$$

$$I_L = \sqrt{3}I_\phi \text{ (delta)}$$

$$\bar{Z}_Y = \bar{Z}_\Delta / 3$$

$$\mu_0 = 4\pi \cdot 10^{-7} \text{ H/m}$$

$$-180^\circ < \theta < 0 \text{ (lead)}$$

$$V_L = \sqrt{3}V_\phi \text{ (wye)}$$

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

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

$$\mathfrak{R} = \frac{l}{\mu A}$$

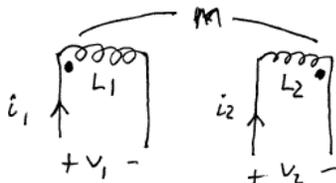
$$MMF = Ni = \phi \mathfrak{R}$$

$$\phi = BA$$

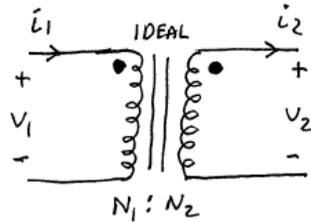
$$\lambda = N\phi$$

$$k = \frac{M}{\sqrt{L_1 L_2}}$$

$$1 \text{ hp} = 746 \text{ Watts}$$

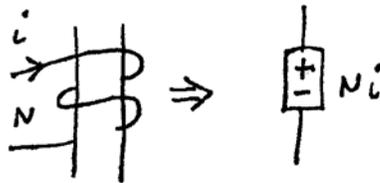


$$v_1 = L_1 \frac{di_1}{dt} - M \frac{di_2}{dt}$$



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

$$\frac{v_1}{v_2} = \frac{N_1}{N_2}$$



Problem 1. (25 points)

The electrical service to your house is called 120/240 Volts, single phase, 3 wire. It consists of 3 wires named L_1 , L_2 , and N coming into your house from the transformer in the back. The voltage drop from L_1 to N is 120 volts angle zero. The voltage drop from L_2 to N is 120 volts angle 180 degrees. The neutral wire (N) is at ground potential. Suppose you hook up loads to these circuits as follows:

- A fan between L_1 and N that draws 5 Amps at a power factor of 0.8 lag.
 - A toaster between L_2 and N that draws 11 Amps at unity power factor.
 - An air conditioner between L_1 and L_2 that draws 24 Amps at a power factor of 0.85 lag.
- a) What is the total real power consumed by your house when the things above are turned on?
- b) How much current is in each of the three wires (magnitude only) when all the things above are turned on?

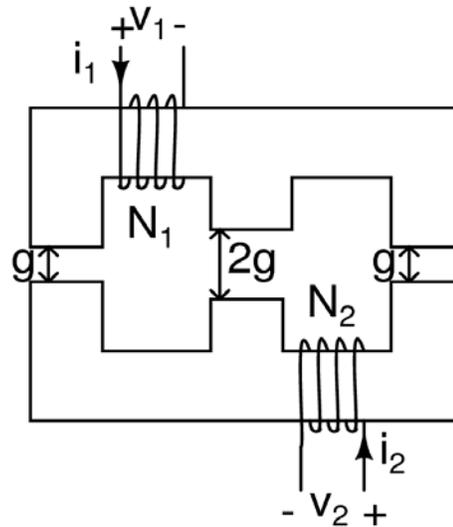
Problem 2. (25 pts)

A 345 KV(line-to-line) three-phase line supplies 750 MVA (3-phase) at 0.8 PF lagging to a three-phase load which is delta connected.

- a) Find the complex impedance per phase of the load
- b) Find the magnitudes of the line and phase currents
- c) Find the MVAR (3-phase) rating of a capacitor bank needed to improve the power factor to be 0.95 lagging.
- d) What will the line current be after the capacitors are installed.

Problem 3. (25 points)

A magnetic core with infinite permeability ($\mu=\infty$) is shown below.



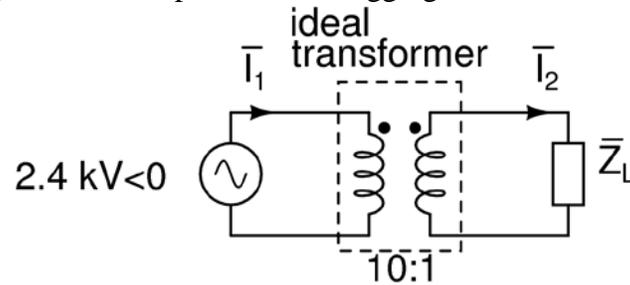
For this problem, you can ignore any resistance in the coil, and any fringing effects in the gaps.

The cross sectional area of the core is 1 cm^2 , $N_1 = 10$, $N_2 = 40$, $g = 1 \text{ mm}$.

- Identify the dot markings of the two windings.
- Draw the magnetic equivalent circuit.
- Find the magnitudes of the self-inductances, the mutual inductance, and the coupling coefficient k . **Note, this part of the problem requires quite a bit of math. If you are short on time, you may want to consider doing the next problem and coming back to this part if time permits.**

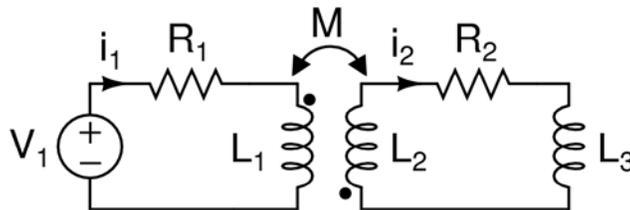
Problem 4. (25 points)

a) An ideal single-phase 60 Hz transformer as shown below is used to supply power to a complex load drawing 1 KW at 0.8 power factor lagging.



- 1) Find the load impedance as seen from the high voltage side.
- 2) Find the magnitudes of currents I_1 and I_2 .

b) The coupled coils L_1 and L_2 are connected in the circuit below (note that L_3 is a regular inductor, and is not coupled).



- 1) Write the two loop equations. You do not need to solve them.