1. (30 pts) The following is a circuit model of a transformer.

Answer the following questions:

a. What element or elements model the leakage flux? \( X_1 \) and \( X_2 \)

b. What element or elements model the real power losses caused by eddy currents in the transformer core? \( R_c \)

c. What element or elements model the hysteresis losses in the transformer core? \( R_c \)

d. What element or elements model the real power losses caused by \( I^2R \) effect in the windings? \( R_1 \) and \( R_2 \)

e. What element or elements model the reactive power associated with setting up the magnetizing flux in the core? \( X_m \)

2. (40 pts) In the circuit below, the primary turns is \( N_1=100 \) and the secondary turns is \( N_2=10 \). Refer all of the numerical quantities indicated over to the primary side and draw the primary-side circuit you would use for analysis. Label the resistive elements appropriately and give their values. Also label the following phasor quantities on your diagram, and for each one, give the corresponding numerical value:

\[
\begin{align*}
\text{I}_1 & = 100 \Omega
\\
\text{I}_{1w} & = 0.3 \angle 0^\circ
\\
\text{E}_1 & = 450 \angle 0^\circ
\\
\text{V}'_2 & = 360 \angle 0^\circ
\\
\text{E}'_2 & = 450 \angle 0^\circ
\\
\text{R}'_b & = 300 \Omega
\\
\text{R}'_c & = 1200 \Omega
\\
\text{I}_2 & = 3 \angle 0^\circ
\\
\text{V}_2 & = 36 \angle 0^\circ
\\
\text{R}_b & = 3 \Omega
\\
\text{R}_c & = 12 \Omega
\\
\end{align*}
\]

Solution:

3. (30 pts) Consider the following circuit which is exactly the same as the one discussed in the last class. It is a per-phase circuit of a three-phase system. The three phase power consumed by load #3 is 95.04 kVA at 0.6 pf leading.
Choose your base line-to-neutral voltage as 5000volts and your base per-phase power as 100,000volt-amperes.

a. Compute the base line current.

b. Compute the base impedance for Y-connected loads.

c. Compute the per-unit voltage applied at load.

d. Compute the per-unit power consumed by load #3.

e. Compute the per-unit impedances for the impedance of the two constant impedance loads.

**Solution:**

a. $I_{\text{base}} = \frac{S_{1,\text{base}}}{V_{\text{L,N, base}}} = \frac{100,000}{5000} = 20$ or $I_{\text{base}} = \frac{S_{3,\text{base}}}{\sqrt{3}V_{\text{LL, base}}} = \frac{300,000}{\sqrt{3} \times 5000} = 20$amps.

b. $Z_{\text{base}} = \frac{V_{\text{L,N, base}}}{I_{\text{base}}} = \frac{5000}{20} = 250$ohms or $Z_{\text{base}} = \frac{(V_{\text{LL, base}})^2}{S_{3,\text{base}}} = \frac{(\sqrt{3} \times 5000)^2}{300,000} = 250$ohms

c. $V_{\text{pu, load}} = \frac{4800}{5000} = 0.96$pu

d. $S_{3,\text{pu}} = \frac{95,040(0.6-j0.8)}{300,000} = 0.3168(0.6-j0.8)$

e. $Z_{1,\text{pu}} = \frac{150+j50}{250} = (0.6+j0.2)$pu; $Z_{2,\text{pu}} = \frac{300+j200}{250} = (1.2+j0.8)$pu.