Problem I: [35 pts.] AC Thévenin-Norton Equivalent Circuits

The following tasks refer to the circuit below:

![Circuit Diagram]

with

\[ i_s(t) = 5 \cos(1 \cdot 10^6 t + 9^\circ) \text{ mA} \]

and \( L=2 \text{ mH}, R=100 \text{ } \Omega, C=15 \text{ nF}, \) and \( g=2 \text{ m}\Omega \).

1. Determine and draw two Norton equivalent circuits - one where the impedance is made up of elements in parallel and one where the impedance is made up of elements in series - for the circuit as seen from terminals A-B. Be sure your equivalent circuits are in the time domain and include all units.

2. Determine the load \( Z_L \) that could be placed across terminals A-B for maximum power transfer from this circuit to the load. Then model that load in the time domain as a combination of elements in series.
Problem II: [40 pts.] Complex Power

The following tasks refer to the circuit below:

![Circuit Diagram](image)

with

\[ v_s(t) = 100 \cos(5000t + 25^\circ) \, \text{V} \]

and \( L_a=80 \, \text{mH}, \, L_b=40 \, \text{mH}, \, R_a=300 \, \Omega, \) and \( R_b=346.41 \, \Omega \) (why would Dr. G make that resistor value so strange? Hmmm...)

(1) Find and draw power triangles for
(a) The power absorbed by Load a
(b) The power absorbed by Load b
(c) The power delivered by the source

Be sure to include proper units and label all three sides of each triangle.

(2) Calculate the power factor for
(a) The power absorbed by Load a
(b) The power absorbed by Load b
(c) The power delivered by the source

Be sure to include all required information.

(3) Determine the current \( i_s(t) \) for this circuit.
The following tasks refer to the circuit below:

(4) A single reactive element can be placed between terminals A and B to correct the power factor seen by the source. Determine what kind of element should be in the box and what its value is.

(5) Determine the current $i_{s,c}(t)$ for the circuit after the power factor has been corrected.
Problem III: [25 pts.] Mutual Inductance

The following tasks refer to the circuit below:

(1) Find the network function \( Z(j\omega) \) in terms of \( L_1, L_2, M_{12}, R_1, R_2, \) and \( R_0 \) where

\[
Z(j\omega) = \frac{I_o}{I_s}
\]

(2) Find a differential equation relating \( i_o(t) \) to \( i_s(t) \).