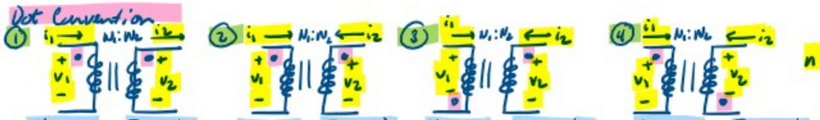
# Transformers

April 20, 2020 1:26 PM

## Dot Convention




$n = \frac{N_2}{N_1}$

① $\frac{V_2}{V_1} = n$, $\frac{I_2}{I_1} = \frac{1}{n}$ ② $\frac{V_2}{V_1} = n$, $\frac{I_2}{I_1} = -\frac{1}{n}$ ③ $\frac{V_2}{V_1} = -n$, $\frac{I_2}{I_1} = \frac{1}{n}$ ④ $\frac{V_2}{V_1} = -n$, $\frac{I_2}{I_1} = -\frac{1}{n}$

- If current enters dotted terminal, opposite dotted terminal = (+)
- $V_1, V_2$ act as sources

## Coils in Series

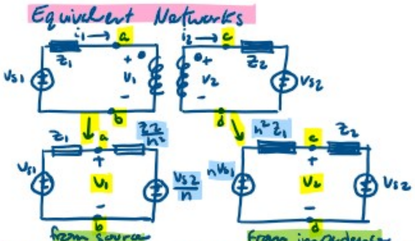

→ 2nd coil induces mutual inductance on 1st coil

**Voltage Drop**: $V = V_1 + V_2 + V_{1M} + V_{2M}$
**Total Inductance**: $L = L_1 + L_2 + 2M$

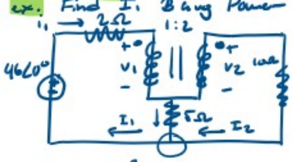
**Voltage Drop**: $V = V_1 + V_2 - V_{1M} - V_{2M}$
**Total Inductance**: $L = L_1 + L_2 - 2M$

- $V_1, V_2$ depends on current directions
- $V_{1M}, V_{2M}$ depends on windings of both coils

## Equivalent Networks




ex. Find $I_1$ & avg Power absorbed by 10Ω




$n = \frac{2}{1} = 2$ ① $\frac{V_2}{V_1} = 2$ ② $\frac{I_2}{I_1} = \frac{1}{2}$

KCL: ③ $\frac{46\angle 0° - 2I_1 - V_1}{5} + I_2 = I_1$

④ $\frac{46\angle 0° - 2I_1 - V_1 + V_2}{10} = I_2$

→ solve: $V_1 = 10V$, $V_2 = 20V$, $I_1 = 8A$, $I_2 = 4A$

$P = 10 I_2^2 = 160W$

## Webwork ST4

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# ST4: Problem 2

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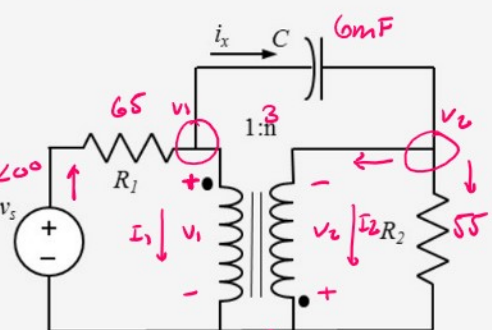
(9 points)
Let $v_s(t) = 95cos(7t)V$, $R_1 = 65\Omega$, $R_2 = 55\Omega$, $C = 6mF$ and $n = 3$. Find the current $i_x$ (as a function of time). (**NB:** for your time-dependent expression to be accepted by WeBWorK, your angle should be expressed in radians, instead of degrees, and with 5 significant figures.)




$i_x(t) =$ A

$n = \frac{3}{1} = 3$

① $\frac{V_2}{V_1} = 3$ ∵ $V_1, V_2$ → diff. polarities

② $\frac{I_2}{I_1} = \frac{1}{3}$ ∵ $I_1, I_2$ → same direction

KCL: ③ $\frac{95\angle 0° - V_1}{65} = I_1 + \frac{V_1 - V_2}{\frac{1}{6\times 10^{-3} s}}$

④ $\frac{V_1 - V_2}{\frac{1}{6\times 10^{-3} s}} = I_2 + \frac{V_2}{55}$

→ $s = 7j$

→ solve: $i_x = 0.35307\cos(7t + 0.260354)$

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# ST4: Problem 5

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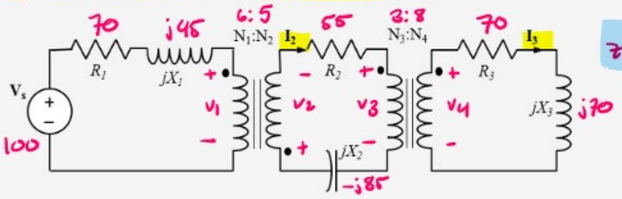
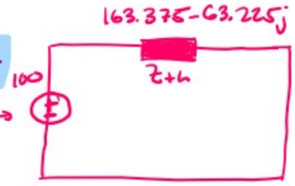
(8 points)

**Important Note** Up to this point, an ideal transformer has been described by a ratio given either as a to 1, for step down transformers, or 1 to a for step up transformers, where a is always greater than 1 (industrial standard). In this exercise, the ratio is given as a ratio of two integer numbers, $N_1$ to $N_2$, where the relative values of the N's tell us if it is a step up or a step down transformer. Example, if $N_1 = 3$ and $N_2 = 2$, the ratio $a = 1.5$ and we have a step down transformer. If, on the other hand, $N_1 = 2$ and $N_2 = 3$, the ratio is still $a = 1.5$ but we have a step up transformer. (Thanks to Mr. Demers for pointing me out the need to clarify this.)

Let $V_s = 100\angle 0^\circ$, $R_1 = 70\Omega$, $R_2 = 55\Omega$, $R_3 = 70\Omega$, $X_1 = 45\Omega$, $X_2 = -85\Omega$, $X_3 = 70\Omega$, $N_1 = 6$, $N_2 = 5$, $N_3 = 3$, and $N_4 = 8$. Compute the complex power supplied by the source and the phasor currents $I_2$ and $I_3$.




$Z_2 = \frac{Z_1}{n^2}$




a) $S = 100 \cdot \left(\frac{100}{Z+h}\right)^*$
$= 57.0834\angle -21.1561°$ VA

**Note:** In this problem, you may only submit numerical answers. (i.e. If 4 is the correct answer, 4 will be marked as correct, but 2+2 will be marked as incorrect.)

$S_s =$ ____ $\angle$ ____ $°VA$

b) $\frac{I_2}{I_1} = -\frac{6}{5}$ $\quad I_2 = 0.685\angle -158.84390°A$

$I_2 =$ ____ $\angle$ ____ $°A$

c) $\frac{I_3}{I_2} = \frac{8}{3}$ $\quad I_3 = 0.256875\angle -158.84390°A$

$I_3 =$ ____ $\angle$ ____ $°A$

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# ST4: Problem 7

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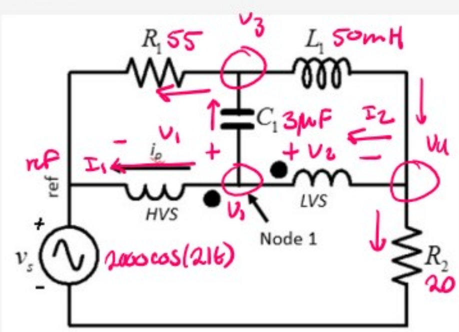
(8 points)

**This question is open for business.**

This shows a circuit that includes an ideal transformer of turns ratio $\alpha : 1$. Let $v_s(t) = 2000cos(21t)\,V$, $R_1 = 55\Omega$, $R_2 = 20\Omega$, $C_1 = 3\mu F$, $L_1 = 50mH$ and $\alpha = 5$. Compute the primary coil time-dependent voltage $v_1(t)$ (that is, the voltage of node 1) and the primary current $i_1(t)$.

$5:1 \rightarrow n = \frac{1}{5}$

**An ideal transformer circuit.**




① $\frac{V_2}{V_1} = \frac{1}{5}$

② $\frac{I_2}{I_1} = 5$

KCL: ③ $I_2 = \frac{V_1 - V_3}{1/3\times10^{-6}s} + I_1$

④ $V_4 = V_1 - V_2$

⑤ $\frac{V_3 - V_4}{50\times10^{-3}s} = I_2 + \frac{V_4 + 2000\angle 0°}{20}$

⑥ $\frac{V_1 - V_3}{1/3\times10^{-6}s} = \frac{V_3}{55} + \frac{V_3 - V_4}{50\times10^{-3}s}$

Report the peak value of $V_1$ ____ $V$

$\rightarrow s = 21j$

Report the phase of $V_1$: ____ $rad$

$\rightarrow$ solve: $V_1 = 1833.5\angle -3.13656$ rad
$i_1 = 5.80227\angle -1.4897$ rad

Report the peak value of $I_1$: ____ $mA$

report the phase of $I_1$: ____ $rad$