ECE 301
Test 4A

(1) You are given the linear transformer circuit shown in Figure 1. Find the input impedance Z_{in} of the circuit.

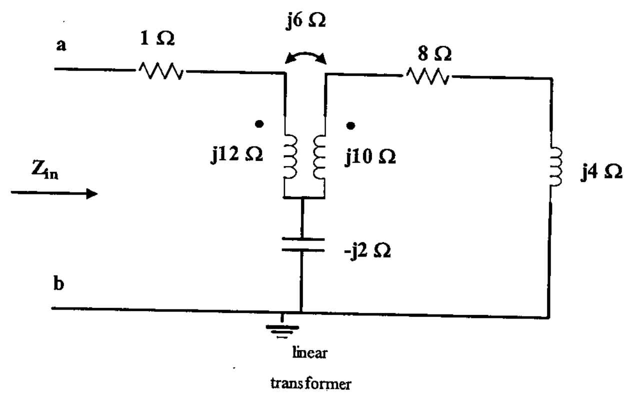
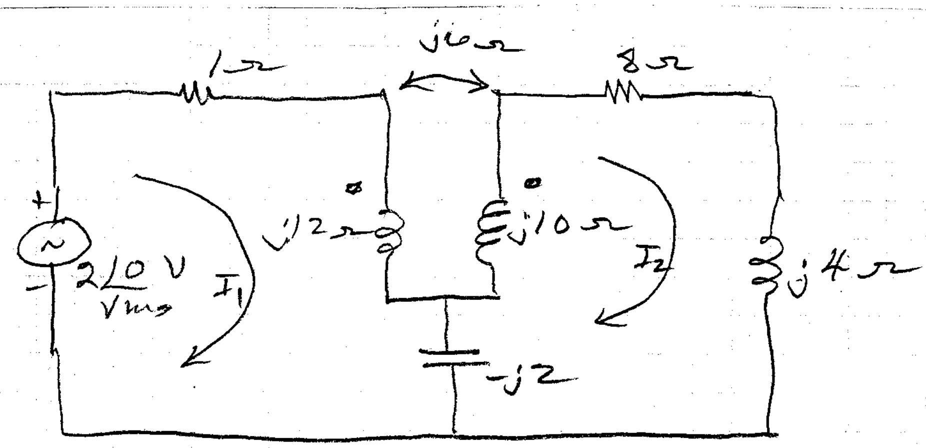


Figure 1: Circuit for problem 1.



$(1 + j12 - j2)I_1 + j2 I_2 - j6 I_2 = 2\angle 0$

$(1 + j10) I_1 - j4 I_2 = 2\angle 0$

$(-j2 + j10 + 8 + j4) I_2 + j2 I_1 - j6 I_1 = 0$

$-j4 I_1 + (8 + j12) I_2 = 0$

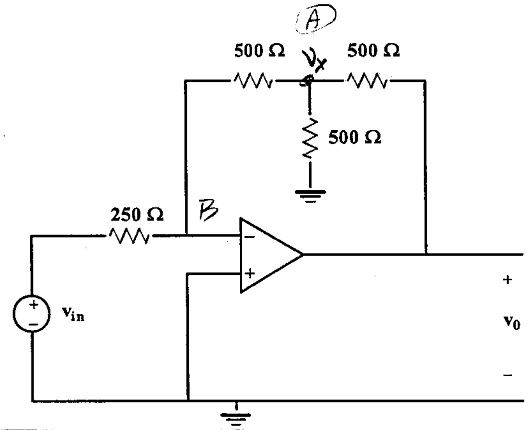
$I_1 = 0.196 \angle -80$

$Z_{ab} = \dfrac{2\angle 0}{0.2169\angle -80}$

$Z_{ab} = 9.22 \angle 80^\circ \ \Omega$

A

(2) Find the output voltage v_0 in terms of the input voltage v_{in} for the op amp circuit of Figure 2.



At B

$$\frac{0 - V_{IN}}{250} + \frac{0 - V_x}{500} = 0$$

$$-2V_{IN} - V_x = 0$$

$$V_x = -2V_{IN}$$

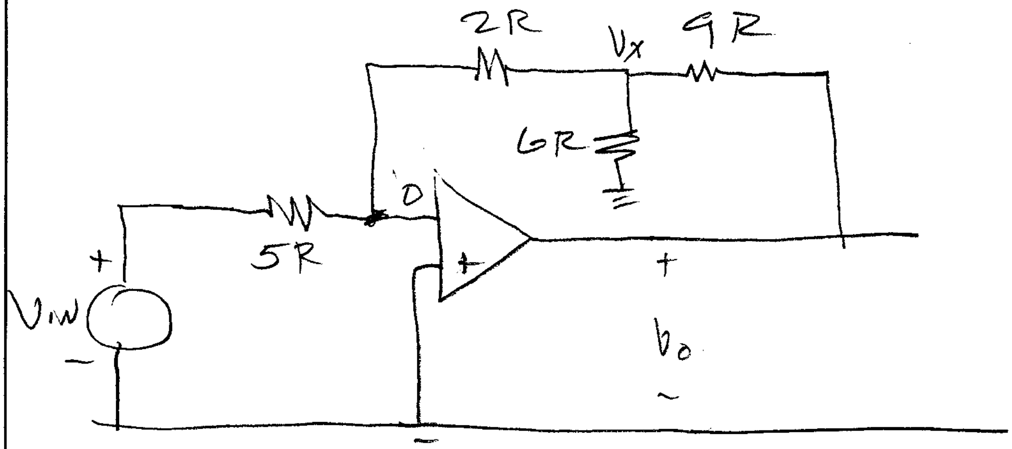
At A

$$\frac{V_x - 0}{500} + \frac{V_x}{500} + \frac{V_x - V_o}{500} = 0$$

$$V_o = 3V_x$$

$$\boxed{V_o = -6V_{IN}}$$

Counter Example #2



$$\frac{-V_{in}}{5R} + \frac{-V_x}{2R} = 0 \qquad \frac{V_x}{2} = \frac{-V_{in}}{5}$$

$$\left(V_x = -\frac{2}{5} V_{in}\right)$$

$$\frac{V_x}{2R} + \frac{V_x}{6R} + \frac{V_x - V_o}{9R} = 0$$

$$54\left(\frac{V_x}{2R} + \frac{V_x}{6R} + \frac{V_x}{9R} = \frac{V_o}{9R}\right)$$

$$27V_x + 9V_x + 6V_x = 6V_o$$

$$42V_x = 6V_o$$

$$V_o = \frac{42}{6}\left(\times \frac{-2}{5}\right) V_{in} = \frac{-84}{30} V_{in} = -\frac{14}{5} V_{in}$$

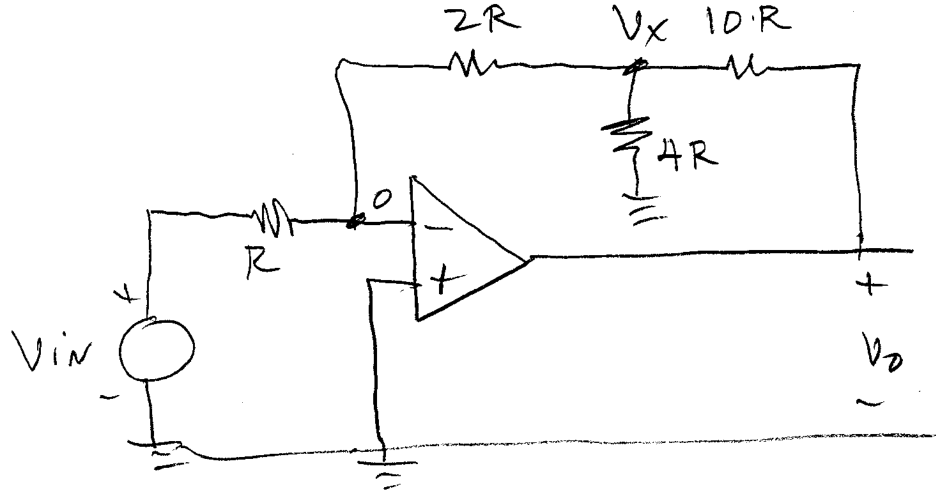
Other Way

$$\frac{-V_{in}}{5R} + \frac{-V_o}{17R} = 0$$

$$V_o = -\frac{17}{5} V_{in}$$

Does not agree

Counter Example #2



$$-\frac{V_{in}}{R} + \frac{(-V_x)}{2R} = 0 \qquad -2V_{in} - V_x = 0$$

$$\underline{V_x = -2V_{in}}$$

At V_x

$$20\left(\frac{V_x - 0}{2R} + \frac{V_x}{4R} + \frac{V_x - V_o}{10R}\right) = 0$$

$$10V_x + 5V_x + 2V_x - 2V_o = 0$$

$$2V_o = 17V_x = 17(-2V_{in})$$

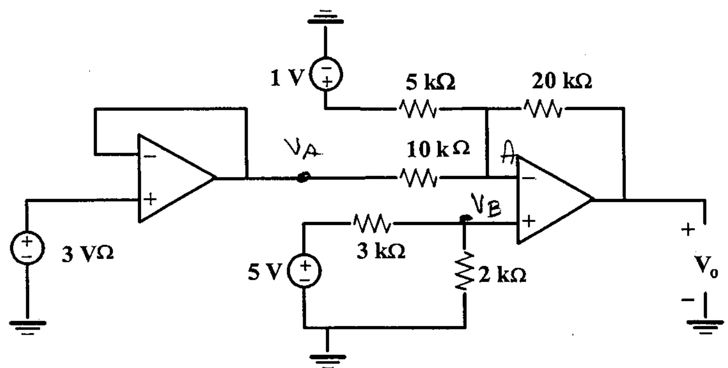
$$\boxed{V_o = -17V_{in}}$$

$$-\frac{V_{in}}{R} - \frac{V_o}{16R} = 0$$

$$V_{in} = -\frac{V_o}{16}$$

$$\boxed{V_o = -16V_{in}}$$ Does not agree

(3) Find the output voltage, V_o, for the op amp circuit shown in Figure 3.



$V_A = 3V$

$V_B = \frac{5 \times 2k}{3k + 2k} = 2\ V$

At A

$$\frac{V_B - 3}{10k} + \frac{V_B - 1}{5k} + \frac{V_B - V_o}{20k} = 0$$

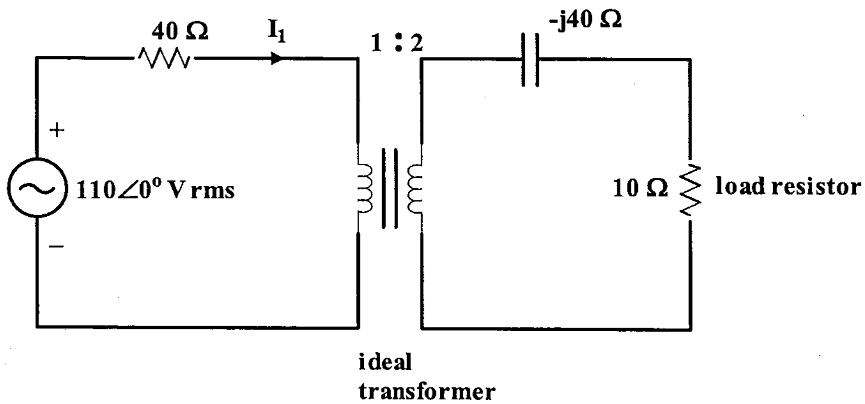
$$-2 + 4 + 2 - V_o = 0$$

$$V_o = +4\ V$$

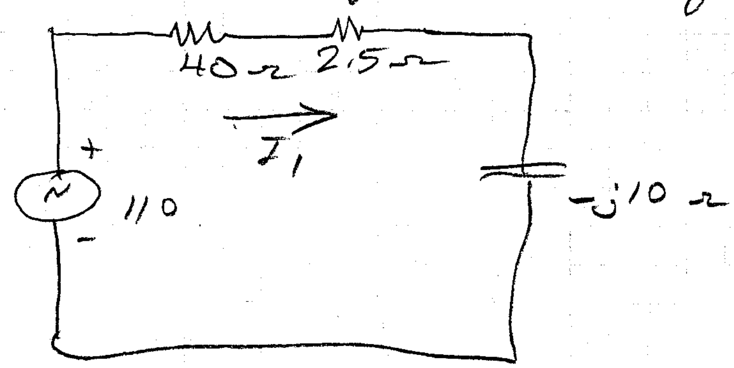
(4) You are given the <u>ideal transformer</u> shown in Figure 4.

(a) Find the phasor current I_1.

(b) Find the power dissipated in the 10 Ω load resistor.



Reflect secondary to primary



$$I_1 = \frac{110\angle 0}{42.5 - j10} = 2.52\angle 13.24^\circ \text{ A rms} = 2.45 + j.577 \text{ A rms}$$

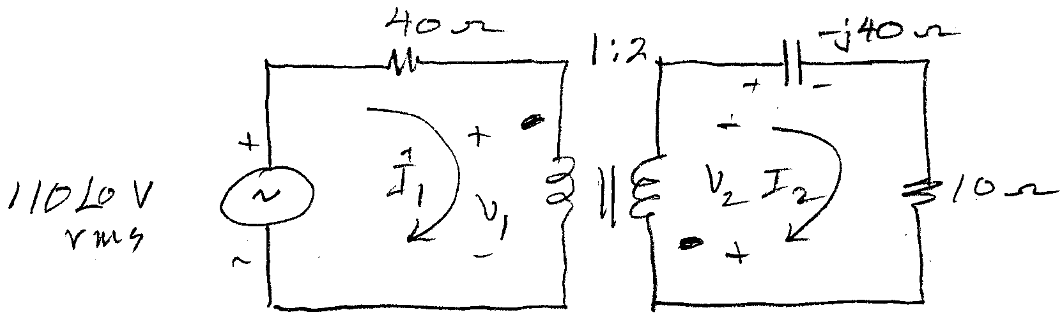
$$\left|\frac{I_1}{I_2}\right| = 2$$

$$|I_2| = 0.5|I_1| = 1.26 \text{ A rms}$$

$$P_{10} = |I_2|^2 \times 10 = 15.88 W$$

(4) This is a tedious and really unnecessary way to work the problem, but I will. One should use reflected impedance

For the answers desired (I_1 & $|I_2|$) it does not matter how I assume dots. I will use the following.



mesh 1

$$V_1 + 40 I_1 = 110\angle 0$$

or

$$40 I_1 + 0 I_2 + V_1 + 0 V_2 = 110\angle 0$$

mesh 2

$$(10 - j40) I_2 + V_2 = 0$$

or

$$0 I_1 + (10 - j40) I_2 + 0 V_1 + V_2 = 0$$

$$\frac{V_2}{V_1} = 2$$

or

$$0 I_1 + 0 I_2 + 2 V_1 - V_2 = 0$$

$$\frac{I_1}{I_2} = -2$$

or

$$I_1 + 2 I_2 + 0 V_1 + 0 V_2 = 0$$

(A) OR

$$\begin{bmatrix} 40 & 0 & 1 & 0 \\ 0, & 10-j40, & 0 & 1 \\ 0 & 0 & 2 & -1 \\ 1 & 2 & 0 & 0 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} 110 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

Need I_1 & I_2

$I_1 = 2.52 \angle 13.2^\circ$ A rms

$I_2 = 1.26 \angle -166.7$ A rms

(b)

$P_{10} = |I_2|^2 \times 10 = (1.26)^2 10$

$P_{10} = 15.88$ W

Real average power always has zero phase angle.