ESE 271 Second Exam Name:

Fall, 2003 ID Number:

Do not place your answers on this front page.

Prob. 1:

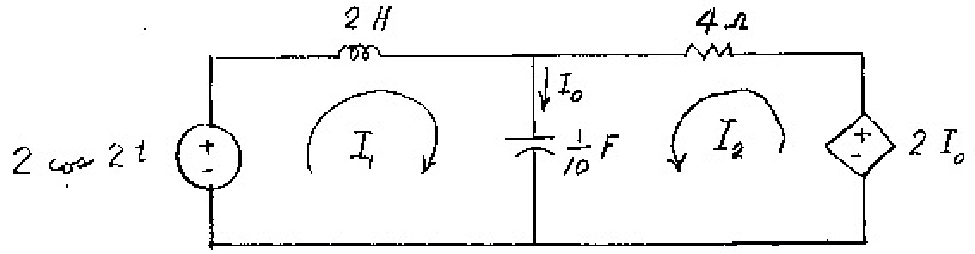
Prob. 2:

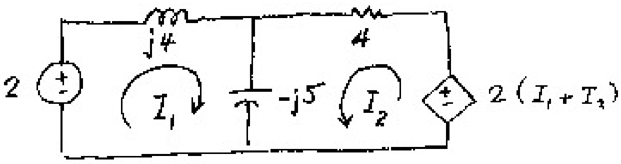
Prob. 3:

Prob. 4:

Prob. 1. (30 points):

Using Cramer's rule, find the phasor current I_1 as a determinant over a determinant. Do a mesh analysis using the two mesh currents I_1 and I_2 shown with their indicated directions. (The entries of the determinants should be complex numbers. Write neatly—or else points will be deducted.)





$$\left(\frac{1}{j\omega C} = -j \frac{1}{2 \times \frac{1}{10}} = -j5 \right)$$

KVL FOR I_1 LOOP: $-2 + j4 I_1 - j5 (I_1 + I_2) = 0$

KVL FOR I_2 LOOP: $-2(I_1 + I_2) + 4 I_2 - j5 (I_1 + I_2) = 0$

THUS:

$$-j I_1 - j5 I_2 = 2$$
$$(-2-j5) I_1 + (2-j5) I_2 = 0$$

(OR)

$$j I_1 + j5 I_2 = -2$$
$$(2+j5) I_1 + (-2+j5) I = 0$$

SO:

$$I_1 = \frac{\begin{vmatrix} 2 & -j5 \\ 0 & 2-j5 \end{vmatrix}}{\begin{vmatrix} -j & -j5 \\ -2-j5 & 2-j5 \end{vmatrix}}$$

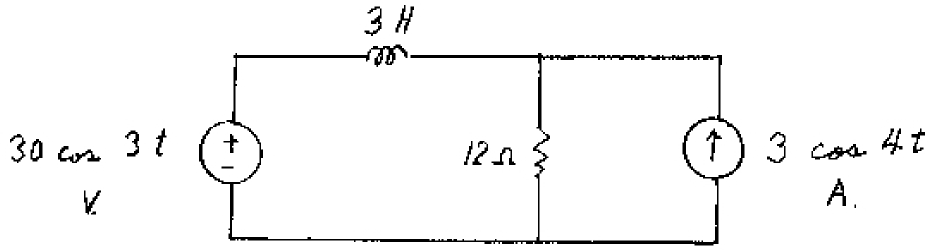
ANOTHER CORRECT ANSWER IS →

$$I_1 = \frac{\begin{vmatrix} -2 & j5 \\ 0 & -2+j5 \end{vmatrix}}{\begin{vmatrix} j & j5 \\ 2+j5 & -2+j5 \end{vmatrix}}$$

(THERE ARE STILL OTHER CORRECT ANSWERS.)

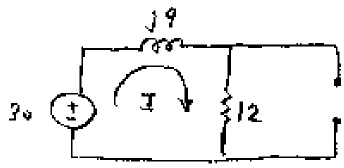
Prob. 2. (30 points)

Find the power P dissipated in the 12 Ω resistor.



SINCE THERE DIFFERENT ω'S, WE MUST USE SUPERPOSITION:

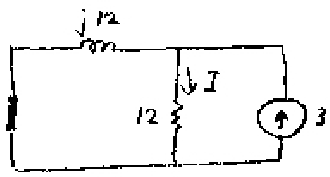
FOR THE 30 cos 3t SOURCE ALONE:



$$I = \frac{30}{12+j9} = \frac{10}{4+j3} = \frac{10}{5\angle \tan^{-1}\frac{3}{4}}$$

$$|I| = 2 \quad , \quad P = \frac{|I|^2 R}{2} = \frac{4 \times 12}{2} = 24\ W$$

FOR THE 3 cos 4t SOURCE ALONE:



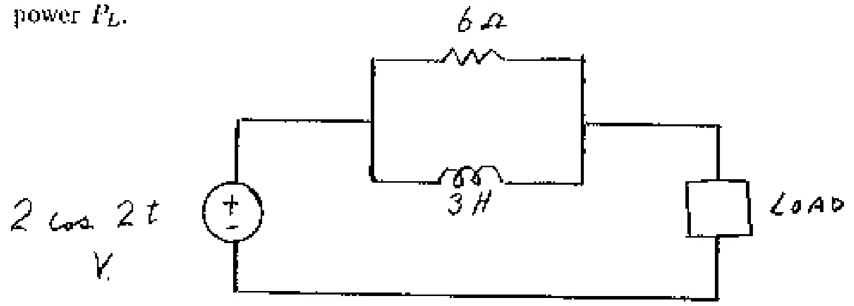
$$I = 3 \cdot \frac{j12}{12+j12} = \frac{3j}{1+j} = \frac{3j}{\sqrt{2}\angle 45^\circ}$$

$$|I| = \frac{3}{\sqrt{2}} \quad , \quad P = \frac{|I|^2 R}{2} = \frac{\frac{9}{2} \times 12}{2} = 27\ W$$

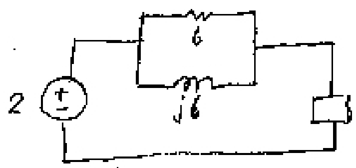
THUS, TOTAL $P = 24 + 27 = 51\ W$

Prob. 3. (30 points

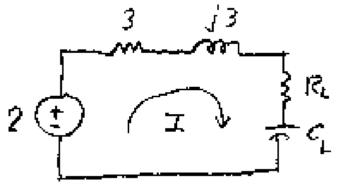
In this circuit, the load is either a resistor R_L in series with an inductor L_L or a resistor R_L is series with a capacitor C_L. Find the values of R_L and of (L_L or C_L) for which the power P_L dissipated in that load is a maximum. Also, find the value of that maximum dissipated power P_L.



THE PHASOR CIRCUIT:



→ SAME AS →



$$\frac{6(j6)}{6+j6} = \frac{j6}{1+j} \cdot \frac{1-j}{1-j} = \frac{6+j6}{2} = 3+j3 .$$

SO, THE LOAD MUST HAVE A CAPACITOR C_L

THUS, $\underline{R_L = 3}$ AND $-j\frac{1}{2C_L} = -j3$. SO, $\underline{C_L = \frac{1}{6} F}$

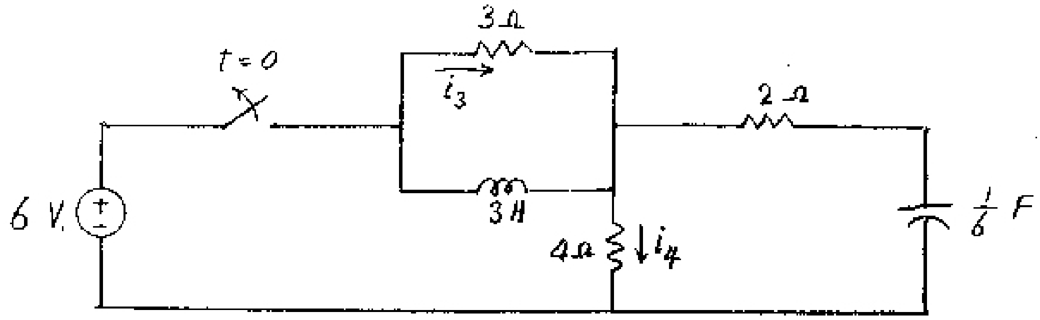
THE MAXIMUM POWER DISSIPATED IS OBTAINED AS FOLLOWS:

$$I = \frac{2}{3+j3+3-j3} = \frac{2}{6} = \frac{1}{3}$$

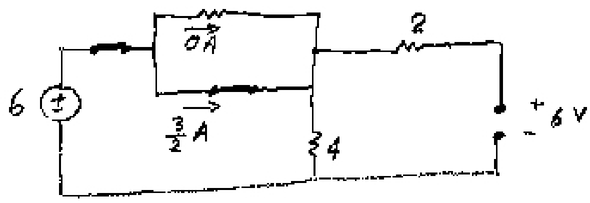
MAX. POWER IN R_L $= \frac{|I|^2 R}{2} = \frac{\left(\frac{1}{3}\right)^2 3}{2} = \underline{\frac{1}{6} W.}$

Prob. 4. (10 points)

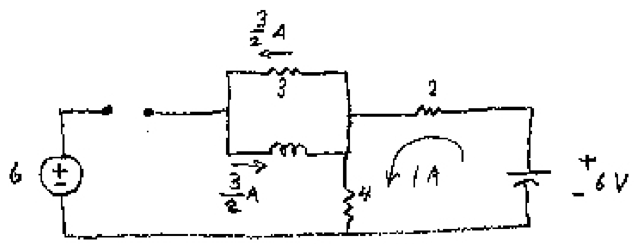
This circuit is in the DC steady state at $t = 0-$ with the switch closed. The switch is opened at $t = 0$. For $t = 0+$, find the current $i_3(0+)$ flowing to the right through the 3 Ω resistor, and also find the current $i_4(0+)$ flowing downward through the 4 Ω resistor.



AT $t = 0-$:



AT $t = 0+$:



BECAUSE CURRENT IN INDUCTOR DOES NOT JUMP AND VOLTAGE ON CAPACITOR DOES NOT JUMP.

THUS,

$$i_3(0+) = -\frac{3}{2}\,A$$

$$i_4(0+) = 1\,A$$