LEHIGH UNIVERSITY

DEPT. OF ELECTRICAL & COMPUTER ENGINEERING

ECE 083 – INTRODUCTION TO ELECTRICAL ENGINEERING

SPRING 2010

FINAL EXAMINATION

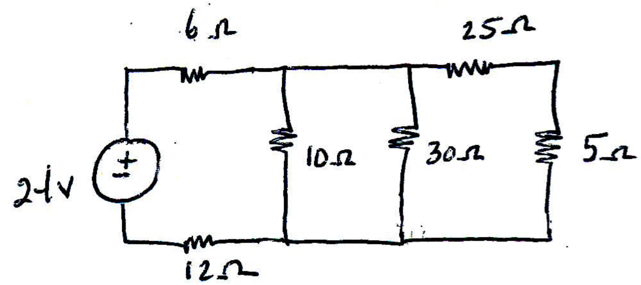
SOLUTIONS

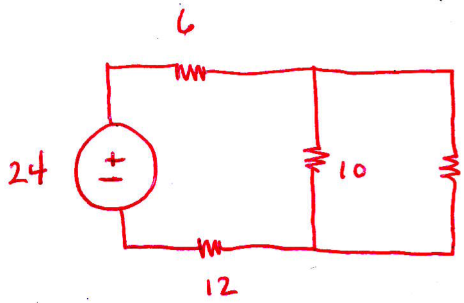
Focus on Problems #4-8

Problem # 1 (5)

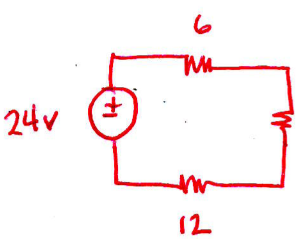
Find $i_{10\Omega}$ and $v_{5\Omega}$

For the given Circuit

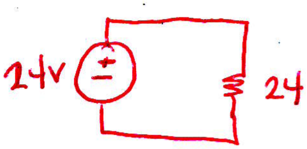




$30 // (25 \text{ S. } 5) = 15$



$10 // 15 = 6$



Hence $i = 1A$

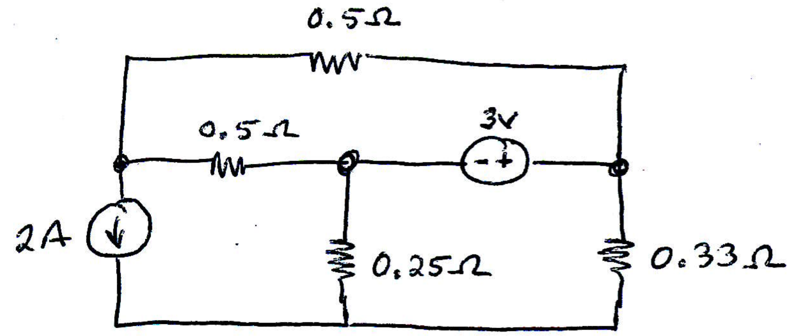
By Current Division : $i_{10} = \frac{15}{10+15}(1) \Rightarrow \boxed{i_{10} = 0.6A}$

By Observation, Noting "Parallel Elements", $\boxed{v_5 = 1V}$

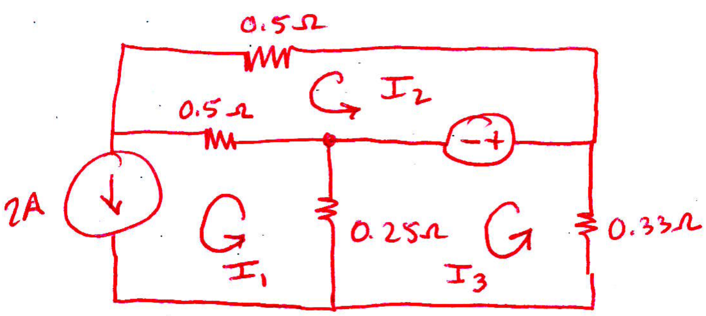
And Voltage Division $\Longrightarrow$

Problem # 2 (10)

Find the Current through the Voltage Source For the Following Circuit



We Will Use "Mesh Analysis"



Note: $I_1 = 2A$

Mesh I_3 : $0.33 I_3 + 3 + (I_3 - 2) = 0$

Mesh I_2 : $0.5 I_2 + 0.5 (I_2 - 2) - 3 = 0$

Solving : $I_3 = -4.31A$

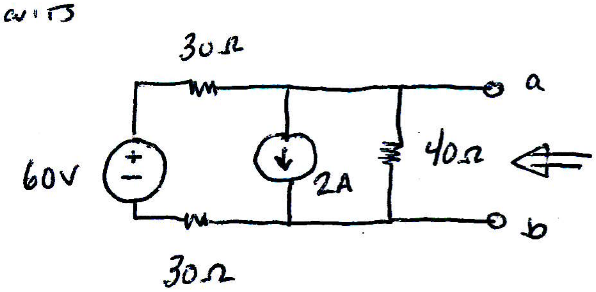
$I_2 = 4A$

Hence $i_{\pm} = 4.31A + 4A$

$\boxed{i_{\pm} = 8.31A \rightarrow}$

PROBLEM # 3 (15)

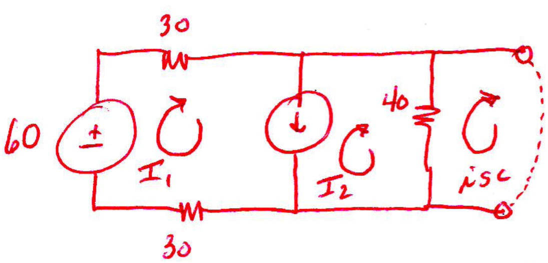
Find the Norton and Thevenin Subcircuits For the Following Circuit.



No Dependent Sources ... Zero Out Sources (current source = OC, voltage source ⇒ SC) And Solve For R_{TH} Directly.

$$R_{TH} = 40 // 30 \text{ S. } 30 \Rightarrow \boxed{R_{TH} = 24\Omega}$$

We Will Use Mesh Noting that We Never Write A Mesh Equation For Anything that Will Contain A Current Source (Unknown V). Then Solve For i_{sc}



(Note: Units V, Ω)

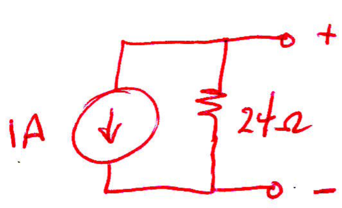
$$30 I_1 + 40 (I_2 - i_{sc}) + 30 I_1 = 60$$

$$40 (i_{sc} - I_2) = 0$$

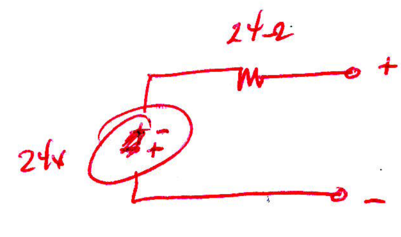
$$I_1 - I_2 = 2 \quad \text{(Compatibility Relationship)}$$

Solving: $i_{sc} = 1A$

Hence:



(N)



(T)

Problem # 4 (10)

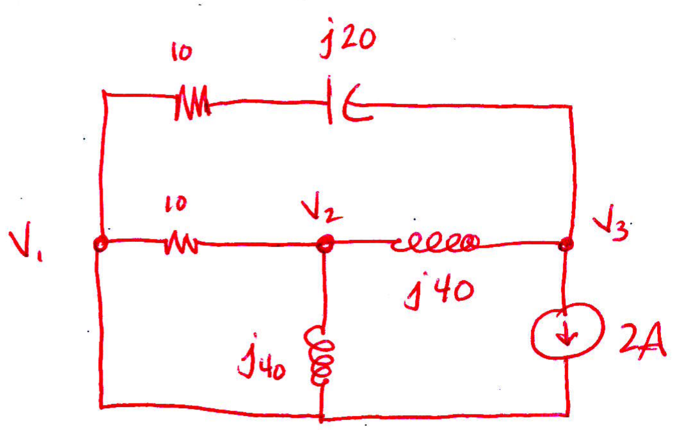
For the Following Set of Equations Construct the Corresponding Circuit

$$\frac{V_1 - V_2}{10} + \frac{V_1 - V_3}{10 - j20} = 0 \quad (1)$$

$$\frac{V_2 - V_1}{10} + \frac{V_2}{j10} + \frac{V_2 - V_3}{j40} = 0 \quad (2)$$

$$\frac{V_3 - V_1}{10 - j20} + \frac{V_3 - V_2}{j40} = -20 \quad (3)$$

There Are Several Solutions to this Problem. Below is Just One of them.



Note: With ω Not Given We Can Only Set this Up Using Impedance Values

PROBLEM # 5 (5)

FIND $v_s(t) = v_1(t) + v_2(t)$

IF $v_1(t) = 10\cos(\omega t - 30)$

$v_2(t) = 15\sin(\omega t + 60)$

$v_1 = 10\cos(\omega t - 30)$

$v_2 = 15\cos(\omega t - 30)$ [Note: Sin → Cos transform]

$v_1 = 10\angle{-30} = 10(\cos 30 - j\sin 30) = 8.66 - j5$

$v_2 = 15\angle{-30} = 15(\cos 30 - j\sin 30) = 12.99 - j7.5$

Since ω is the Same For Both Signals:

$v_1(t) + v_2(t) = 21.65 - j12.5$

$= \sqrt{21.65^2 + 12.5^2}\ \angle \tan^{-1}\left(\frac{-12.5}{21.65}\right)$

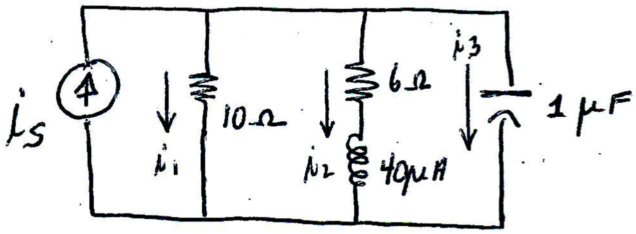
$= 25\angle{-30}$

$$\boxed{v_s(t) = 25\cos(\omega t - 30)}$$

Note: We Could Have Noted this At the Beginning Since Both $v_1(t)$ & $v_2(t)$ Had Same ω and θ So they Could Have Been JUST ADDED!

Problem # 6 (20)

For the Following Circuit
Find v_s, i_1, i_2, and i_3
Let $i_s = 8\cos(200{,}000t)\,A$



$Z_1 = 10$ $\quad Z_2 = 6 + j8 \quad Z_3 = -j5$

$i_s = 8\angle 30$ with $\omega = 200{,}000$

Note: $Z_R = R$, $Z_L = j\omega L$, $Z_C = \frac{-j}{\omega C}$

Hence $\boxed{Z_{eq} = 5\angle -36.8}$

Then $v_s = (8\angle 0)(5\angle -36.8) = 40\angle -36.8$

$\boxed{v_s(t) = 40\cos(200{,}000t - 36.8°}$

Then: $i_1 = \frac{V_s(t)}{10} \Rightarrow i_1 = \frac{40\angle -36.8)}{10} = 4\angle -36.8 \Rightarrow \boxed{i_1 = 4\cos(200{,}000t - 36.8)}$

$i_2 = \frac{v_s(t)}{6 + j8} = \frac{40\angle -36.8}{10\angle 53.1} = 4\angle -90 \Rightarrow \boxed{i_2 = 4\cos(200{,}000t - 90)}$

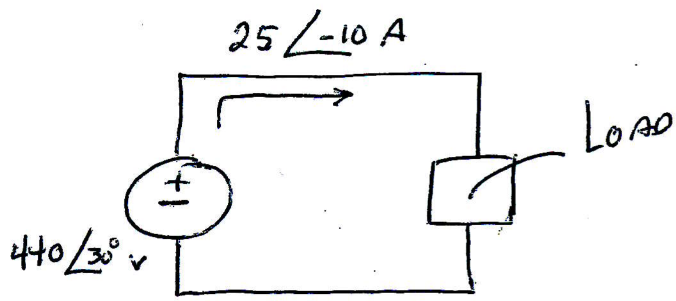
$i_3 = \frac{v_s(t)}{-j5} = \frac{40\angle -36.8}{5\angle -90} = 8\angle 53.2 \Rightarrow \boxed{i_3 = 8\cos(200{,}000t + 53.2)}$

Note: If you Add $i_1 + i_2 + i_3$ you Will Arive @ $\underline{i_s = 8\angle 0}$

Nice Check!

Problem #7 10

Determine the Real Power, Complex Power, Reactive Power and Apparent Power absorbed by the load. Also, find the pF for the load



$V_{Rms} = \frac{440}{\sqrt{2}} = 311.13V$ $\quad I_{rms} = \frac{25}{\sqrt{2}} = 17.68A$ $\quad \theta = (\theta_v - \theta_i) = 40°$

$P_{Avg} = P_{real} = V_{rms} I_{rms} \cos(\theta) = \underline{\underline{4213.2\ W}}$

$Q = P_{reactive} = V_{rms} I_{rms} \sin(\theta) = \underline{\underline{3535.33\ VAR}}$

$P_{App} = V_{rms} I_{rms} = 5500\ VA$

$pf = \cos\theta = .766$ or 76.6%

$S_{complex} = P_{real} + j P_{reactive}$

$= P_{real} + jQ$

$= 4213.2 + j3535.33$

$= 5500\angle 40°$

Note: This checks with P_{app} & θ !

Problem # 8 (15)

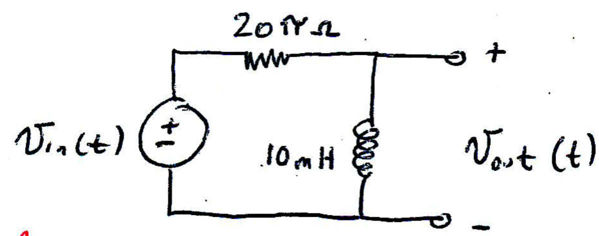
Signals Have Different ω, Must Analyze Separately !!

An Input Signal given By

$$v_{in}(t) = 3 + 4\cos(1000\pi t) + 5\cos(2000\pi t - 30^\circ)$$

is Applied to an RL Filter As Shown.

Find the Output Signal.



Analyzing this Circuit We See this is A First-Order High Pass Filter.

Hence: $|H(f)| = \dfrac{f/f_B}{\sqrt{1+(f/f_B)^2}}$ and $f_B = \dfrac{R}{2\pi L} = 1000\ Hz$

① $\omega = 0 \rightarrow f = 0$

$|H(0)| = 0 \quad \angle H(f) = 0 \Longrightarrow$ Note: This Makes Sense As We Said that A HPF Will Not Let A DC Signal Pass

② $\omega = 1000 \rightarrow f = 500$

$|H(500)| = 0.447 \quad \angle H(f) = 63.43$

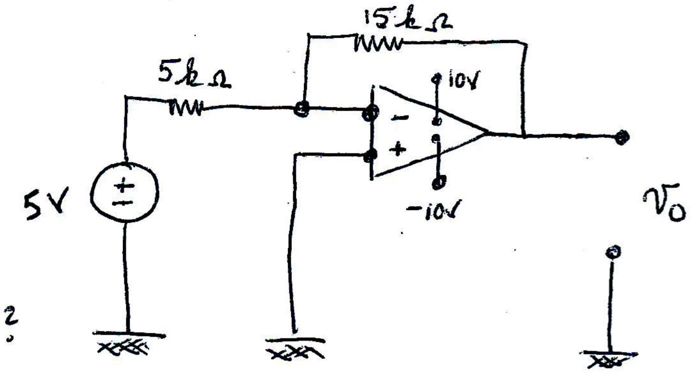
③ $\omega = 2000 \rightarrow f = 1000$

$|H(1000)| = 0.707\angle 45^\circ$

Hence: $V_{out} = (0)(3) + (.447)(4)(\cos(1000\pi t + 63.43) + (0.707)(5)(\cos 2000\pi t + 15)$

$$\boxed{V_{OUT} = 1.79\cos(1000\pi t + 63.43) + 3.53\cos(2000\pi t + 15)}$$

Problem # 9 (10)



For the given circuit shown

1) What type of Op-Amp is this?

2) If we say this is Ideal what does this mean?

3) Calculate V_o

(1) This is a schematic of an "Inverting" Amplifier

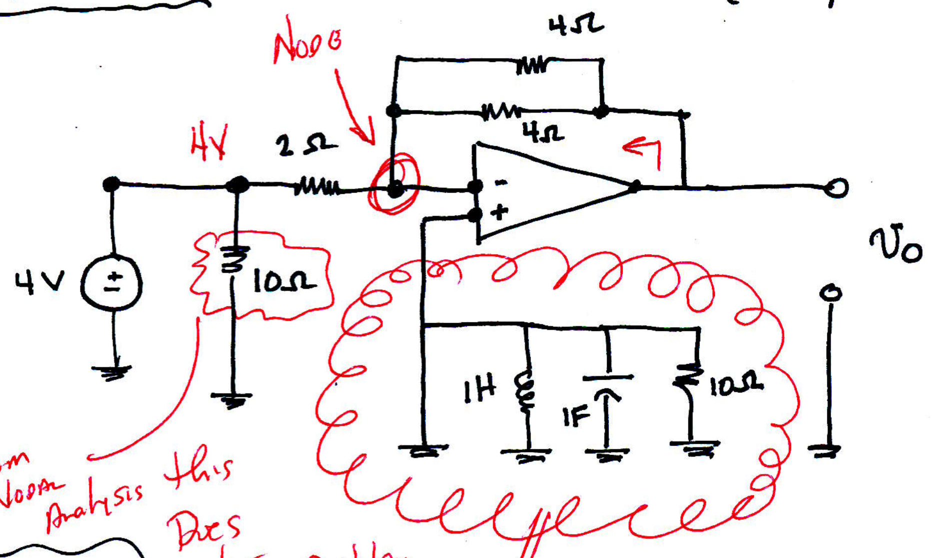
(2) For our purposes Ideal means that the Summing-Point Constraint is valid. This means that $i_p = i_n = 0$ and $V_p = V_n$. Also Ideal means that V_o must lie within "Voltage of Op-Amp".

(3) Negative Feedback is present

$$V_o = -\frac{15}{5}(5) = -15V$$

Hence this lies outside the ±10V range so we say that the Op-Amp is saturated. Hence $V_o = -10V$

Problem #10 Extra Credit {10 points}



From Nodal Analysis this Does Not Affect Problem

Find v_o

Please Observe these Are grounded So Nothing Passes through them! They Do Not Affect the Op-Amp.

KCL For Node: $\frac{4}{2} + \frac{v_o}{2} = 0$

2 4Ω resistors in // ⇒ $R_{eq} = 2\Omega$

$$\boxed{v_o = -4V}$$