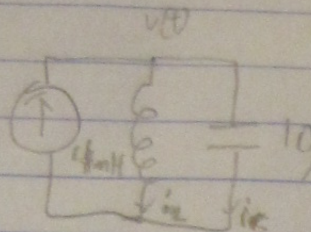
~~22 pts total~~ 20 pts total

~~(Normalize to 20 on grade spreadsheet)~~

1)



$i_L = 0.1\cos(5000t)$ Amps – Given

$V(t) = 4mH \cdot i_L'$

$= -5000 \cdot 0.1 \cdot 4m \cdot \sin(5000t)$

$= -2\sin(5000t)$

3 pts

$i_C(t) = 10\mu \cdot v'(t) = -10\mu \cdot 2 \cdot 5K\cos(5000t) = -100\cos(5000t)\ mV = -0.1\cos(5000t)\ V$

$i(t) = i_L + i_C = 0\ mA.$

→ What this means is that adding a nonzero current source to a parallel LC circuit can not yield $i_L = 0.1\cos(5000t)$

(1) Total energy is $\frac{1}{2}\cdot(0.1A)^2\cdot 4mH = 0.02\ mW = \frac{1}{2}10\mu F\cdot(2V)^2$

3 pts 2) Position 1: $V_C = 2$, $i_L = 0$

Short cut

Position 2: Normal LC circuit w/ $\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{0.01}} = 10\ sec.$

(1) $V_C(t) = 2\cos(10t)$, so $i_L(t) = i_C(t)\ C\cdot V_C'(t) = -0.2\sin(10t)$

Or the long way! $I_C = I_L$

$\int \frac{I_C}{C} + L\frac{dI_C}{dt} = 0$

$\frac{I_C}{C} + L I_C'' = 0$

$I'' = -\frac{I_C}{LC} \Rightarrow s^2 = -\frac{1}{LC}$ $s_{1,2} = \sqrt{-\frac{1}{LC}} = \pm j\omega_0$

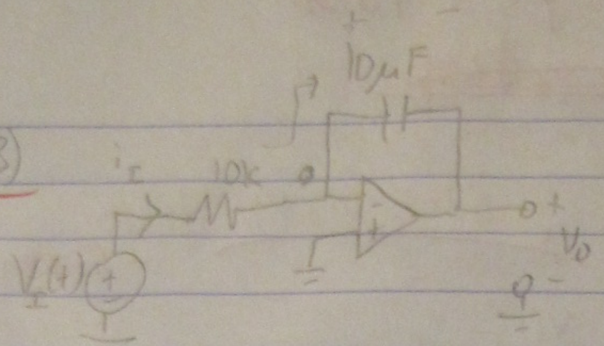
$\omega_0 = \frac{1}{\sqrt{LC}}$

Use initial condition to find constants...

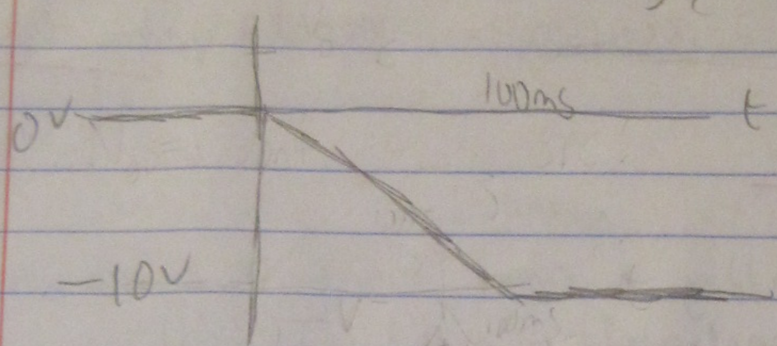
(1) etc. etc as we did in lecture II (July 16th)

3)

2 pts



$$i_I = \frac{V_I(t)}{10k} \qquad V_o = -\int \frac{i_I}{C} = -\int \frac{V_I(t) \cdot dt}{10\mu \cdot 10k} = \boxed{-10 \int V_I(t)\,dt}$$



1 pt for all of 4.

Don't count off for no work.

4a) $(8+j7)(5e^{j30})(e^{-j39})(0.3-j0.1)$

$(10.63\angle 0.718)(5\angle 30^\circ)(1\angle -39^\circ)(0.3162\angle -0.3218)$

$\boxed{16.8\angle 0.2391}$ or $\boxed{16.8\angle 13.7^\circ}$

b) $\dfrac{(8.5+j34)\cdot(20e^{-j25^\circ})(60)(\cos(10)+j\sin(10))}{25e^{j20^\circ}\cdot 37e^{j23^\circ}}$

$\dfrac{(35.04\angle 1.32)(20\angle 0.43)(60\angle 0)\,1\angle -2.56}{25\angle 0.349 \cdot 37\angle 0.4014}$

$\boxed{45\angle 0.31 \quad \text{or} \quad 45.47\angle 18^\circ}$

c) $\dfrac{(25\angle 0.52)\cdot(10\angle 0.4712)(19.1\angle -6.748)}{2.23\angle -1.1}$

$2140\angle 1.35$ or $2140\angle 78$

2 pts

total 1

5) a) (5.83 ∠1.03)(4 ∠ 0.87)(7∠ -0.349)

163.24 ∠ 1.55

163.2667 ∠ 1.554

2.7461 + 163.2436

- Note that with such an extreme angle rounding errors can be pretty big so full credit if you're within a factor of 5.

Keep this in mind if you're doing some design problem someday

b) $(10\angle 0.8727)(1\angle 0.349) = 10\angle 1.2218$

$3.4195 + 9.3972j$

c) $10\angle 0.8727 \cdot \angle \omega$

$10\angle(\omega + 0.8727)$

$10\cos(\omega + 0.8727)$

d) $|E| e^{j\theta} \cdot e^{j\omega t} = |E| e^{j(\theta + \omega t)}$

Note this is not $|E|\angle\theta$

$|E|\cos(\omega t + \theta)$

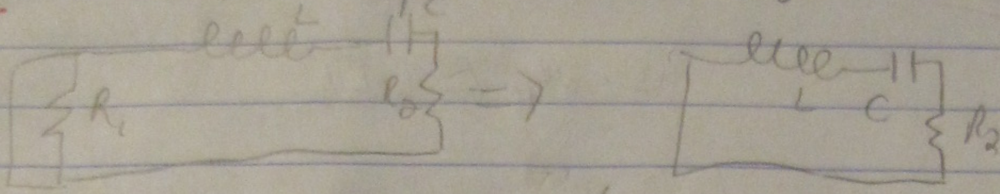
$|E|\angle\theta$ is just another way to write $|E|e^{j\theta}$

This has an $e^{j\omega t}$ stuck to it.

6. No question 6.

1pt

7. Zero-input response is when $V_s = 0$.



$\alpha = R/2L = \frac{15}{2\mu H} = 7.5\times10^{-6}$ $\quad w_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{10^{-14}}} = \frac{1}{10^{-7}} = 10^{7}$

$\alpha < w_0$, so underdamped

1pt

8. $i\,5e^{j\pi}$

ii. $5\angle\pi$

iii. $-5+0j$

These could also be $-5\angle 0$, $5\angle 3\pi$, $-5\angle-\pi$ etc.

[NOT $5+0j$]!!!

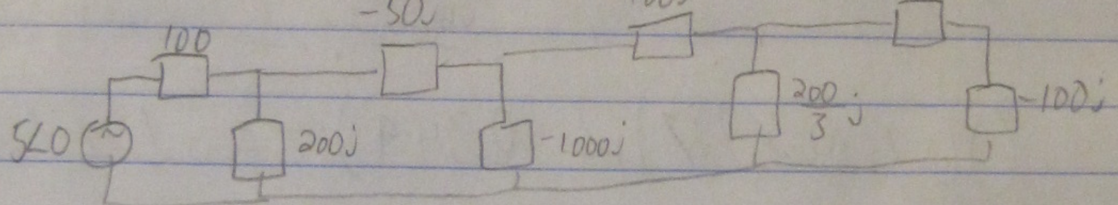
4 pts total

b. $\sqrt{13}\cos(20t + 0.588)$ — or 36.99°

9.

1pt

a.



Using $Z_C = \frac{1}{jwC} = -\frac{j}{100\cdot C}$ $\quad Z_L = jwL = 100jL$

1pt

b. $Z_{eq} = (((((-100j + -100j) \,\|\, \frac{200}{3}j + 100j) \,\|\, -1000j) - 50j) \,\|\, 200j) + 100$

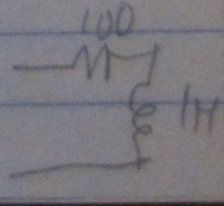
$100j$

$(200j \,\|\, -1000j) = 250j$

$(200j \,\|\, 200j) = 100j$

$Z_{eq} = 100 + 100j$

so, for example, Z_{eq} could also be from much simpler



c. $\frac{5\angle 0}{100+100j} = \frac{5\angle 0^\circ}{\sqrt{2}\,100\angle 45^\circ} = \frac{1}{20\sqrt{2}}\angle -45^\circ = \hat{I}$

½ pt

d. $i_{s,p}(t) = \frac{1}{20\sqrt{5}}\cos(100t - 45^\circ)$

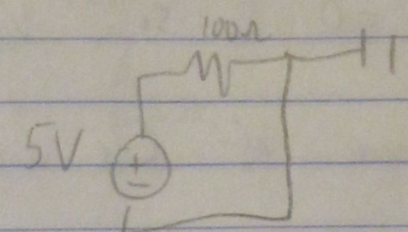
½ pt

e. $i_s(t) = \frac{1}{20\sqrt{2}}\cos(100t - 45^\circ)$

0 pts

f) $i_s(t) = 5V/100\Omega = 50mA$ since inductors are shorts and caps are open

½ pt



½ pt

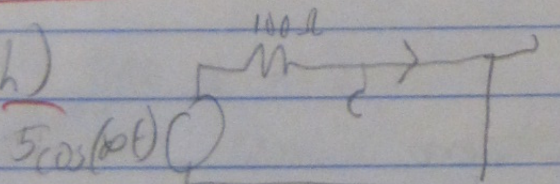
g) Z_C goes to zero (short) as $w \to \infty$

Z_C goes to infinity (open) as $w \to 0$

Z_L goes to infinity (open) as $w \to \infty$

Z_L goes to zero (short) as $w \to 0$

h)



$\lim_{w\to\infty} i_s(t) = \frac{5\cos(wt)}{100}$

Not for a grade

i) Node A: $\frac{V_a - 5\cos(100t)}{100} + \int \frac{V_a}{2H} + 200\mu F(V_a' - V_b') = 0$

Node B: $200\mu F(V_b' - V_a') + 10\mu F\, V_b' + \int \frac{V_b}{1H} - \int \frac{V_c}{1H} = 0$

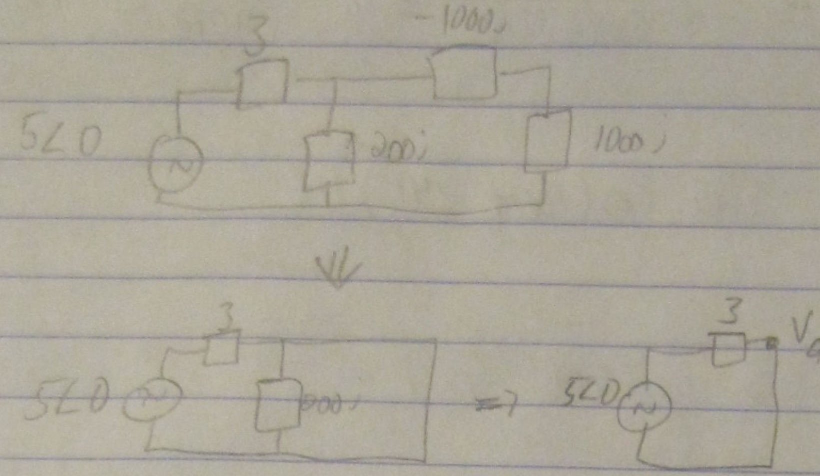
Node c: $\int \frac{V_c}{1H} - \int \frac{V_b}{1H} + \int \frac{V_d \cdot 3}{2H} + 100\mu F \cdot (V_c' - V_d') = 0$

Node d: $(V_d' - V_c')\cdot 100\mu F + V_d' \cdot 100\mu F = 0$

Defining nodes left to right

3 pts.

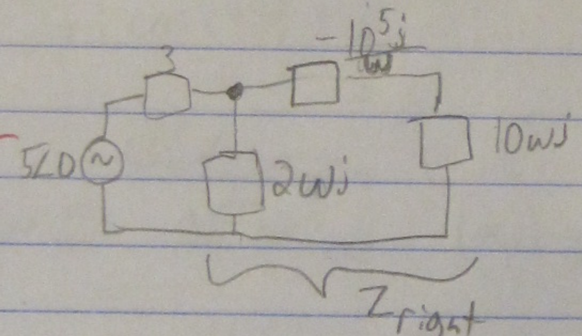
10 a)



$\hat{V}_a = 0$ so $V_a(t) = 0 \cdot \cos(100t + 0) = 0V$.

b. Impedances of Cs and Ls change.

c.



$$\hat{V} = \frac{Z_{right}}{Z_{right} + 3} \cdot 5\angle 0$$

Thus: $\hat{V} = 0$ iff Z_{right} is zero.

$$Z_{right} = \frac{\left(10\omega j - \frac{10^5 j}{\omega}\right) \cdot 2\omega j}{\left(10\omega j - \frac{10^5 j}{\omega} + 2\omega j\right)}$$

Zero iff numerator is zero or denominator is infinite

numerator: $\left(10\omega j - \frac{10^5 j}{\omega}\right) \cdot 2\omega j = 20\omega^2 j - 2 \cdot 10^5 j$,

assuming $\omega \neq 0$ - because I canceled ω / ω

$\omega^2 = \frac{2 \cdot 10^5}{20} = 10000$ $\omega = \pm 100$

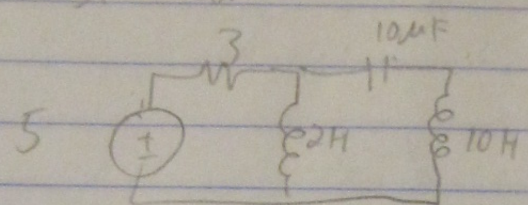
because $5\cos(-100t) = 5\cos(100t)$

$w = -100$ is the same thing as $w = 100$, so I guess that's kind of another w.

Then checking $w = 0$, we have $Z = \frac{0 \cdot \infty}{\infty}$

Could use L'Hôpital's rule, but better way is to abandon phasors since $V(t)$ is no longer AC if $w = 0$.

Thus, we just consider:



In steady state, $V_a(t) = 0V$.

So $w = -100$ and $w = 0$ give same answer

↑ but this one is "same" as $w = 100$.

d. It decays to zero. Increasing R makes it hit steady state faster — not for a grade

No time to write solutions for extra problems. email me* or come to office hours.

* At first, it seemed bizarre to write a personal message on a piece of paper to be read by other people. Then I remembered that all those suckers before us actually did this as a primary form of communication