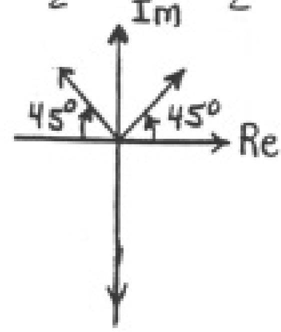
EECS 210 W97
midterm#2 (Winick)

(25 points)
Problem # 1

10 (a) $A\cos(10t+\theta) = 5\cos(10t+45°) + 5\cos(10t+135°) + 10(2)^{1/2}\sin(10t)$
Find A.

A = $5\sqrt{2} = 7.07$

$$A\angle\theta = 5\angle 45° + 5\angle 135° + 10\sqrt{2}\angle -90°$$
$$= \left(\frac{5\sqrt{2}}{2} + j\frac{5\sqrt{2}}{2}\right) + \left(-\frac{5\sqrt{2}}{2} + j\frac{5\sqrt{2}}{2}\right) - 10\sqrt{2}j$$
$$= -5\sqrt{2}j$$



convert to phasor form
& then add phasors.
Find magnitude of resultant phasor.

10 (b)

$$x + jy = \frac{(4.33 + j\,2.5)(1.414 + j\,1.414)(-2.121 + j\,2.121)}{(2.5 - j\,4.33)(3 - j\,5.196)}$$

Find x and y.

$$= \frac{(5\angle 30°)(2\angle 45°)(3\angle 135°)}{(5\angle 300°)(6\angle 300°)} = 1\angle -30°$$
$$= .866 - j.5$$

x = .866   y = -.5

Do computation using polar form.

5 (c) $x+jy = (1+j.176325)^{30}$ Find x and y.

x = 0.7915   y = -1.371

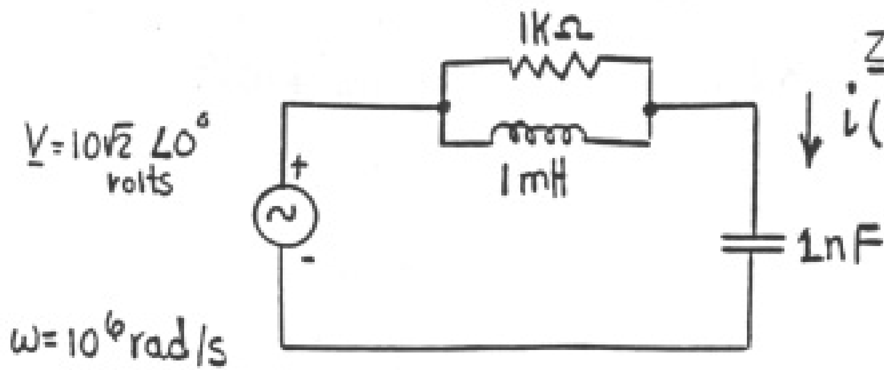
$$z = (1+j.176325)$$
$$= 1.01543\angle 10°$$
$$\therefore z^{30} = (1.01543)^{30}\angle 300°$$
$$= 1.583\angle 300°$$
$$= 0.7915 - j1.371$$

(25 points)

Problem # 2

Consider the following circuit.

$1K\Omega \| 1mH = 500 + j\,500\,\Omega$



$\underline{Z}$ = (1nF) series with $1K\Omega \| 1mH = -j1000 + 500 + j500 = 500 - j\,500\,\Omega$

10 (a) Find i(t).

$\underline{I} = \underline{V}/\underline{Z} = 20\angle 45^\circ$ mA

↑ impedance seen by source

i(t) = $20\cos(10^6 t + 45^\circ)$ mA

10 (b) Find the average power supplied by the voltage source.

P_{av} = 100 mW

$P_{av} = \frac{1}{2}\mathrm{Re}[\underline{V}\,\underline{I}^*]$

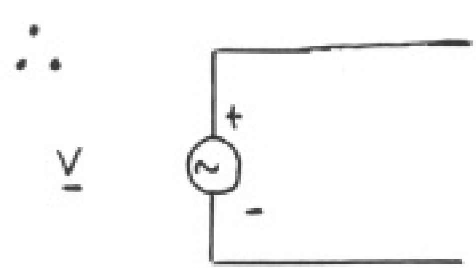
$= \frac{1}{2}(10\sqrt{2}\,V)(20\,mA)\cos(-45^\circ)$

$= 100\,mW$

5 (c) Sketch an equivalent circuit when $\omega \to 0$.

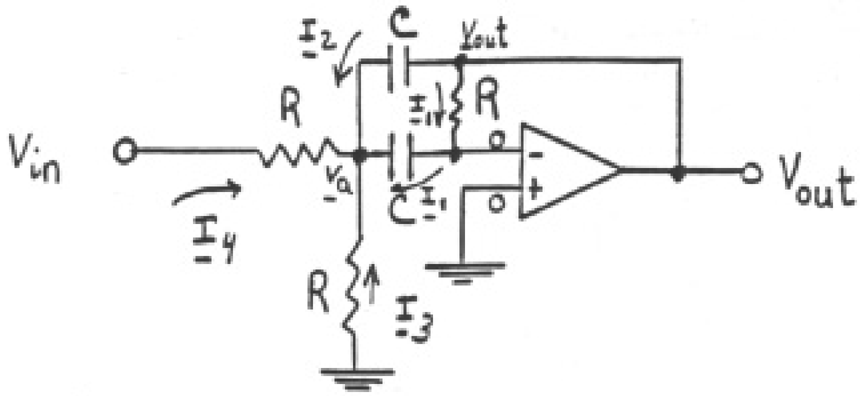
When $\omega \to 0$, capacitor is open & inductor is short

∴



(25 points)
Problem # 3

Consider the Op-Amp circuit shown below.



$V_{in}(t) = \sqrt{5}\cos(10^6 t + \pi/3)$ vo

$R = 1\,\Omega$

$C = 1\,\mu F$

Find $v_{out}(t)$.

$v_{out}(t) =$ $\cos(10^6 t + 266.565°)$ volts

$I_1 = V_{out}/R = V_{out}$ (1)

$V_a = -I_1\left(\frac{1}{j\omega C}\right) = -I_1\left(\frac{1}{j}\right) = jI_1$ (2)

$\therefore$ $V_a = jV_{out}$ (3)

KCL @ node a $\quad I_4 + I_2 + I_1 + I_3 = 0$ (4)

$\therefore \left(V_{in} - V_a\right)/R + \left(V_{out} - V_a\right)j\omega C + V_{out}/R - V_a/R = 0$ (5)

Combine Eqs. (5) & (3)

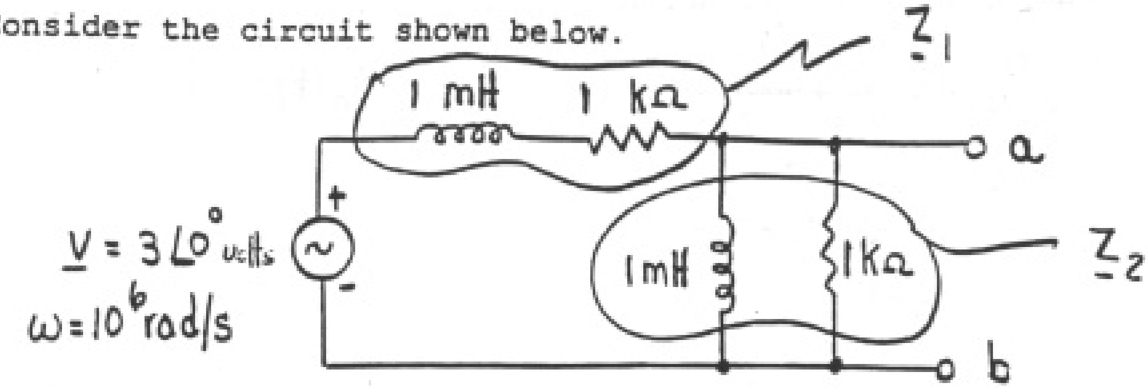
$\left(V_{in} - jV_{out}\right) + j\left(V_{out} - jV_{out}\right) + V_{out} - jV_{out} = 0$ (6)

$\Longrightarrow V_{out} = \frac{1}{-2+j} V_{in} = \left(\frac{1}{\sqrt{5}} \angle 206.565°\right) V_{in}$

$\therefore V_{out}(t) = \cos(10^6 t + 266.565°)$

(25 points)
Problem # 4

Consider the circuit shown below.



10 (a) Find the Thevenin equivalent voltage v_T.

v_T = $1\angle 0°$ volts

$Z_2 = 1\text{mH} \,\|\, 1\text{k}\Omega = 500 + j500 \ \Omega$

Z_1 = 1 mH series 1 kΩ

$= 1000 + j1000$

voltage divider ⇒ $V_{oc} = \frac{Z_2}{Z_1 + Z_2} V = \frac{1}{3} V = 1\angle 0°$

10 (b) Find the Thevenin equivalent impedance Z_T.

Z_T = $1000/3 + j1000/3 \ \Omega$

$= 471.3 \angle 45°$

$Z_T = Z_2 \| Z_1 = \frac{Z_1 Z_2}{Z_1 + Z_2} = \frac{2}{3} Z_2$

(turn-off the independent voltage source) i.e., short circuit it

5 (c) A load impedance Z_L=500+j1500 Ω is connected across terminals a and b. Find the power, P_L, delivered to the load.

P_L = 61.64 μW

$I_L = \frac{V_T}{Z_T + Z_L} = \frac{1}{833.3 + j1833.3}$

$P_L = \frac{1}{2} |I_L|^2 R_L = \frac{1}{2}(2.466 \times 10^{-7})\ 500$