Name:

Honor Code: KEY

Instructions:

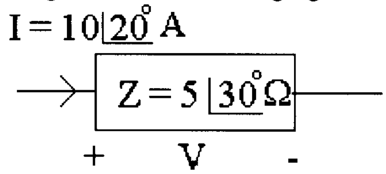
- Complete the 6 problems in the allotted time, and *report your answers in the box provided on this page.*
- Use the space on the accompanying pages to work the problems. Do not use a bluebook. Attach additional worksheets if necessary.
- If you wish to have partial credit awarded for any of your incorrect answers **you must write clearly and legibly.** Explain your work in words, if necessary.
- Don't Panic.

Good Luck.

	Problem	Answer
10	1	i. B vi. D ii. A vii. D iii. C viii. B iv. C ix. B v. D x. A
15	2	Vout = $\frac{R_1}{R_1+R_2}(V_1 - V_2 - V_3)$ Volts
15	3	Vout = $30/29$ V $= 1.0345$ V
25	4	Vout = $(-1.4523 + j\,7.0540)$V $= 7.2020 \angle 101.6337^\circ$ V
25	5	$P_V = -57.9235$ W $P_{1mh} = 0$ W $P_{10\Omega} = 28.343$ W $P_{20\Omega} = 74.9993$ W $P_{2mh} = 0$ W $P_{10uf} = 0$ W $P_{25A} = -45.4247$ W
10	6	R= $1000\ \Omega$ L= .01 H

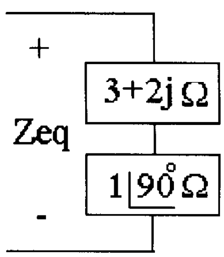
(10 Points) 1. Choose the best answer for each of the 10 multiple choice problems below

i. The voltage, V, in the following figure is:



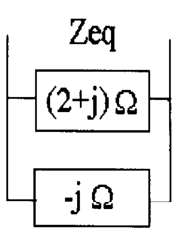
a. $2\angle -10°$ Volts
b. $50\angle 50°$ Volts
c. $5\angle 10°$ Volts
d. $15\angle 50°$ Volts

ii. The equivalent impedance, Zeq, is:



a. (3+3j) Ω
b. (3+j) Ω
c. (3j-2) Ω
d. (2+j) Ω

iii. The equivalent impedance, Zeq, is:



a. 2 Ω
b. –2j Ω
c. (-j+0.5) Ω
d. (2+j) Ω

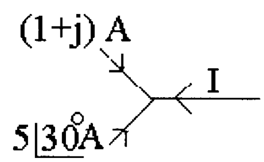
iv. In rectangular form, (1+j)/(2-j) is

a. 3
b. (-0.2-0.6j)
c. (0.2 + 0.6j)
d. (3+j)

v. In polar form, (-1-j) is

a. $1.414\angle 45°$
b. $1\angle -135°$
c. $1\angle 45°$
d. $1.414\angle -135°$

vi. The current, I, in the following figure is:



a. $5\angle 30°$ A
b. $1.41\angle 45°$ A
c. $6.37\angle 33.29°$ A
d. $6.37\angle -146.71°$ A

vii. A certain element has V= 5 Volts and I = (2+3j) Amps. The impedance, Z, must be:

a. (0.4-0.6j) Ω
b. (10 - j15) Ω
c. (0.4 - 0.6j) Ω
d. (.7692 - j1.1538) Ω

viii. The element of vii above consists of a resistor and another component in series. The second component must be:

a. a resistor
b. a capacitor
c. an inductor
d. Cannot be determined.

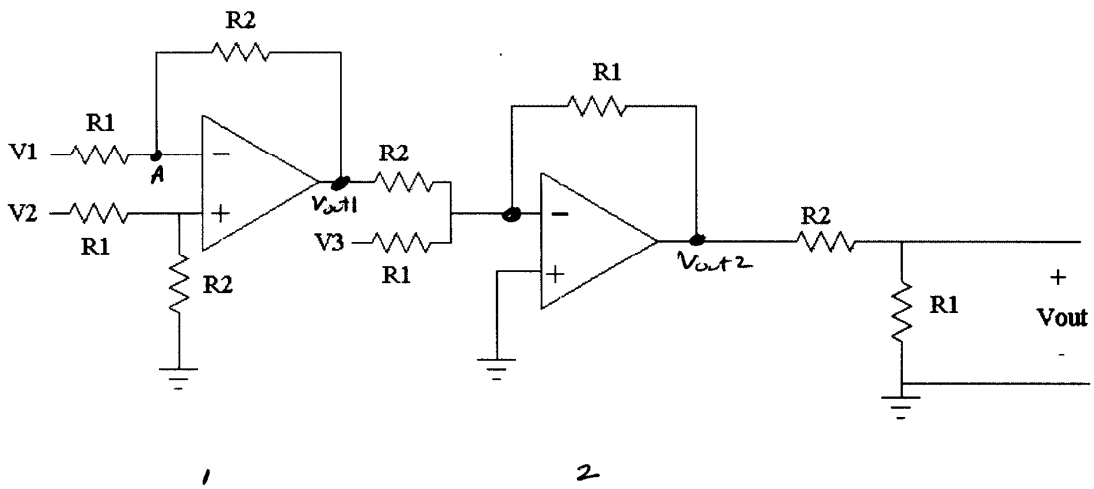
ix. It is possible to construct an impedance of –3Ω using resistors, capacitors, and inductors alone.

a. True
b. False

x. Consider the figure of problem iii. The –jΩ impedance is just a capacitor. If ω=1000 rad/sec, what is the capacitance, C?

a. 1mF
b. 1000F
c. 1uF
d. Cannot be determined.

2. (15 Points) Find Vout as a function of the inputs V1, V2, and V3 in the following circuit.



opamp 1:

$$\frac{A-V_1}{R_1} + \frac{A-V_{out}}{R_2} = 0 \quad \text{or} \quad V_{out1} = A\left(\frac{R_2}{R_1}+1\right) - \frac{R_2}{R_1}V_1$$

$$\frac{A-V_2}{R_1} + \frac{A}{R_2} = 0 \qquad A\left(\frac{1}{R_1}+\frac{1}{R_2}\right) = V_2/R_1$$

$$A = \left(\frac{R_1 R_2}{R_1+R_2}\frac{V_2}{R_1}\right)$$

$$\therefore \quad V_{out1} = \frac{V_2}{R_1}\left(\frac{R_2+R_1}{R_1}\right)\left(\frac{R_1 R_2}{R_1+R_2}\right) - \frac{R_2}{R_1}V_1$$

$$= \frac{R_2 V_2}{R_1} - \frac{R_2}{R_1}V_1 \qquad \underline{V_{out1} = \frac{R_2}{R_1}(V_2 - V_1)}$$

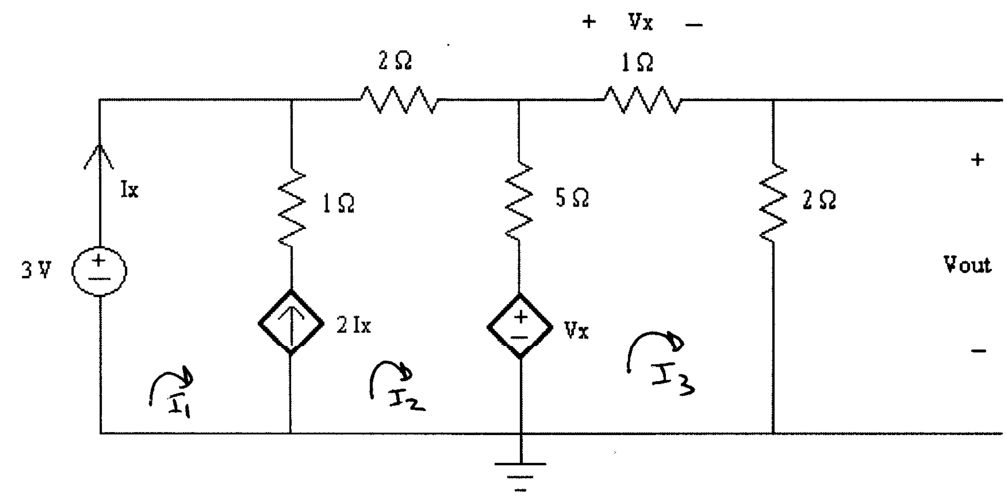
opamp2:

$$\frac{0-V_{out1}}{R_2} + \frac{0-V_3}{R_1} + \frac{0-V_{out2}}{R_1} = 0 \qquad V_{out2} = -V_{out1}\left(\frac{R_1}{R_2}\right) - V_3$$

$$= \underline{V_1 - V_2 - V_3}$$

$$\boxed{V_{out} = \frac{R_1}{R_1+R_2}(V_1 - V_2 - V_3)}$$

3. (15 Points) Find Vout in the following circuit.



loop: $-3 + 2I_2 + 5(I_2 - I_3) + V_x = 0$

$7I_2 - 5I_3 + V_x = 3$ $\qquad\qquad V_x = I_3$

$\underline{7I_2 - 4I_3 = 3}$

$-V_x - 5(I_2 - I_3) + V_x + 2I_3 = 0$

$\underline{-5I_2 + 7I_3 = 0}$

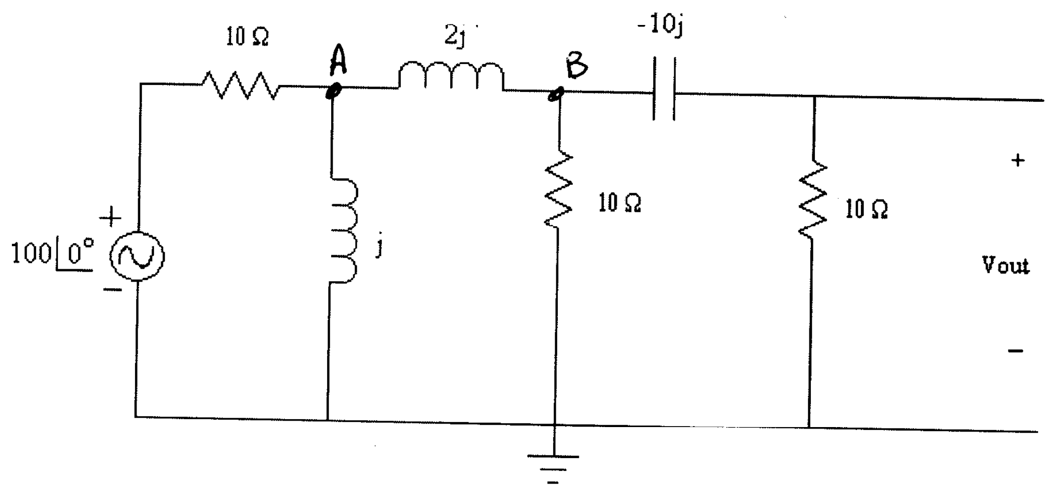
rewrite $\qquad 35I_2 - 20I_3 = \cancel{20}\,15$

$-35I_2 + 49I_3 = 0$

$29I_3 = 15 \qquad I_3 = \frac{15}{29}$

$V_{out} = 2 \times \frac{15}{29} = \boxed{\frac{30}{29} \text{ Volts}}$

4. (25 Points) Find Vout in the following circuit.



$$\rightarrow \frac{A-100}{10} + \frac{A}{j} + \frac{A-B}{2j} = 0 \qquad A\left(\frac{1}{10}+\frac{1}{j}+\frac{1}{2j}\right) - B\left(\frac{1}{2j}\right) = 10$$

$$1: \quad \underline{A(.1 - 1.5j) + B(.5j) = 10}$$

$$\rightarrow \frac{B-A}{2j} + \frac{B}{10} + \frac{B}{10-10j} = 0 \qquad A(.5j) + B\left(\frac{1}{2j} + \frac{1}{10} + \frac{1}{10-10j}\right) = 0$$

$$\frac{1}{10-10j} \times \frac{10+10j}{10+10j} = \frac{10+10j}{200} = \frac{1}{20} + \frac{1}{20}j$$

$$A(.5j) + B(-.5j + .1 + .05 + .05j) = 0$$

$$2: \quad \underline{A(.5j) + B(.15 - .45j) = 0}$$

$$2' \quad A = \frac{B(.45j - .15)}{.5j} = B(.9 + .3j)$$

$$1' \quad B(.9+.3j)(.1-1.5j) + B(.5j) = 10$$

$$B[.09 + .03j - 1.35j + .45 + .5j] = 10$$

(over)

$$B(.54 - 0.82j) = 10$$

$$B = 5.6017 + 8.5062j$$

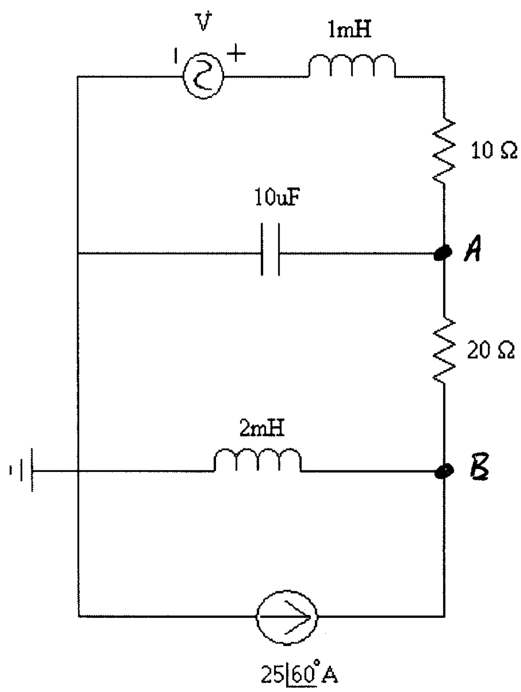
$$V_{out} = B\left(\frac{10}{10-10j}\right) = \frac{56.017 + 85.062j}{200}(10+10j)$$

$$= \frac{56.017 + 85.062j}{20}(1+j)$$

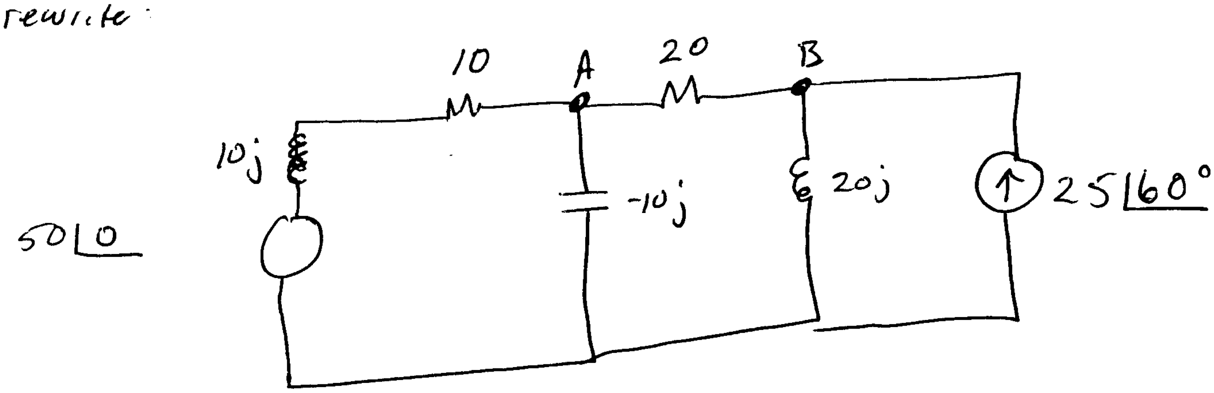
$$= \frac{56.017 + 85.062j + 56.017j - 85.062}{20}$$

$$= (-1.4523 + 7.0540j)\ V$$

5. (25 points) Find the power absorbed/supplied by each of the elements in the following circuit. Show that the powers sum to zero. V = 1 cos (100t+0) Volts.



rewrite:



$$\frac{A-50}{10+10j} + \frac{A}{-10j} + \frac{A-B}{20} = 0 \qquad \frac{B-A}{20} + \frac{B}{20j} = 2.5\angle 60^\circ$$

over.

$$2' \quad A\left(\frac{1}{20}\right) = -25\angle 60^\circ + B\left(\frac{1}{20}+\frac{1}{20j}\right)$$

$$A = B\left(1+\frac{1}{j}\right) - 500\angle 60^\circ$$

$$A = B(1-j) - 500\angle 60^\circ$$

$$1' \quad A\left(\frac{1}{10+10j}\right) + A\left(\frac{-1}{10j}\right) + A\left(\frac{1}{20}\right) - \frac{B}{20} = \frac{50}{10+10j}$$

$$A\left(\frac{1}{10+10j} - \frac{1}{10j} + \frac{1}{20}\right) - \frac{B}{20} = \frac{50}{10+10j}$$

$$A\left(\frac{10-10j}{200} + .1j + .05\right) - \frac{B}{20} = \frac{50(10-10j)}{200}$$

$$A(.1+.05j) - B(.05) = 2.5-2.5j$$

$$B(1-j)(.1+.05j) - B(.05) = 2.5-2.5j + 500\angle 60^\circ(.1+.05j)$$

$$B = 10.359 + 35.9808j = 37.4423\angle 73.9387^\circ$$

$$A = B(1-j) - 50\angle 60^\circ = 21.3397 - j\,17.67951$$

Powers: $CQ: \frac{1}{2} I_m V_m \cos(\theta_v - \theta_z) = -45.4247\,W$

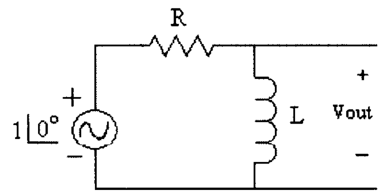
$$I_{20\Omega} = \frac{B-A}{20} = 2.7386\angle 101.5651 \qquad P = \frac{1}{2}\,2.7386^2\,20 = 74.9993W$$

$$I_{10\Omega} = \frac{A-50}{10+10j} = 2.3811\angle 166.6690^\circ \qquad P = \frac{1}{2}\,2.3811^2\,10 = 28.3432W$$

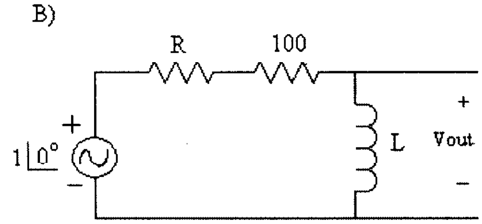
$$I_{VS} = \frac{1}{2} I_m V_m \cos(\theta_v - \theta_z) = \left(\frac{1}{2}\right)(2.3811)(50)\cos(-166.6690^\circ)$$
$$= -57.9235W$$

6. (10 points) Consider the two circuits shown below.

A)



B)



When w=58,000 rad/sec, the output of circuit A is found to be $0.5017\angle 59.8863^\circ$. The output of circuit B at w=58,000 rad/sec is found to be $0.4664\angle 62.1985^\circ$.

Find the values of R and L.

$$V_{out\,A} = \frac{j\omega L}{R + j\omega L}\, 1\angle 0^\circ \qquad \cancel{\angle V_{out\,A} =}$$

$$= \frac{j\omega L\,(R - j\omega L)}{R^2 + \omega^2 L^2} = j\omega L R + \omega^2 L^2$$

$$\Rightarrow \angle V_{out\,A} = \tan^{-1}\left(\frac{\omega L R}{\omega^2 L^2}\right)$$

$$= \tan^{-1}\left(\frac{R}{\omega L}\right)$$

Similarly, $\angle V_{out\,B} = \tan^{-1}\left(\frac{R+100}{\omega L}\right)$

$$\therefore \quad \tan^{-1}\left(\frac{R}{58000\,L}\right) = 59.8863 \qquad \tan^{-1}\left(\frac{R+100}{58000\,L}\right) = 62.1985^\circ$$

$$\Rightarrow R = 1000\,\Omega$$
$$L = .01\ H$$