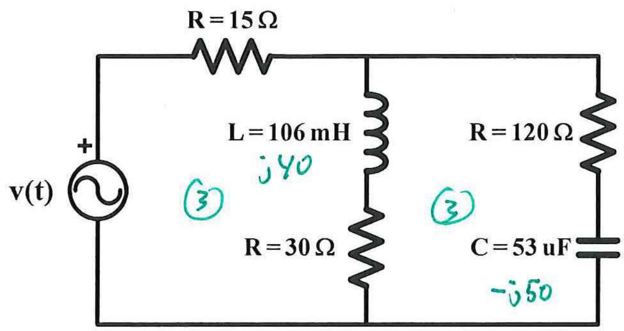
ECET 3000 – Spring 2018

Electrical Principles – Exam II **Print Name (Last Name First):** KEY

Instructions: Show all of your work... No credit will be given for illegible or illogical work, or for final answers that are not justified by the work shown. Place all final answers in the spaces provided. This exam is **closed book,** except for one, 8½"x11" sheet of handwritten notes that may **NOT** contain any numerically-solved problems.

milli ≡ m = 10^{-3} **micro ≡ u = 10^{-6}** **nano ≡ n = 10^{-9}** **pico ≡ p = 10^{-12}**

Problem #1) Given the following AC circuit, determine the equivalent impedance, $\boldsymbol{Z_{eq}}$, of the circuit as seen by the source if the source frequency is **60Hz**.



I.e. – express the loads in terms of their impedance values and then perform series and/or parallel conversions to simplify all of the loads down to a single equivalent impedance.

Express the answer in rectangular form.

(6) $Z_p = (30+j40) \| (120-j50) = 35.7 + j24.4$

$Z_{eq} = 15 + Z_p = \boxed{50.7 + j24.4\ \Omega}$

Z_{eq} = 50.7 + j24.4 Ω (12)

(56.3∡25.7°)

Problem #2) Given the following voltage and current waveforms:

$$v(t) = 150 \cdot \sin(314 \cdot t + 40°) \text{ volts}$$

$$i(t) = 22 \cdot \sin(314 \cdot t + 70°) \text{ amps}$$

a) Determine the **phasor values of the voltage and current** (in polar form). Be sure to express the phasor values in terms of their RMS magnitudes.

b) Determine the **frequency** of the voltage and current waveforms.

c) Determine the **real power, P,** and the **reactive power, Q,** produced by the source.

$\frac{150}{\sqrt{2}} = 106$ $\frac{22}{\sqrt{2}} = 15.56$ $\frac{314}{2\pi} = 50$

$S = \tilde{V}\tilde{I}^* = (106∡40)(15.56∡-70)$

$= 1428 - j825$

(5) $\tilde{V}$ = 106∡40° V

$\tilde{I}$ = 15.56∡70° A

(2) f = 50 Hz

(5) P = 1428 W

Q = -825 VARs (12)

1) 12 2) 12 3) 14 4) 16 5) 12 6) 14 7) 20

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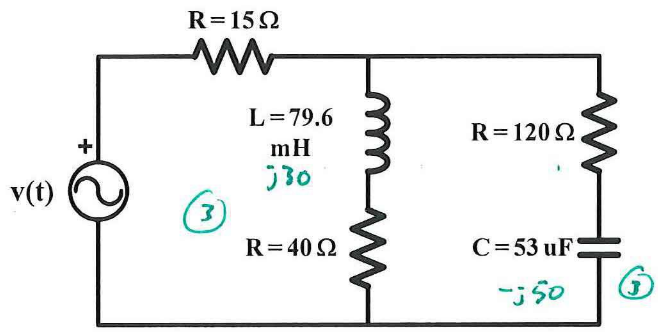
milli ≡ m = 10^{-3} **micro ≡ u = 10^{-6}** **nano ≡ n = 10^{-9}** **pico ≡ p = 10^{-12}**

Problem #1) Given the following AC circuit, determine the equivalent impedance, Z_{eq}, of the circuit as seen by the source if the source frequency is **60Hz.**



I.e. – express the loads in terms of their impedance values and then perform series and/or parallel conversions to simplify all of the loads down to a single equivalent impedance.

Express the answer in rectangular form.

6 $Z_P = (40+j30)\|(120-j50) = 37.5+j14.7$

$Z_{eq} = 15 + Z_P = 52.5 + j14.7\ \Omega$

$Z_{eq} =$ 52.5 + j14.7 (54.5∡15.6°) Ω 12

Problem #2) Given the following voltage and current waveforms:

$$v(t) = 150 \cdot \sin(314 \cdot t + 40°) \text{ volts}$$
$$i(t) = 24 \cdot \sin(314 \cdot t + 70°) \text{ amps}$$

a) Determine the **phasor values of the voltage and current** (in polar form). Be sure to express the phasor values in terms of their RMS magnitudes.
b) Determine the **frequency** of the voltage and current waveforms.
c) Determine the **real power**, **P**, and the **reactive power**, **Q**, produced by the source.

$\frac{150}{\sqrt{2}} = 106$ $\frac{24}{\sqrt{2}} = 17$ $\frac{314}{2\pi} = 50$

$S = (106∡40)(17∡-70) = 1560 - j901$

5/ 3/ $\tilde{V} =$ 106∡40° V

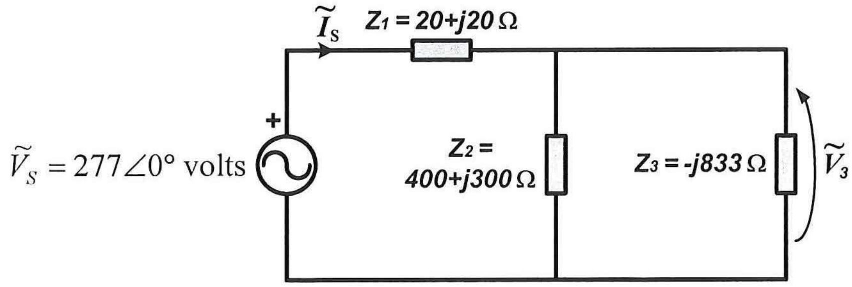
2/ $\tilde{I} =$ 17∡70° A

2/ $f =$ 50 Hz

5/ $P =$ 1560 W

$Q =$ -901 VARs 12

Problem #3) Given the following AC circuit, determine the **source current**, $\tilde{I}_S$, and the **load voltage**, $\tilde{V}_3$, across impedance Z_3, both expressed in phasor form.



(6) $Z_2 \| Z_3 = \left(\frac{1}{400+j300} + \frac{1}{-j833}\right) = (0.0016)^{-1} = 625\,\Omega$

$Z_{eq} = Z_1 + Z_2 \| Z_3 = (20+j20) + (625) = 645+j20$

(4) $\tilde{I}_S = \frac{\tilde{V}_S}{Z_{eq}} = \frac{277\angle 0}{645+j20} = 0.429\angle -1.78°$ amps

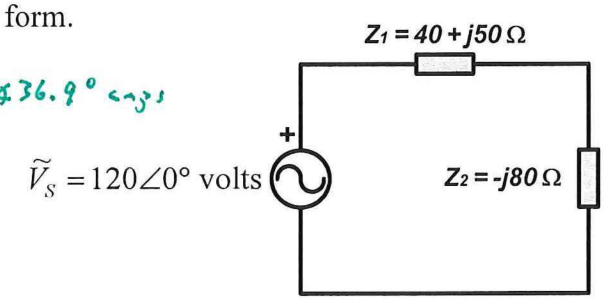
(4) $\tilde{V}_3 = \tilde{I}_S \cdot (Z_2 \| Z_3) = (0.429\angle -1.78)(625) = 268.3\angle -1.78°$ volts

or $\tilde{V}_3 = \tilde{V}_S \left(\frac{Z_2\|Z_3}{Z_{eq}}\right) = 277\angle 0° \left(\frac{625}{645+j20}\right) =$ same

$\tilde{I}_S =$ $0.429\angle -1.78°$ A

$\tilde{V}_3 =$ $268.3\angle -1.78°$ V (14)

Problem #3) Given the following AC circuit, determine the **complex power**, S_{source}, produced by the source and the **complex powers**, S_1 and S_2, consumed by the load impedances Z_1 and Z_2 respectively, all expressed in rectangular form.



(4) $\tilde{I} = \frac{120\angle 0}{(40+j50)+(-j80)} = \frac{120\angle 0}{(40-j30)} = 2.4\angle 36.9°$ amps

(4) $\tilde{V}_1 = \tilde{I} \cdot Z_1 = 153.7\angle 88.2°$ volts

$\tilde{V}_2 = \tilde{I} \cdot Z_2 = 192\angle -53.13°$ volts

(8) $S_{source} = \tilde{V}_S \cdot \tilde{I}^* = 230 - j173$

$S_1 = \tilde{V}_1 \tilde{I}^* = 230 + j288$

$S_2 = \tilde{V}_2 \tilde{I}^* = 0 - j461$

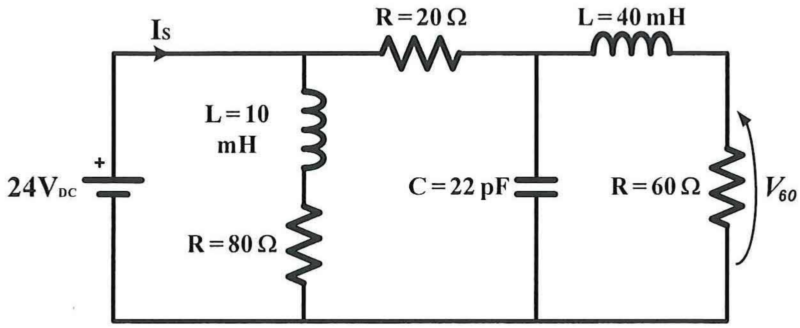
NOT $\tilde{I}^*$ ~~461~~ -511 ~~461~~

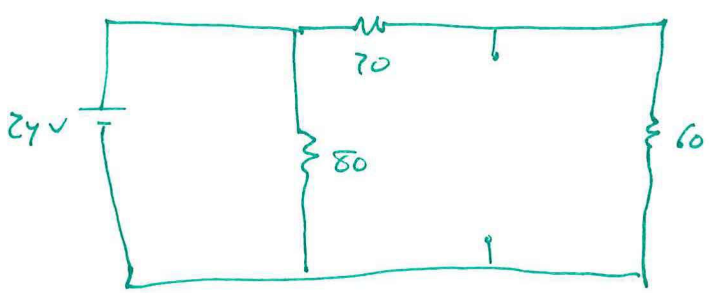
$S_{source} =$ $230 - j173$

$S_1 =$ $230 + j288$

$S_2 =$ $0 - j461$ (16)

Problem #4) Given the **DC steady-state circuit**, determine the **source current**, I_S, and the voltage, V_{60}, across the 60Ω resistor.





$R_{eq} = 80 // (20+60) = \left(\frac{1}{80} + \frac{1}{80}\right)^{-1} = 40\Omega$

$I_s = \frac{24}{40} = 0.6\,A$

$V_{60} = 24\left(\frac{60}{20+60}\right) = 18\,V$

τ_{ckt} (4) I_s (2)

R_{eq} (3) V_{60} (1)

I_S = 0.6 A

V_{60} = 18 V

Problem 5) Specify whether each of the statements are **TRUE** or **FALSE**.

TRUE — Given a circuit containing both an AC voltage source and an ~~capacitor~~ inductor, the **magnitude** of the impedance of the ~~inductor~~ [illegible] will increase if the frequency of the source is increased.

FALSE — The **current** flowing in an inductor will be proportional to the rate of change (derivative) of the voltage across the inductor.

FALSE — The **magnitude** of the impedance of a specific capacitor will be greater when it is connected to a 60Hz voltage source compared to when it is connected to a 50Hz source.

FALSE — When analyzing a DC circuit under steady-state conditions, a **capacitor** can be replaced by an "open circuit" because there will be no ~~voltage~~ (current through) across the capacitor.

TRUE — Given an AC voltage and current relating to a "complex" load impedance, the **phase angle** of the current must be within 90° of the phase angle of the voltage.

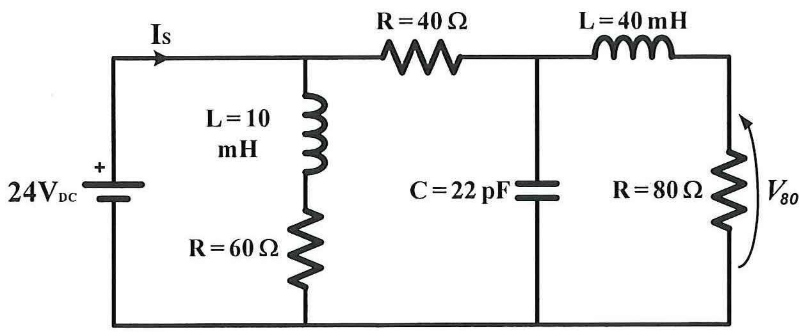
TRUE — When connected to an AC voltage source, the **power** consumed by a resistor (as a function of time) fluctuates at a frequency that is twice (2x) the frequency of the applied voltage.

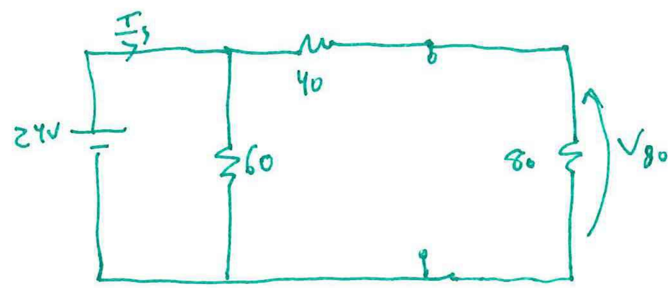
TRUE — When supplied by an AC source, the **real power** consumed by a purely inductive load will always be zero.

Do Not Write Below This Line

1) 12 2) 12 3) 14 4) 16 5) 12 6) 14 7) 20 **Total)**______ **/100**

Problem #4) Given the **DC steady-state circuit**, determine the **source current**, I_S, and the voltage, V_{80}, across the 80Ω resistor.





$R_{eq} = 60 \| (40+80) = \left(\frac{1}{60} + \frac{1}{120}\right)^{-1} = 40\,\Omega$

$I_S = \frac{24\,V}{40\,\Omega} = 0.6\,A$

$V_{80} = 24\left(\frac{80}{80+40}\right) = 16\,V$

cct (4) I_s (2)

R_{eq} (3) V_{80} (3)

$I_S =$ 0.6 A

$V_{80} =$ 16 V

Problem 5) Specify whether each of the statements are **TRUE** or **FALSE**.

TRUE Given a circuit containing both an AC voltage source and an capacitor, the **magnitude** of the impedance of the inductor will increase if the frequency of the source is increased.

FALSE The **magnitude** of the impedance of a specific capacitor will be greater when it is connected to a 60Hz voltage source compared to when it is connected to a 50Hz source.

TRUE When connected to an AC voltage source, the **power** consumed by a resistor (as a function of time) fluctuates at a frequency that is twice (2x) the frequency of the applied voltage.

TRUE When supplied by an AC source, the **real power** consumed by a purely inductive load will always be zero.

FALSE The **current** flowing in an inductor will be proportional to the rate of change (derivative) of the voltage across the inductor.

FALSE When analyzing a DC circuit under steady-state conditions, a **capacitor** can be replaced by an "open circuit" because there will be no voltage across the capacitor.

TRUE Given an AC voltage and current relating to a "complex" load impedance, the **phase angle** of the current must be within 90° of the phase angle of the voltage.

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1)_____ 2)_____ 3)_____ 4)_____ 5)_____ 6)_____ Total)_______ /100

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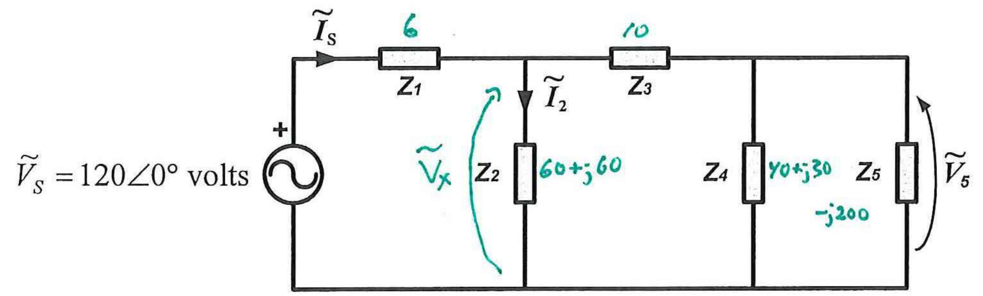
Problem #7) Determine the **source current**, $\tilde{I}_S$, the **current**, $\tilde{I}_2$, flowing through load impedance Z_2, and the **voltage**, $\tilde{V}_5$, across load impedance Z_5 using the ***Reduce and Return Method***.

Also, determine the **complex power**, S_{source}, produced by the source and the **real power**, P_2, consumed by load impedance Z_2.



$Z_1 = 6\,\Omega$

$Z_2 = 60 + j60\,\Omega$

$Z_3 = 10\,\Omega$

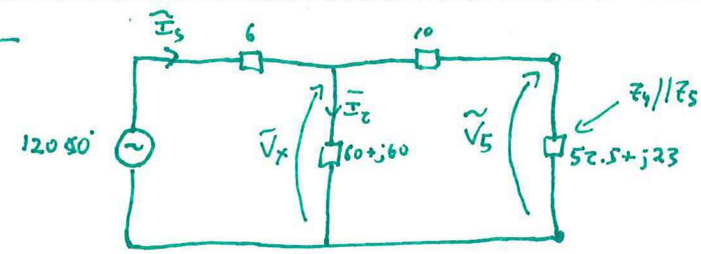
$Z_4 = 40 + j30\,\Omega$

$Z_5 = -j200\,\Omega$

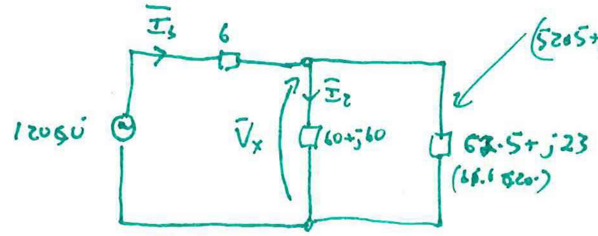
You must show work utilizing the Reduce and Return Method to receive credit for this problem.

Each time that you "reduce" the circuit, completely draw the reduced circuit and fully label all relevant circuit parameters.

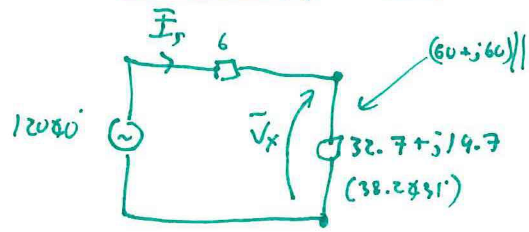
(6)



$Z_4 \| Z_5 = \left(\frac{1}{40+j30} + \frac{1}{-j200}\right)^{-1} = 52.5 + j23.0\,\Omega$



$(52.5+j23) + 10$



$(60+j60) \| (62.5+j23) = 32.7 + j19.7$

$\tilde{I}_2 = \frac{\tilde{V}_x}{60+j60} = 1.243\angle -40.9°$ A

$S_2 = \tilde{V}_2 \tilde{I}_2^* = (105.5\angle 4.1°)(1.243\angle +40.9°)$

$= 92.7 + j92.7$

$P_2 = 92.7$ W

$\tilde{V}_5 = \tilde{V}_x \left(\frac{52.5+j23}{10+52.5+j23}\right) = 90.8\angle 7.54°$ volts

$\tilde{I}_s = \frac{120\angle 0}{6+(32.7+j19.7)} = 2.76\angle -27°$ A

$\tilde{V}_x = \tilde{I}_s(32.7+j19.7)$

$= 105.5\angle 4.1°$ volts $(= \tilde{V}_2)$

$S_{source} = \tilde{V}_s \tilde{I}_s^*$

$= (120\angle 0)(2.76\angle +27°)$

$= 296 + j150$

(2) $\tilde{I}_S =$ $2.76\angle -27°$ (−0.47 rad) (2.46 − j1.25) A

(3) $\tilde{I}_2 =$ $1.243\angle -40.9°$ (−0.714 rad) (0.94 − j0.81) A

(4) $\tilde{V}_5 =$ $90.8\angle 7.54°$ (0.131 rad) (90 + j11.9) V

(3) $S_{source} =$ $296 + j150$ (331∠26.9)

(3) $P_2 =$ 92.7 W