# CARLETON UNIVERSITY

FINAL
**EXAMINATION**
December 2019

DURATION 3 HOURS — No. of Students 460

Department Name & Course Number: Electronics ELEC 2501 A,B,C
Course Instructor(s): Prof. John W. M. Rogers and Pavan Gunupundi

| AUTHORIZED MEMORANDA | Calculators Only |
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**Students MUST count the number of pages in this examination question paper before beginning to write and report any discrepancy immediately to a proctor. This question paper has 12 pages.**

**This examination question paper** MAY **be taken from the examination room.**

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Information and Instructions:

1. **READ** the questions carefully.
2. Attempt all questions.
3. The exam marks total 25.
4. You MUST right your exam version # on the scan sheet. This version 1.

## Formulas that might be useful:

$\omega = 2\pi f,\ T = \frac{1}{f},\quad \sqrt{\frac{1}{T_2-T_1}\int_{T_1}^{T_2}(f(t))^2 dt}\ ,\ i(t) = \frac{dq(t)}{dt}\quad ,\quad v = \frac{dw}{dq}, p(t) = v(t)\cdot i(t),\ \ v = iR,$

$\sum_{j=1}^{N} i_j(t) = 0,\ \sum_{j=1}^{N} v_j(t) = 0\ ,\ \frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_N},\ R_S = R_1 + R_2 + \cdots + R_N$

$R_a = \frac{R_1R_2}{R_1+R_2+R_3} R_b = \frac{R_2R_3}{R_1+R_2+R_3} R_c = \frac{R_1R_3}{R_1+R_2+R_3}$

$R_1 = \frac{R_aR_b+R_bR_c+R_cR_a}{R_b} R_2 = \frac{R_aR_b+R_bR_c+R_cR_a}{R_c}\ R_3 = \frac{R_aR_b+R_bR_c+R_cR_a}{R_a}$

$C = \frac{\epsilon\cdot A}{d}, i = C\frac{dv}{dt}, E(t) = \frac{1}{2}Cv^2(t), \frac{1}{C_S} = \sum_{i=1}^{N}\frac{1}{C_i} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots + \frac{1}{C_N}, C_P = \sum_{i=1}^{N} C_i$

$v(t) = L\frac{di(t)}{dt}, E(t) = \frac{1}{2}Li^2(t), L_S = \sum_{i=1}^{N} L_i, \frac{1}{L_P} = \sum_{i=1}^{N}\frac{1}{L_i} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \cdots + \frac{1}{L_N}$

$x(t) = K_1 + K_2 e^{\frac{-t}{\tau}}\ , \tau = RC, \tau = \frac{L}{R}$

$Z = R, Z = j\omega L, Z = \frac{1}{j\omega C}, Z_S = Z_1 + Z_2 + \cdots + Z_N, \frac{1}{Z_P} = \frac{1}{Z_1} + \frac{1}{Z_2} + \cdots + \frac{1}{Z_N}, Y = \frac{1}{Z},$

$Y_P = Y_1 + Y_2 + \cdots + Y_N,\quad \frac{1}{Y_S} = \frac{1}{Y_1} + \frac{1}{Y_2} + \cdots + \frac{1}{Y_N}$

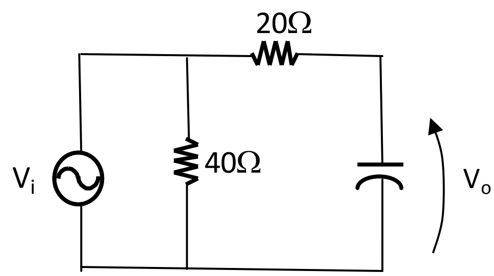
$\omega_o = \frac{1}{\sqrt{LC}}\ , Q = \frac{\omega_o L}{R} = \frac{1}{\omega_o CR} = \frac{1}{R}\sqrt{\frac{L}{C}}\ , \omega_{LO} = \omega_o\left[\frac{-1}{2Q} + \sqrt{\left(\frac{1}{2Q}\right)^2 + 1}\right] \omega_{HI} = \omega_o\left[\frac{1}{2Q} + \sqrt{\left(\frac{1}{2Q}\right)^2 + 1}\right]$

$BW = \omega_{HI} - \omega_{LO} = \frac{\omega_o}{Q}, \omega_{HI}\cdot\omega_{LO} = {\omega_o}^2, Q = 2\pi\frac{\omega_S}{\omega_D},\ \omega_r = \sqrt{\frac{1}{LC} - \left(\frac{R}{L}\right)^2}$

$P = \frac{V_M I_M}{2}\cos(\theta_v - \theta_i) = V_{RMS}I_{RMS}\cos(\theta_v - \theta_i),\ PF = \cos(\theta_v - \theta_i) = \cos(\theta_{Z_L}) = \cos(-\theta_{Z_L}),$

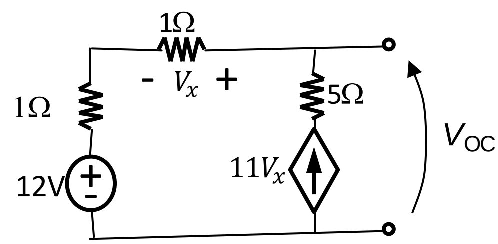
$S = V_{RMS}{I_{RMS}}^*\ ,\ \frac{i_1}{i_2} = \frac{v_2}{v_1} = \frac{N_2}{N_1}\ , Z_p = \left(\frac{N_p}{N_s}\right)^2 Z_s$

1) What is the value of the impedance of the capacitor at the corner frequency in the following circuit?



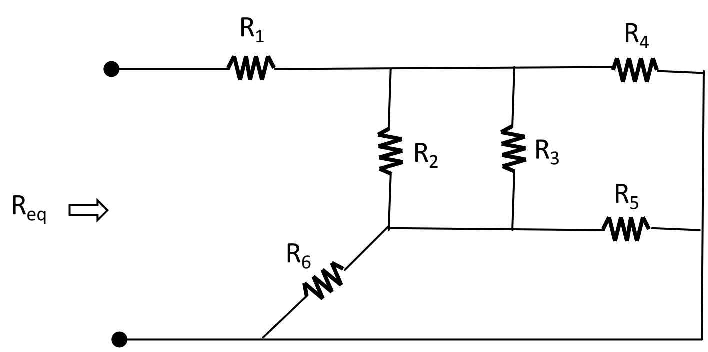

(a) -60j
(b) -20j
(c) -13.3j
(d) -40j
(e) It is impossible to determine without the value of the capacitor.

2) What is the thevenin resistance of the following circuit?



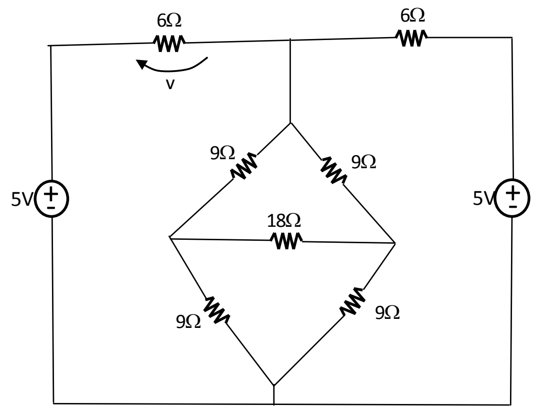

(a) -0.2Ω
(b) 2.0Ω
(c) 0.2 Ω
(d) 1.43 Ω
(e) None of these answers is correct.

3) Find $R_{eq}$:




(a) $R_{eq} = R_1 + [(R_2//R_3+R_4//R_5//R_6)]$
(b) $R_{eq} = R_1 + [(R_2//R_3//R_4+R_5//R_6)]$
(c) $R_{eq} = R_1 + R_4//[(R_2//R_3+R_5//R_6)]$
(d) $R_{eq} = R_1//R_4//[(R_2//R_3+R_5//R_6)]$
(e) None of these answers is correct.

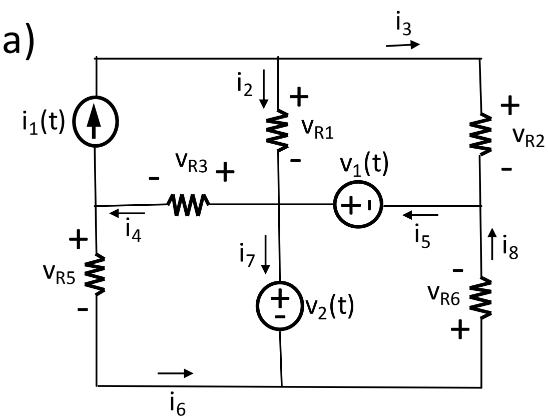
4) Find v:



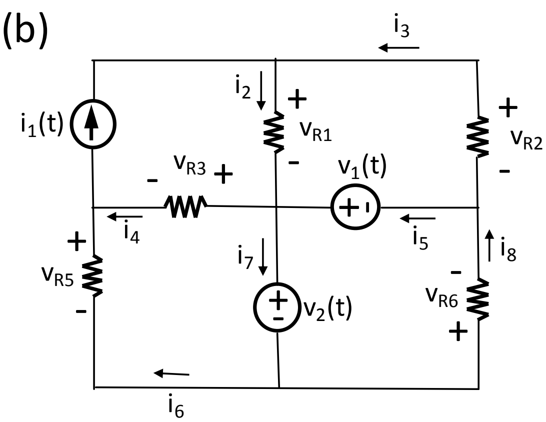

(a) 2.25V
(b) 2.5V
(c) 3.75V
(d) 1.25V
(e) None of these answers is correct.

5) A student in ELEC 2501 has labeled a circuit voltages and currents four different ways. Which way will yield a correct answer (assuming all subsequent analysis is performed correctly?)

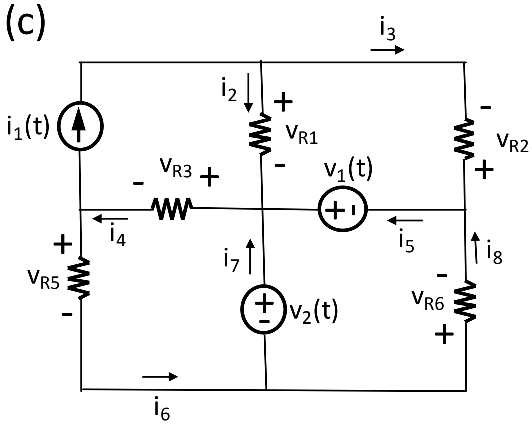
(a)



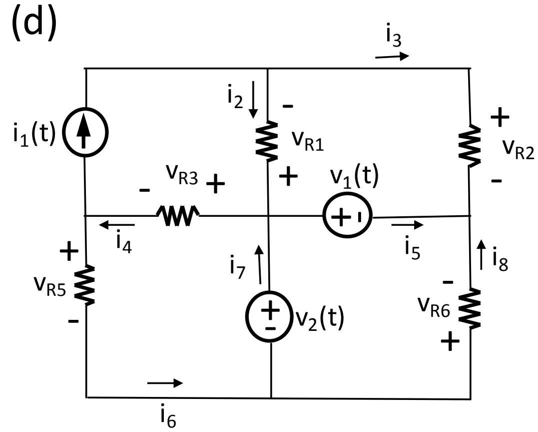

(b)




(c)

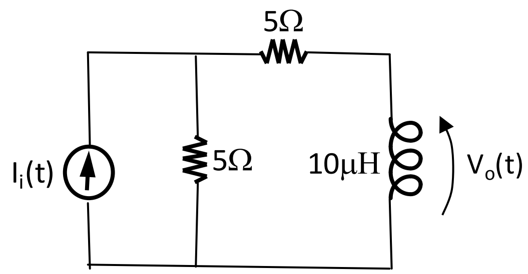


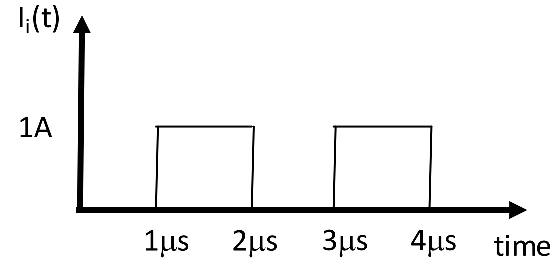

(d)




(e) Any of the above labeling schemes will work.

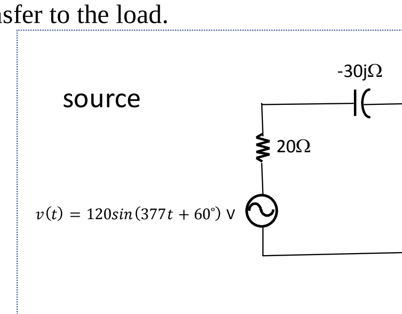
6) Below is shown a circuit and a time dependent current. What is the maximum instantaneous value of $V_o(t)$?

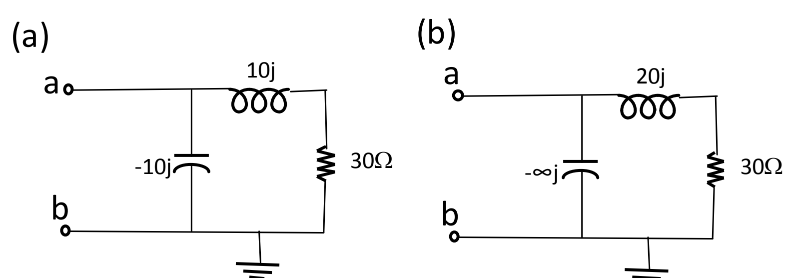


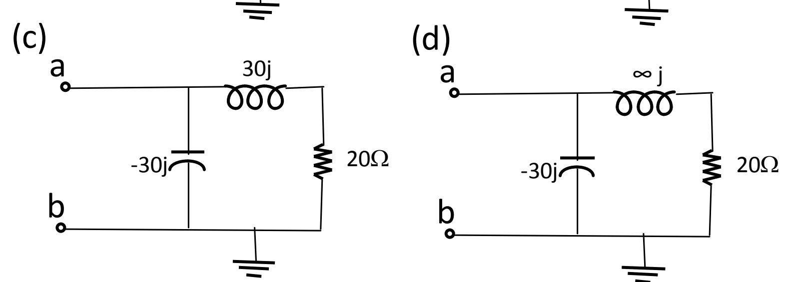




(a) 2.5V
(b) 0V
(c) 2.718V
(d) 5V
(e) None of these answers is correct.

7) Below is a drawing of a source. Draw a load circuit that can be attached between points a and b that will maximize the power transfer to the load.

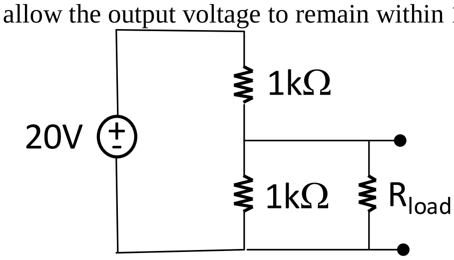


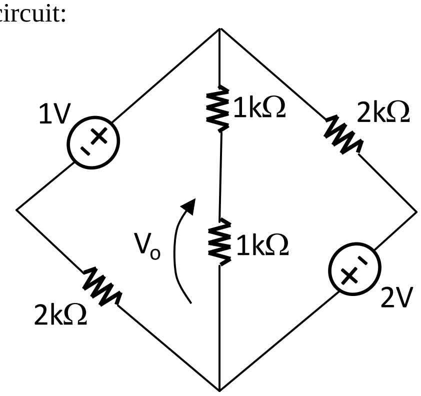

(e) None of these are correct.

8) The following circuit has been designed to provide a specific voltage to a load resistor $R_{Load}$. What range of values for $R_{Load}$ will allow the output voltage to remain within 10% of the desired value?



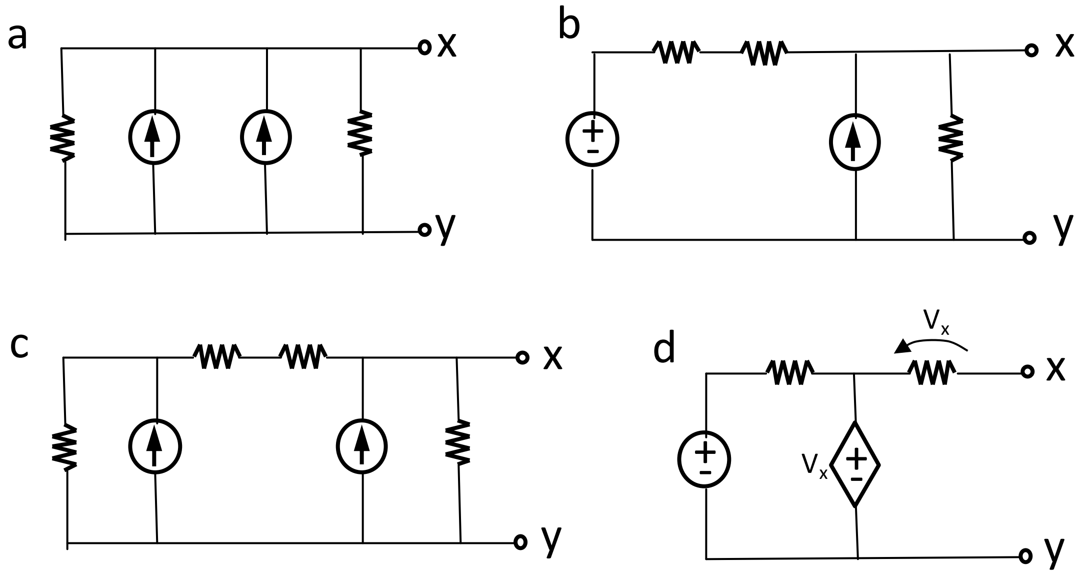

(a) $R_{load} \leq 1k\Omega$
(b) $R_{load} \geq 1k\Omega$
(c) $R_{load} \geq 4.5k\Omega$
(d) $R_{load} \geq 3.546k\Omega$
(e) None of these answers is correct.

9) Find $V_o$ in the following circuit:



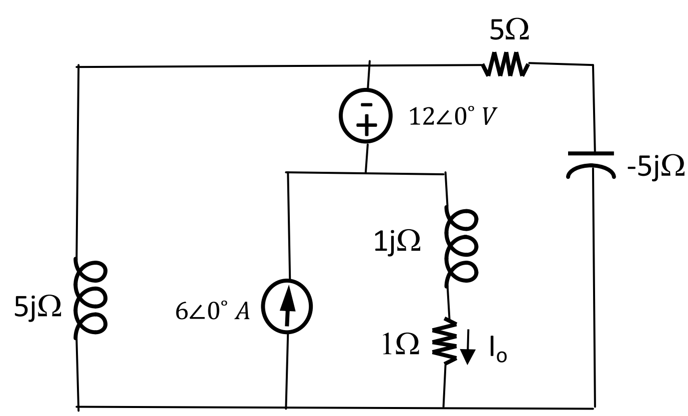

(a) -167mV
(b) 342mV
(c) -542mV
(d) 735mV
(e) None of these are correct.

10) Assuming that any values can be chosen for components not already specified which of the following circuits cannot be made equivalent to the others looking into terminals x and y?




(e) They can all be made equivalent.

For the following circuit:




11) Find the fraction of $I_o$ which is due to the voltage source.
(a) $1.414\angle 45°$
(b) $2.3\angle 0°$
(c) $1.543\angle 22.9°$
(d) $1.414\angle -45°$
(e) None of the answers is correct.

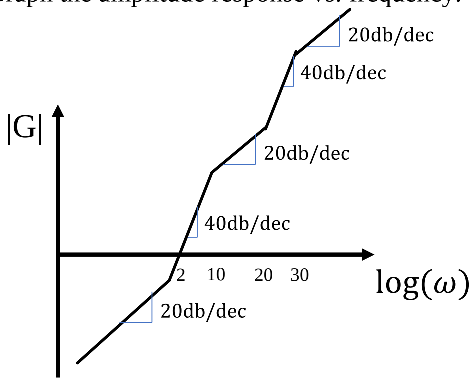
12) Find the fraction of $I_o$ which is due to the current source.
(a) $1.414\angle 78°$
(b) $5\angle 0°$
(c) $3.45\angle 26.3°$
(d) $1.56\angle -33.6°$
(e) None of the answers is correct.

For the following transfer function:

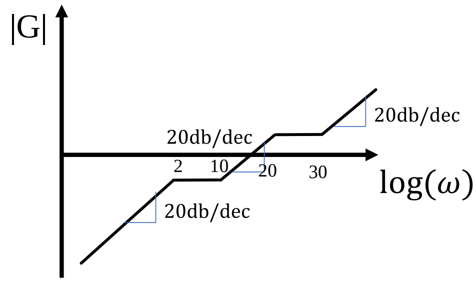
$$G(j\omega) = \frac{j\omega\left(1 + j\frac{\omega}{2}\right)\left(1 + j\frac{\omega}{20}\right)}{\left(1 + j\frac{\omega}{10}\right)\left(1 + j\frac{\omega}{30}\right)}$$

13) Graph the amplitude response vs. frequency.

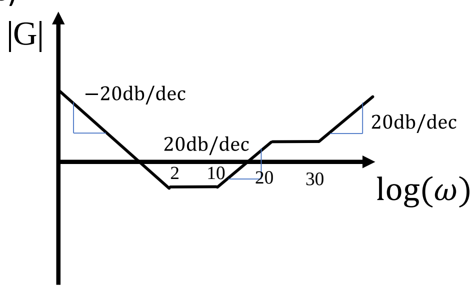
(a)



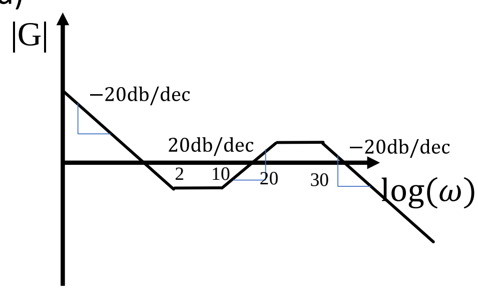

(b)




(c)



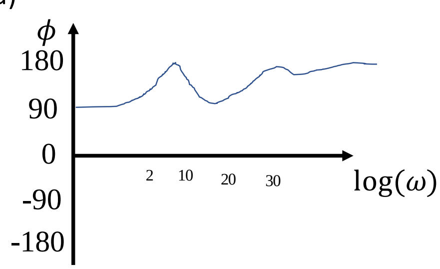

(d)



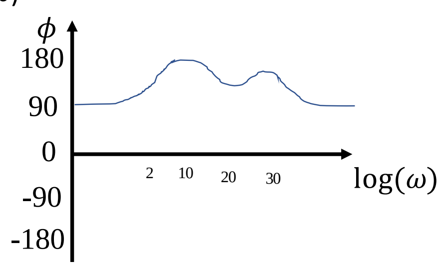

(e) None of these graphs are correct.

14) Graph the phase response vs. frequency.

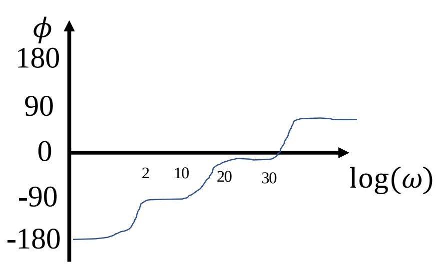
(a)



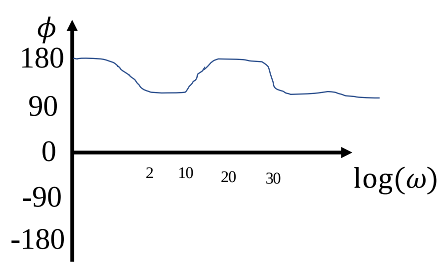

(b)



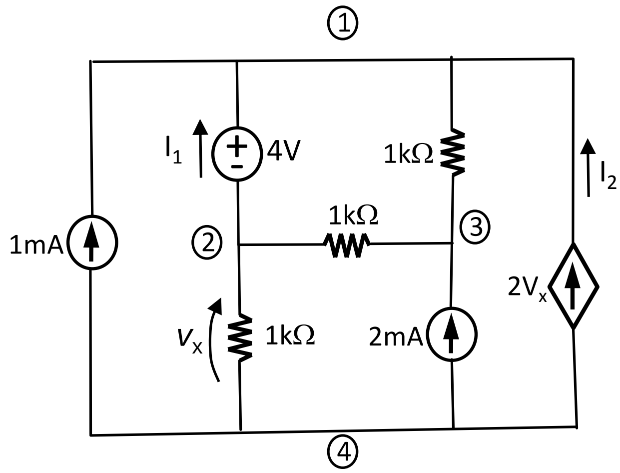

(c)




(d)



15) For the following circuit:




Write a set of equations sufficient to find all voltages and currents in the circuit.

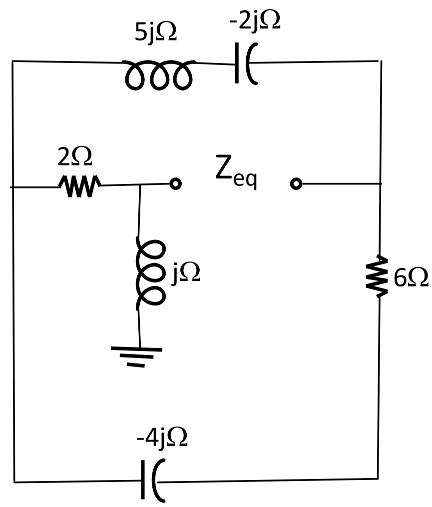
(a) $V_4 = 0$
$1mA + I_1 + 2V_2 + (V_3 - V_1)/1k = 0$
$V_2/1k + (V_2 - V_3)/1k + I_1 = 0$
$4V - (V_1 - V_3) + (V_2 - V_3) = 0$

(b) $V_x = V_2$
$V_4 = 0$
$1mA + I_1 + 2V_2 + (V_3 - V_1)/1k = 0$
$V_2/1k + (V_2 - V_3)/1k + I_1 = 0$
$(V_3 - V_2)/1k - 2mA + (V_3 - V_1)/1k = 0$
$3mA + 2V_2 - V_2/1k = 0$

(c) $V_x = V_2$
$V_4 = 0$
$1mA + I_1 + 2V_2 + (V_3 - V_1)/1k = 0$
$V_2/1k + (V_2 - V_3)/1k + I_1 = 0$
$(V_3 - V_2)/1k - 2mA + (V_3 - V_1)/1k = 0$

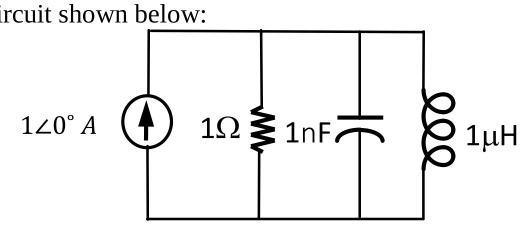
(d) $V_x = V_2$
$V_4 = 0$
$1mA + I_1 - 2V_2 + (V_3 - V_1)/1k = 0$
$V_2/1k - (V_2 - V_3)/1k + I_1 = 0$
$(V_3 - V_2)/1k - 2mA + (V_3 - V_1)/1k = 0$

16) Find $Z_{eq}$ for the following circuit:




(a) 1.56 – 0.56j
(b) 3.46 + 3.24j
(c) 4.52 + 0.56j
(d) 3.56 -0.94j
(e) None of the answers is correct.

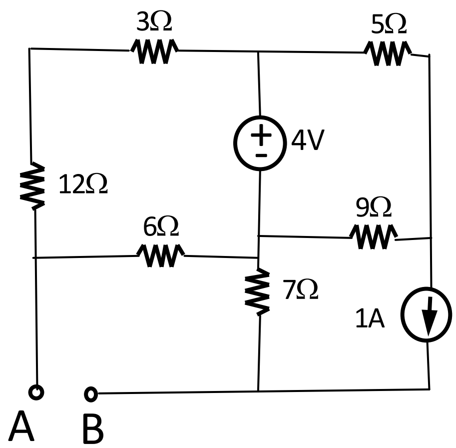
For the circuit shown below:

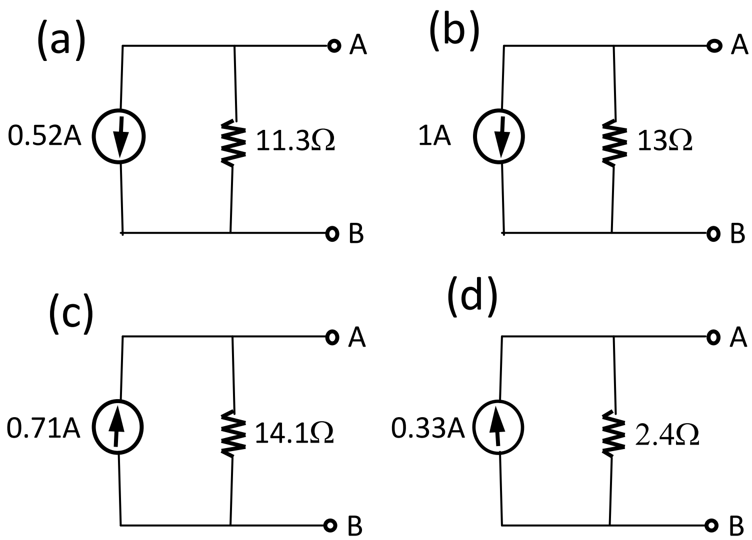



17) What is the center frequency in Hz?
(a) 31.6MHz
(b) 5.03MHz
(c) 4.32MHz
(d) 3.62kHz
(e) None of these answers is correct.

18) What is the voltage across the capacitor at the center frequency?
(a) $1.414\angle 180°$
(b) $3.67\angle 0°$
(c) $2.55\angle 25.2°$
(d) $1.00\angle 0°$
(e) None of the answers is correct.

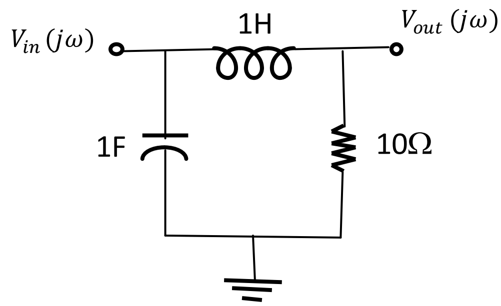
19) For the circuit shown below, find the Norton equivalent source between nodes A and B:




(e) None of these circuits is correct.

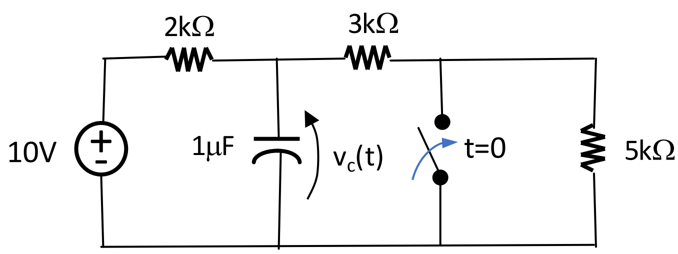
For the following circuit:




20) Derive the gain as a function of frequency:
  (a) $\frac{V_{out}(j\omega)}{V_{in}(j\omega)} = \frac{j\omega}{1+j\omega}$
  (b) $\frac{V_{out}(j\omega)}{V_{in}(j\omega)} = \frac{1}{1+j\omega}$
  (c) $\frac{V_{out}(j\omega)}{V_{in}(j\omega)} = \frac{1}{1+\frac{j\omega}{10}}$
  (d) $\frac{V_{out}(j\omega)}{V_{in}(j\omega)} = \frac{j\omega-\frac{1}{j\omega}}{1+j}$
  (e) None of the equations is correct.

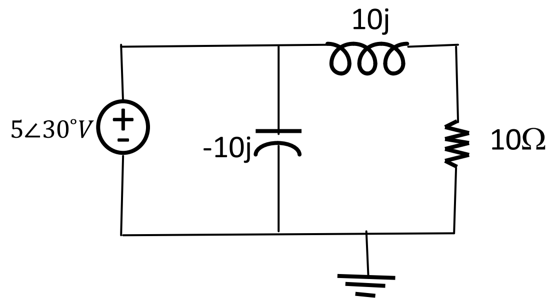
21) Is this circuit a:
  (a) Lowpass filter?
  (b) Highpass filter?
  (c) Bandpass filter?
  (d) Bandstop filter?
  (e) It is not a filter.

22) For the circuit shown below, find $v_c(5ms)$.



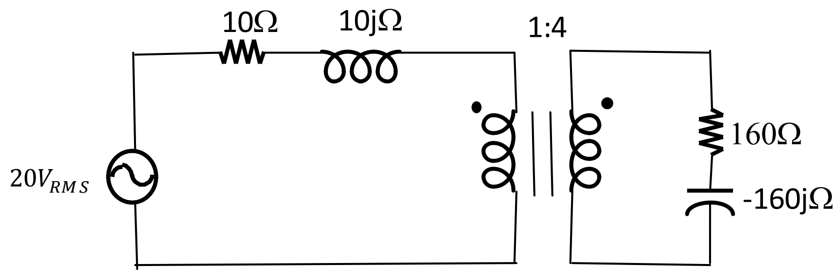

  (a) 4.7V
  (b) 7.2V
  (c) 3.9V
  (d) 6.7V
  (e) None are correct.

23) Find the power supplied to the resistor in the following circuit:




(a) 0.625W
(b) 1.25W
(c) 0W
(d) 0.35W
(e) None is correct.

24) What is the RMS current in the following circuit?




(a) 1.35∠240°
(b) 1∠0°
(c) 1.65∠35.2°
(d) 3.25∠40°
(e) None of the answers is correct.

25) We often prefer to use RMS as opposed to average values for time varying waveforms when computing power because
a) RMS is harder to calculate and thus justifies higher engineering salaries.
b) The average power can be used just as easily as RMS.
c) Average values cannot be used because they are always zero for any time varying waveform.
d) The RMS value is proportional to the amplitude of the waveform while the average value is not.
e) None of the above is true.