



UNIVERSITY OF MINES AND TECHNOLOGY, TARKWA

SECOND SEMESTER EXAMINATIONS, APRIL/MAY 2019

COURSE NO: CE, EL 162

COURSE NAME: CIRCUIT THEORY

CLASS: CE/EL I

TIME: 3 HOURS

Name: _____ Index Number: _____

SECTION A

Attempt all questions in this section. For each question, write the letter corresponding to the correct answer in your answer sheet provided.

The switches in the circuit shown in **Figure 1** are initially closed for a long time before opening simultaneously at $t = 0$.

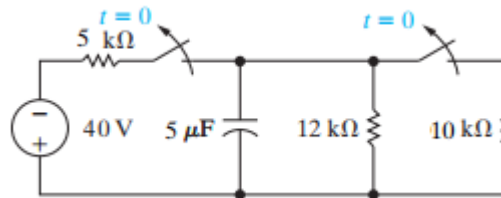


Figure 1 Circuit Diagram for Questions 1 and 2

Using the above information, determine the correctness or otherwise of the following Assertions [A] and the Reasons [R] provided.

1. **Assertion [A]:** The voltage across the capacitor just before the switches operate ($t = 0^-$) is the same as just after they operate ($t = 0^+$).

Reason [R]: Current through a capacitor cannot change instantaneously.

- A. Both [A] and [R] are true and [R] is the correct reason for [A]
- B. Both [A] and [R] are true but [R] is not the correct reason for [A]
- C. [A] is true but [R] is false
- D. Both [A] and [R] are false

2. **Assertion [A]:** A long time after the switches operate ($t = +\infty$) the voltage across the capacitor will be zero

Reason [R]: Voltage across a capacitor cannot change instantaneously.

- A. Both [A] and [R] are true and [R] is the correct reason for [A]
- B. Both [A] and [R] are true but [R] is not the correct reason for [A]
- C. [A] is true but [R] is false
- D. Both [A] and [R] are false

The switch in the circuit shown in **Figure 2** has been in position *a* for a long time. At $t = 0$ the switch moves to position *b*. Use this information to answer Questions 3 to 5.

3. Find the initial voltage drop across the capacitor $v_c(0)$ at time $t \leq 0$
 - A. 20 V
 - B. 15 V
 - C. 12 V
 - D. 0 V
4. Determine the final voltage on the capacitor $v_c(\infty)$ at $t = \infty$
 - A. 0 V
 - B. 20 V
 - C. 40 V
 - D. 50 V
5. The time constant τ of the circuit will be
 - A. 1 ms
 - B. 2 ms
 - C. 3 ms
 - D. 4 ms

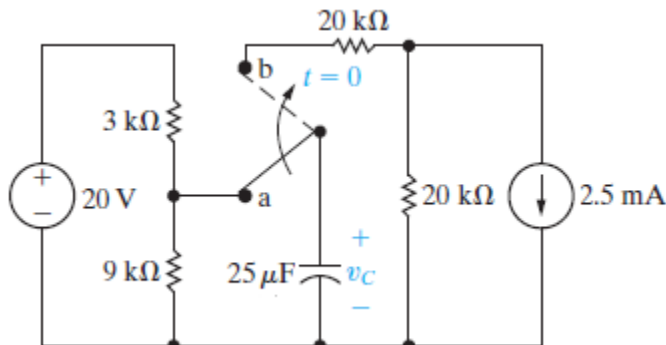


Figure 2 Circuit Diagram for Questions 3 through 5

6. For the circuit shown in Figure 3 (a), find the Norton's equivalent impedance Z_N external to the terminals a and b .
 - A. $Z_N = 18.11 \Omega \angle 6^\circ$
 - B. $Z_N = 10.00 \Omega \angle 0^\circ$
 - C. $Z_N = 4.55 \Omega \angle 8^\circ$
 - D. $Z_N = 5.00 \Omega \angle 0^\circ$

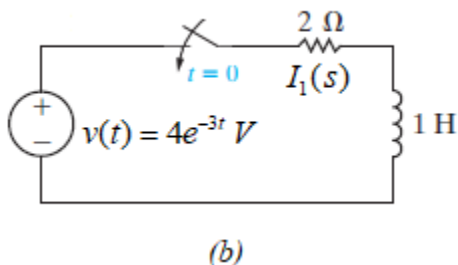
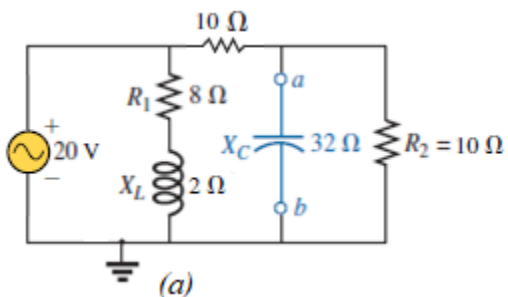


Figure 3 Circuit for (a) Questions 6 and 7 (b) Question 8

7. For the circuit shown in Figure 3 (a), find the Norton's equivalent current I_N external to the terminals a and b .
 - A. $I_N = 2.00 \text{ A} \angle 0^\circ$
 - B. $I_N = 4.80 \text{ A} \angle 24^\circ$
 - C. $I_N = 12.50 \text{ A} \angle 0^\circ$
 - D. $I_N = 16.00 \text{ A} \angle 42^\circ$
8. For the circuit of Figure 3 (b), determine the Laplace transform representation of the current $i_1(s)$ when is close at $t = 0$ [Assume initial current in the inductor is 0].
 - A. $I_1(s) = \frac{4}{(s-2)(s-3)}$
 - B. $I_1(s) = \frac{4}{(s+2)(s+3)}$
 - C. $I_1(s) = \frac{3}{(s+2)(s-2)}$
 - D. $I_1(s) = \frac{3}{(s-2)(s+4)}$

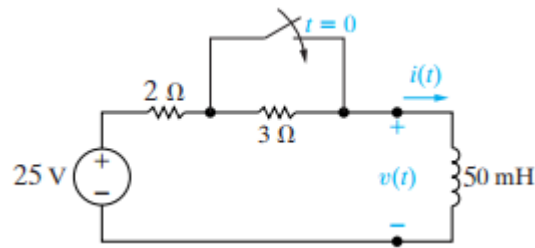


Figure 4 Circuit Diagram for Questions 16 to 18

19. The Fourier transform of the impedance of an 80 mH inductor connected across a 50 Hz source is
 A. $j25.15 \Omega$ B. $j4.0 \Omega$ C. $-j50.0 \Omega$ D. 64.3Ω
20. A current is given as $-j20e^{-j30^\circ}$ A, this current can equally be expressed as
 A. $-20e^{-j30^\circ}$ C. $20e^{j60^\circ}$
 B. $20e^{-j120^\circ}$ D. $-50e^{j60^\circ}$
21. Source transformation of the voltage source of Figure 5 (a) yields a current source _____ in parallel with Z .
 A. $I = 0.3125 \text{ mA} \angle -60^\circ$ C. $I = 80 \text{ mA} \angle -60^\circ$
 B. $I = 0.3125 \text{ mA} \angle 60^\circ$ D. $I = 3.2 \text{ mA} \angle 30^\circ$

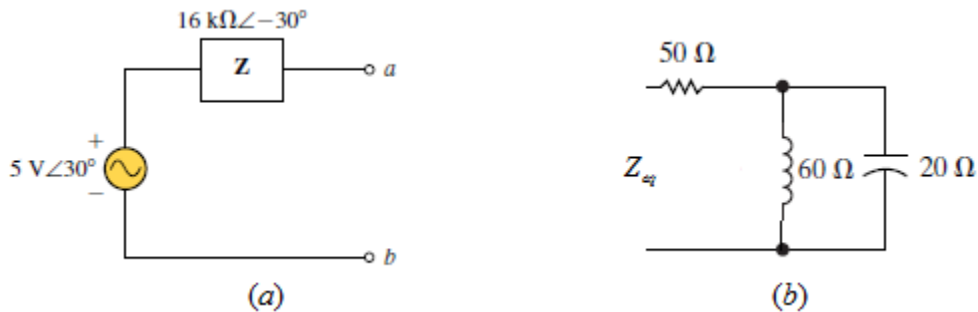


Figure 5 Circuit for (a) Question 21 and (b) Question 22

22. Determine in Ohms, the equivalent impedance Z_{eq} of the circuit in Figure 5 (b)
 A. 65 B. $50 - j30$ C. $50 + j30$ D. $j65$
23. The current $I = 20 \text{ A} \angle 30^\circ$ is equivalent to
 A. $17.32 + j10 \text{ V}$ C. 35 V
 B. $20 + j15 \text{ V}$ D. 5 V
24. A circuit has a transfer function $H(\omega) = \frac{8}{1 + j4\omega}$. Its inverse Fourier transform is
 A. $8e^{-t}$ C. $2e^{-\frac{1}{2}t}$
 B. $8e^{-0.25t}$ D. $2e^{-0.25t}$
25. An alternating sinusoidal current has RMS value of 20 mA and a frequency of 50 Hz. This current can be expressed as

- A. $20\sin 50t$ mA
 B. $28.28\sin 314.16t$ mA
 C. $50\sin 20t$ mA
 D. $28.28\sin 50t$ mA
26. As the supply frequency increases, the impedance of a capacitor _____
 A. Decreases
 B. Increases
 C. Fluctuates
 D. Remains the same
27. A voltage controlled current source gives out constant _____ whose value is determined by _____ elsewhere.
 A. Current, current
 B. Voltage, voltage
 C. Voltage, current
 D. Current, voltage
28. The node voltage method is based on
 A. Kirchoff's voltage law
 B. Kirchoff's current law
 C. Ohm's law
 D. Millman's theorem
29. A resistor and an inductor are connected in series across a voltage source. As the frequency of the voltage source increases, the _____ increases while the _____ decreases
 A. Total impedance, Resistance of the resistor
 B. Total impedance, current
 C. Inductance of the inductor, Resistance of the resistor
 D. Inductance of the inductor, Total impedance
30. In a purely resistive circuit, current
 A. Lags behind the voltage by 90°
 B. Leads the voltage by 90°
 C. Can lead or lag the voltage by 90°
 D. Is in phase with the voltage
31. The AC voltage rating of an electrical appliance is 100 V. This number represents _____ value
 A. Average
 B. RMS
 C. Peak
 D. Median
32. The capacitive reactance of a capacitor is given as 10Ω . Its impedance in complex representation is
 A. 10Ω
 B. $-j 0.1 \Omega$
 C. $-j10 \Omega$
 D. $j10 \Omega$
33. Given $I = j(5 - j12)$ A, find the corresponding $i(t)$ in sinusoidal form.
 A. $i(t) = 13\cos(\omega t + 22.62^\circ)$ A
 B. $i(t) = 13\cos(\omega t - 22.62^\circ)$ A
 C. $i(t) = 13\cos(\omega t + 67.38^\circ)$ A
 D. $i(t) = 13\cos(\omega t - 67.38^\circ)$ A
34. The complex number $I + j$ is equivalent to
 A. $\sqrt{2}e^{j45}$
 B. $\sqrt{2}e^{j0}$
 C. $1e^{j45}$
 D. 1
35. Any branch of an electrical circuit has the same _____ along its length
 A. Voltage
 B. Current
 C. Resistance
 D. Admittance
36. When two or more circuit elements are connected in series
 A. the currents flowing through them are the same
 B. the voltages across them are the same
 C. the powers dissipated in them are the same

D. the energies stored in them are the same

37. Kirchhoff's Current Law (KCL) can be stated as

- A. The sum of the currents flowing into any node is zero
- B. The sum of the currents flowing around any closed loop is zero
- C. The sum of the currents through all elements equals the sum of the voltages across the elements
- D. The current through an element is proportional to the voltage across the element

38. The relationship between the phasor voltage V , the phasor current I and the impedance Z is

- A. $I = ZV$
- B. $Z = VI^*$
- C. $Z = V + I$
- D. $V = ZI$

39. The impedance of a resistor R at angular frequency ω is

- A. $Z = jR$
- B. $Z = j\omega R$
- C. $Z = R$
- D. $Z = 1/R$

40. "In any network containing more than one source of e.m.f., the current in any branch is the algebraic sum of a number of individual currents, each of which is due to each source of e.m.f. acting alone when the remaining sources of e.m.f. are replaced by short circuits"

The above statement is associated with

- A. Thevenin's theorem
- B. Norton's theorem
- C. Superposition theorem
- D. None of the above

SECTION B

Attempt **ONLY TWO** questions in this section. Each question carries equal marks. Answer the questions in your answer booklet.

PART I

Methods of AC Circuit Analysis and Network Theorems

Question 1 (20 marks)

- Find the Norton's equivalent circuit for the network external to terminals *a* and *b* in Figure 6(a). [10 Marks]
- Use your solution in 1a) to determine the current flowing through the $10\ \Omega$ resistor. [3 Marks]
- Determine the voltage across the $5\ \text{k}\Omega$ resistor in figure 6 (b). [7 Marks]

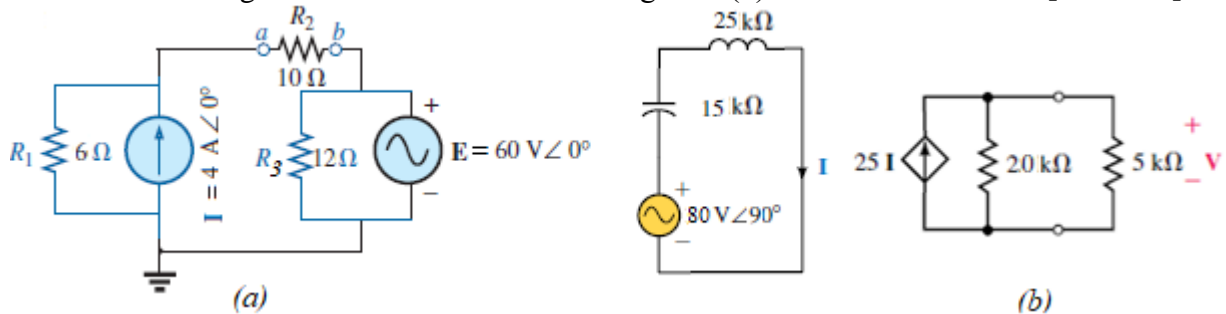


Figure 6 Circuit for (a) Problem 1a) and b); (b) Circuit for Problem 1 c)

PART II

First Order Circuits

Question 2 (20 marks)

The two switches shown in the circuit in Figure 7 operate simultaneously. Prior to $t = 0$ each switch has been in its indicated position for a long time. At $t = 0$ the two switches move instantaneously to their new positions. Find

- $i_o(0)$, the initial current flowing through the inductor for $t \leq 0$ [5 Marks]
- $i_o(t)$, the expression for the inductor's current for $t \geq 0$ [5 Marks]
- $v_{R(2)}(t)$, the expression for voltage across the $20\ \text{k}\Omega$ resistor for $t \geq 0$ [5 Marks]
- The value of the current through the inductor after 2 ms [5 Marks]

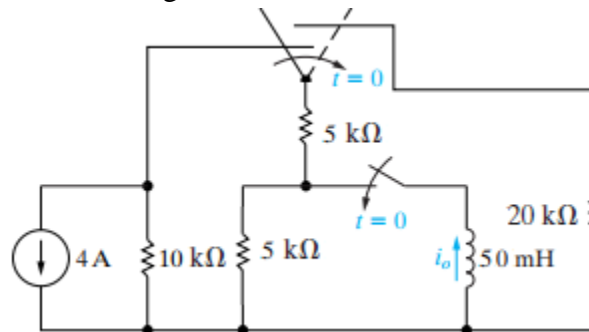


Figure 7 Circuit Diagram for Question 2

PART III
Laplace Transform, Fourier Transform and Circuit Analysis

[Tables of Laplace and Fourier Transforms will be provided on request]

Question 3 (20 marks)

The switch in the circuit shown in Figure 8 has been in position *a* for a long time. At $t = 0$, the switch moves to position *b*.

- a) Using the Laplace transform approach, write the expression for the capacitor's voltage $v_o(t)$ for time $t \geq 0$. **[10 Marks]**
- b) Using the solution in 3(a) above, determine the current $i_o(t)$ flowing through the capacitor for any time $t \geq 0$. **[3 Marks]**

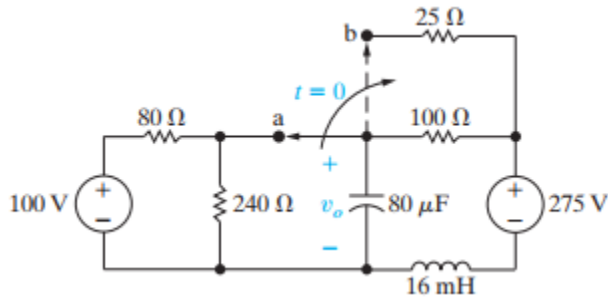


Figure 8 Circuit Diagram for Questions 3 (a) and (b)

- c) Using the Fourier transform, write the frequency domain expression for each of the loops indicated in Figure 13 given that $i_s(t) = 4e^{-t}u(t)$ V. **[7 Marks]**

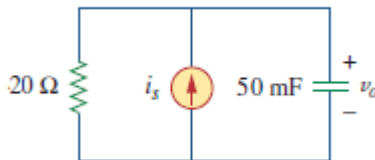


Figure 9 Circuit Diagram for Questions 3 (c)