THE UNIVERSITY OF QUEENSLAND

School of Information Technology and Electrical Engineering

Mid-Semester Examination

ENGG1300

Introduction to Electrical Systems

Time: **TEN (10)** minutes for perusal
NINETY (90) minutes for working

THIS EXAM CONSISTS OF THIRTY (30) MULTIPLE CHOICE QUESTIONS. ANSWER EACH QUESTION ON THE MULTIPLE CHOICE ANSWER SHEET PROVIDED.

During perusal, you are permitted to write on the rough paper provided.

This examination is closed book – No materials permitted.

No electronic aids are permitted (e.g. laptops, phones).

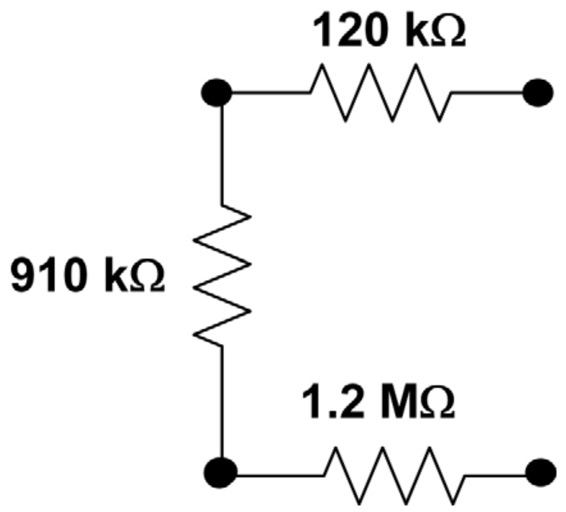
A UQ approved calculator (with label), or a casio FX-82 series calculator is allowed.

For each question, choose the one answer which is most correct.

Where "none of the above" is the correct answer option, the associated numerical answer will be different to any of the provided numerical answers by at least +/-5%.

Question 1.

Consider the one-port network shown below:

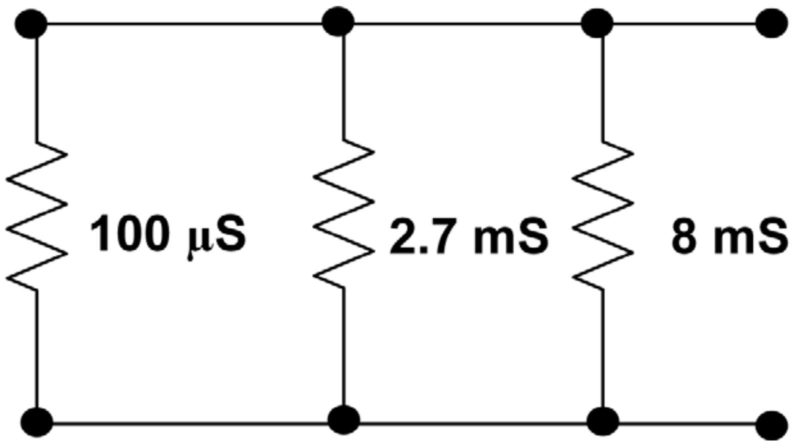


What is the equivalent resistance of this network?

A. 1031.2 kΩ
B. 2.230 MΩ
C. 97.41 kΩ
D. 373.4 Ω
E. None of the above.

Question 2.

Consider the one-port network shown below.
Note that the resistor values are shown as conductances.

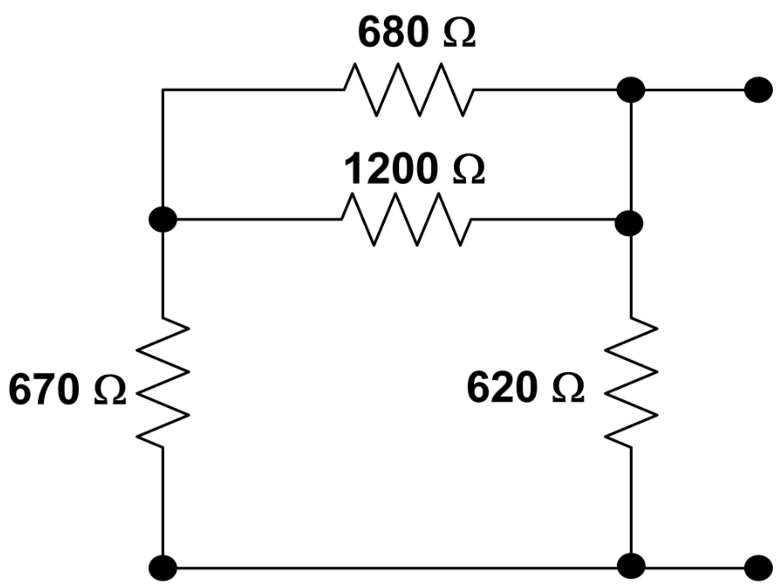


What is the equivalent resistance of this network?

A. 95.30 μΩ
B. 10.80 mΩ
C. 92.59 Ω
D. 92.59 mΩ
E. None of the above.

Question 3.

Consider the one-port network shown below.



What is the equivalent resistance of this network?

A. 397.0 Ω
B. 3170.0 Ω
C. 465.4 Ω
D. 184.7 Ω
E. None of the above.

Question 4.

Which of the following is a unit of inductance?

A. Ohms
B. Siemens
C. Amperes
D. Farads
E. None of the above

Questions (5)−(15) all refer to solution of the circuit below in Figure 1. First solve this circuit, and then check your working to make sure it is correct before answering the subsequent questions.

In all cases be very careful about the sign of the answers.

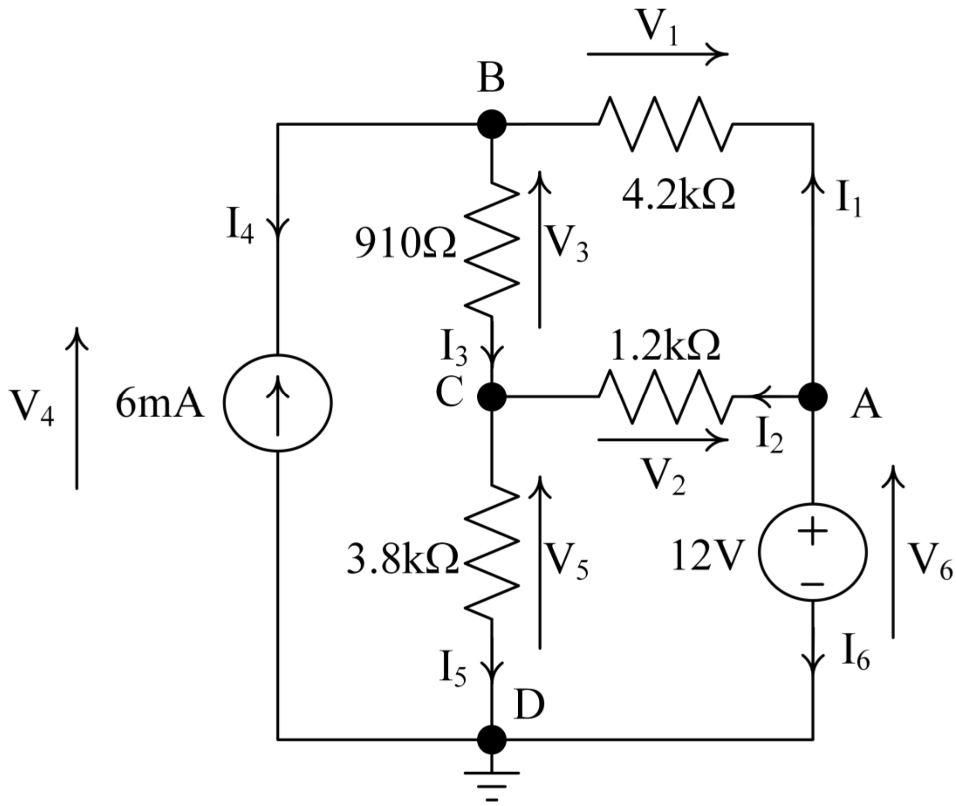


Figure 1: Circuit Schematic for Question (5)-(15)

<u>*Space for working*</u>

Space for working

Question 5

With reference to Figure 1, which of the following is a correct Kirchoff's Voltage Law Equation?

A. $V_1 + V_2 + V_3 = 0$

D. $V_1 = V_2 + V_3$

B. $V_2 = V_1 + V_3$

C. $V_3 = V_1 + V_2$

E. None of the above.

Question 6

With reference to Figure 1, which of the following is a correct Kirchoff's Current Law Equation?

A. $\frac{V_B - V_C}{910} + \frac{V_C - V_D}{3800} + \frac{V_C - V_A}{1200} = 0$

B. $\frac{V_B - V_C}{910} + \frac{V_D - V_C}{3800} + \frac{V_C - V_A}{1200} = 0$

C. $\frac{12 - V_B}{4200} + \frac{V_c - V_B}{910} = 0.006$

D. $\frac{V_B - 12}{4200} + \frac{V_B - V_c}{910} = 0.006$

E. None of the above.

Question 7

With reference to Figure 1, which of the following is a correct Kirchoff's Current Law Equation at node D?

A. $I_4 = I_5 + I_6$

B. $I_5 = I_4 + I_6$

C. $I_6 = I_4 + I_5$

D. It is impossible to write this equation because the current entering the earth connection is unknown.

E. None of answers (A)-(C) are correct, but it is possible to write a correct Kirchoff's Current Law Equation at node D

Question 8

In the circuit shown in Figure 1, what is the value of current I_4?

A. 0.600 A
B. -0.600 A
C. 6 mA
D. -6 mA
E. None of the above.

Question 9

In the circuit shown in Figure 1, what is the value of current I_5?

A. 4.66 mA
B. -6.00 mA
C. 3.52 mA
D. -3.52 mA
E. None of the above.

Question 10

In the circuit shown in Figure 1, what is the value of node voltage V_B?

A. 17.63 V
B. 12.0 V
C. 24.0 V
D. -13.42 V
E. None of the above

Question 11

In the circuit shown in Figure 1, what is the value of branch voltage V_6?

A. 14.67 V
B. -14.67 V
C. 12 V
D. -12 V
E. None of the above.

Question 12

In the circuit shown in Figure 1, what is the value of branch voltage V_2?

A. 12.0 V
B. 1.381 V
C. 13.381 V
D. 16.95 V
E. None of the above.

Question 13

In the circuit shown in Figure 1, what is the value of the power **consumed** by the 6mA current source?

A. 105.7 mW
B. –105.7 mW
C. 0 W
D. -72 mW
E. None of the above

Question 14

In the circuit shown in Figure 1, what is the value of the power **consumed** by the 910Ω resistor?

A. 19.8 mW
B. -19.8mW
C. 0 W
D. 22 mW
E. None of the above

Question 15

In the circuit shown in Figure 1, what is the value of the power **consumed** by all the components in the circuit in total (i.e. including the 4200Ω, 1200Ω, 910Ω and 3800Ω resistors; the 12V voltage source; and the 6mA current source)?

A. 0 W
B. 135.6mW
C. 152.1 mW
D. 76.04 mW
E. None of the above.

Questions (16)−(21) all involve analysis of the one−port network shown below in Figure 2. In particular, you will be asked to calculate the Thevenin and Norton equivalent circuits.

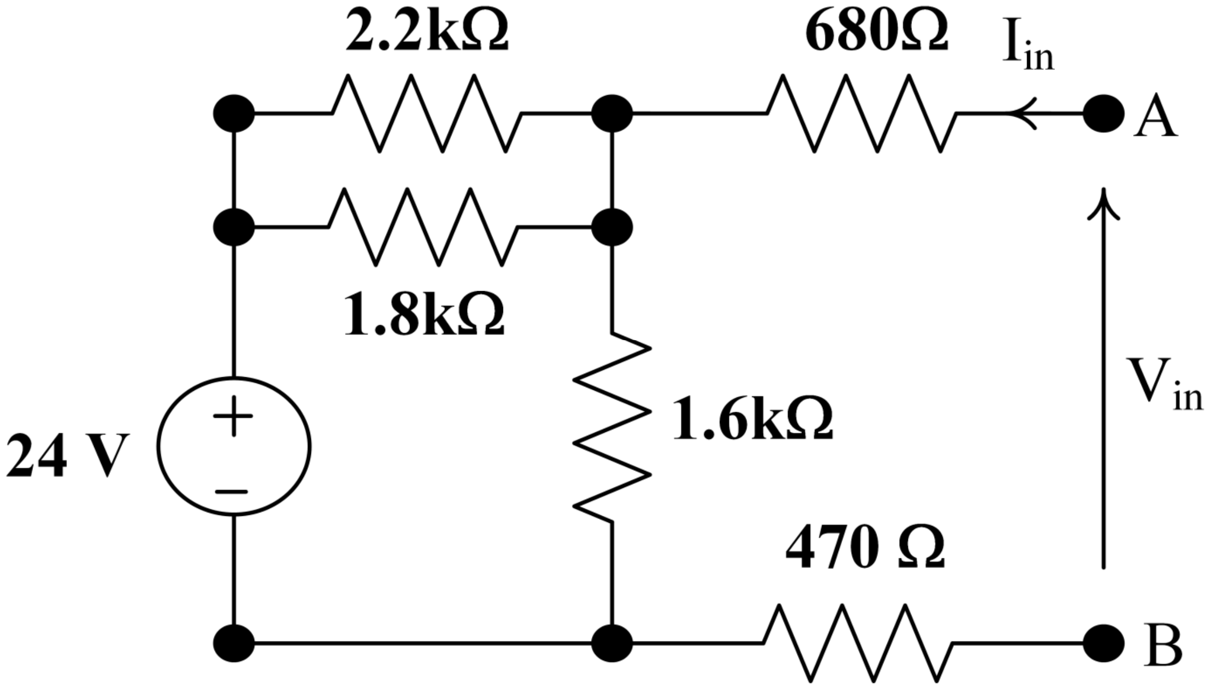


Figure 2: Circuit Schematic for Question's (16)-(21)

<u>*Space for working*</u>

Question 16

If the one-port network of Figure 2 is replaced by its Thevenin Equivalent Circuit, what is the value of the voltage source in that equivalent circuit, V_T?

A. 24.0 V
B. 9.17 V
C. 14.83 V
D. 6.67 V
E. None of the above.

Question 17

If the one-port network of Figure 2 is replaced by its Thevenin Equivalent Circuit, what is the value of the series resistor in that equivalent circuit, R_T?

A. 1761.6 Ω
B. 611.6 Ω
C. 6750.0 Ω
D. 2750.0 Ω
E. None of the above.

Question 18

If the one-port network of Figure 2 is replaced by its Norton Equivalent Circuit, what is the value of the current source in that equivalent circuit, I_N?

A. 6.92 mA
B. -6.92 mA
C. 8.42 mA
D. -8.42 mA
E. None of the above.

For Questions (20)-(23), a non-linear diode is placed across the terminals of the one port network shown in Figure 2 to give the circuit of Figure 3. The I−V characteristic of the diode is shown in Figure 4.

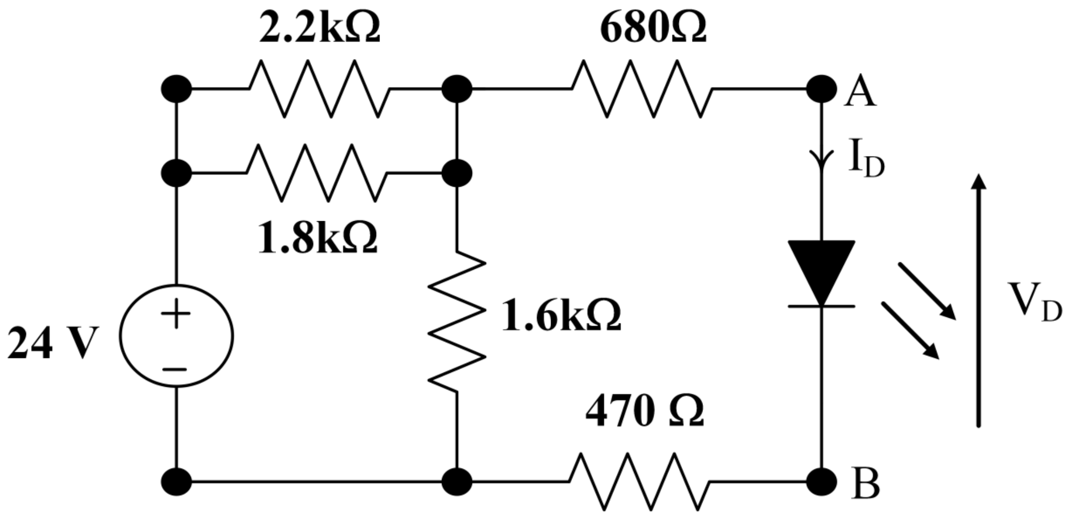


Figure 3: Circuit Schematic for Questions (19)-(21)

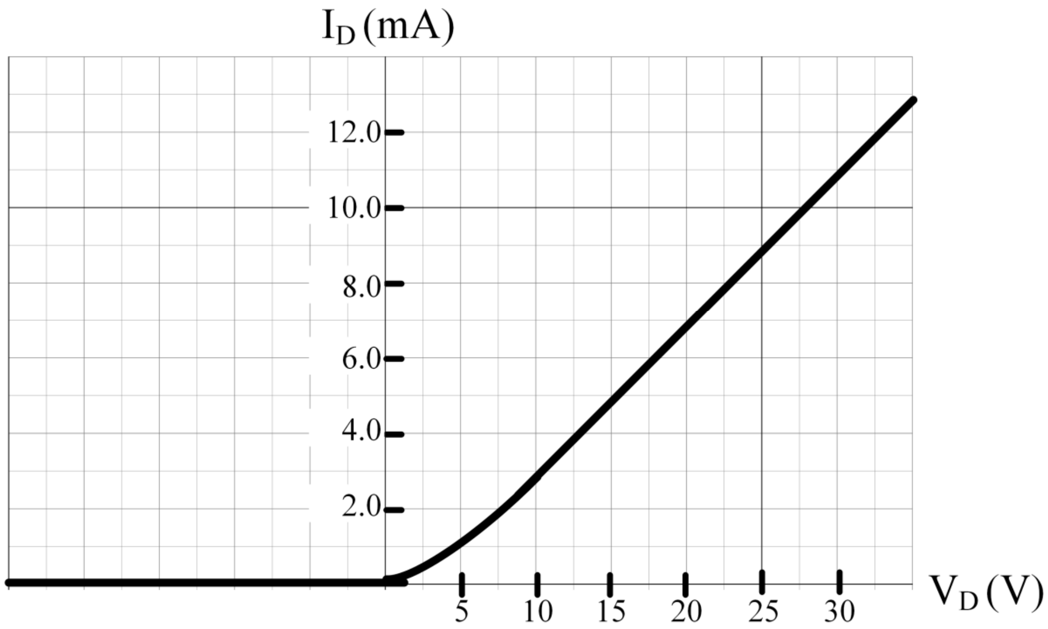


Figure 4: The characteristics of the LED described in questions (19)-(23)

<u>*Space for working*</u>

Question 19

Which of the following equations must the solution to the circuit in figure 4 satisfy?

Note, R_{TH} refers to the Thevenin resistance as calculated in Question (17); I_N refers to the Norton current calculated in Question (18); V_D refers to the voltage across the diode, and I_D refers to the current through the diode (as labelled in figure 4).

A. $I_D = -(R_{TH}V_D + I_N)$

B. $I_D = R_{TH}V_D - I_N$

C. $I_D = I_N - \frac{1}{R_{TH}}V_D$

D. $I_D = \frac{1}{R_{TH}}V_D - I_N$

E. It is not possible to express the solution to this circuit as a linear relationship between I_D and V_D because the diode is a non-linear component.

Question 20

Given the circuit in Figure 3, and the diode I−V characteristic of Figure 4, which of the following is **closest** to the value of V_D?

A. V_D is 5V or less

B. 10 V

C. 15 V

D. 20 V

E. V_D is 25V or greater.

Question 21

Given the circuit in Figure 3 and the diode I−V characteristic of Figure 4, which of the following is closest to the value of I_D?

A. 2.0 mA or less

B. 3mA

C. 5mA

D. 7mA

E. I_D is 9mA or greater.

Questions 22 and 23 refer to the I−V characteristic of the diode as shown in Figure 4 above. These questions introduce a new design problem and DO NOT require information provided in either of Figure 2 or Figure 3.

Question 22

You are designing an LED light. This will consist of a 24V lead-acid battery connected in series with a single resistor and the LED characterised in figure 4 above. The battery can be modelled as a 24V ideal voltage source. The datasheet for the diode recommends that for maximum operational life, the voltage across the diode should be set to 15V. Which of the following values for the series resistor will result in a voltage across the diode (V_D) that is **closest** to 15V?

A. 2200Ω
B. 3100Ω
C. 4800Ω
D. The resistor should be less than 1600Ω, or greater than 750Ω
E. It is not possible to estimate the required resistor value with the information provided

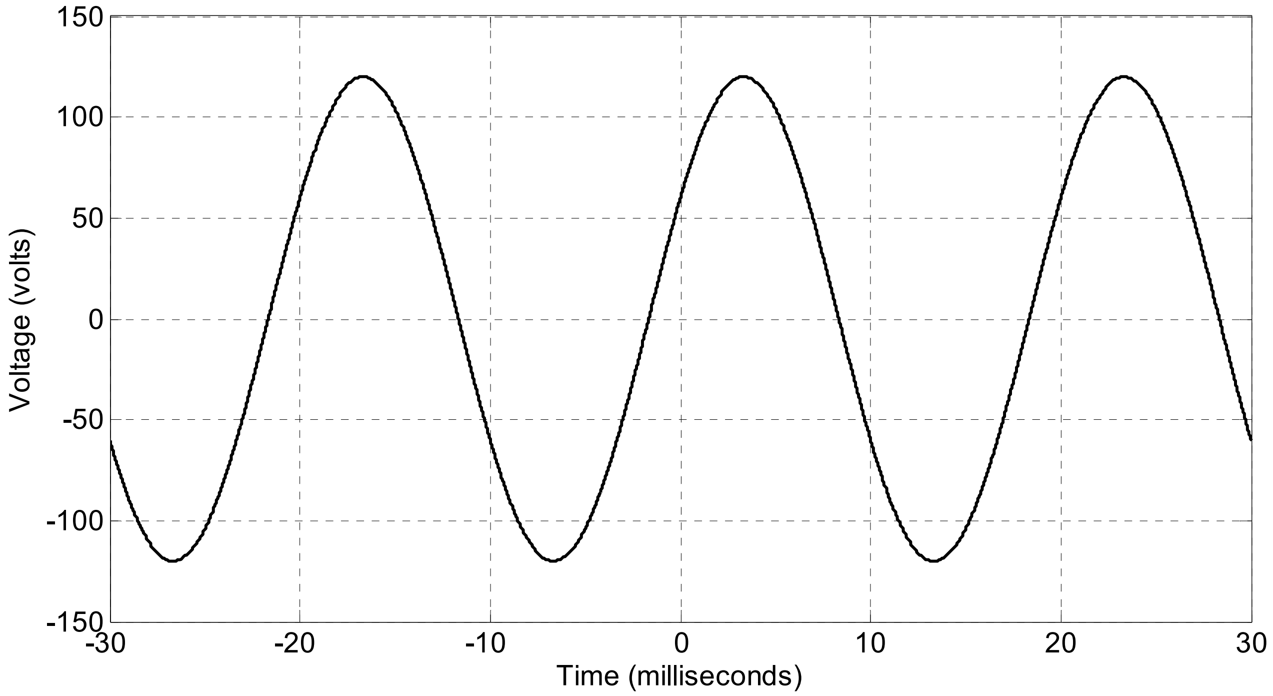
Question 23

The LED characterised in figure 4 can be assumed to be 100% efficient (i.e. all power dissipated by the LED is converted to light). What is the overall efficiency of the circuit described in Question (22) when the voltage across the diode is set to 15V (i.e. what percentage of total power supplied by the battery is converted to light)?

A. 0%
B. 37.5%
C. 62.5%
D. 100%
E. The overall efficiency of the circuit cannot be estimated with the information provided.

Question 24

A sinusoidal voltage is displayed in the figure below.



Which of the following equations best models the sinusoidal voltage displayed?

A. $Vs(t) = 120Cos(50t + 0.003)$
B. $Vs(t) = 240Sin(50t - 0.003)$
C. $Vs(t) = 240Cos(315t + 1.0)$
D. $Vs(t) = 120Cos(315t - 1.0)$
E. $Vs(t) = 240Sin(315t - 1.0)$

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Questions (25) and (26) refer to the schematic in Figure 5 where L_1 = 220mH, R_2 = 120Ω, C_3 = 47μF.

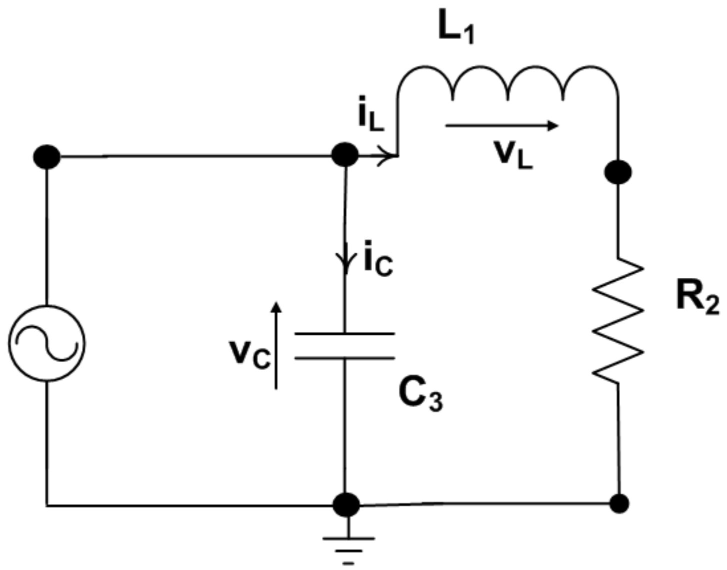


Figure 5: Circuit Schematic for Questions (25)-(26)

<u>Question 25.</u>

At a particular instant of time, v_c = -9V, i_c = -600mA, v_L = 3.6V, i_L = 700mA. At that instant of time, how much energy is stored in the inductor?

A. 1.42 J
B. -1.42 J
C. 53.9 mJ
D. –53.9 mJ
E. none of the above

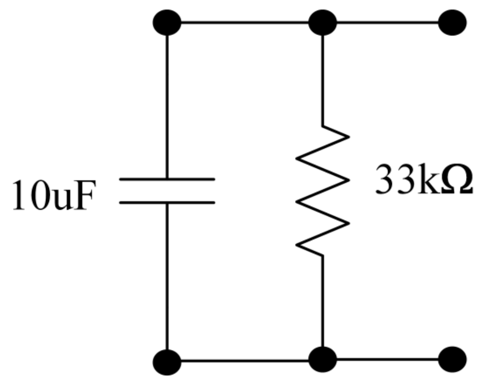
<u>Question 26.</u>

At a particular instant of time, v_c = -9V, i_c = -600mA, v_L = 3.6V, i_L = 700mA. At that instant of time, how much energy is stored in the capacitor?

A. 1.90 mJ
B. -1.90 mJ
C. 8.46 μJ
D. –8.46 μJ
E. None of the above

Question 27.

Consider the one-port network shown below.

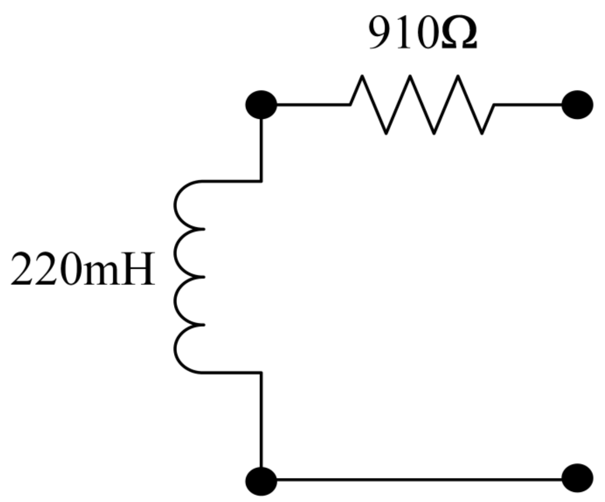


If the frequency of operation is 2Hz, what is the equivalent impedance of this network?

A. 33000 –j7957 Ω
B. 1769 – j7529 Ω
C. 2200 - j628.3Ω
D. 33000 - j(10^{-5}) Ω
E. 33000 + j(10^{-5}) Ω

Question 28.

Consider the one-port network shown below.



If the frequency of operation is 700Hz, what is the equivalent impedance of this network?

A. $910e^{j2.42\times10^{-4}}\Omega$
B. $910e^{-j2.42\times10^{-4}}\Omega$
C. $910e^{-j1.14\times10^{-6}}\Omega$
D. $1328e^{j0.816}\Omega$
E. $1328e^{-j0.816}\Omega$

Questions (29)-(30) refer to the schematic in Figure 6 below, where:

- ***VS** = 6 e^{j0} volts, f = 120Hz*
- ***R = 330Ω***
- ***C = 2.7 μF***
- ***L = 160mH***

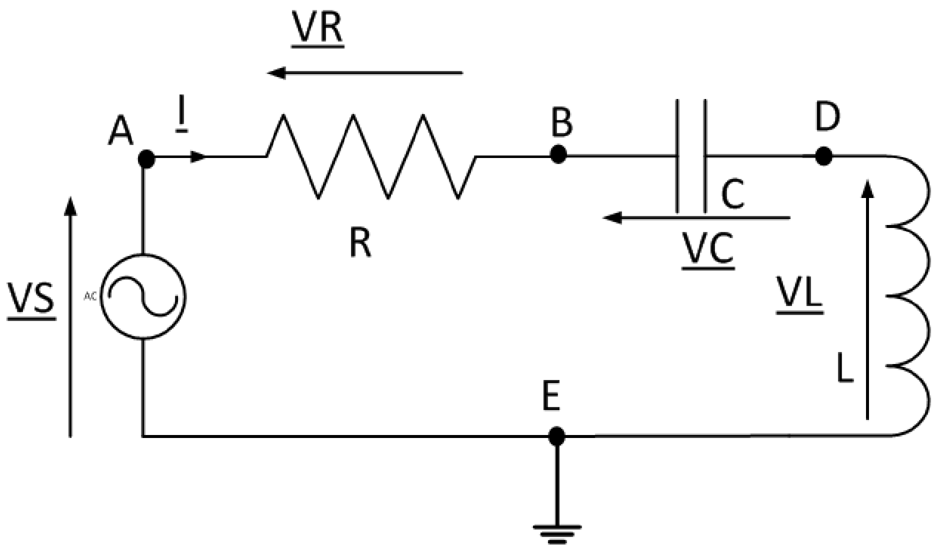


Figure 6: Circuit Schematic for Questions (29)-(30)

Question 29.
In the circuit shown in Figure 6 with the component values listed above, what is the value of the phasor current **I**?

A. 18.2 mA
B. $7.61e^{-j0.91}$mA
C. $7.61e^{j0.91}$mA
D. $12.1e^{j0.84}$mA
E. It is impossible to calculate the phasor current with the provided information.

Question 30.
In the circuit shown in Figure 6 with the component values listed above, what is the value of the phasor voltage across the inductor, **VL**?

A. $1.46e^{-j2.41}$V
B. $1.46e^{j2.41}$V
C. 0 V
D. $0.918e^{-2.48}$V
E. It is impossible to calculate the phasor voltage across the inductor with the provided information.

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