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.

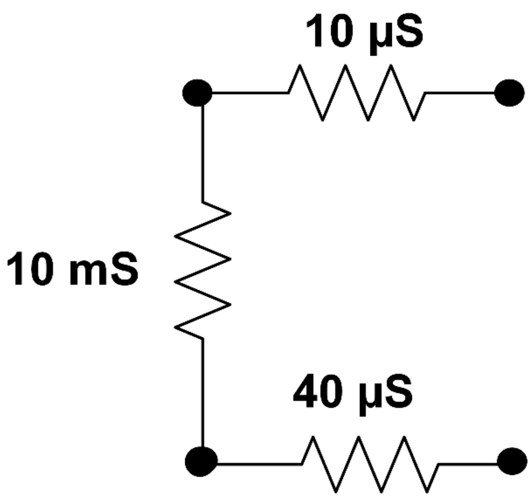
For each question, choose the one answer which is most correct.

Each question is worth ONE (1) mark each.

In a question requiring a numerical answer 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. Note that the resistor values are shown as conductances.

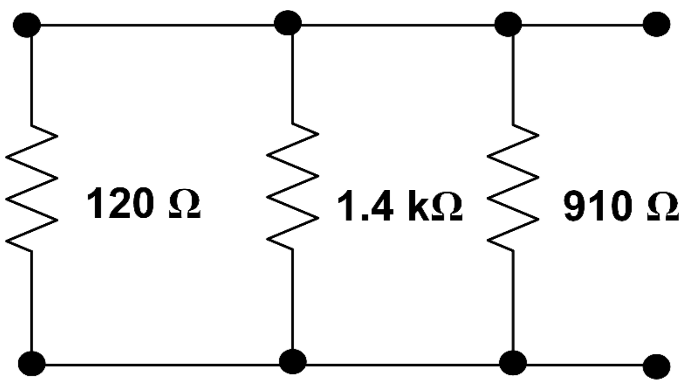


What is the equivalent resistance of this network?

A. 952.4 Ω
B. 1.05 mΩ
C. 125.1 kΩ
D. 7.99 µΩ
E. None of the above.

Question 2.

Consider the one-port network shown below.

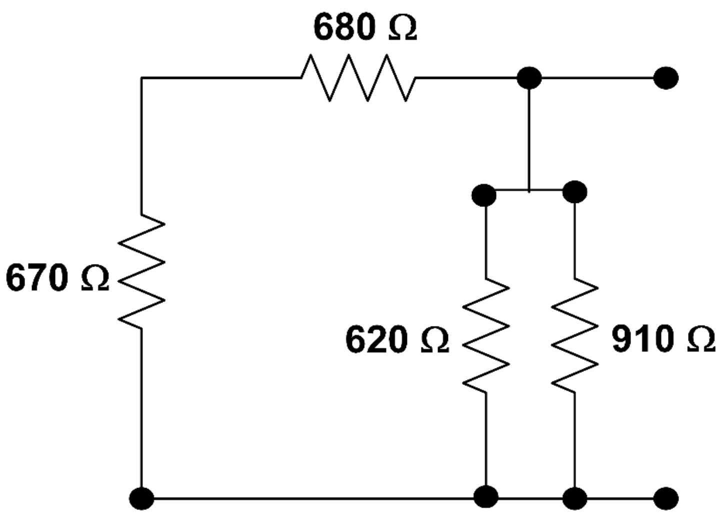


What is the equivalent resistance of this network?

A. 2430 Ω
B. 10.1 mΩ
C. 98.6 Ω
D. 1.38 Ω
E. None of the above.

Question 3.

Consider the one-port network shown below.



What is the equivalent resistance of this network?

A. 2880 Ω
B. 176.2 Ω
C. 1719 Ω
D. 289.6 Ω
E. None of the above.

Question 4.

Which of the following is a unit of conductance?

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. You are advised to carefully read the questions; then solve the circuit and check your working to make sure it is correct; and finally answer each of the questions.

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

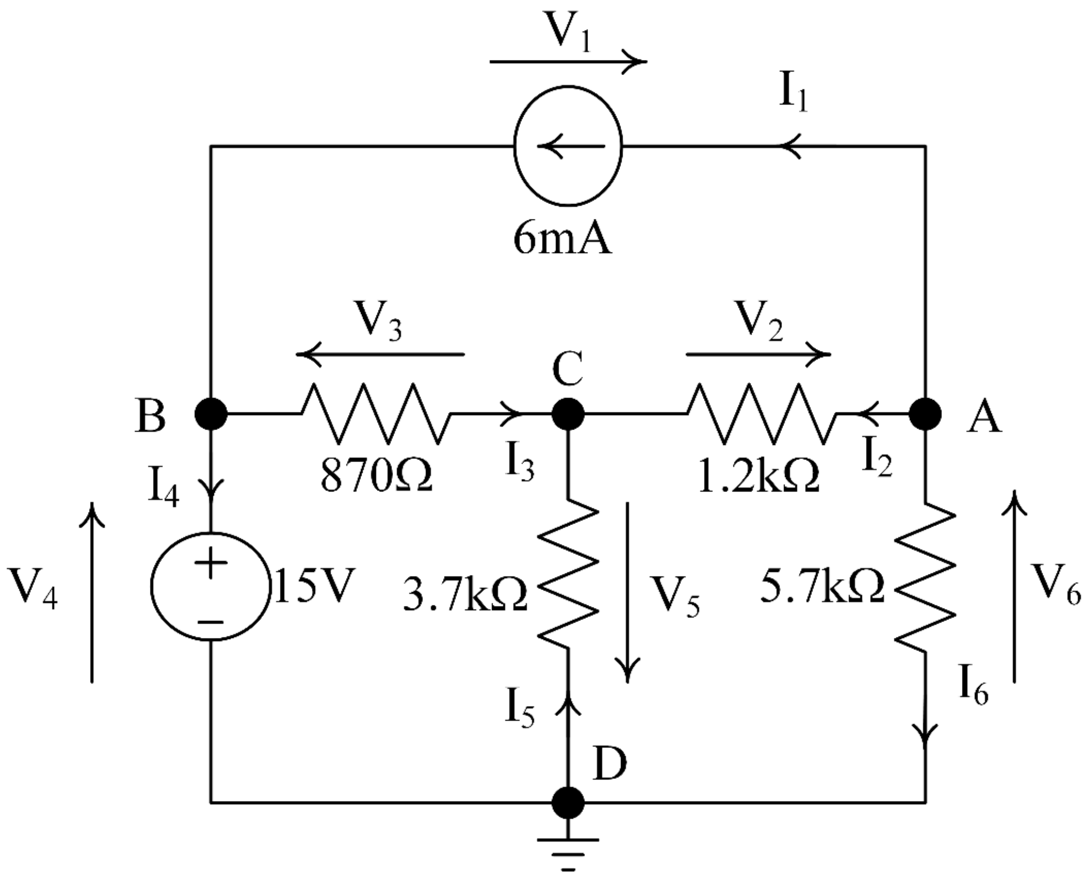


Figure 1: Circuit Schematic for Question (5)-(15)

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

Space for working

Question 5

One way to solve linear circuits is the method of *superposition*. When using the method of superposition, which of the following schematics in the figure below is a correct representation of the circuit when the 15V voltage source is set to zero?

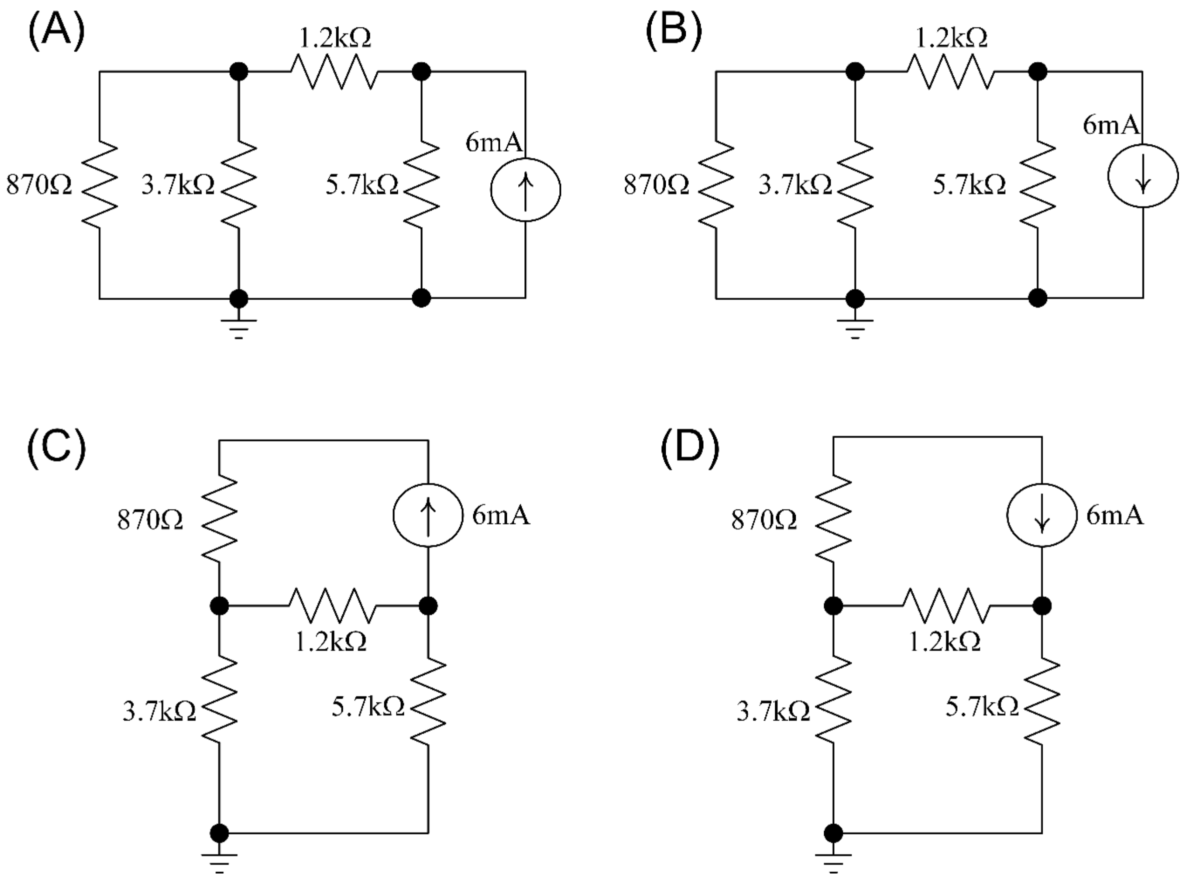
A. Figure (A)

B. Figure (B)

C. Figure (C)

D. Figure (D)

E. It is not possible to solve this circuit using superposition.



Question 6

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

A. $1200I_2 + 3700I_5 = 5700I_6$

C. $1200I_2 + 3700I_5 + 5700I_6 = 0$

C. $1200I_2 = 3700I_5 + 5700I_6$

D. $3700I_5 = 5700I_6 + 1200I_2$

E. None of the above.

Question 7

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

A. $\frac{V_B - V_C}{870} + \frac{V_D - V_C}{3700} + \frac{V_A - V_C}{1200} = 0$

B. $\frac{V_B - V_C}{870} + \frac{V_D - V_C}{3700} + \frac{V_C - V_A}{1200} = 0$

C. $\frac{15 - V_B}{870} + \frac{V_c - V_B}{870} = 0.006$

D. $\frac{V_B - 15}{5700} + \frac{V_B - V_c}{870} = -0.006$

E. None of the above.

Question 8

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 9

In the circuit shown in Figure 1, what is the value of voltage V_4?

A. 12 V
B. -12 V
C. 15 V
D. -15 V
E. None of the above.

Question 10

In the circuit shown in Figure 1, what is the value of current I_3?

A. 8.21 mA
B. -8.21 mA
C. 21 mA
D. 6 mA
E. None of the above.

Question 11

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

A. 15.0 V
B. 7.86 V
C. -6.21 V
D. -13.42 V
E. None of the above

Question 12

In the circuit shown in Figure 1, what is the value of branch voltage V_1?

A. 15.00 V
B. -14.45 V
C. 3.269 V
D. 0.5510 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 15V voltage source?

A. 33.2 mW
B. –33.2 mW
C. 0 W
D. -47.3 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 3.7kΩ resistor?

A. 0 W
B. 10.42 mW
C. 16.65 mW
D. 37.6 mW
E. None of the above

Question 15

In the circuit shown in Figure 1, what is the value of the total power **consumed** by all the resistors in the circuit (i.e. including the 870Ω, 1.2kΩ, 3.7kΩ and 5.7kΩ resistors)?

A. 0 W
B. 76.04 mW
C. 152.1 mW
D. 119.9 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.

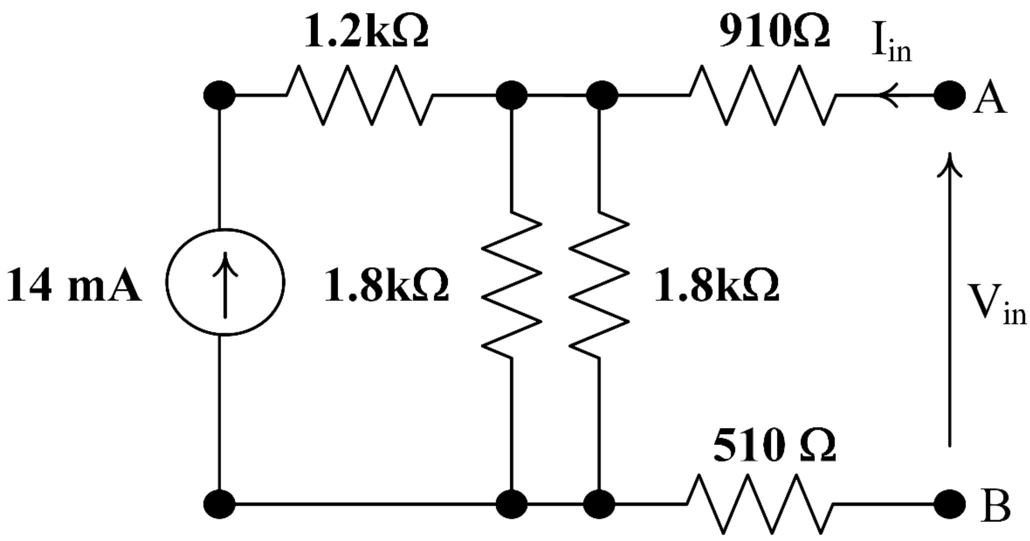


Figure 2: Circuit Schematic for Question's (16)-(21)

<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 (V_{TH}) in that equivalent circuit?

A. 14 mV
B. 12.6 V
C. 25.23 V
D. 32.5 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 (R_{TH}) in that equivalent circuit?

A. 2320 Ω
B. 514 Ω
C. 1934 Ω
D. 910 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 (I_N) in that equivalent circuit?

A. 14 mA
B. 2.31 mA
C. -2.31 mA
D. 5.43 mA
E. None of the above.

Space for working

For Questions (19)-(21), a non-linear light emitting diode (LED) 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.

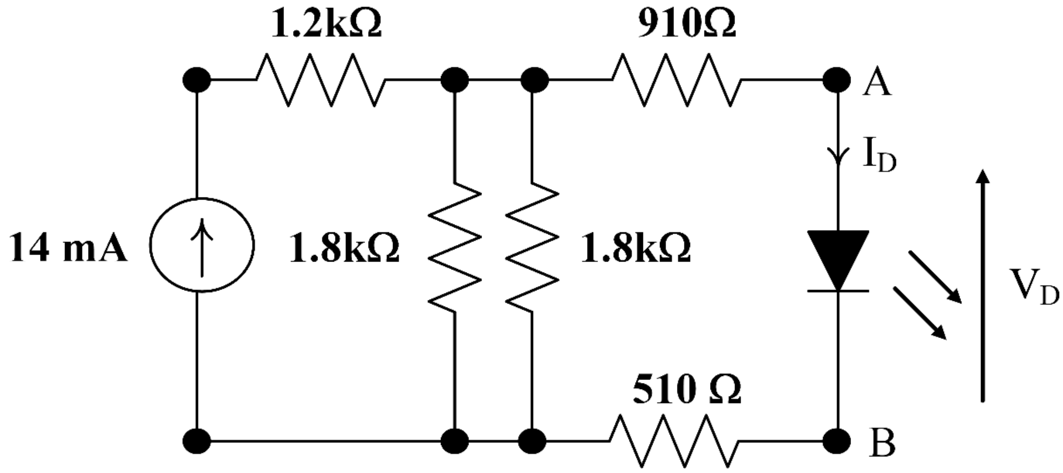


Figure 3: Circuit Schematic for Questions (19)-(21)

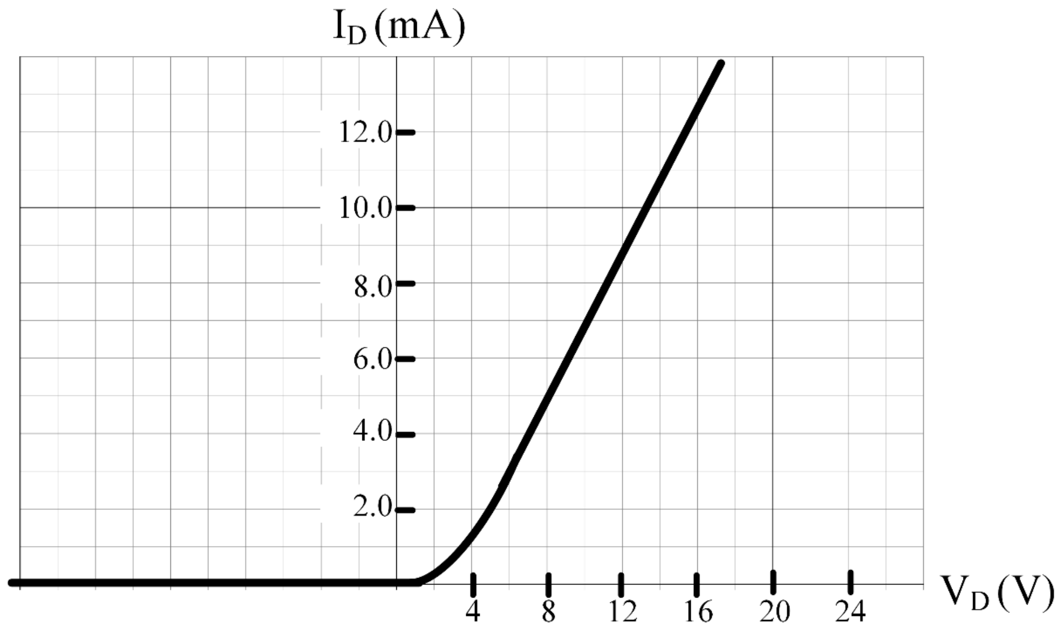


Figure 4: The I-V characteristics of the LED described in questions (19)-(23)

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

Question 19

Which of the following equations must the solution to the circuit in Figure 3 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 3).

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

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

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

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

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 2V or less
B. 4 V
C. 6 V
D. 8 V
E. V_D is 10V 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?

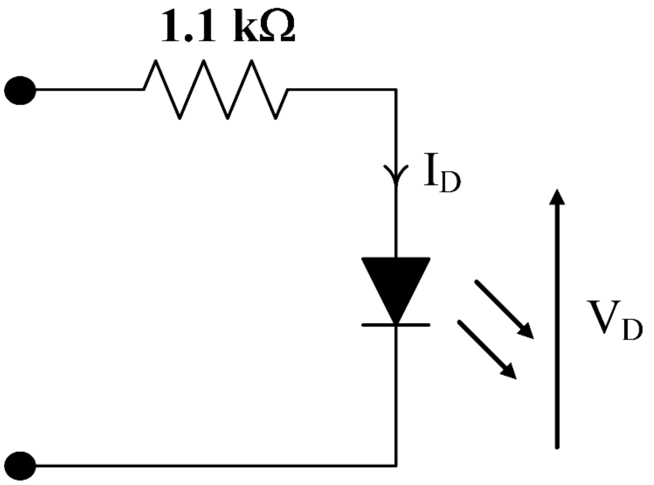
A. I_D is 1 mA or less
B. 2 mA
C. 3 mA
D. 4 mA
E. I_D is 5 mA or greater.

Space for working

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 a LED light, and have purchased a light element which consists of a LED (with the characteristics shown in Figure 4) connected in series with a 1.1 kΩ resistor. This light element is shown below.



This light will be powered using a lithium-polymer battery/batteries. Each lithium-polymer battery can be modelled as a 3.3V ideal voltage source. Which of the following battery configurations, when connected to the light element, will achieve a current through the LED which is **closest** to 2.0mA?

A. One battery only
B. Two batteries connected in series
C. Three batteries connected in series
D. Four batteries connected in series
E. Five or more batteries connected in series

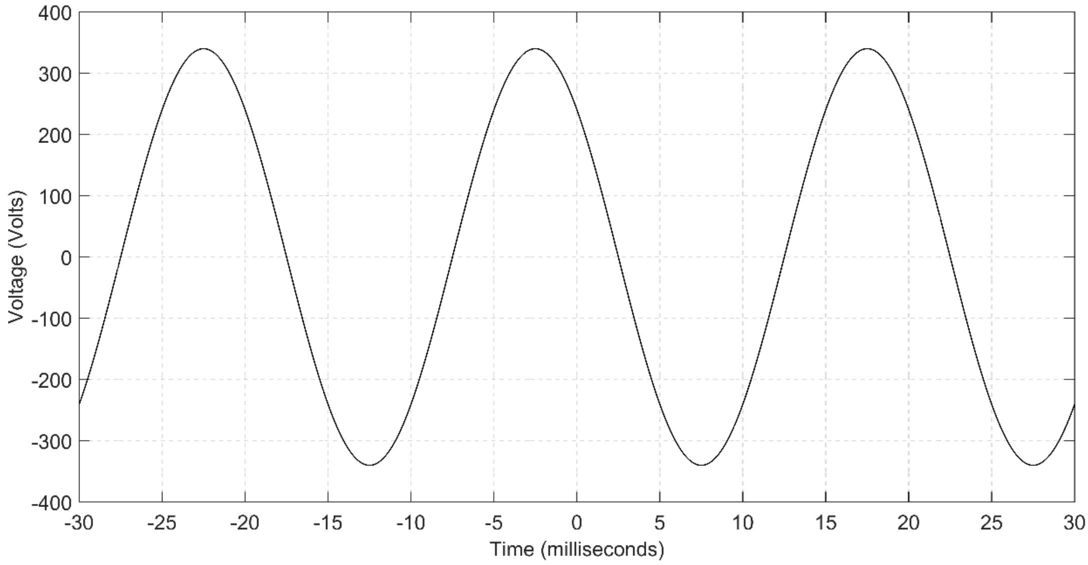
Question 23

The LED characterised in Figure 4 can be assumed to be 90% efficient (i.e. 90% of power dissipated by the LED is converted to light). Which of the following is **closest** to the overall efficiency of the circuit described in Question (22) when the battery configuration is chosen such that the current through the LED is set to 2.0 mA (i.e. what percentage of total power supplied by the battery/batteries is converted to light)?

A. 0%
B. 52.5%
C. 68.2%
D. 84.1%
E. 90%

Question 24

A sinusoidal voltage is displayed in the figure below.



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

A. $Vs(t) = 340Cos(50t - 0.0025)$
B. $Vs(t) = 340Cos(50t + 0.0025)$
C. $Vs(t) = 680Cos(315t - 0.8)$
D. $Vs(t) = 340Cos(315t + 0.8)$
E. $Vs(t) = 340Cos(315t + 0.0025)$

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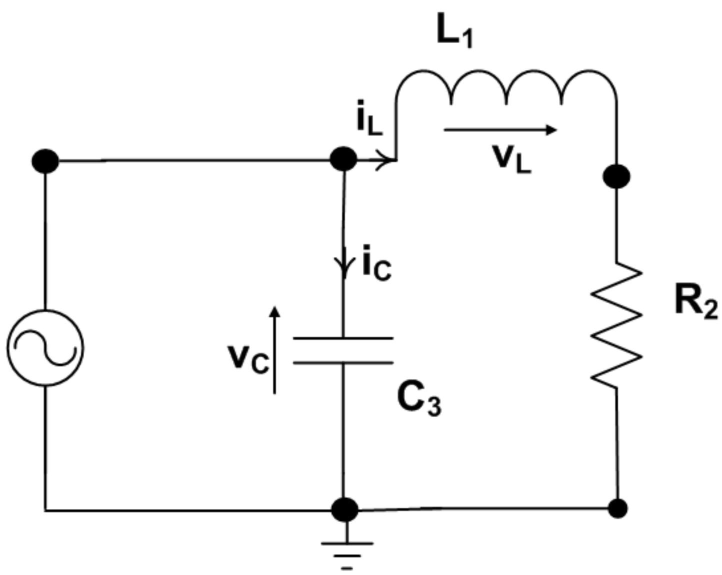
Question 25.

Consider the circuit below where L_1 = 1.2mH, R_2 = 1.6kΩ, C_3 = 0.1μF.



At a particular instant of time, v_C = 12V, i_C = 1.3A, v_L = -9.3V, i_L = -2.2A. At that instant of time, how much energy is stored in the inductor?

A. 2.904 mJ
B. –2.904 mJ
C. 59.1 mJ
D. –59.1 mJ
E. none of the above

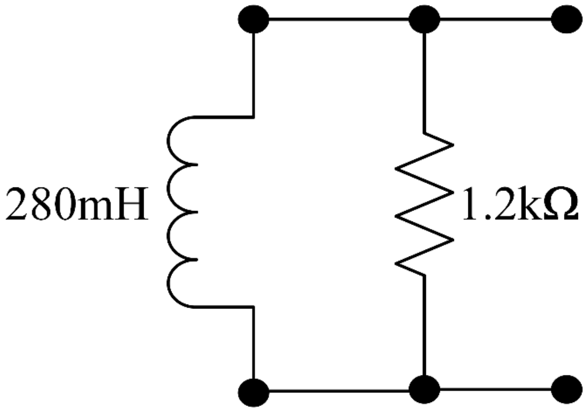
Question 26.

Which of the following expressions correctly models the voltage *v(t)* across a capacitor (with capacitance C) to the current *i(t)* through the capacitor?

A. $v(t) = C \times i(t)$
B. $v(t) = \frac{1}{C} \times i(t)$
C. $v(t) = C\frac{di(t)}{dt}$
D. $i(t) = C\frac{dv(t)}{dt}$
E. None of the above

Question 27.

Consider the one-port network shown below.

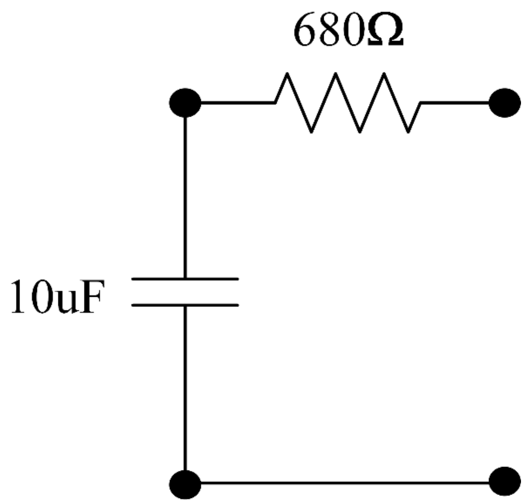


If the frequency of operation is 600Hz, what is the equivalent impedance of this network?

A. 1200 + j0.28 Ω
B. 1200 + j1055.6 Ω
C. 522.6 + j595.8 Ω
D. 227.0 Ω
E. None of the above

Question 28.

Consider the one-port network shown below.



If the frequency of operation is 50Hz, what is the equivalent impedance of this network?

A. $750e^{-j0.43}\Omega$
B. $750e^{j0.43}\Omega$
C. $680e^{-j1.47\times10^{-8}}\Omega$
D. 680.00001 Ω
E. None of the above

Questions (29)-(30) refer to the schematic in Figure 5 below, where:

- $\underline{VS} = 15e^{j0}$ V, f = 60Hz
- R = 610 Ω
- C = 4.7 μF
- L = 220 mH

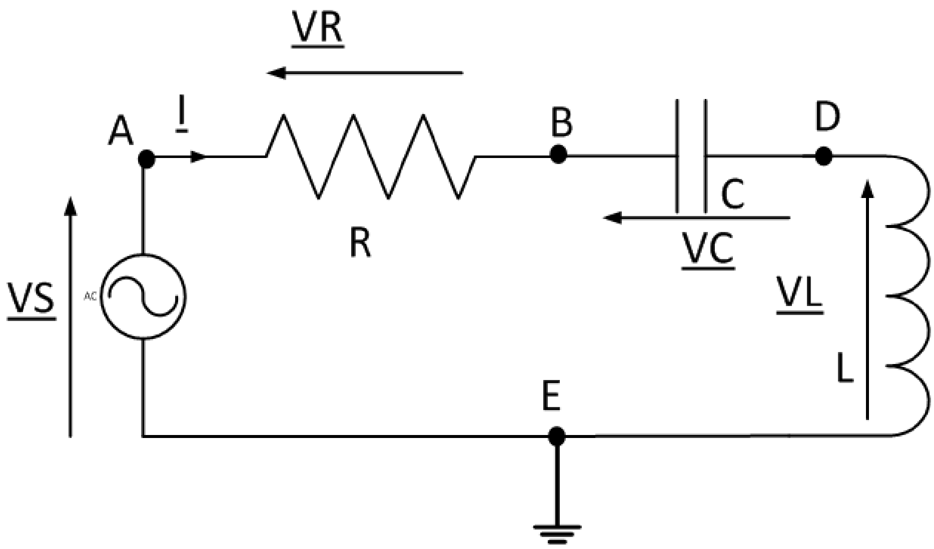


Figure 5: Circuit Schematic for Questions (29)-(30)

Question 29.

In the circuit shown in Figure 5 with the component values listed above, what is the value of the phasor current **I**?

A. 98.3 mA
B. $7.83e^{-j1.23}$mA
C. $12.6e^{j0.91}$mA
D. $19.3e^{j0.668}$mA
E. It is impossible to calculate the phasor current with the provided information.

Question 30.

In the circuit shown in Figure 5 with the component values listed above, what is the value of the phasor voltage across the capacitor, **VC**?

A. $10.89e^{j0.90}$V
B. $10.89e^{-j0.90}$V
C. $1.49e^{j0.668}$ V
D. 0.462 V
E. It is impossible to calculate the phasor voltage across the capacitor with the provided information.

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