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.

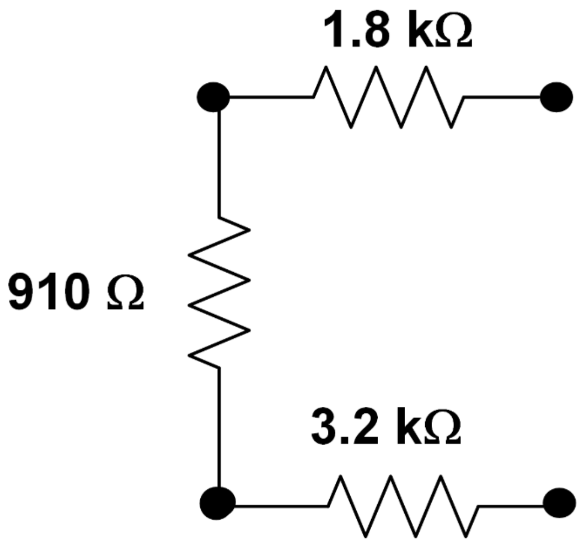
Each question is worth ONE (1) mark each.

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

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.

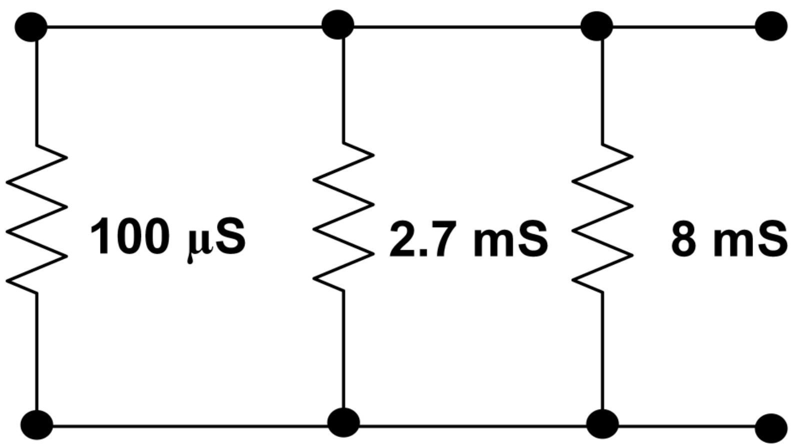


What is the equivalent conductance of this network?

A. 508.4 S
B. 1.97 μS
C. 5910 S
D. 169 μS
E. None of the above.

Question 2.

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

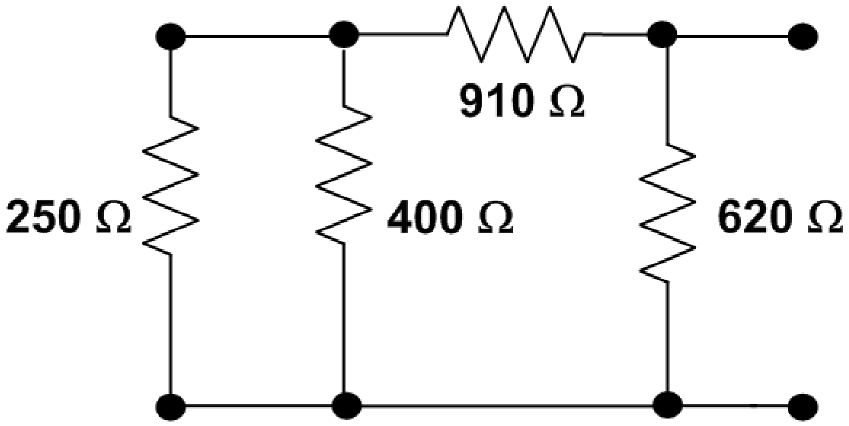


What is the equivalent resistance of this network?

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.



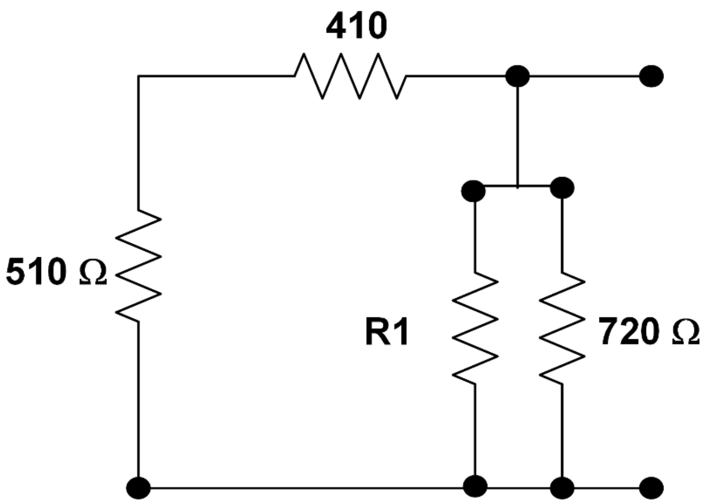
What is the equivalent resistance of this network?

A. 2180.0 Ω
B. 1683.8 Ω
C. 2.55 mΩ
D. 391.7 Ω
E. none of the above.

Space for working

<u>Question 4.</u>

Consider the circuit below.



The equivalent resistance of this network is measured as being 1030Ω. What is the value of the resistor R1?

A. 110 Ω
B. 664 Ω
C. A unique value of the resistor R1 **is** able to be calculated with the information provided, but neither (A) or (B) are correct.
D. A unique value of the resistor R1 **is not** able to calculated with the information provided, but there is at least one physical resistor value that satisfies the overall resistance of the network.
E. There is no possible physical resistor value for R1 which satisfies the overall resistance of the network.

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.

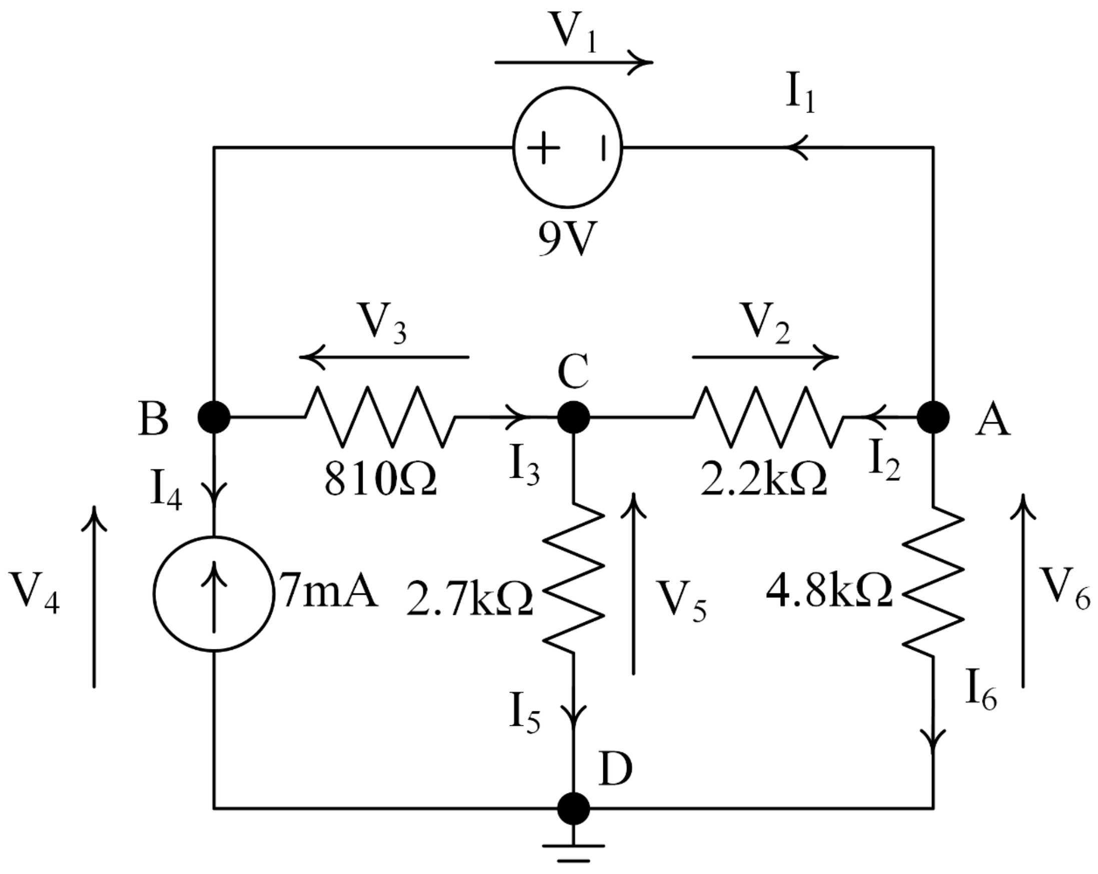


Figure 1: Circuit Schematic for Question (5)-(15)

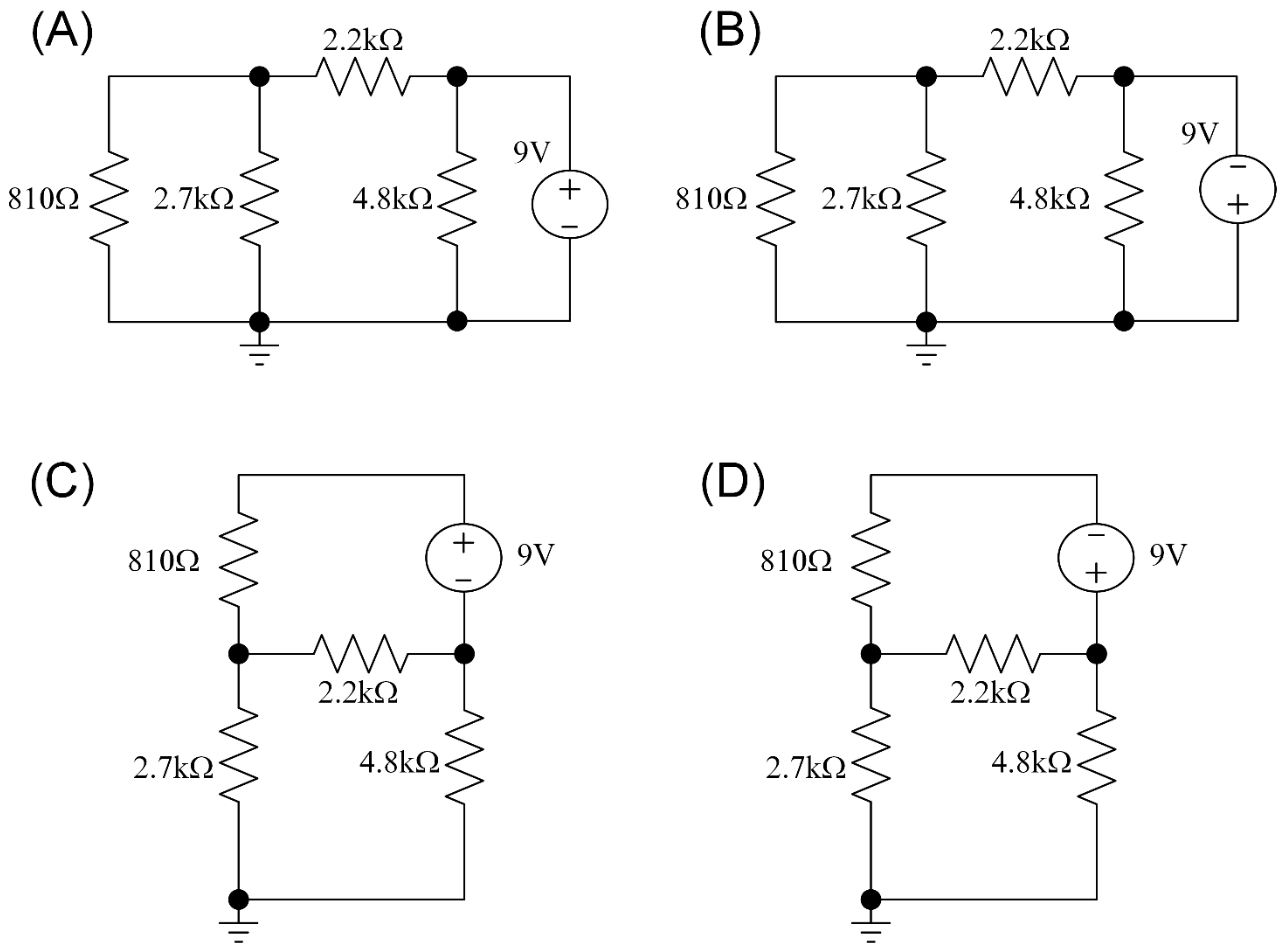
<u>*Space for working*</u>

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 7mA current source is set to zero?

A. Figure (A)
B. Figure (B)
C. Figure (C)
D. Figure (D)
E. None of the above



Question 6

When using the method of superposition, what is the value of current I_3 when the 9V voltage source is set to zero?

A. 6.11 mA
B. -6.11 mA
C. 3.03 mA
D. -3.03 mA
E. None of the above

Question 7

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

A. $2200I_2 + 2700I_5 = 4800I_6$

B. $2200I_2 + 2700I_5 + 4800I_6 = 0$

C. $2200I_2 = 2700I_5 + 4800I_6$

D. $2700I_5 = 4800I_6 + 2200I_2$

E. None of the above.

Question 8

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

A. $\frac{V_B - V_C}{810} + \frac{V_C - V_D}{2700} + \frac{V_A - V_C}{2200} = 0$

B. $\frac{V_B - V_C}{810} + \frac{V_D - V_C}{2700} + \frac{V_A - V_C}{2200} = 0$

C. $\frac{9 - V_B}{890} + \frac{V_C - V_B}{810} = -0.007$

D. $\frac{V_A - V_C}{2200} + \frac{V_A}{4800} = 9$

E. None of the above.

Question 9

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

A. $I_4 + I_6 + I_5 = 0$

B. $I_4 - I_6 - I_5 = 0$

C $I_4 + I_6 - I_5 = 0$

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 10

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

A. 15 V
B. -15 V
C. 9 V
D. -9 V
E. None of the above.

Question 11

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

A. 7 mA
B. -4.43 mA
C. 4.96 mA
D. -6.76 mA
E. None of the above.

Question 12

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

A. -9 V
B. -2.36 V
C. 12.4 V
D. 9.77V
E. None of the above

Question 13

In the circuit shown in Figure 1, what is the value of branch voltage V_3?

A. 5.37 V
B. -5.37 V
C. 11.2 V
D. -11.2 V
E. None of the above.

Question 14

In the circuit shown in Figure 1, what is the value of the power **supplied** by the 7mA current source?

A. -131.4 mW
B. -30.8 mW
C. 26.7 mW
D. 78.3 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 810Ω, 2.2kΩ, 2.7kΩ and 4.8kΩ resistors)?

A. 0 W
B. 32.3 mW
C. 78.4 mW
D. 127.9 mW
E. None of the above.

Questions (16)−(22) 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.

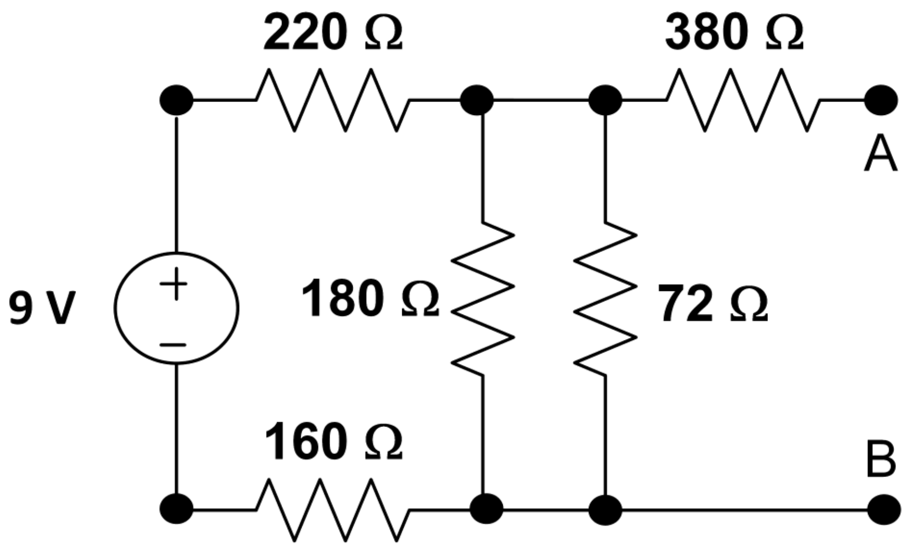


Figure 2: Circuit Schematic for Question's (16)-(21)

<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. 1.07 V
B. 2.56 V
C. 4.5 V
D. 9.00 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. 380 Ω
B. 45.3 Ω
C. 425.3 Ω
D. 1012 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. 2.52 mA
B. -2.52 mA
C. 20.9 mA
D. -20.9 mA
E. none of the above.

Question 19

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

A. 380 Ω
B. 45.3 Ω
C. 425.3 Ω
D. 1012 Ω
E. none of the above.

Space for working

For Questions (20)-(22), 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.

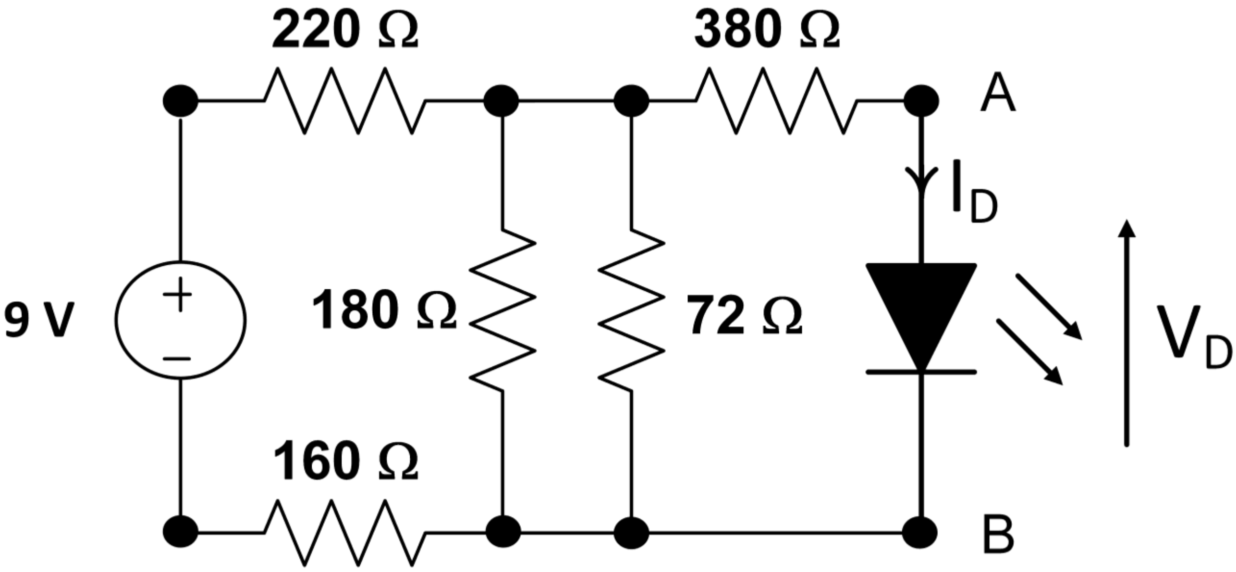


Figure 3: Circuit Schematic for Questions (20)-(22)

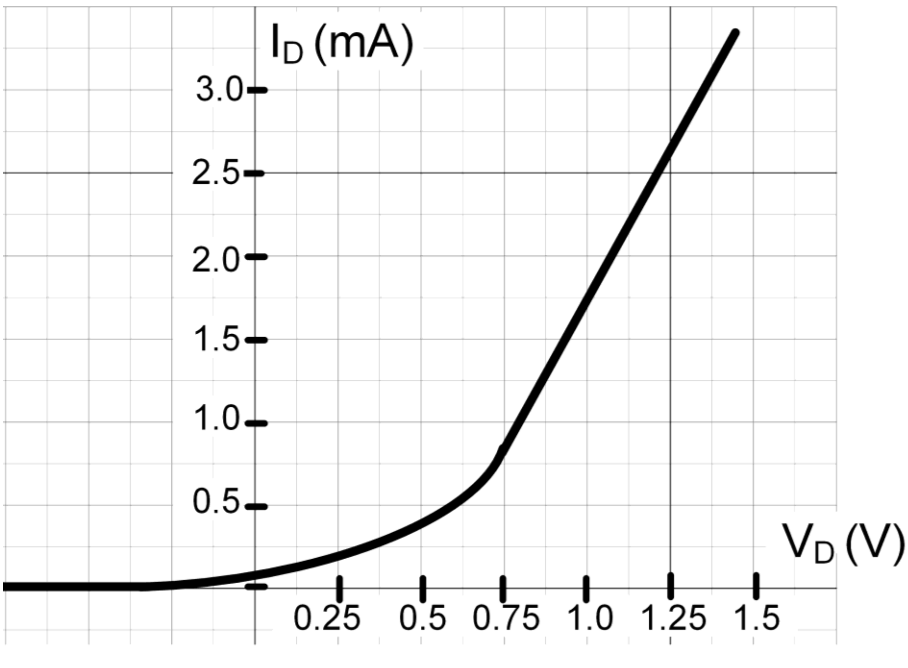


Figure 4: The I-V characteristics of the LED described in questions (20)-(22)

<u>Space for working</u>

Question 20

Which of the following equations must the solution to the circuit in Figure 3 satisfy?

Note, R_N refers to the Norton resistance as calculated in Question (19); V_{TH} refers to the Thevenin Voltage calculated in Question (17); 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. $V_D = V_{TH} - R_N I_D$

B. $I_D = R_N V_D - V_{TH}$

C. $I_D = \frac{1}{R_N} V_D - V_{TH}$

D. $V_D = R_N (V_{TH} - I_D)$

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 21

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

A. 0.5 V
B. 1.1 V
C. 0.75 V
D. 1.25 V
E. V_D is less than 0.25 V or greater than 1.5 V.

Question 22

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

A. 0.5 mA
B. 0.75 mA
C. 1.5 mA
D. 2.5 mA
E. I_D is less than 0.25 mA or greater than 3.0 mA.

Space for working

Questions 23 and 24 refer to the I−V characteristic of the diode as shown in Figure 5 below. These questions introduce a new design problem and DO NOT require information provided in any of Figure 2, Figure 3 or Figure 4.

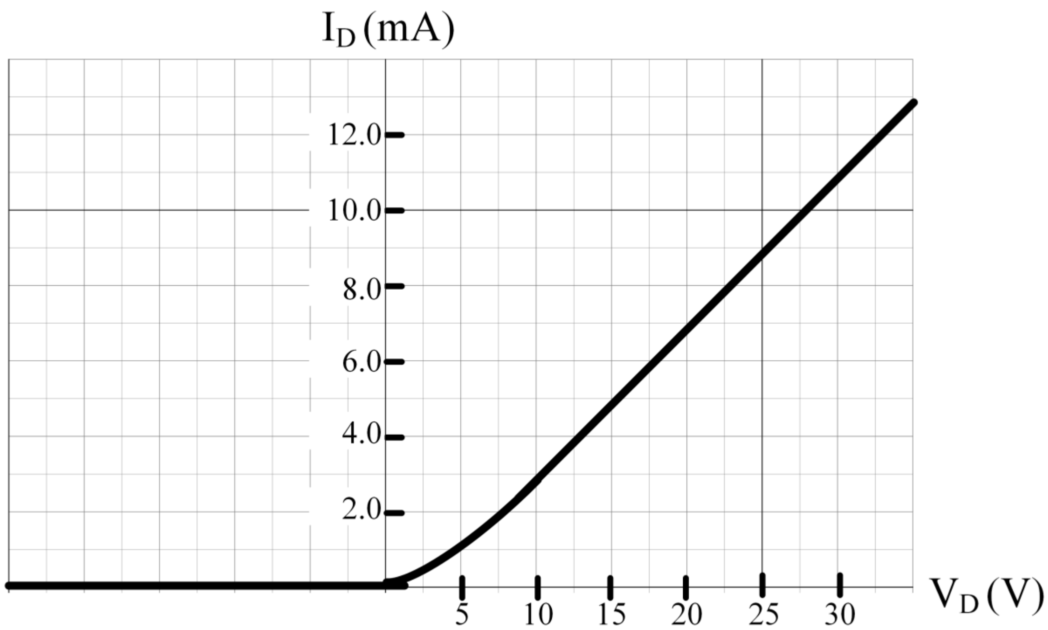


Figure 5: The characteristics of the LED described in questions (22)-(23)

Question 23

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 5 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 5800Ω
E. It is not possible to estimate the required resistor value with the information provided

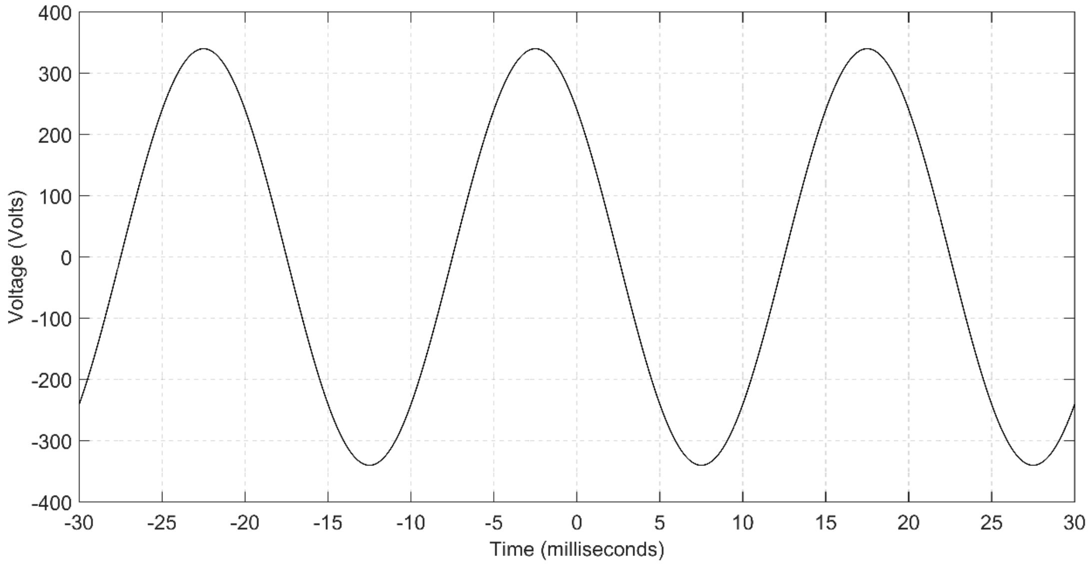
Question 24

The LED characterised in figure 5 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 25

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. $Vs(t) = 340Cos(315t + 0.0025)$

Space for working

Question 26.

Which of the following expressions correctly models the voltage *v(t)* across an inductor (with inductance L) to the current *i(t)* through the inductor?

A. $v(t) = L \times i(t)$

B. $v(t) = \frac{1}{L} \times i(t)$

C. $i(t) = \frac{1}{L} \int v(t)\, dt$

D. $i(t) = L \frac{dv(t)}{dt}$

E. None of the above

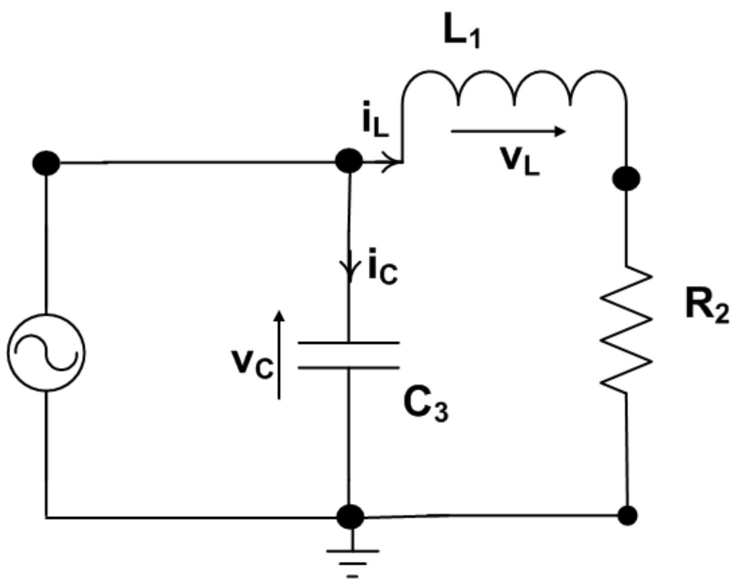
Question 27.

A practical inductor does not allow an instantaneous step change in its:

A. Voltage
B. Current
C. Magnetic Field
D. Both (A) and (B)
E. Both (B) and (C)

Question 28.

In the circuit shown below, L_1 = 10 H, R_2 = 50 Ω, C_3 = 38 μF.

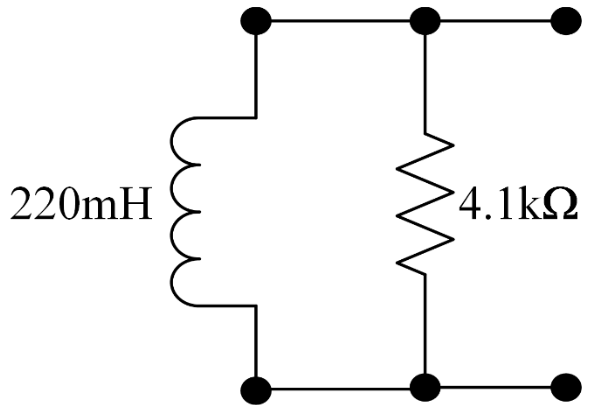


At a particular instant of time, $V_C = -14$V, $i_C = -4$ A, V_L = 12V, i_L = 5A.
At that instant of time, how much energy is stored in the capacitor?

A. 3.72 mJ
B. −3.72 mJ
C. 0.304 mJ
D. −0.304 mJ
E. None of the above.

Question 29.

Consider the one-port network shown below.



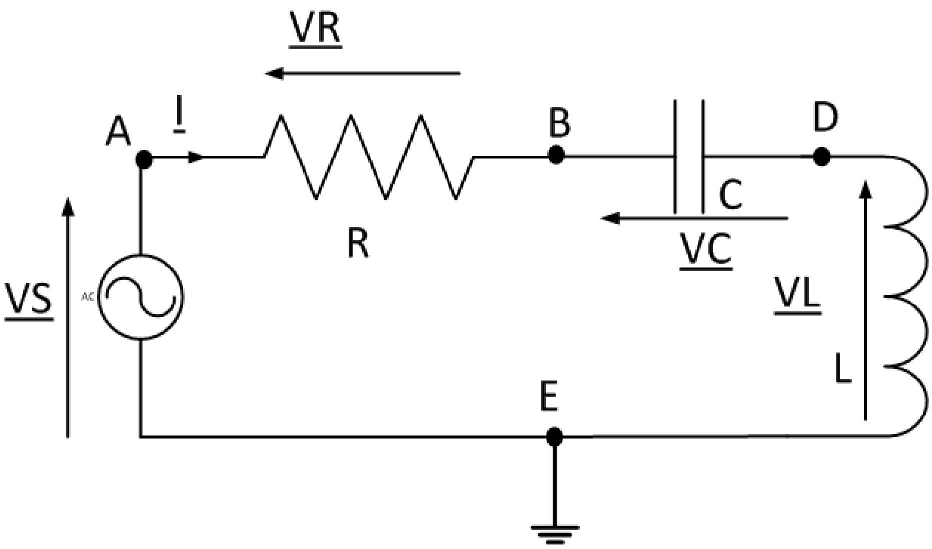
If the frequency of operation is 10kHz, what is the equivalent impedance of this network?

A. 4100 + j0.220 Ω
B. 1769 – j7529 Ω
C. 3765 + j1123.8Ω
D. 0.2199Ω
E. None of the above

Question 30.

Refer to the figure below where:

- VS = 12e^{j0} V, f = 100Hz
- R = 21 Ω
- C = 82 uF
- L = 33 mH



What is the value of the phasor voltage across the capacitor ($\underline{V}_C$)?

A. 3.8e^{j0} V
B. $7.67e^{j1.46}$V
C. $11.08e^{-j1.63}$V
D. $14.17e^{-j0.33}$V
E. None of the above.

Space for working

Space for working