University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

SEMESTER I EXAMINATIONS - 2012/2013

School of Electrical, Electronic and Communications Engineering

EEEN10010 Electronic & Electrical Engineering I

Professor McLaughlin

Professor Brazil

Dr. Duignan*

Time Allowed: 2 hours

Instructions for Candidates

Attempt all 15 questions in Section A and 3 out of 4 questions in Section B. Each question in Section A is worth 4 marks. Each question in Section B is worth 20 marks. The exam is worth a total of 120 marks.

Please complete Section A on a Multiple Choice Answer Sheet using a HB pencil.

Instructions for Invigilators

Please supply one Answer Book and one Multiple Choice Answer Sheet to each candidate

Non-programmable calculators are permitted.

No rough-work paper is to be provided for candidates.

Section A

Answer all of the following multiple-choice questions. Each question is worth 4 marks.

1. In Figure 1, the switch is initially open. It is closed for 1 minute then opened again. How much charge moves through the switch in the 1 minute interval?

   (A) 0.5 C

   (B) 12 C

   (C) 30 C

   (D) 120 C

   (E) 25 C

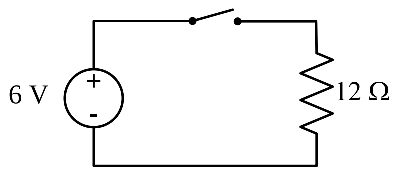


Figure 1

2. Two points A and B, 120 m apart, are electrically connected by three cables of equal length in series. The cables are made of the same material. The first has a resistance of 250 Ω. The second has ten times the cross sectional area of the first. The third has twice the cross sectional area of the first. What is the total resistance between A and B?

   (A) 400 Ω

   (B) 40 Ω

   (C) 120 Ω

   (D) 250 Ω

   (E) 3.25 kΩ

3. Which V-I characteristic in Figure 1 below describes the behaviour of an ideal voltage source?

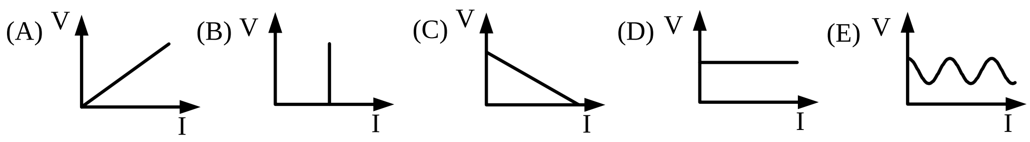


Figure 2

4. What is the power dissipated in the 30kΩ resistor in the circuit shown in Figure 3?

   (A) 15 W

   (B) 30 kW

   (C) 100 W

   (D) 30 mW

   (E) 7.5 mW

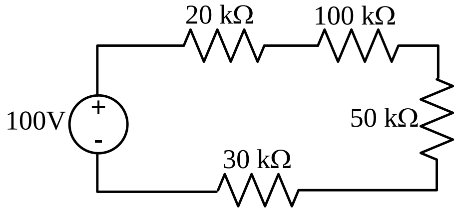


Figure 3

5. What is the current I flowing through the 15 kΩ resistor in the circuit shown in Figure 4?

(A) 3 mA

(B) 6 mA

(C) 9 mA

(D) 18 mA

(E) 24 mA

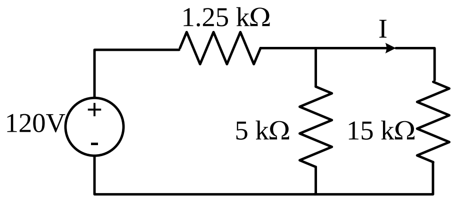


Figure 4

6. What is the voltage V across the 35 Ω resistor in the circuit shown in Figure 5?

(A) 2.5 V

(B) 8.75 V

(C) 6.25 V

(D) 7.5 V

(E) 7 V

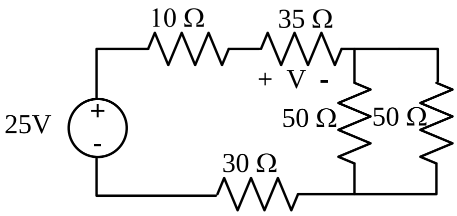


Figure 5

7. The following voltage signal

$$v(t)= 2\cos((\pi/2)-2\pi f_1 t) + 10\sin(2\pi f_2 t) + 1.5\sin(2\pi f_2 t)$$

is transmitted through an ideal communications channel, where f_1=2 MHz, f_2=200 kHz and f_3=4 MHz. What is the minimum bandwidth required of the channel?

(A) 1.8 MHz

(B) 2 MHz

(C) 6.2 MHz

(D) 4 MHz

(E) 3.8 MHz

8. What is decimal number 241 in binary format?

(A) 11110001

(B) 11110011

(C) 11100001

(D) 10110001

(E) 11111101

9. What is the Thévenin equivalent circuit for the circuit shown in Figure 6?

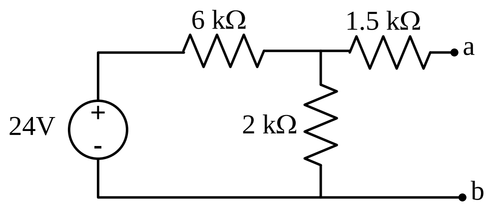
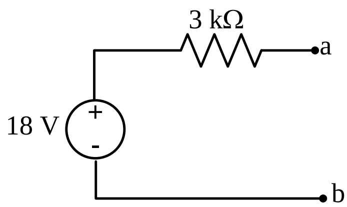
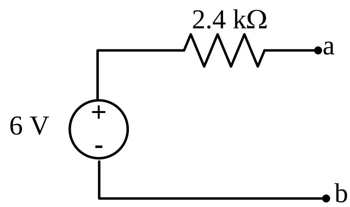


Figure 6



(A)



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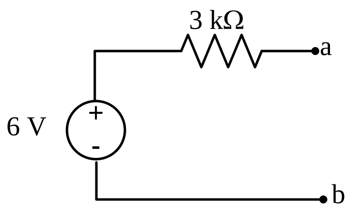

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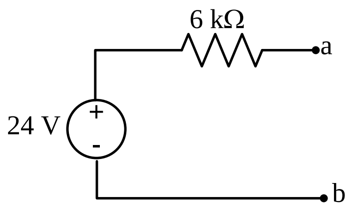


(D)

10. What are the values of the signals Y and Z in the logic circuit shown in Figure 7?

(A) Y=0 and Z=0

(B) Y=1 and Z=0

(C) Y=0 and Z=1

(D) Y=1 and Z=1

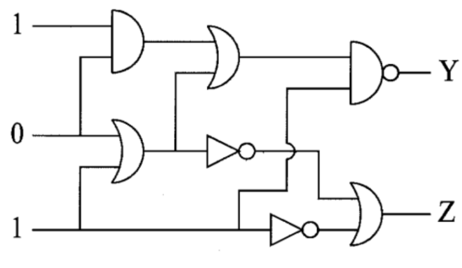


Figure 7

11. Which single logic element can implement the Boolean expression $R = \overline{P} + \overline{Q}$

(A) XOR

(B) AND

(C) OR

(D) NAND

(E) NOR

12. An analogue signal can take on any value from -12V to +12V. The signal is to be quantised to a resolution of 0.2 V or better. What is the minimum number of bits needed to represent each sample of the signal?

    (A) 5

    (B) 6

    (C) 7

    (D) 8

    (E) 9

13. Complete the sentence. “A music signal with highest frequency 15kHz can be represented without any loss of information if we sample the signal ....”

    (A) 4000 times a second
    (B) 7500 times a second
    (C) 15000 times a second
    (D) 20000 times a second
    (E) 32000 times a second

14. An electron is moving down the page between the poles of a magnet, as shown in Figure 8. In which direction will the electron be deflected by the magnetic field?

    (A) Right
    (B) Left
    (C) Into the page
    (D) Out of the page

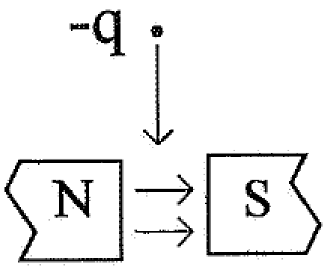


Figure 8

15. A transformer converts 550 kV from a transmission line into 110 kV for a distribution line. If there are 20 turns on the secondary side, how many turns are there on the primary side?

    (A) 4

    (B) 40

    (C) 100

    (D) 500

    (E) 50

Section B

Answer *three* of the following four questions. Each question is worth 20 marks.

16.

(a) Find the Thévenin equivalent resistance seen by the load R_L of the circuit shown in Figure 9.

(b) Find the Thévenin equivalent voltage seen by the load R_L of the circuit shown in Figure 9.

(c) Draw the Thévenin equivalent circuit seen by the load R_L of the circuit shown in Figure 9.

(d) Hence or otherwise, determine the resistance of the unknown load resistor R_L such that the load draws (5/3) A of current.

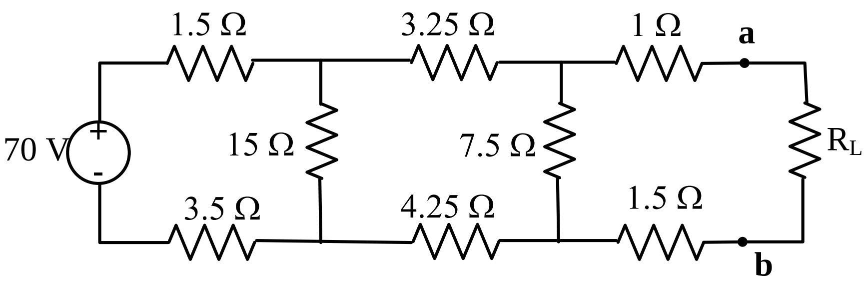


Figure 9

17. The Engineering facilities team in Google's Data Centres monitor and operate some of the most sophisticated electrical and HVAC systems in the world. In particular this team must monitor for any physical threats to the IT equipment that could jeopardize the centre infrastructure.

These physical threats can be classified into four categories and each category is given a numerical value that rates the significance of the threat (see Figure 10) : Liquid leaks - 8, Unauthorised human presence - 9 , Air quality threats (Temperature and Humidity) - 7 and Smoke and fire from data centre hazards - 6. If the sum of these numbers goes to 15 or above an alarm must be raised.

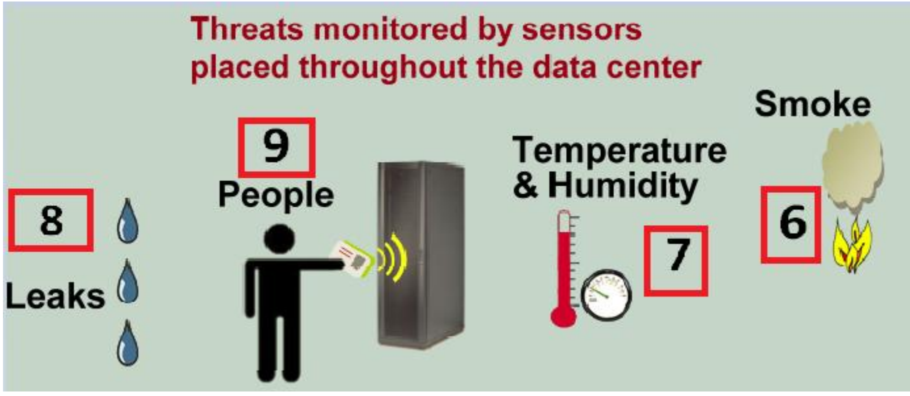


Figure 10

You are asked to design a digital circuit to be used in Google for a data centre systems operation check (X) which will indicate when the threat level is 15 or greater (X=1).

(a) Generate the truth table to describe the digital circuit output X for all possible combinations of physical threats.

(b) Write a Boolean logic expression for the systems check (X).

(c) Use a Karnaugh Map to find the minimum sum of products expression for the logic function X.

(d) Draw a logic circuit to realise this function.

(e) Using De Morgan's Laws, show how this function could also be implemented using just NAND gates. Draw a diagram of your circuit.

18. (a) The mystery device pictured in Figure 11 has the V-I characteristic pictured in Figure 12. What is the device likely to be? Be as specific as possible.

Figure 11

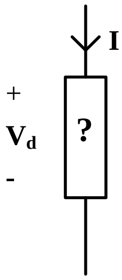
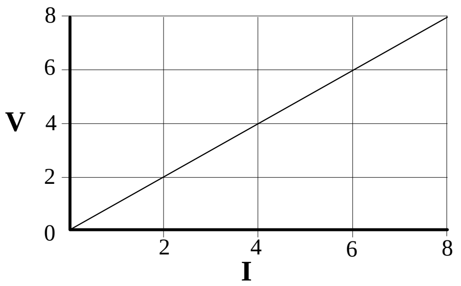


Figure 12



(b) It is discovered that the V-I characteristic of the device depends on room temperature for the room in which the device is placed. The dependence is that the slope of the line in the V-I characteristic changes linearly with the temperature. For example, when the room temperature is 25 degrees, the slope is 1V per 1A as shown in Figure 12. When the room temperature is 30 degrees, the slope increases to 1.1V per 1A. When a current of 5A flows through the device, what is the voltage across the device

i. when the temperature is 22 degrees?

ii. when the temperature is 26 degrees?

(c) The device is put into a circuit with an ideal 5A current source and an ideal voltage source of V_x volts as shown in Figure 13. The voltage across the device and the voltage source, V(t) is put through an amplifier and then passed to a display which displays the input voltage as listed in Table 1. What should the gain of the amplifier and the voltage V_x of the voltage source be so that the correct room temperature is displayed?

Input Voltage	Displayed Symbols
0.0 V	0.0
0.2 V	0.2
:	:
10.0 V	10.0
:	:
40.0 V	40.0

Table 1

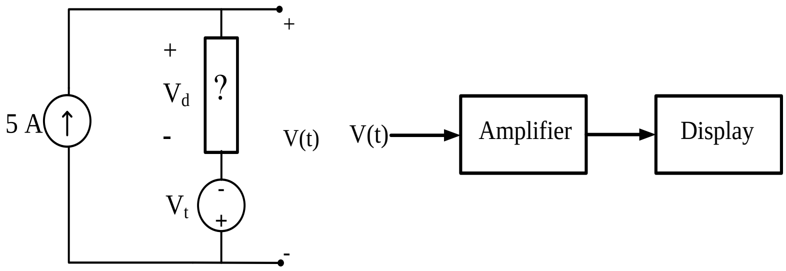


Figure 13

19. (a) A wire of length ℓ carrying current I sits in a uniform magnetic field with magnetic flux density B, as shown in Figure 14. Using Lorenz's force law, $F = QuB\sin(\theta)$, show that the force felt by the wire is $F = I\ell B$.

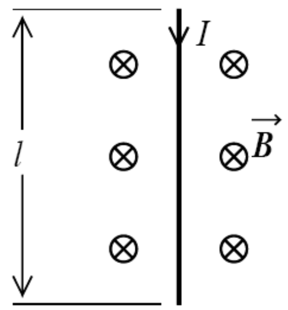


Figure 14

(b) A plane circular loop of conducting wire of radius r = 10cm which possesses N=15 turns is placed in a uniform magnetic field. The direction of the magnetic field makes an angle of 30^{o} with respect to the normal direction to the loop. The magnetic field-strength B is increased at a constant rate from B_1 = 1T to B_2 = 5T in a time interval of Δt = 10 s.

i. What is the voltage generated around the loop?

ii. If the electrical resistance of the loop is R=15 Ω what current flows around the loop as the magnetic field is increased?

(c) In a simple electric motor the speed of rotation is limited by an electromagnetic effect known as electromagnetic induction. Briefly explain how this effect limits the speed of rotation.

Formulae

The symbols below have their usual meanings.

$\vec{F} = Q\vec{E}$	$R = \frac{L}{\sigma A}$	$\overline{\overline{A}} = A$	$A+B = B+A$	$A + A\cdot B = A$
$W = QV$	$V = RI$	$A\cdot A = A$	$A\cdot B = B\cdot A$	$A\cdot(A+B) = A$
$I = \frac{dq}{dt}$	$\frac{V_2}{V_1} = \frac{N_2}{N_1}$	$A\cdot\overline{A} = 0$	$A+(B+C) = (A+B)+C$	$A+\overline{A}\cdot B = A+B$
$P = VI$	$\vec{F} = Q(\vec{u}\times\vec{B})$	$A\cdot 0 = 0$	$A\cdot(B\cdot C) = (A\cdot B)\cdot C$	$A\cdot(\overline{A}+B) = A\cdot B$
$\vec{J} = \sigma\vec{E}$	$F = BlI$	$A\cdot 1 = A$	$A\cdot(B+C) = A\cdot B + A\cdot C$	$\overline{A\cdot B} = \overline{A}+\overline{B}$
$\lvert\vec{E}\rvert = \frac{V}{L}$	$v = N\frac{d\phi}{dt}$	$A+A = A$	$A+(B\cdot C) = (A+B)\cdot(A+C)$	$\overline{A+B} = \overline{A}\cdot\overline{B}$
$\lvert\vec{J}\rvert = \frac{I}{A}$	$\lvert\vec{B}\rvert = \frac{\phi}{A}$	$A+\overline{A} = 1$	$A+0 = A$	$A+1 = 1$
$G = \frac{\sigma A}{L}$	$\lvert\vec{B}\rvert = \frac{\mu I}{2\pi d}$	$I = GV$	$\lvert\vec{B}\rvert = \frac{\mu NI}{l}$	Charge on electron= -1.6×10^{-19}C

"oOo"