University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

SEMESTER I EXAMINATIONS - 2011/2012

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. A constant current of 5mA flows through a circuit element. How much charge passes through the circuit element in 5 minutes?

   (A) 15 C

   (B) 1.5 C

   (C) 0.025C

   (D) 0.25C

   (E) 25 C

2. A length of wire has a resistance of 100 Ω. A second wire of the same material and at the same temperature is half as long and has a cross-sectional area five times that of the first wire. What is the resistance of the second wire?

   (A) 100 Ω

   (B) 10 Ω

   (C) 500 Ω

   (D) 50 Ω

   (E) 250 Ω

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

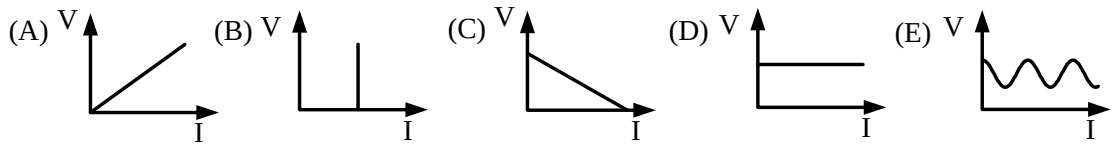

Figure 1

4. A 100W light bulb is on for 15 minutes. How much energy does it consume?

   (A) 1.5 kJ

   (B) 150 J

   (C) 9 kJ

   (D) 90 kJ

   (E) 900 J

5. What is the voltage V in the circuit shown in Figure 2?

(A) 1.56 V
(B) 7.5 V
(C) 4.5 V
(D) 45 V
(E) 2.77 V

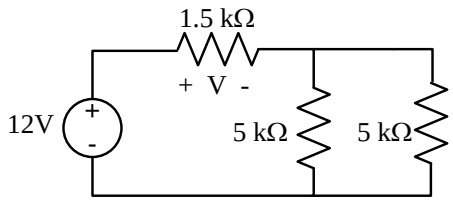

Figure 2

6. What is the current flowing in the 4 Ω resistor in the circuit shown in Figure 3?

(A) 4 mA
(B) 3.2 mA
(C) 8 mA
(D) 1.6 mA
(E) 2 mA

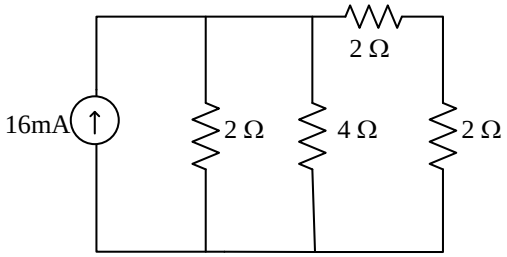

Figure 3

7. In the circuit in Figure 4 the ammeter, which measures the current passing through it, reads 0.25 A. What is the voltage V across the 70Ω resistor?

(A) 52.5 V
(B) 7 V
(C) 70 V
(D) 350 V
(E) 35 V

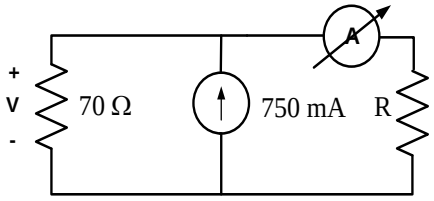

Figure 4

8. What is decimal number 73 in binary format?

(A) 1010101
(B) 1010110
(C) 1001001
(D) 1100101
(E) 1101110

9. Subtract binary number 110101 from binary number 1011100?

   (A) 111011

   (B) 101010

   (C) 101100

   (D) 100111

   (E) 100101

10. Which of the following combinations of inputs (ABCD) will produce an output of X = 1 in the logic circuit shown in Figure 5?

    (A) 0000

    (B) 0001

    (C) 0010

    (D) 0110

    (E) 1001

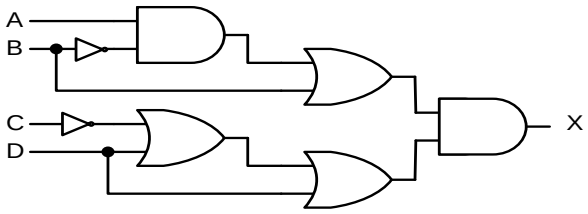

Figure 5

11. An electron is moving to the right between the poles of a magnet, as shown in Figure 6. In which direction will the electron be deflected by the magnetic field?

    (A) Into the page

    (B) Out of the page

    (C) To the left

    (D) Upwards

    (E) Downwards

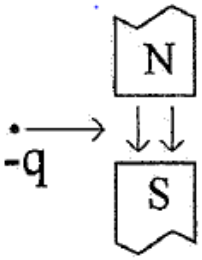

Figure 6

12. Which signal best describes the frequency spectrum shown in Figure 7?

    (A) $v(t)= 2\sin(25\pi t) + 4\sin(100\pi t) + 8\sin(150\pi t)$

    (B) $v(t)= 2\sin(50\pi t) + 4\sin(200\pi t) + 8\sin(300\pi t)$

    (C) $v(t)= 2\sin(50\pi t) + 4\sin(200\pi t) + 4\sin(300\pi t)$

    (D) $v(t)= 2\sin(100\pi t) + 4\sin(200\pi t) + 8\sin(800\pi t)$

    (E) $v(t)= 8\sin(50\pi t) + 4\sin(200\pi t) + 2\sin(800\pi t)$

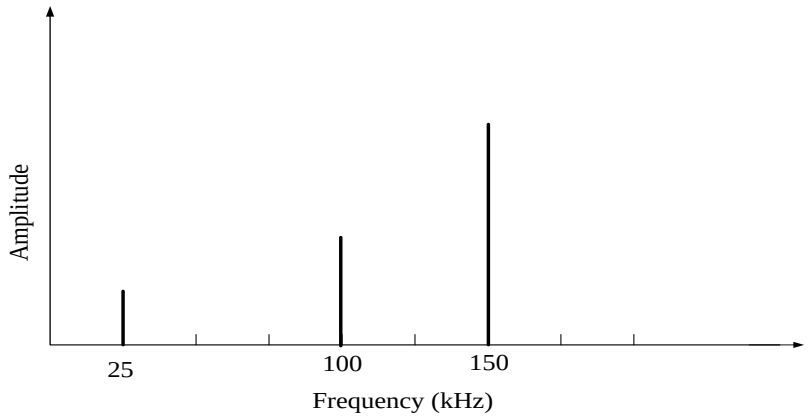

Figure 7

13. A signal is sampled with a sampling frequency of 30 kHz. What is the highest frequency component that the original signal should contain for it to be sampled accurately?

    (A) 15 kHz
    (B) 30 kHz
    (C) 10 kHz
    (D) 20 kHz
    (E) 60 Hz

14. Which of the following is an alternative expression for $X = AB + \overline{B}C$?

    (A) $X = \overline{\left(\overline{AB}\right)\left(\overline{B}C\right)}$
    (B) $X = AC$
    (C) $X = \overline{\overline{AB} + \overline{\overline{B}C}}$
    (D) $X = \overline{\left(\overline{A} + \overline{B}\right)\left(B + \overline{C}\right)}$
    (E) $X = \overline{\left(A + B\right)\left(B + \overline{C}\right)}$

15. A transformer converts 230 kV from a transmission line into 23 kV for a distribution line. If there are 500 turns on the primary side, how many turns are there on the secondary side?

(A) 10

(B) 100

(C) 200

(D) 50

(E) 500

Section B

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

16. (a) Find the Thévenin equivalent resistance of the circuit shown in Figure 8.

(b) Find the Thévenin equivalent voltage of the circuit shown in Figure 8.

(c) Draw the Thévenin equivalent circuit of the circuit shown in Figure 8.

(c) A 1.5 Ω resistor is connected between terminals A and B in Figure 8. Calculate the power dissipated in the 1.5 Ω resistor.

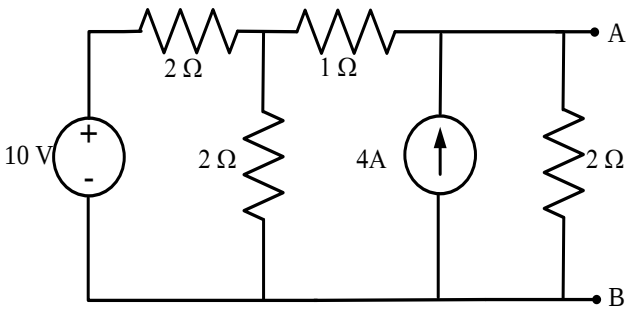

Figure 8

17. The National Control Centre (NCC) ensures the safe, secure and economic operation of the electrical transmission system in Ireland. There is a requirement on the system to have a certain amount of reserve to maintain system security in the event of a generator trip.

In a particular area, 4 power stations can be used to generate the reserve requirement and are labelled A, B, C and D. Power station A can generate 80MW, power station B can generate 115MW, power station C can generate 210MW and power station D can generate 130MW.

You are asked to design a digital circuit to be used in the NCC for a systems security check (X) which will indicate when the reserve is 300MW or greater (X=1). You should assume that each power station is either not generating electricity (False/0) or is generating at full capacity (True/1).

(a) Generate the truth table to describe the digital circuit output X for all possible combinations of power station inputs.

(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.

18. A Holter monitor is a portable device for continuously monitoring heart activity (i.e. it records electrocardiogram (ECG) signals) and is useful in observing occasional cardiac arrhythmias.

You are asked to design a system for processing the ECG signals recorded by the Holter monitor. The signal is to be first filtered and amplified and then converted from analogue to digital format. The frequency content of the ECG signal ranges from 0.01 Hz to 150 Hz and the signal is recorded within the range ±5mV.

(a) Chose a suitable amplifier gain if the range of the analogue to digital convertor is ±0.5V.

(b) Chose an appropriate sampling frequency for the ECG signal to produce an accurate digital signal.

(c) How many binary digits are needed to represent each sample in order that the resolution of the analogue to digital convertor be at least 0.5mV?

(d) Chose appropriate filtering to remove unwanted interference in your signal while retaining the frequency components that you are interested in. Sketch the frequency response of the filter, or filters, that you chose.

(e) Explain the difference between analogue and digital signals.

19. (a) A long vertical wire of length carries a down ward current of 25A. What is the magnitude and direction of the magnetic flux density at a point 50mm south of the wire ($\mu_0 = 4\pi \times 10^{-7}$ Tm/A) ?

(b) A rectangular coil of wire has 5 turns, dimensions 30mm x 15mm and can rotate about its long axis. The coil is placed between the poles of a magnet which produces a uniform magnetic field with flux density B=0.5T, as shown in Figure 9.

i. If the coil is stationary at an angle $\Theta=45^o$ to the magnetic field, find the torque that is acting on the coil when a 2A current passes through the coil in the clockwise direction

ii. At the point marked A in Figure 9, the current flows in the direction into the page along the long axis of the coil. Describe what would happen if the coil is released so that it is free to rotate about its axis.

iii. Explain how this system could be modified to produce an electric motor.

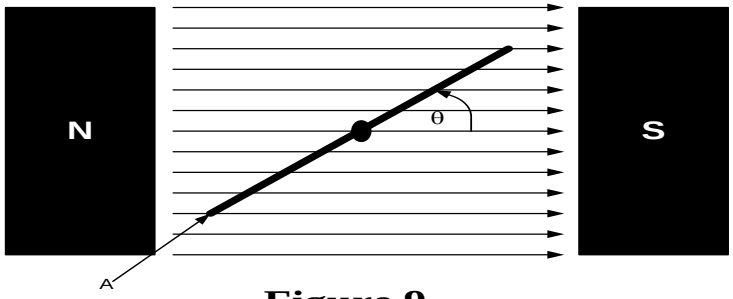

Figure 9

Formulae

The symbols below have their usual meanings.

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

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