University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

SEMESTER I EXAMINATIONS - 2010/2011

School of Electrical, Electronic and Mechanical Engineering

EEEN10010 Electronic & Electrical Engineering I

Professor McLaughlin

Professor Fitzpatrick

Professor Brazil

Ms. 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. Electrons pass through a wire cross-section at a rate of 5×10^{12} electrons every 5 seconds. What is the current flowing in the wire?

   (A) -0.16 μA

   (B) -16 mA

   (C) -90 μA

   (D) -160 μA

   (E) -9 mA

2. A cylindrical silver conductor has a cross sectional area of 4 mm^2. The resistance measured between the ends of the conductor is 4 Ω. Using Table 1, what is the approximate length of the conductor?

   (A) 1 m

   (B) 100 m

   (C) 1000 m

   (D) 200 m

   (E) 500 m

Material at 20°C	Resistivity (Ωm)
Silver	1.6×10^{-8}
Copper	1.72×10^{-8}
Gold	3.14×10^{-8}
Tungsten	6.28×10^{-8}

Table 1

3. What is measured in Volts per Ohm?

   (A) Charge

   (B) Current

   (C) Permittivity

   (D) Conductivity

   (E) Force

4. Find the average power input to a device that consumes 5400 J in 5 minutes?

   (A) 180 W

   (B) 90 W

   (C) 18 W

   (D) 9 W

   (E) 900 W

5. What is the magnitude of the force exerted by a charge q_1= 20 μC due to a charge q_2= 300 μC a distance 3m away? Assume the charge lies in free space (i.e. ε_0= $8.85\times10^{-12}\ C^2N^{-1}m^2$)

   (A) 12 N

   (B) 18 N

   (C) 2 N

   (D) 6 N

   (E) 8 N

6. In Figure 1 what is the value of R?

   (A) 10 Ω

   (B) 12 Ω

   (C) 14 Ω

   (D) 16 Ω

   (E) 18 Ω

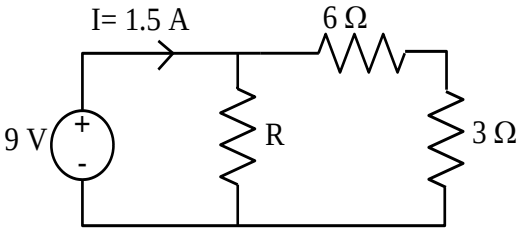

Figure 1

7. For the circuit in Figure 2, which equation relates the current of the current source, I_S, and the current flowing through resistor R_1?

   (A) $I_1 = \dfrac{1/R_1}{1/R_1 + 1/R_2} I_S$

   (B) $I_1 = \dfrac{R_1}{1/R_1 + 1/R_2} I_S$

   (C) $I_1 = \dfrac{R_1 R_2}{1/R_1 + 1/R_2} I_S$

   (D) $I_1 = \dfrac{1/R_2}{1/R_1 + 1/R_2} I_S$

   (E) $I_1 = \dfrac{1/R_1}{R_1 + R_2} I_S$

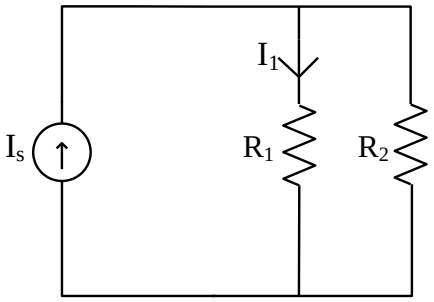

Figure 2

8. In the circuit in Figure 3 what is the power dissipated in the 15kΩ resistor?

(A) 0.6 W
(B) 6 W
(C) 60 W
(D) 8 W
(E) 80 W

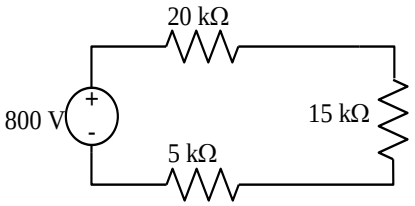

Figure 3

9. In the Logic circuit shown in Figure 4 A=1, B=1 and C=0. What are X and Y?

(A) X=0 and Y=0
(B) X=1 and Y=0
(C) X=0 and Y=1
(D) X=1 and Y=1

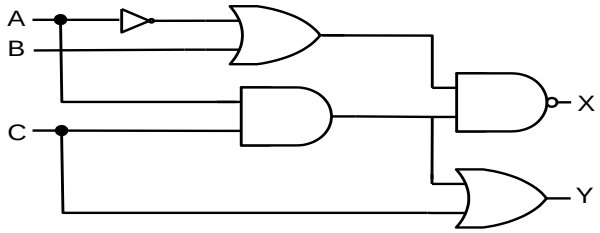

Figure 4

10. A solenoid with a free space core has 10 turns and carries a current of 10A. What happens to the magnitude of the magnetic flux density in the core, if the air is replaced with a metal with permeability 500 times that of free space and current is reduced to 0.2 A?

(A) Increases by a factor of 10
(B) Increases by a factor of 10
(C) Decreases by a factor of 5
(D) Nothing
(E) Decreases by a factor of 2

11. What is decimal 87 in binary format?

(A) 1110101
(B) 1010111
(C) 1011011
(D) 1100101
(E) 1101110

12. Which signal best describes the frequency spectrum shown in Figure 5?

(A) $v(t)= 5\sin(200\pi t) + 3\sin(100\pi t) + 2\sin(8000\pi t)$

(B) $v(t)= 2\sin(200\pi t) + 3\sin(400\pi t) + 5\sin(100\pi t)$

(C) $v(t)= 5\sin(200\pi t) + 3\sin(100\pi t) + 5\sin(400\pi t)$

(D) $v(t)= 3\sin(100\pi t) + 5\sin(200\pi t) + 2\sin(400\pi t)$

(E) $v(t)= 3\sin(200\pi t) + 5\sin(400\pi t) + 2\sin(1000\pi t)$

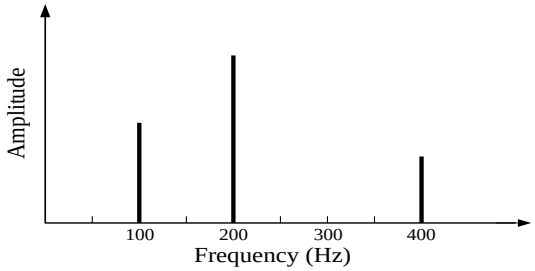

Figure 5

13. In order to select the component with the smallest amplitude and eliminate the other components, the signal in Figure 5 should be put through?

(A) A Low Pass Filter (B) A Band Pass Filter (C) A Band Stop Filter
(D) A High Pass Filter (E) An Amplifier

14. Figure 6 illustrates the Left Hand Rule. The thumb points in the direction of Force. Which of the following statements is also true?

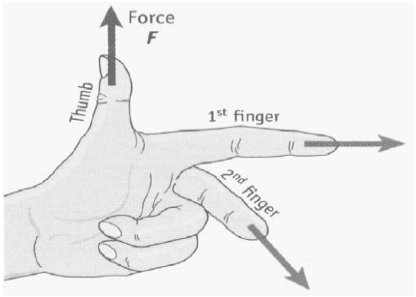

Figure 6

(A) The 1st Finger points in the direction of the magnetic field and the 2nd finger points in the direction of the current.

(B) The 1st Finger points in the direction of the current and the 2nd finger points in the direction of the magnetic field.

(C) Both fingers point in the direction of the magnetic field.

(D) The 1st Finger points in the direction of the magnetic field and the 2nd finger points in the direction of the force.

15. Find the minimum sum of products expression of the function represented by the Karnaugh map shown in Figure 7.

(A) $f = \overline{W}.Y + X.Z$

(B) $f = \overline{W}.Y + X.Z + W.\overline{X}.\overline{Z}$

(C) $f = \overline{W}.YX + X.Z + W.\overline{Z}$

(D) $f = \overline{W}.Y + X.Z + W.X.Z$

(E) $f = X.Z + W.\overline{Z}$

WX \ YZ	00	01	11	10
00	0	0	1	1
01	0	1	1	1
11	0	1	1	0
10	1	0	0	1

Figure 7

Section B

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

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

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

(c) A 3Ω resistor is connected between terminals A and B in Figure 8. Calculate the power dissipated in the 3Ω resistor.

(d) When the voltage across a capacitor changes at a rate of 480 V per minute, a steady state current of 4mA flows through the capacitor. Find the capacity.

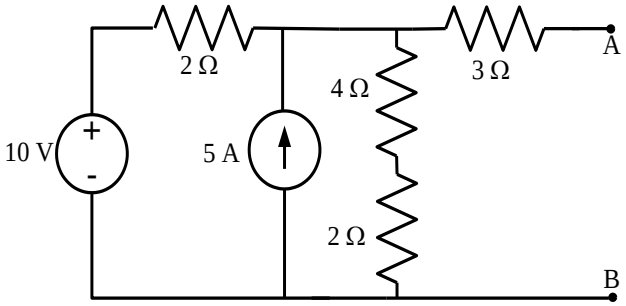

Figure 8

17. (a) The frequency content of an EEG signal ranges from 1 to 80 Hz. The signal has a maximum value of 0.3 V and a minimum value of –0.5 V. The signal is to be sampled, filtered and quantised.

i. What is the lowest rate the signal can be sampled to produce an accurate digital signal?

ii. If the signal is digitised using an 8 bit analog to digital converter, with a full scale range of ± 1 V. What is the resolution of the converter?

iii. The EEG signal is contaminated with 50 Hz power-line interference. Describe an appropriate filter and the corresponding filter cut-off frequencies that could be used to remove this interference.

(b) What is the value of V_{out} when the potentiometer is set to its midpoint in Figure 9?

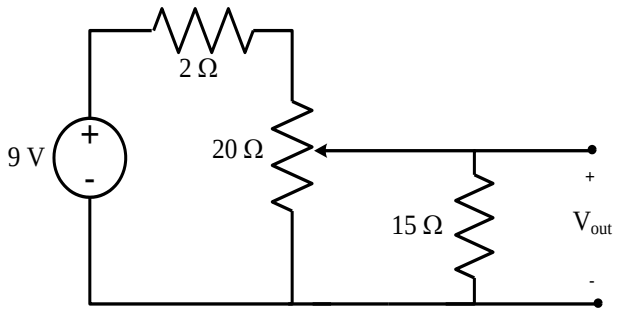

Figure 9

18. (a) A wire of length ℓ carrying current I sits in a uniform magnetic field with magnetic flux density B, as shown in Figure 10. Using Lorenz's force law, $F = QuB\sin(\theta)$, show that the force felt by the wire is $F = I\ell B$.

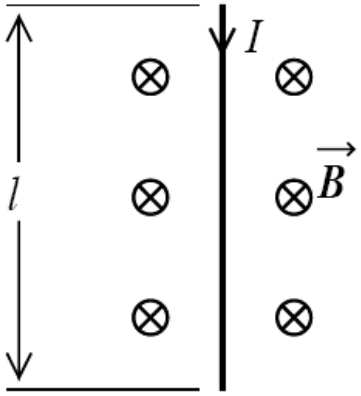

Figure 10

(b) The electric motor in Figure 11 has a uniform magnetic field of 1T and a square coil of side 4 cm with 5 turns. The coil carries a current of 2A.

i. What is the torque when the coil is at an angle of 30 degrees to the magnetic field lines?

ii. If there are now 10 turns instead of 5, what is the torque?

iii. What direction will the loop spin?

(c) Based simply on the analysis in part b, the motor should spin faster and faster without end. However, this does not occur. Clearly friction plays one role in limiting the speed of rotation, but what electromagnetic effect is the main cause of this limitation and how does it limit the speed?

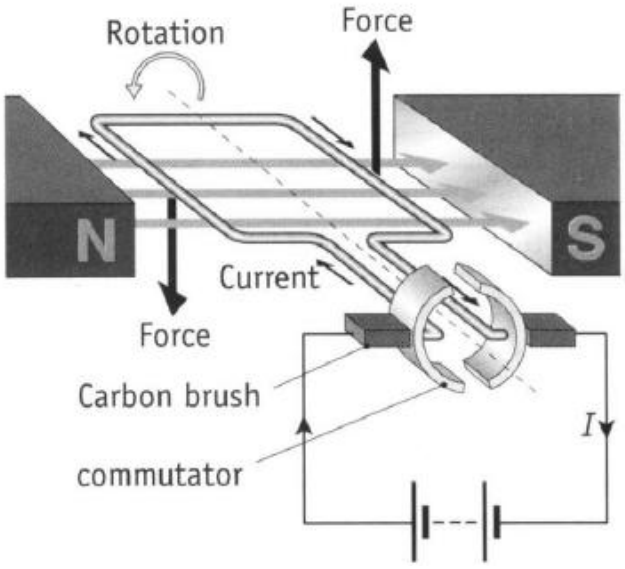

Figure 11

19. (a) Explain the difference between analog and digital signals.

(b) You are asked to design an alarm system that monitors a hospital patient's vital statistics. The alarm system consists of the following signals.

B= position in bed (out of bed=1; in bed=0)

H= Heart rate (Heart rate drops below 40 beats per minute (bpm)=1; Heart rate remains stable=0)

T= Temperature (Temperature increases above 96^{o}C=1; Temperature drops below 96^{o}C=0)

M= Intravenous Medication (Medication levels drop below 10ml=1; Medication levels stay above 10ml=0)

The alarm will sound alerting the nurse on duty under the following conditions; if the patient's heart rate drops below 40bpm and his temperature increases above 96^{o}C; if the medication levels drop below 10ml and his temperature increases above 96^{o}C; if the patient gets out of bed and his heart rate drops below 40bpm; or if his temperature drops below 96^{o}C and he gets out of bed and his heart rate drops below 40bpm.

i. Generate the truth table for this specification.

ii. Generate a Boolean Algebra expression that describes the operation of the alarm.

iii. Design a circuit to implement this system using the minimum number of logic gates.

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

"**oOo**"