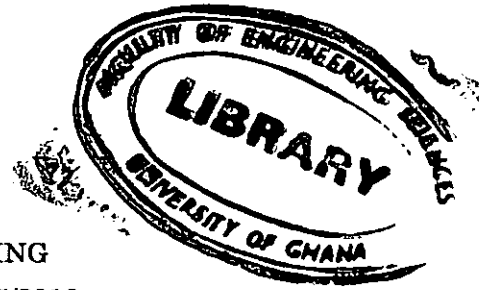




UNIVERSITY OF GHANA

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BACHELOR OF SCIENCE IN ENGINEERING
SECOND SEMESTER EXAMINATIONS: 2015/2016

DEPARTMENT OF COMPUTER ENGINEERING
CPEN 206: LINEAR CIRCUITS (3 Credits)

INSTRUCTION: *Answer any five (5) Questions of your choice.*

TIME ALLOWED: *THREE (3) HOURS*

1. (a) What do you understand by the term “linear circuit”? Give two (2) reasons why it is important to study linear circuit and four (4) areas of application of linear circuits. [7 marks]
(b) The current flowing through the positive terminal of a TV set is given as $I(t) = 15e^{-4t}$ and the voltage across the device is $V(t) = 20dI/dt$. Find the power absorbed by the TV and calculate the energy consumed by the TV in 20 seconds. [9 marks]
(c) Find the resistance of a 1m length of copper wire with rectangular cross section area of 2.5cm by 0.05cm. Assume that $\rho = 1.724 \times 10^{-8}$ ohm-meter. [4 marks]
2. (a) Explain the difference between an *ideal independent* voltage source and an *ideal dependent* voltage source. Give one example each of an independent current source and an independent voltage source. [4 marks]
(b) A 12V source supplies a 3Ω resistor that is connected to a parallel combination of 8Ω resistor and 4Ω resistor. The 4Ω resistor is in turn connected to a parallel combination of a 7Ω resistor and a 5Ω resistor. The 5Ω resistor is connected to a 9V power supply. Sketch the circuit diagram and find the branch currents in the circuit using node analysis method. [9 marks]
(c) The characteristics of a voltage signal in a telephone wire is given as follows: $v(t) = 0$ at $t = 0$, $v(t) = 20\mu V$ at $t = 20ms$, $v(t) = 0$ at $t = 30ms$, $v(t) = -20\mu V$ at $t = 40ms$, and $v(t) = 0$ at $t = 50ms$. Sketch the voltage signal and derive an expression

- for the voltage signal in the wire. [7 marks]
3. (a) Explain the difference between *Thevenin theorem* and *Norton theorem*. Use simple circuit diagrams to support your answer. [4 marks]
- (b) A 2V source supplies a 2Ω resistor that is connected to a parallel combination of 12Ω resistor and 1Ω resistor. The 1Ω resistor is in turn connected to the parallel combination of a 5Ω resistor and a 3Ω resistor. The 3Ω resistor is supplied by a 4V voltage supply.
- (i) Sketch the circuit diagram and find the Thevenin equivalent voltage V_{TH} and Thevenin equivalent resistance R_{TH} of the circuit. [10 marks]
- (ii) Find the current in the 5Ω resistor. [2 marks]
- (iii) What is the condition under which maximum power will be transferred to the 5Ω resistor? What is the value of this maximum power? [4 marks]
4. (a) Sketch a diagram of the 8-pin operational amplifier and indicate the function of each pin. State four (4) application areas of an operational amplifier. [6 marks]
- (b) Sketch the circuit diagram of the differentiator circuit and derive an expression for the output of the circuit at time $t = 0$. Assume the input voltage to the circuit is $V_{in} = 2\cos 3000\pi t$, $R = 100k\Omega$, and $C = 0.02\mu F$. [7 marks]
- (c) A triangular input voltage $v(t)$ with the following characteristics is applied to the differentiator circuit in 4 (b) above: $v(t) = 0$ at $t = 0V$, $v(t) = 4V$ at $t = 2ms$, $v(t) = 0V$ at $t = 4ms$, $v(t) = -4V$ at $t = 6ms$, and $v(t) = 0V$ at $t = 8ms$. Sketch the input voltage and derive an expression for the input voltage signal. Find the output signal voltage signal from the differentiator and sketch the signal. [7 marks]
5. (a) Design an inverting operational amplifier circuit that could be used for the amplification of signals received from a sensor. Your circuit must have an input resistance of $20k\Omega$ and a gain of 40dB. [7 marks]
- (b) A passive filter circuit has a series arrangement of an L, C and R elements. The input voltage to the circuit $V_s = 20\sin(\omega t)$, $R = 2\Omega$, $L = 1mH$, and $C = 0.4pF$. Find resonance frequency in Hz and magnitude of the current at resonance. [6 marks]
- (c) A 4-bit DAC circuit has a feedback resistor $R_f = 10k\Omega$ and input resistors $R_1 = 10k\Omega$, $R_2 = 20k\Omega$, $R_3 = 30k\Omega$ and $R_4 = 40k\Omega$. The binary input voltage is $[V_1, V_2, V_3, V_4]$ with V_1 as the MSB and V_4 as the LSB. Sketch the circuit diagram of the DAC and find the analog output for the binary input [0101]. [7 marks]

6. (a) Briefly explain the following linear circuit terms: *source-free circuit*, *time constant*, and *natural response of a circuit*. [6 marks]
- (b) A 20V source has a series resistor of 3Ω that is in turn connected to a parallel combination of a 20mF capacitor and a 1Ω resistor. The 1Ω resistor is connected to a 20Ω resistive load. If the capacitor voltage at time $t = 0$ is 20V, sketch the circuit diagram and find the voltage across the capacitor and the load at time $t > 0$. Find initial energy ($t = 0$) and final energy ($t > 0$) stored in the capacitor. [9 marks]
- (c) With the support of a simple circuit diagram, briefly describe how a first order RC circuit can be applied in camera application. [5 marks]

