L-3/T-2/EEE

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2  B. Sc. Engineering Examinations 2012-2013

Sub: EEE 309 (Communication Theory)

Full Marks: 210  Time: 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are FOUR questions in this Section. Answer any THREE.

Answer in brief and to the point. Symbols have their usual meanings. Fig. attached for Q. 4(a)

1. (a) Name the two major fundamental limitations of a communication system. Define information, I, carried by a multi-level information-bearing signal with equally spaced interval in a time span of T seconds and derive the expression for system capacity, C. Comment on what poses the limit to the information transmission and how they are related to the fundamental limitations you have mentioned above.

(b) What is the function of a communication channel? Name the two types of distribution or impairment a communication channel can cause to an intelligence signal. Calculate the attenuation and delay for each frequency component of the input signal $x(t) = 0.6 \cos(2400 \pi t) + 0.5 \cos(3000 \pi t) + 0.8 \cos(3600 \pi t)$, as it passes through a communication channel with the following propagation characteristic:

$$\gamma = \alpha + j \beta = \frac{600\pi}{\omega} + j \left(0.05\omega + \frac{10^{-5}}{2\pi\omega^2}\right)$$

Can the channel pass the signal, $x(t)$, to the destination without distortion?

(c) Explain, with suitable sketches, how the signal distortions caused by a communication channel are mitigated in a practical communication system.

2. (a) What is noise? Distinguish between noise and interference. Calculate the maximum available thermal noise power ($N$ in watt) that a resistive termination in a standard band-limited telephone channel (300 Hz - 3400 Hz) will produce at 27°C. (Boltzman constants, $k = 1.38 \times 10^{-23}$ J/°K)

Define signal to noise power ratio (SNR) in dB. What is the acceptable level of SNR in dB for analog speech signals in a telecommunication channel? Compute the signal power, $S$, in watt, required to achieve the acceptable SNR for the noise power, $N$, obtained as above.

(b) Mention the most major limitation of an analog communication system. With appropriate attenuation characteristics of lossy and lossless communication channels as a function of distance, explain in brief, the said drawback and possible suggestions for improving the performance using amplifier(s). Which suggestion is adopted in a practical analog communication system and why?
(c) Using Shannon's maximum capacity theorem, explain how in 1939, A. H. Reeves of Bell Laboratories did suggest the basic principle of overcoming the major limitation cited in part of Q No. 2.

3. (a) What is modulation? Mention the major purposes of modulation in brief. Calculate the size of the antenna for transmitting an analog baseband signal of 20 kHz frequency in wireless communication. Compute the same for a 3 MHz signal frequency and comment on which antenna is suitable for practical use. (5+5)

(b) For a single-tone modulation, \( m(t) = A_m \cos(2\pi f_m t) \), carrier wave, \( c(t) = A_c \cos(2\pi f_c t) \); write down the equation for the amplitude modulated wave and derive the expression for the efficiency \( \eta = \text{sideband power} / \text{total power} \) of a standard amplitude modulator in terms of the modulation index \( m_a \). If an AM wave is represented by \( s(t) = A_c[1 + 0.3 \cos(2\pi f_1 t) + 0.4 \cos(2\pi f_2 t) + 0.5 \cos(2\pi f_3 t)] \). Calculate the overall modulation index, \( m_a \), and determine the efficiency of the amplitude modulator. (7+8)

(c) Write down the equation of an SSB-SC signal for a modulating signal \( m(t) \). Describe the corresponding coherent detection technique and the problem of synchronization. "Although the standard amplitude modulation is both wasteful of power and bandwidth compared to SSB-SC modulation" - Why is the former used in practical AM broadcasting? (8+2)

4. (a) Define FM and PM with appropriate equations. Sketch FM and PM waves produced by the sawtooth wave as shown in Fig. For Q. No. 4(a). (Assume \( A = 1 \) V and \( T = 1 \) second.) (4+6)

With appropriate equations and block diagram, explain how you can achieve FM using an available phase modulator. (10)

(b) Describe, in brief, the direct method of generating FM.

(c) Derive the Fourier series representation of the single-tone FM wave for an arbitrary \( \beta \). Simplify the equation for a narrow band approximation. (8+4+3)
Compute the bandwidth of an FM wave for an intelligence signal $m(t)$ that has a frequency band of 300 Hz - 3400 Hz from the simplified equation derived above. Also, compare the two major advantages of FM over AM.

**SECTION - B**

There are **FOUR** questions in this Section. Answer any **THREE**.

5. (a) A PCM system generates a bit sequence [10011011], which is to be transmitted using DPSK modulation. Assume that the encoding scheme uses the principle of '0' means transition and the reference bit is 1.

   (i) Draw the block diagram of the transmitter and the receiver of the DPSK system.
   (ii) Determine the encoded bit sequence, phase of each encoded bit and the detected bit sequence.

(b) An ASK based digital communication system transmits $A_0 \cos \omega_c t$ and $A_1 \cos \omega_c t$ for bit 0 and bit 1, respectively. Draw the block diagram of the transmitter and the receiver of the system. Write the expressions of the signals at each point of the transmitter and the receiver.

(c) Compare ASK, FSK and PSK in terms of bandwidth requirement and noise performance.

6. (a) A DS-CDMA system with 4-transmitter-receiver pairs uses PN sequences of 128 Chips long. If each of the transmitter-receiver pairs has a bit rate equal to 64 kbps requiring 32 kHz bandwidth for direct bit transmission,

   (i) Calculate the bit rate and the chip rate of the system?
   (ii) What is the bandwidth requirement for the DS-CDMA system? What would have been the required bandwidth if TDMA were used?

(b) With necessary diagram, explain why an FH-CDMA system is called spread-spectrum system. Why is an FH-CDMA system difficult to jam?

(c) The detected bit sequence by receiver 1 of a 2-user DS-CDMA system is [1 0 1]. Let the signals in the channel corresponding to the 3-bits are presented as $[+2 0 -2 0]$, $[-2 -2 0 -2]$ and $[-2 +2 0 +2]$, respectively. The two PN sequences used by the system are [1 0 0 1] and [0 1 1 0]. Determine the PN sequence used by the receiver 1. If the receiver 1 uses the other PN sequence, what will be the detected bit sequence and how many bits will be erroneously detected?
7. (a) For a uniform symmetric L-level quantizer, derive the expression of signal-to-quantization-noise-ratio (SQNR) in terms of signal power $P$ and step size $\Delta$. 

(b) A DPCM system with a symmetric message signal $m(t)$ of amplitude $A_m$ generates error signal (comparator output) $e(t)$ in the range of $+E_m$ to $-E_m$. Let $P_m$ and $P_e$ denote the power of $m(t)$ and $e(t)$, respectively.

(i) Assuming equal number of quantization levels for both PCM and DPCM systems, show that the SNR improvement in DPCM over PCM system is proportional to $P_m/P_e$.

(ii) For keeping the SNR of DPCM system equal to that of PCM system, show that the reduction in the number of quantization levels in DPCM is proportional to $E_m/A_m$.

(c) Consider an FDM system with a channel bandwidth equal to 200 kHz. If the system requires guardbands equal to 500 Hz and each source has a baseband spectrum at 300-3400 Hz, calculate the number of sources that can be multiplexed over the system.

8. (a) State four desirable properties of line coding schemes. For each of these properties, identify one suitable line coding schemes and explain the reason of suitability.

(b) A 3-bit PCM system with input $m(t) = 4\sin 4\pi ft$ uses $\mu$-law non-uniform quantization. The compressor uses $\mu = 255$, whereas the quantizer is of mid-rise type with a step size equal to 1 volt.

Calculate the quantized output at the sampling instances $t = 0, \pm 1/8, \pm 2/8, \pm 3/8$ seconds. Compare these values with the outputs if uniform quantization were used.

(c) A digital audio system records audio signals digitally by using binary coded PCM system. Assume that the audio signal bandwidth equals 20 kHz.

(i) If the signal is sampled at a frequency twice that of Nyquist rate and the samples are uniformly quantized into $L = 65,536$ levels, calculate the bit rate for the system.

(ii) If the audio signal has average power of 0.1 watt and peak voltage of 1 volt, find the resulting SQNR of the system.

(iii) Calculate the required bit rate of the system for achieving an SQNR 20 dB higher than the one calculated in part (ii).
SECTION - A

There are FOUR questions in this Section. Answer any THREE.

1. (a) Two LTI systems are connected as shown with their I/O relationships.

\[ y_1(n) = \sum_{k=n-2}^{n} x(k) \]

\[ y_2(n) = \sum_{k=n-7}^{n} x(k) \]

(i) Determine and plot \( h_1(n) \) and \( h_2(n) \).
(ii) Justify the stability of the systems.
(iii) Justify the causality of the systems.
(iv) Find and plot \( h(n) \) of overall system.
(v) Find \( y(n) \) with \( x(n) = (-1)^n [u(n) - u(n-2)] \).

(b) Define quantization and write its necessity. With an example, describe aliasing, its causes and remedy.

2. (a) Define correlation of LTI system. Describe how correlation is related with output. Describe how signal buried in noise can be determined using autocorrelation.
(b) Find the condition of stability of an LTI system in terms of impulse response. Find the condition of stability of a system having

\[ h(n) = a^n u(-n) + b^n u(n-1) \]

3. (a) Describe poles and zeros in z-domain, and their significance. Describe pole-location and time domain behavior of a system with a suitable example.
(b) Describe Schur-Cohn stability test. Using this test, find the condition of stability for a system having

\[ H(z) = \frac{1}{1 + a_1 z^{-1} + a_2 z^{-2}} \]

4. (a) Consider the following causal system:
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Contd... Q. No. 4(a)

(i) Determine the system function and impulse response if \( H(z)_{z=1} = 1 \)

(ii) Is the system stable?

(iii) Sketch the possible implementation of the system and write corresponding difference equation.

(b) Define different forms of realization structure and describe the steps of converting one form to other. With justification, draw both forms for an FIR MA system.

SECTION - B

There are FOUR questions in this Section. Answer any THREE.

5. (a) Consider \( x[n] = \sum_{r=-\infty}^{\infty} x[n-rN] \), where a finite-length signal \( x[n] = 0 \) except \( 0 \leq n \leq N-1 \). Show that \( N \) equally spaced samples of \( X(e^{j\omega}) \), Fourier transform of \( x[n] \), can be expressed as \( \tilde{X}[k] \), discrete Fourier series coefficients of \( \tilde{x}[n] \), i.e.,

\[
X(e^{j\omega})_{\omega=2\pi k/N} = \tilde{X}[k]
\]

(b) \( x_1[n] = \begin{bmatrix} a & b & c & d & e & 0 & 0 \\ 0 & 1 & 2 & 3 & 4 & 5 & 6 \end{bmatrix} \)

\( x_2[n] = \begin{bmatrix} d & e & 0 & 0 & a & b & c \end{bmatrix} \)

The above two eight-point sequences have discrete Fourier transforms \( X_1[k] \) and \( X_2[k] \), respectively. Determine the relationship between \( X_1[k] \) and \( X_2[k] \).

(c) \( x[n] = \cos \left( \frac{n\pi}{2} \right) \), \( n = 0, 1, 2, 3 \)

\( h[n] = 2^n \), \( n = 0, 1, 2, 3 \)

(i) Calculate \( X[k] \), four point DFT of \( x[n] \)

(ii) Calculate \( H[k] \), four point DFT of \( h[n] \)

(iii) Calculate \( y[n] = x[n] \circledast h[n] \) (four point circular convolution)

(iv) Also calculate \( y[n] \) using IDFT.

6. (a) Derive the general expression of frequency response \( H(e^{j\omega}) \) for Type II FIR linear phase filter.

(b) A causal linear time-invariant discrete-time system has following system function.

\[
H(z) = \frac{\left(1 - 0.5z^{-1}\right)\left(1 + 4z^{-2}\right)}{\left(1 - 0.64z^{-2}\right)}
\]

Contd ........ P/3
i) Find expressions for a minimum-phase system \( H_1(z) \) and an all-pass system \( H_{ap}(z) \), such that \( H(z) = H_1(z) H_{ap}(z) \).

(ii) Between two group delays corresponding to \( H_1(z) \) and \( H(z) \), which one is lower and why?

(iii) Find expressions for a different minimum-phase system \( H_2(z) \) and a generalized linear-phase FIR system \( H_{lin}(z) \), such that \( H(z) = H_2(z) H_{lin}(z) \).

\[
H(z) = \frac{1 + \frac{1}{2} z^{-1}}{\left(1 - 2z^{-1}\right)\left(1 - \frac{4}{3} e^{-j \frac{2\pi}{4} z^{-1}}\right)\left(1 - \frac{4}{3} e^{-j \frac{2\pi}{4} z^{-1}}\right)}
\]  

(i) Sketch the pole-zero plot of \( c(z) = H(z)H^*(z) \).

(ii) Sketch the pole-zero plot of all possible systems which are both causal and stable and have the same \( c(z) \) found in (i).

(iii) Sketch the pole-zero plot of a minimum phase system which has the same \( c(z) \) found in (i) and also sketch the magnitude spectrum of this system.

7. (a) Explain with necessary graphical representations the reason behind the generation of ripples in the resulting filter when a rectangular window is used in windowing method of FIR filter design. Mention the advantages of using Hamming window instead of using rectangular window.

\[
1 - 0.01 \leq |H(e^{j\omega})| \leq 1 + 0.01, \quad 0 \leq |\omega| \leq 0.4\pi
\]

\[
|H(e^{j\omega})| \leq 0.03, \quad 0.5\pi \leq |\omega| \leq 0.65\pi
\]

\[
0.250 - 0.005 \leq |H(e^{j\omega})| \leq 0.250 + 0.005, \quad 0.7\pi \leq |\omega| \leq \pi
\]

A multi-band FIR filter is to be designed using the Kaiser window method based on the above specifications. Find (i) Filter length, (ii) \( \beta \) for Kaiser window, (iii) impulse response of the desired filter, (iv) expression of Kaiser window function \( w[n] \) and (v) impulse response of the designed filter.

8. (a) What is the main problem of impulse invariance method of IIR filter design? Show that by using bi-linear transform method of IIR filter design, causal stable continuous type filter can map into causal stable discrete time filter.
Consider that $x_c(t)$ is a bank-limited signal with a band limit of 2 kHz. $x[n]$ is generated from $x_c(t)$ using a sampling frequency $F_s = 24 \text{ K samples/sec}$ and then $s[n]$ is obtained by downsampling $x[n]$ with a factor 2. Design a discrete-time IIR filter using the bilinear transform method with the following specifications:

$$0.75 \leq |H(e^{j\omega})| \leq 1, \quad 0 \leq |\omega| \leq \omega_p$$

$$|H(e^{j\omega})| \leq 0.25, \quad \omega_s \leq |\omega| \leq \pi$$

Select $\omega_p$ such that the frequency characteristic of $x_c(t)$ is preserved and use $\Delta \omega = \omega_s - \omega_p = 0.3\pi$. 

(25)
BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA
L-3/T-2  B.Sc. Engineering Examinations 2012-2013
Sub: EEE 315 (Microprocessor and Interfacing)
Full Marks: 210  Time: 3 Hours
The figures in the margin indicate full marks.
USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A
There are FOUR questions in this Section. Answer any THREE.
Control words for peripheral devices are attached.

1. (a) What are the functional components of 8255 programmable peripheral interface device?

(b) A permanent magnet dc motor is controlled through PB0, PB1 of 8255 having a base address of 80 H. Write an assembly program that would scan command inputs from port A at PA0, PA1 and operate the motor according to the following function table.

<table>
<thead>
<tr>
<th>Command</th>
<th>PA0</th>
<th>PA1</th>
<th>PB0</th>
<th>PB1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run Clockwise</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Run anti Clockwise</td>
<td></td>
<td></td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Stop running</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
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</tbody>
</table>

Devise a scheme for the inputs and control circuit of the DC motor using appropriate devices and circuit components.

2. (a) With a neat diagram explain the functional blocks of 8251 USART.

(b) An 8086 microprocessor board has onboard 8254 (programmable Timer) and an 8251 (USART), and is connected to a PC thorough RS-232 serial port. The serial communication requires a baud rate of 1200 for both TXC and RXC, 7-bit character length, 1-stop bit and even parity. The baud rate is supplied from counter 0 of 8254 having a clock input of 1.0 MHz. Consider 16-bit addresses for both 8254 and 8251.

(i) Write an assembly program to configure both 8254 and 8261 making the system ready for transmission and reception of data through the USSART.

(ii) Write an assembly program so that on reception of data (command code) from PC the microprocessor will

1) configure counter 1 for programmable clock out at a rate of 100 kHz if received word is decimal 1,

2) Configure counter 1 for programmable clock out at a rate of 20 kHz if received word is decimal 2.

3) Halt the processor if received word is 0.

3. (a) A system utilization an 8259 (Priority Interrupt Controller) in an 8086 microprocessor board to generate interrupts 43, 44 and 45 assigned to suitable 8259 interrupt inputs. The hardware interrupts in turn produces software interrupts of INT 100, INT 200 and INT 250.

Contd ............ P/2
Write an assembly program to serve the interrupts and interrupt service routines so that INT 100 resets the 8086 processor, INT 200 pushes the flag-register into the stack and INT 250 pops stack data into AX register.

(b) What are the special features of DSP processors over general purpose microprocessors? Under what circumstance do you recommend DSP processor for an application?

4. (a) With neat diagram explain the memory organization of AT89C52 microcontroller.

(b) Design a system using AT89C52 microcontroller to blink "EEE" on three 7 segment LED displays connected to P0, P1 and P2. Draw the system schematic along with necessary interface devices, and write a program with C-language consisting SFR deflections available in AT 8952-h file.

SECTION – B

There are FOUR questions in this Section. Answer any THREE.

Assume reasonable any missing data. Symbols carry have their usual meaning.

Provide necessary comments in assembly language codes.

5. (a) Draw the internal architecture of the Intel 8086 microprocessor. Also mention the components of the execution unit and discuss their roles.

(b) How can we endure an even address for a word variable in assembly language? Explain why it is necessary to do so in light of the memory banking system of an 8086 microprocessor.

6. (a) Explain the roles of ALE, M/IO, READY and BHE signals in the execution of a basic instruction of an 8086 microprocessor.

(b) Write an assembly language code which will take the length of three sides of a triangle AB, BC and CA as inputs and will check whether the triangle is a right-angle triangle or not. If it is a right-angle triangle then the program will set carry flag or it will clear carry flag. Assume the lengths are word variables and their products will fit in 16 bits.

(c) What are the difference between 'near' and 'far' procedures in 8086? Write a procedure which will toggle the cases of a character array.

7. (a) What is 'memory segmentation'? Explain why a logical address is not unique?

(b) The purpose of the following code snippet is to calculate the sum of the following series: \[ 1 + 1 + 1 + 1 + \ldots + 1 \]

'N' is the number of terms to be added. What will be value of AX if N is set to zero. What can be done to avoid such output? Rewrite the corrected code.
(c) Determine the value of AX if MUL BL is executed when AL contains 0ABH and BL contains 10H. Also determine the values of CF and OF after the execution of this instruction.

(d) Determine whether the following instructions are correct or wrong? If wrong, give explanation and correct the instruction if possible.

(i) PUSH 0A2F4H
(ii) ROL AL, 5
(iii) DIV 02H
(iv) MOV AX, [DX]
(v) RET 5

8. (a) Design an 8086 microprocessor based system with eight 4Kbytes ROMs, two 16Kbytes ROMs and two 32Kbytes RAMs. Starting address of RAMs is 00000H. It is required to have 32Kbytes of ROM right after RAMs. The rest of the ROMs can have any suitable starting address considering the operation of 8086 microprocessor. Implement even-odd addressing. Show the memory map and the connection schematic. Use logic gates (of arbitrary number of inputs) to implement the address decoders.

(b) Suppose SUB AX, BX is executed. For each of the following cases, give the resulting value of AX and tell whether there is an overflow or not. If there is an overflow then explain whether it is a signed or unsigned overflow.

(i) AX has 2143H and BX has 1986H
(ii) AX has 8BCDH and BX has 71ABH
### 8255A Mode Set Control Word

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<th>D6</th>
<th>D5</th>
<th>D4</th>
<th>D3</th>
<th>D2</th>
<th>D1</th>
<th>D0</th>
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<tbody>
<tr>
<td>Mode Flag</td>
<td>Port A Mode</td>
<td>Port A I/O</td>
<td>Port C (U) I/O</td>
<td>Port B I/O</td>
<td>Port C (L) I/O</td>
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### 8251 Mode Instruction (Asynchronous Mode)

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<tr>
<td>Fla!! I/O Mode</td>
<td>I/O Port C</td>
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### 8251 Command Word

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### 8251 Status Word

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### 8254 Control Word

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### 8259 PIC Control Words

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<th>ICW3</th>
<th>ICW4</th>
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1. (a) The frequency response an RC Network is given by \[ H(f) = \frac{1}{1 + j2\pi f RC} \]. The input to the network, \( x(t) \), is a WSS Gaussian random process with power spectral density (PSD) \( \frac{N_o}{2} \) where \( N_o > 0 \). Find (i) \( S_{yy}(0) \) (ii) \( R_{yy}(t) \) and (iii) average power of \( y(t) \), where \( y(t) \) is output of the RC network. If \( y(t) \) is sampled to generate the discrete random process \( z(n) \), determine \( S_{zz}(0) \) . The sampling interval is 10 sec.

(b) A discrete-time random process \( y(n) \) is given by

\[ y(n) = x(n) + C \]

where \( x(n) \) is a WSS discrete random process and \( C \) is a constant. Find the autocorrelation function of \( Y \). Also determine the conditions for which \( X \) and \( Y \) shall be (i) independent and (ii) orthogonal.

2. (a) A random process \( X(t) \) is defined as

\[ X(t) = A \cos(\omega_0 t) + B \sin(\omega_0 t) \]

where \( \omega_0 \) is a constant, \( A \) and \( B \) are uncorrelated random variables with zero mean and equal variance \( \sigma^2 \). Both \( A \) and \( B \) have different probability density functions. Determine (i) whether \( X(t) \) is mean-ergodic in the mean-square sense and (ii) if \( X(t) \) has a derivative in the mean-square sense.

(b) Let \( X_1, X_2, \ldots, X_n \) be the i.i.d. exponential random variables with a common parameter \( \lambda \). Find the ML estimate of \( \lambda \). Is the estimate unbiased?

3. (a) A deterministic signal \( x(t) \) is given by

\[ x(t) = u(t) \left( e^{-\alpha W_1 t} - e^{-\alpha W_2 t} \right) \]

Where \( \alpha > 1 \), \( W_1 \) and \( W_2 \) are real positive constants. The signal is received at the input of a matched filter with a noise process for which

\[ S_{NN}(w) = \frac{W_2}{W_2 + w^2} \]

where \( S_{NN}(w) \) denotes the PSD of the noise process \( N(t) \). Find the transfer function of the matched filter. Next, determine the impulse response of the filter and the condition for which it will be coausal. Assume that the noise process is WSS.
(b) Determine if the following functions represent the valid PSDs of WSS random processes:

\[
\begin{align*}
&\text{(i) } \frac{w^2 + 1}{w^6 + 3w^2 + 3}, \\
&\text{(ii) } e^{-(w-1)^2}, \\
&\text{(iii) } \frac{1}{\sqrt{1 - 3w^2}}
\end{align*}
\]

What is rms bandwidth of a random process?

4. (a) \(X\) and \(Y\) are two zero-mean random processes for which

\[
R_{xx}(\tau) = e^{-|\tau|} \quad \text{and} \quad R_{yy}(\tau) = \cos(2\pi \tau)
\]

Define: \(W_1 = X + Y\), \(W_2 = X - Y\).

Determine \(R_{ww_1}\), \(R_{ww_2}\) and \(R_{ww_1}R_{ww_2}\). Are these two processes \(W_1\) and \(W_2\) independent, uncorrelated and orthogonal?

(b) Find the probability density function (pdf) of the random variable \(Z\), where

\[
Z = \frac{X}{X + Y}
\]

Use the auxiliary variable method. \(X\) and \(Y\) are independent exponential random variables with the same parameter \(\alpha\).

SECTION – B

There are FOUR questions in this Section. Answer any THREE.

5. (a) Each of three friends throws his/her coin in a box and then the coins are mixed. Each of them randomly selects a coin from the box one after another. Determine (i) the probability that the first friend obtains his/her own coin, (ii) the probability that the second friend obtains his/her own coin, (iii) the probability that the third friend obtains his/her own coin, (iv) the probability that none of them obtains his/her own coin, and (v) the probability that all of them obtain their own coins.

(b) In order to increase the reliability of a communication system, three independent wired links are connected in parallel between the transmitter and the receiver of the system to transfer a signal from the transmitter to the receiver. The probability that a link is out of service is 0.1. Determine the probability that the signal will be received by the receiver. Compare this result with a communication system with one wired link. Also determine the probability that the link-1 is out of service given that the signal is received by the receiver.
EEE 331

6. (a) The probability distribution function of a random variable $X$ is given by

$$f_X(x) = \begin{cases} \frac{ce^{-2x}}{2}, & 0 \leq x \leq \infty \\ 0 & \text{otherwise.} \end{cases}$$

(i) Determine the value of $c$ and sketch $f_X(x)$.

(ii) Determine the cumulative distribution function $F_X(x)$ of the random variable $X$ and sketch $F_X(x)$.

(iii) Determine $P(X > 1)$, $P(X \leq 2)$ and $P(1 < X \leq 2)$.

(b) The probability distribution function of fading parameter of wireless channel is given by

$$f_X(x) = \begin{cases} 2xe^{-2x}, & 0 \leq x \leq \infty \\ 0 & \text{otherwise}. \end{cases}$$

Determine the mean and variance of the fading parameter. Note that

$$\int_0^\infty y^{n-1}e^{-y} \, dy = \Gamma(n), \quad \Gamma(n) = (n-1)$$

and

$$n + \frac{1}{2} = \frac{2n}{4^n} \sqrt{n}.$$

7. (a) State and explain the Central Limit Theorem. The lifetime of a bulb is a random variable with mean 4 months and standard deviation 2 months. A bulb is used until it damages and then it is replaced by a new one. Approximate determine the probability that over 13 yrs can be passed by using a stock of 36 bulbs. The lifetime of the bulbs are independent and identically distributed. The cumulative distribution function of Normal distribution can be approximated as

$$\phi(x) = \left[ 1 + \exp \left( -\frac{358x}{23} + 111 \tan^{-1} \left( \frac{37x}{294} \right) \right) \right]^{-1}.$$ 

(b) The number of calls in a mobile phone base station (BS) in a day is Poisson distributed with mean 10,000. The amount of money spent for a call is uniformly distributed over $(0, 20)$. Determine the mean value of money earned from the BS in a day.

8. (a) The joint probability distribution function of two random variables $X$ and $Y$ is given by

$$f_{X,Y}(x,y) = \begin{cases} 2e^{-(x+y)}, & 0 \leq x < y \leq \infty \\ 0 & \text{otherwise.} \end{cases}$$

The random variables $Z$ and $W$ are given as $Z = X + Y$ and $W = \frac{Y}{X}$. (i) Determine the joint probability distribution function of $Z$ and $W$. (ii) Verify if the random variables $Z$ and $W$ are independent.
(b) Let $X$ and $Y$ are two independent Poisson distributed random variables with parameters $\lambda_1$ and $\lambda_2$. Show that the random variable $Z = X + Y$ is also a Poisson distributed random variable with parameter $\lambda_1 + \lambda_2$.

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### Table E.1 Common Fourier Transform Pairs

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<thead>
<tr>
<th>Signal (time domain)</th>
<th>Transform (frequency domain)</th>
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<tbody>
<tr>
<td>$\text{rect}(t/t_0)$</td>
<td>$t_0 \text{sinc}(ft_0)$</td>
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<td>$\text{tri}(t/t_0)$</td>
<td>$t_0 \text{sinc}^2(ft_0)$</td>
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<tr>
<td>$\exp\left(-\frac{t}{t_0}\right) u(t)$</td>
<td>$\frac{t_0}{1 + j2\pi ft_0}$</td>
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<td>$\exp\left(-\frac{</td>
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<td>$\text{sinc}(t/t_0)$</td>
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<td>$\text{sinc}^2(t/t_0)$</td>
<td>$t_0 \text{tri}(ft_0)$</td>
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<tr>
<td>$\exp(j2\pi f_0 t)$</td>
<td>$\delta(f - f_0)$</td>
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<tr>
<td>$\cos(2\pi f_0 t + \theta)$</td>
<td>$\frac{1}{2}\delta(f - f_0)e^{j\theta} + \frac{1}{2}\delta(f + f_0)e^{-j\theta}$</td>
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<tr>
<td>$\delta(t - t_0)$</td>
<td>$\exp(-j2\pi ft_0)$</td>
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<td>$\text{sgn}(t)$</td>
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<td>$u(t)$</td>
<td>$\frac{1}{2}\delta(f) + \frac{1}{2j\pi f}$</td>
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<td>$\exp(-t(t_0)^2)$</td>
<td>$\sqrt{\pi t_0^2} \exp(-\pi f t_0^2)$</td>
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BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2012-2013

Sub: **EEE 351** (Analogue Integrated Circuits)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

**SECTION – A**

There are **FOUR** questions in this Section. Answer any **THREE**.

1. (a) Prove that, superposition theorem can be applied for two uncorrelated noise sources. Also, show that polarity does not matter for this addition.  
   (b) The channel noise current of an NMOSFET is \(4 \times kT \frac{\partial}{\partial g_m}\) and the flicker noise voltage is \(\frac{k}{C_{ox} W/L f}\). Calculate the noise corner.  
   (c) What do you understand by noise Bandwidth? Explain.  
   (d) Calculate the input referred thermal noise voltage of the amplifier shown in Fig. for Q. No. 1(d), assuming both transistors are in saturation. Also, determine the total output thermal noise if the circuit drives a load capacitance \(C_L\). What is the output signal-to-noise ratio if a low frequency sinusoid of amplitude \(V_m\) is applied to the input?

2. (a) Prove that the base to emitter voltage of a BJT has negative temperature coefficient.
   Given that, \(I_C = I_s \exp \left( \frac{V_{BE}}{V_T} \right)\), \(I_s = \alpha \mu kT n_i^2\), \(u = u_a u_i T^n\), \(n_i^2 = \alpha T^3 \exp \left( \frac{-E_g}{kT} \right)\), \(m = -\frac{3}{2}\), where symbols hold their usual meaning.  
   (b) Calculate \(\Delta V_{BE}\) for the circuit of Fig for Q. No. 2(b).
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Contd … Q. No. 2

(c) Design a circuit to generate temperature independent reference voltage. (9)

(d) Calculate \( I_{\text{out}} \) for the circuit of Fig. for Q. No. 2(d). Why do we need a start-up circuit to operate this system? Draw the start-up connection. (9)

![Circuit Diagram](image)

3. (a) What is the disadvantage of using NMOS as a switch? What is the disadvantage of PMOS? Illustrate with an appropriate equation and diagram. How can you solve these problems? (11)

(b) Discuss charge injection problem of NMOSFET. Propose two ways to solve this problem. (9)

(c) Draw the circuit diagram of a switched capacitor unity gain buffer. How does it operate in sampling mode and buffering mode? Explain with diagram. Discuss appropriate switching sequence to reduce charge injection problem in this circuit. Design a circuit to realize this switching sequence. Draw the circuit diagram for its differential operation. Why is differential operation used? (15)

4. (a) Draw the basic block diagram of phase locked loop. Write about its application. (5)

(b) Describe the basic concept of a device that may be used to design the voltage controlled oscillator in a PLL. (7)

(c) Describe with neat sketch why D-FlipFlop cannot be used as a frequency detector. (10)

(d) Starting from the block diagram and a timing diagram of a PFD, design a charge pump PLL and describe different modes of its operation. (13)

SECTION – B

There are FOUR questions in this Section. Answer any THREE.

5. (a) "A MOSFET can operate as a resistor whose value is controlled by the overdrive voltage" – Explain the statement. For the circuit shown in Fig. for Q. No. 5(a), plot the ON resistance of \( M_1 \) as a function of \( V_G \). (15)

![Circuit Diagram](image)
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Contd ... Q. No. 5

(b) Sketch the capacitance of $M_1$ in Fig. for Q. No. 5(b) as $V_X$ varies from 0 to 3 V. Assume, $V_{TH} = 0.6V$ and $\lambda = \gamma = 0$. Also given that in a reverse biased p-n Junction the junction capacitance $C$ is given as

$$C = C_0 \frac{V_X}{1 + \frac{V_X}{\Phi_B}}^m$$

where $C_0$, $\Phi_B$ and $m$ are positive constants and $V_R$ is applied reverse bias.

When MOS is turned off, the gate to source capacitance is given as $W C_{ov}$, where $C_{ov}$ is the overlap capacitance per unit width. Additionally, the capacitance of gate to source region changes from Cut-off to triode to saturation region.

6. (a) (i) Draw the analog design octagon and write about its significance in analog IC design.

(ii) What kind of single-stage amplifier topology is the one shown in Fig. for Q. No. 6(a)? Derive the expression of load resistance and gain of this topology. What are the limitations of this topology? How can you reduce these limitations? Provide mathematical expressions.

(b) (i) What is cascade topology? Why do we use cascade? Draw the circuit diagram of a folded cascade. Explain its operation and drive its output resistance.

(ii) Calculate the output resistance of a common source amplifier with source degradation resistance.

7. (a) Explain the half circuit-concept and prove it. Apply the concept to calculate the small signal gain of the differential amplifier shown in Fig. for Q. No. 7(a)
(b) What is variable gain amplifier (VGA)? With circuit diagram show different steps in designing a Gilbert cell. Show the final diagram and operation of the Gilbert cell.

8. (a) Calculate the small signal voltage gain of the circuit shown in Fig. for Q. No. 8(a)

(b) What is active Current mirror? Derive the gain of the circuit shown in Fig. for Q. No. 8(b).

(c) What is the advantage of the cascade current mirror (ii) Over that of (i) shown in Fig. for Q. No. 8(c)? Design circuit to generate $V_b$. 

Fig. for Q. No. 7(a)

Fig. for Q. No. 8(a)

Fig. for Q. No. 8(b)

Fig. for Q. No. 8(c)
1. The machine # 2 in a multi-machine system was delivering 1.5 p.u. power to an infinite bus at a rotor position of 16° just before a fault occurred on a certain line in the system. The machine inertia constant is 8 MJ/MVA on the system base. The system frequency is 50 Hz. The fault was cleared at 0.3 second. The power transferability of the machine during the fault and after clearing the fault are respectively as follows:

\[ P_{e,df} = 0.1545 + 5.5023 \sin(\delta_2 - 0.755°) \]
\[ P_{e,af} = 0.1804 + 6.4934 \sin(\delta_2 - 0.847°) \]

Using the step by step algorithm compute \( t \) vs. \( \delta_2 \) starting at \( t = 0 \) at an interval \( \Delta t = 0.1 \) sec and up to 0.4 seconds. In each step you must show calculation of \( P_a, n \), \( kP_a, n-1 \), \( \Delta \delta_2n \), \( \delta_2n \) and relative angular velocity \( \omega_n, n - \frac{\Delta \delta_2n}{n} \). Also calculate actual angular velocity \( \omega_n \) in each interval noting that it is equal to synchronous velocity plus \( \omega_n, n - \frac{\Delta \delta_2n}{n} \). Present all the values in a Table.

2. (a) Using a diagram for TSSC (thyristor switched series capacitor) explain how the power flow and voltage drop in a long high voltage AC line can be controlled? What is the problem of this method and how can you overcome this?

(b) Explain how does a unified power factor flow controller (UPFC) control real and reactive power flow? Show relevant diagrams.

(c) Why is tap charger usually provided on the high voltage side of a transformer?

3. (a) Draw the equivalent circuit of a complete HVDC link with constant \( \delta \) control on the inverter side.

(b) Describe the back to back HVDC interconnection between India and Bangladesh.

(c) What are the main advantages and disadvantages of PWM (Pulse width modulation) and LC (line commutation) converters for use in HVDC transmission system?

(d) In a 6 pulse monopolar HVDC line both side converter transformers’ secondary voltage is set at 120 kV line to line and each has a per phase reactance of 15 \( \Omega \) (ohm). If \( \alpha \) at the rectifier side is 10° and \( \delta \) at the inverter side is 15° then determine the DC current transmitted through the line having a loop resistance of 5 \( \Omega \) (ohm).

Contd ............ P/2
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4. (a) What are the causes and effects of harmonics, sag and flicker? Mention just two remedies for each.

(b) A 6.35 kV single phase cable has a dielectric loss angle of 0.03 radians. It draws a total charging current of 3 Amps. Calculate the equivalent insulation resistance of the cable.

(c) In the Fig. for Q. 4(c) the maximum short circuit current \( I_{sc} \) at different points as PCC (point of common coupling) on a 33 kV feeder are indicated. If an electric arc furnace (EAF) has a maximum load of 100 Amps \( (I_L = 100 \text{ Amps}) \) and a total demand distortion (TDD) of 7%, then what is the best location for placing such a load? Explain to the point.

\[ P_{sc} \approx q \cdot I(c) \]

**SECTION – B**

There are FOUR questions in this Section. Answer any THREE.

5. (a) Derive an expression for inductance of a single phase composite conductor transmission line in terms of GMD and GMR.

(b) Six conductors of ACSR drake constitute a 50-Hz double circuit three phase line arranged as shown in Fig. for Q. No. 5(b). Find the inductance per phase (in H/mi) and the inductive reactance (in \( \Omega/\text{mi} \)). Consider GMR = 0.0373 ft. and the outside diameter of the conductor as 1.108 in.

(c) One circuit of a single phase transmission line is composed of three solid 0.25-cm-radius wires. The return circuit is composed of two 0.5-cm-radius wires. The arrangement of conductors is shown in Fig. for Q. No. 5(c). Find the inductance due to current in each side of the line and the inductance of the complete line in henrys per meter.
6. (a) Derive an equation for the capacitance to neutral in farads per meter of a single phase line, taking into account the effect of ground.

(b) Using the derived equation in Q. No. 6(a), calculate the capacitance to neutral in farads per meter of a single-phase line composed of two solid conductors, each having a diameter of 0.229 in. The conductors are 10 ft apart and 25 ft above ground. Compare the results with the value obtained without considering ground effect.

(c) A three-phase 50 Hz line has flat horizontal spacing. The conductors have an outside diameter of 3.28 cm with 12 m between conductors.

(i) Determine the capacitive reactance to neutral in ohm-meters and the capacitive reactance of the line in ohms if its length is 125 mi.

(ii) Determine the same as in (i) but take into account the effect of ground. Assume that the conductors are horizontally placed 20 m above ground.

7. (a) Consider the single line diagram shown in Fig. for Q. No. 7(a). All impedances are in per unit.

The machine is delivering 1.0 p.u. power and both the terminal voltage and the infinite bus voltages are 1.0 p.u. Determine

(i) the power angle equation of the system,
(ii) corresponding swing equation if \( P_m = 1.0 \) p.u.,
(iii) operating point of the system and
(iv) the value of the synchronous power coefficient at the operating point.

(b) The system in Q. No. 7(a) is operating under steady state condition when a three-phase fault occurs at midpoint P of the line of Fig. for Q. No. 7(a). Determine the power angle equation for the system with the fault on and the corresponding swing equation. Assume \( H = 5 \) MJ/MVA. Use Y-Δ transformation where applicable.

(c) Derive the swing equation from the swing equation of a machine

(i) for two coherently swinging machines at the same power plant.
(ii) for two non-coherent machines.

8. (a) The power angle equations of a generator which was delivering \( P_m \) p.u. power to an infinite bus, are as follows:

Before the fault: \( P_e = P_0 \sin \delta \)
During the fault: \( P_e = P_1 \sin \delta \)
After the fault: \( P_e = P_2 \sin \delta \)
Contd ... Q. No. 8(a)

Derive an expression for the critical clearing angle using the given power angle equations.

(b) In a one machine to an infinite bus (OMIB) system operating under steady state condition, $P_m = 1.0$ p.u. and $P_e = 2.10 \sin \delta$. A three-phase fault occurs in the system and no power is transferred during the fault. When the fault is cleared the system returns to the previous operating condition. Calculate the critical clearing angle and the critical clearing time for the system. Assume, $H = 5 \text{ MJ/MVA}$. (10)

(c) With necessary equations mention how the different factors affect transient stability. What are the design and operational strategies to improve transient stability? (10)
1. (a) Dany Steel fabricates various products from two basic inputs, bar stock and sheet stock. Bar stock is used at a steady rate of 1000 units per year and cost $200 per bar. Sheet stock is used at a rate of 500 units per year and costs $150 per sheet. The company policy of computing annual holding cost is 20% of purchasing price. The fixed cost to place an order is $50 of which $10 is cost of placing the purchase order and $40 is the fixed cost of truck delivery. The Plant runs 365 days a year.

(i) Use EOQ formula to compute the optimal order quantities, order interval and annual cost for bar stock and sheet stock. What fraction of total annual cost consists of fixed trucking cost?

(ii) Using a week as the base interval, round the order intervals for bar stock and sheet stock to the nearest Power of two. If you charge the fixed trucking fee only once for deliveries that coincides. What is the annual cost now?

(b) A Chemical firm produces sodium bisulfate in 100 pound bags. Demand for this product is 20 tons per day. The capacity for producing the product is 50 tons per day. Setup cost is $100 and storage cost is $5 per ton per year. The firm operates 200 days a year. Now please find out the following:

(i) How many bags per ton are optimal?

(ii) What would be the average inventory for this lot size?

(iii) Approximate length of production run in days

(iv) The number of runs in a year.

Note: 1 ton = 2000 pounds.

2. (a) Discuss qualitative and quantitative methods of forecasting and their relative advantages and disadvantages.

(b) Do you think that averaging techniques used in forecasting are accurate? If not, what is the reason behind this inaccuracy?

(c) Use Johnson's rule to find the optimum sequence for processing the jobs shown following through two work centers. Times at each center are in hours. Also determine the total processing time and idle time for two work centers.
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Contd … Q. No. 2(c)

<table>
<thead>
<tr>
<th>Job</th>
<th>Workcenter 1</th>
<th>Workcenter 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>B</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>C</td>
<td>18</td>
<td>9</td>
</tr>
<tr>
<td>D</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>E</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>F</td>
<td>10</td>
<td>15</td>
</tr>
</tbody>
</table>

3. (a) Briefly discuss about different capacity options available in aggregate planning with relevant examples. Why aggregate planning is called “Rolling Planning Horizon?”

(b) Differentiate continuous and discontinuous manufacturing with examples.

(c) Develop a “PPB” solution and calculate total cost for the data given below:

<table>
<thead>
<tr>
<th>Period</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross requirement</td>
<td>30</td>
<td>-</td>
<td>40</td>
<td>-</td>
<td>30</td>
<td>70</td>
<td>20</td>
<td>-</td>
<td>10</td>
<td>80</td>
<td>-</td>
<td>50</td>
</tr>
</tbody>
</table>

Holding cost = $2.50/unit/week, setup cost = $150, lead time = 1 week, beginning inventory = 40.

4. (a) A dependent demand inventory model requires information on five different items. Briefly explain these items with examples.

(b) Discuss the significance of five forces in determining segment structural attractiveness. Analyze the following situations using Five force model:

(i) Starting a stationary shop equipped with photocopy machines along with other stationary products just besides your university.

(ii) Entrance of a new mobile company in Bangladesh.

(c) Suppose an agent from life insurance company (LICO) came to you at your office and tried to convince you to have an insurance policy. He mentioned different policies offered by ‘LICO’ i.e. life insurance, health and accidental benefits, retirement savings etc. Which marketing concept did ‘LICO’ follow and provide reasoning behind your answer.

SECTION – B

There are FOUR questions in this Section. Answer any THREE.

5. (a) Explain different management levels and the skills needed for effective performance at different levels.

(b) Write down the names of roles performed by managers according to Henry Mintzberg. What is the difference between disseminator and spokesperson?

(c) What are the principles of management according to Fayol?

(d) Describe the contingency approach.
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6. (a) Give examples of different types of departmentalization. (5)
   (b) What do you mean by formalization? Differentiate between mechanistic and organic structure. (7)
   (c) What is delegation? What are the pre-requisites and advantages of delegation? (13)
   (d) Assume guaranteed base rate is 25 Tk./hour. Total number of pieces to be produced is 300 pieces. Low task is 100 pieces/hour which is 75% of standard task. The worker takes 2 hours to complete the job and his share is 40%. Calculate the rate of incentive for worker according to Halsey plan. (10)

7. (a) Describe Maslow's hierarchy of needs. (8)
   (b) What is a competitive strategy? Briefly explain different competitive strategies with appropriate examples. (10)
   (c) Differentiate between rationality and bounded rationality. (5)
   (d) Explain how BCG matrix can be helpful to develop competitive strategies. How strategic flexibility can be achieved? (7+5)

8. (a) Explain different performance appraisal methods along with their advantages and disadvantages. (13)
   (b) What are the typical strategies available for market leaders to defend their Market share? Elaborate each of them with relevant examples. (14)
   (c) Briefly explain the concept of niche marketing by providing a suitable example. (8)