L-3/T-1/EEE

Date: ~~05/05/2024~~ 26/5/24

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2022-2023

Sub: **EEE 307** (Electrical Properties of Materials)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks.

The corresponding Course Outcomes (COs) of each part of Question 1 and 5 are mentioned on the right most column. The COs of the Course are mentioned at the end of the question paper.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer to **Question No. 1 is compulsory.**

Answer any TWO questions from Questions 2-4.

1. (a) Si has the diamond and GaAs has the zinc blende crystal structure. Given the lattice parameters of Si and GaAs, a = 0.543 nm and a = 0.565 nm, respectively, and the atomic masses of Si, Ga, and As as 28.08, 69.73, and 74.92 g mol^{-1}, respectively. Calculate the density of Si and GaAs. What is the atomic concentration (atoms per unit volume) in each crystal? **(10)** (CO1)

(b) Given the static dielectric constant of water as 80, its optical frequency dielectric constant (due to electronic polarization) as 4, its density as 1 g cm^{-3} calculate the permanent dipole moment p_o per water molecule using Clausius-Mossotti equation and assuming that it is the orientational and electronic polarization of individual molecules that gives rise to the dielectric constant. Compare your results with the permanent dipole moment of the water molecule which is 6.2×10^{-30} C m. **(15)** (CO2)

What is ε_r calculated from the Clasius-Mossotti equation taking the true p_o (6.2×10^{-30} C m) of a water molecule?

What is your conclusion? (The molecular mass of water M_{mol} is 18×10^{-3} kg mol^{-1}, its density is $d = 10^3$ kg m^{-3})

(c) What are the maximum atomic and weight percentages of Cu that can be added to Au without exceeding a resistivity that is twice that of pure gold? Nordheim coefficient for Cu in Au at 20°C is C = 450 nΩ m. Resistivity of Au at 20°C is 22.2 nΩ m. (M_{Cu}=63.54 g mol^{-1}, M_{Au}=196.67 g mol^{-1}) **(10)** (CO3)

2. (a) Draw the followings: (i) [1 4 0], (ii) (1 1 2) and (iii) (1 1 $\bar{2}$) **(15)**

(b) Liquid xenon has been used in radiation detectors. The density of the liquid is 3.0 gcm^{-3}. What is the relative permittivity of liquid xenon given its electronic polarizability, $a_e = 4.45\times10^{-40}$ Fm^2? (M_{Xe} = 131.3 g mol^{-1}) **(10)**

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Contd... Q. No. 2

(c) Electrolytic capacitors tend to be modeled by a series $R_s + 1/(j\omega C_s)$ equivalent circuit. A nominal 22 μF Ta capacitor (22 μF at low frequencies) has the following properties at 10 kHz, $\varepsilon_r' \approx 20$ (at this frequency), $\tan\delta \approx 0.05$, dielectric thickness $d = 0.16$ μm, effective area $A = 150$ cm^2. Calculate C_p, R_p, C_s and R_s. **(10)**

Note: The elements R_p and C_p in the parallel equivalent circuit and the elements R_s and C_s in the series circuit are related. We can write down the impedance between the terminals for both the circuits, and then equate Z (Parallel) = Z (Series) to show that

$$R_s = \frac{R_p}{1+(\omega R_p C_p)^2} \text{ and } C_s = C_p\left(1+\frac{1}{(\omega R_p C_p)^2}\right)$$

3. (a) Write short notes on (i) Cole-Cole Plot, (ii) Dielectric breakdown of liquids, (iii) Pyroelectricity, and (iv) Ferroelectric Crystal. **(20)**

(b) We are given the depth of a gold film $D = 1$ μm and the current through the film $I = 0.1$ A. The Hall voltage can be taken to be $V_H = 1$ μV. Calculate the magnetic field B per μV of Hall voltage. $M_{Au} = 196.67$ gmol^{-1} and density $d_{Au} = 19.3$ g/cm^3. Since gold has a valency of 1 electron, the concentration of free electrons is equal to the concentration of Au atoms. **(15)**

4. (i) Consider a 100 W, 120 V incandescent bulb (lamp). The tungsten filament has a length of 0.579 m and a diameter of 63.5 μm. Its resistivity at room temperature is 56 nΩm. Given that the resistivity of the filament can be represented as $\rho = \rho_0\left[\frac{T}{T_0}\right]^n$ where T is the temperature in K, ρ_0 is the resistance of the filament at T_0 K (room temperature 293 K), and $n = 1.24$, estimate the temperature of the bulb when it is operated at 120 V. Note that the bulb dissipates 100 W at 120 V. **(35)**

(ii) Suppose that the electrical power dissipated in the tungsten wire is totally radiated from the surface of the filament. The radiated power at the absolute temperature T can be described by Stefan's Law- $P_{\text{radiated}} = \varepsilon\sigma_s A(T^4 - T_0^4)$ where σ_s is Stefan's constant (5.67×10^{-8} W m^{-2} K^{-4}), ε is the emissivity of the surface (0.35 for tungsten), A is the surface area of the tungsten filament, and T_0 is the room temperature (293 K). Assuming that all of the electrical power is radiated from the surface, estimate the temperature of the filament and compare it with your answer in part (i).

(iii) If the melting temperature of W is 3407°C, what is the voltage that guarantees that the light bulb will blow?

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SECTION – B

There are **FOUR** questions in this section. Answer to **Question No. 5 is compulsory.**

Answer any TWO questions from Questions 6-8.

5. (a) Design a toroidal inductor to store an energy of 4.665×10^{11} J using a superconductor having $B_{c2} = 100$ T and $J_c = 5 \times 10^{10}$ A m^{-2}. The superconducting wire has a diameter of 5 mm and is available at any desirable length. The mean circumference of the toroid is $L = \pi(D_{toroid})$, where D_{toroid} is the mean diameter. You need $D_{toroid} >> D$, where D is the diameter of the core. Assume $Nd \approx$ L and the energy per unit volume is, $E_{vol} = B^2/(2\mu_o)$. **(20)** (CO3)

(b) Find the current in the coil designed in part (a). **(5)** (CO1)

(c) Whether the current found in part (b) is sufficiently below the critical current at that field. **(10)** (CO2)

6. (a) Consider bismuth with $\chi_m = -16.6\times10^{-5}$ and aluminum with $\chi_m = 2.3\times10^{-5}$. Suppose a magnetic field of 1 T is applied to each sample. What is the magnetization and the equivalent magnetic field in each sample? Which is paramagnetic and which is diamagnetic? **(20)**

(b) The Fermi energy of calcium is 4.68 eV. Evaluate the paramagnetic susceptibility of calcium **(15)**

7. (a) The solution to Schrödinger equation for a particular situation is given by, $\Psi(x) = \sqrt{2/a_0}\, e^{-x/a_0}$. Determine the probability of finding the particle between $a_0/4 < x < a_0/2$. **(10)**

(b) Consider a free electron bound within a two-dimensional infinite potential well defined by $V = 0$ for $0 < x < a$, $0 < y < b$, and $V = \infty$ elsewhere. Determine the expression for the allowed electron energies. Describe any similarities and any differences with the results of the one-dimensional infinite potential well. **(20)**

(c) A particle with a mass of 15 mg is bound in a one-dimensional infinite potential well that is 1.2 cm wide. If the energy of the particle is 15 mJ, determine the value of n for that state. **(5)**

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8. (a) Consider two-dimensional electron gas in which the electrons are restricted to move freely within a square area a^2 in the xy plane. Show that the density of states $g(E)$ is constant (independent of energy) **(15)**

(b) The minimum energy of an electron at the bottom conduction band in Silicon crystal can be approximated by $E = E_0 - E_1 \cos\alpha(k - k_0)$ where k_0 is the value of k at the minimum energy. Determine the effective mass of the electron at $k = k_0$ in terms of the equation parameters. **(10)**

(c) What is the functional form of a $1s$ wavefunction, $\psi(r)$? Sketch schematically the atomic wavefunction $\psi_{1s}(r)$ as a function of distance from the nucleus. What is the total wavefunction $\psi_{1s}(r,t)$? **(10)**

Course Outcomes of EEE 307

CO No.	CO Statement
1	**apply** the physics-based knowledge to solve problems relevant to the electrical, thermal, dielectric and magnetic properties of materials.
2	**analyse** the properties of materials based on the underlying physics.
3	**design** electrical and electronic devices such that specified performance characteristics are attained.

L-3/T-1/EEE Date: ~~20/04/2024~~ 20\05\2024

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2022-2023

Sub: **EEE 309** (Communication System I)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks.

The corresponding Course Outcomes (COs) of each part of Question 1 and 5 are mentioned on the right most column. The COs of the Course are mentioned at the end of the question paper.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer to **Question No. 1 is compulsory.**

Answer any TWO questions from Questions 2-4.

1. (a) Compare among TDM, FDM and CDMA interms of operation, advantages and disadvantages. **(15)** (CO3)

(b) Design a DS-CDMA system with four transmitter-receiver pairs and a noisy channel. The system uses orthogonal PN sequences of length 4. The PN sequence of the first user $C1 = [+1+1+1+1]$. The data bit sequences (3-bit length) of the users are respectively, D1 = [1 1 0], D2 = [1 0 silent], D3 = [0 1 1] and D4 = [silent 0 silent]. **(20)** (CO4)

(i) Determine the possible PN sequence of the user-2, user-3 and user-4.

(ii) How many transmitter-receiver can be multiplexed in this communication setup considering the above first PN sequence?

(iii) What is signal in channel and received bit sequence of user-2?

(vi) Consider a wide-band interference is present in the channel, n = [0.3 0.25 –0.35 0.04 0.2 0 0.1 –0.6 0 0.35 0.2 –0.25]
For each of the receiver, determine the number of bits that will be erroneously detected.

2. (a) Consider a PCM system using, A-law non-uniform mid-rise symmetric rounding type quantizer. Periodic message signal, **(25)**

$m(t) = -10\cos\left(3000\pi t + \frac{\pi}{4}\right) + 5\sin\left(9000\pi t - \frac{3\pi}{4}\right)$ is sampled at a rate of 20 times of the maximum frequency of the message signal. The number quantization levels are such that maximum allowed SQNR is 15 dB. The first sample is taken at t = 0 s. Assume that (i) the signal range and the quantizer range are same, (ii) the maximum values of the input, and the output of the compressor are equal, and (iii) A = 87.6.
Calculate the sampled value, compressed values, quantized value, encoded bit, reconstructed values the quantization errors for the first seven samples.

Contd P/2

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Contd... Q. No. 2(a)

Hint: A-law compressor:

$$y = \begin{cases} y_{max}\left(\dfrac{A\left(\frac{|x|}{x_{max}}\right)}{1+\ln(A)}\right) sign(x), & when\ 0 < \dfrac{|x|}{x_{max}} \leq \dfrac{1}{A} \\ y_{max}\left(\dfrac{1+\ln\left(A\frac{|x|}{x_{max}}\right)}{1+\ln(A)}\right) sign(x), & when\ \dfrac{1}{A} < \dfrac{|x|}{x_{max}} < 1 \end{cases}$$

(b) Why it is necessary to have **DC-null condition** of line coding? Compare Polar, Unipolar, Bipolar and Manchester line coding technique analyzing the PSD based on this criterion. **(10)**

3. (a) The prediction filter for DPCM system shown in Figure for Q. 3(a) is designed as, **(20)**

$$\hat{m}(nTs) = 0.8 \times m_q[nT_s] + 0.2 \times m_q[(n-1)T_s]$$

For a message signal, $m(t) = 5e^{(-0.5t)}\cos(t-1.4)+1.3$, determine and draw the sampled value $m(nTs)$, data sequence $e_q(nTs)$ and, detected value $\hat{m}(nTs)$ as a function of time for first 6 samples. Consider one bit Quantizer with the sampling frequency, $f_s = 1$, step size, $\Delta = 2$ and first sample is taken at t = 0 s. All sample value, $m(nTs) = 0$, for $t < 0\ s$.

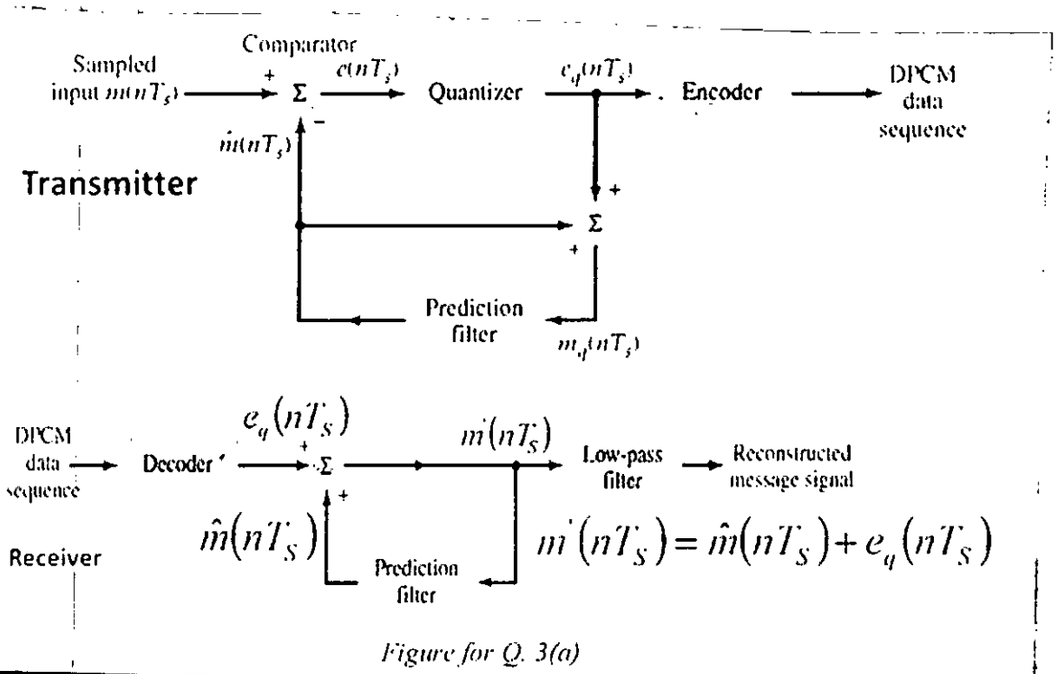

Figure for Q. 3(a)

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Contd... Q. No. 3(a)

(b) What is the purpose of 'Flat-topping' in PAM signal? For a message signal, $m(t) = 4\sin(2\pi 600t) + 6\cos(2\pi 1000t)$ draw the spectrum of Pulse Amplitude modulated signal for (i) Ideal (ii) Natural and (iii) flat-top sampling with proper labeling. Assume the message is sampled at 3 times of the Nyquist condition and duty cycle d = 1/5. **(15)**

4. (a) Draw a comparative analysis among BASK, BFSK and BPSK modulation scheme. **(10)**

(b) Design a DPSK transmitter and a receiver where '1' mean a transition and initial reference bit is '0'. Justify your design mentioning an appropriate logic gate at the transmitter and comparator logic at the receiver. Determine the (i) differentially encoded bit (ii) transmitted phase (iii) detected bit for the original data stream of [1 0 1 1 0 0 0 1 0 1 0 0]. **(10)**

What happens during detection if an errorenous bit alteration ('1' instead of '0' and vice-versa) occurs for the second differentially encoded bit?

(c) Design a QPSK transmitter and receiver for the constellation diagram sown in *Figure for Q. 4(c)*. Draw the transmitted waveform for the data stream [10 1 1 0 1 0 0] with proper labeling. Consider sinusoidal carrier with carrier frequency $f_c = 20$ kHz and data rate 8 kbps. **(15)**

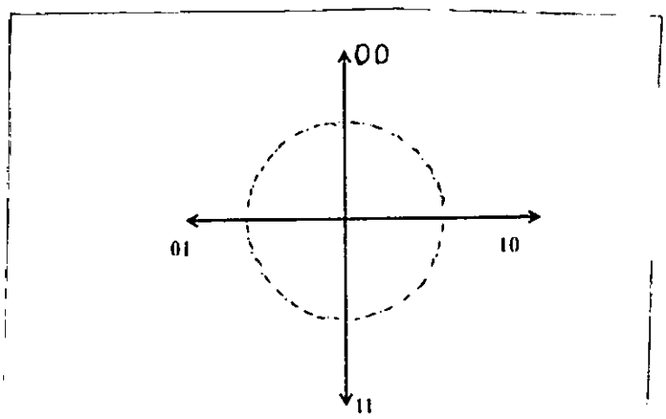

Figure for Q. 4(c)

SECTION – B

There are **FOUR** questions in this section. Answer to **Question No. 5 is compulsory.**

Answer any TWO questions from Questions 6-8.

5. (a) Explain how the transmission channel impairments affect the digital communication system and comment on how they can be mitigated. Suppose, a

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Contd... Q. No. 5(a)

message, $m(t)=6\cos(24\times10^3 t)+5\cos(50\times10^3 t)$ is transmitted through a channel with attenuation profile, $\alpha(w)=7+(w-37\times10^3)^2$ and phase profile, $\beta(w)=5.5w+3$. Will the signal be distorted after propagating through the channel? Justify your answer. **(10+5)** (CO1)

(b) Consider an intelligence signal $m(t)=2\cos(1000\pi t)+3\cos(600\pi t)$ and the carrier signal $c(t)=6\cos(2\pi\times10^5 t)$. (CO2)

(i) Derive the expression of DSB +C signal showing all the components. **(5)**

(ii) Calculate the modulation index and power efficiency. **(5)**

(iii) Sketch the amplitude spectrum after suppressing the USB spectrum and write the expression of the remaining signal. Also, determine its bandwidth. **(5)**

(iv) Is it possible to demodulate the remaining signal non-coherently? Explain. **(5)**

6. (a) Suppose, in a non-linear channel, the output y(t) is related to the input x(t) as $y(t)=5x(t)+1.5x^2(t)+4x^3(t)$. What are the harmonics and intermodulation products for the input signal, $x(t)=\sin(1100\pi t)-\cos(700\pi t)$? **(10)**

(b) Briefly explain the differences between noise and interference. Suppose, the signal power at the input of a cascaded system of two amplifiers is 2 μW. The gain of the first and second amplifiers are 30 and 60 respectively and the internal noise power of each amplifier is –25 dBm. Answer the following questions: **(5+8)**

(i) Calculate the noise figure of the cascaded system in dB.

(ii) Determine the noise temperature assuming ambient temperature as 25°C.

(c) Write down the characteristics of the following communication channels: coaxial cable, fiber-optic cable and microwave links. Also, comment on their relative merits and demerits. **(6+6)**

7. (a) Define different demodulation techniques for AM signals. What are the conditions of detecting intelligence signal from AM signal using envelope detection? Verify the conditions. **(4+6)**

(b) What is the common required of SSB modulation methods? Mention the limitations of the phase shift method and the selective filtering method. **(5+5)**

(c) Draw the block diagram of superheterodyne receiver for DSB - SC signal reception and explain how the carrier frequency is converted to intermediate frequency at the mixer stage. What are the modifications required for FM reception? Redraw the block diagram with necessary information. **(8+7)**

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8. (a) Consider an FM system with a single tone message with amplitude A_m = 2V and frequency, f_m = 10 kHz. The carrier has an amplitude, A_c = 4V and frequency, f_c = 8 MHz. Using the Bessel function plot as shown in Fig. Q8(a), answer the following questions:

(i) Determine the modulation for which the component in FM signal with frequency, $(f_c + f_m)$ has 25% of the total transmitted power. **(4)**

(ii) Calculate the bandwidth using Carson's rule. **(3)**

(iii) Draw the FM amplitude spectrum. **(4)**

(iv) How many significant sidebands are contained within the bandwidth calculated in part (ii)? **(2)**

(v) Now, using the FM amplitude spectrum, calculate the bandwidth using the 1% rule. **(2)**

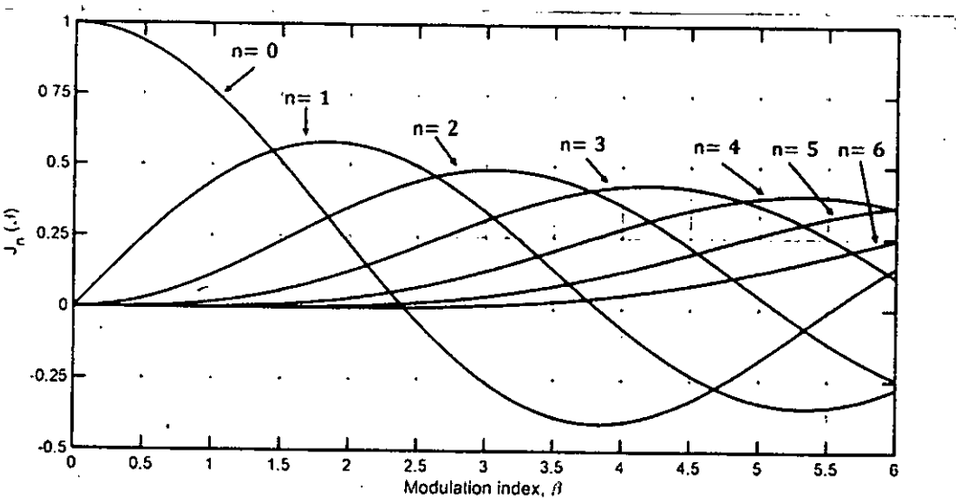
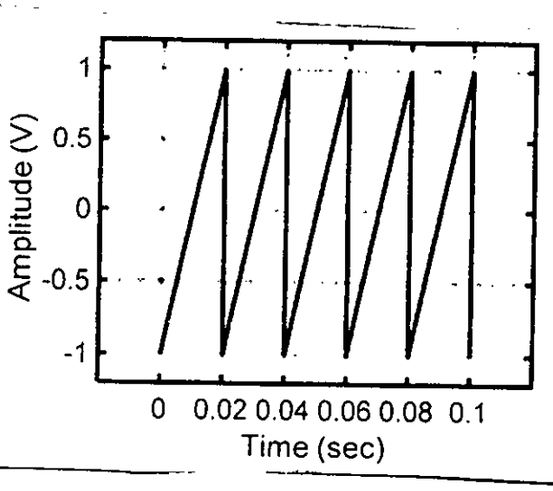


Fig. for Q. No. 8(a)

(b) Find the expressions for and sketch the FM and PM waves produced by the sawtooth wave as shown in Fig. Q8(b). **(10)**



Contd P/6

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Contd... Q. No. 8

(c) Considering a signal-tone modulating signal, derive the expressions of effective bandwidth (approximate transmission bandwidth) of an FM signal and a PM signal. **(10)**

Course Outcomes of EEE 309

CO No.	CO Statement	Corresponding PO(s)*
CO1	Explain the elements, environments, and impairments of communication systems	PO(a)
CO2	Apply the knowledge of mathematics and analyse the transmitted and received signals of various transmission schemes in time domain as well as in frequency domain	PO(a)
CO3	Explain the essential concepts of various channel sharing multiplexing techniques for communication systems	PO(a)
CO4	Design the parameters of communication systems so that certain requirements are satisfied	PO(a)

L-3/T-1/EEE Date: ~~25/04/2024~~ 13/05/2024

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2022-2023

Sub: **EEE 311** (Digital Signal Processing I)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks

The corresponding Course Outcomes (COs) of each part of Question 1 and 5 are mentioned on the right most column. The COs of the Course are mentioned at the end of the question paper.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. **Question No 1 is compulsory.**

Answer any **TWO** from **Question No.2-4.**

1. (a) A digital communication link carries binary-coded words representing samples of an input signal **(15)** (CO1, CO2)

$$x_a(t) = 5\cos(1600\pi t) - 3\cos(2400\pi t)$$

(j) Find the corresponding discrete time signal x[n] if sampling frequency is chosen 2000 samples/sec. What will be the corresponding reconstructed signal?

(ii) In the quantization process, if a resolution $\Delta = 0.017$ is chosen, find the bit rate in the A/D converter and SQNR (signal to quantization noise ratio) in dB.

(b) Consider an LTI system with discrete-time input x[n] and output y[n] given by **(10)** (CO1)

$$x[n] = 5\frac{\sin[0.4\pi n]}{\pi n} + 10\cos[0.5\pi n]$$

$$y[n] = 10\frac{\sin[0.3\pi[n-10]]}{\pi[n-10]}$$

Determine the frequency response $H(e^{jw})$ and the impulse response h[n] for the LTI system.

(c) In a communication system, due to channel distortion, the transmitted signal s[n] turns into $s_d[n]$. The channel is modeled as a casual stable LTI system with $H_d(z)$ given by **(10)** (CO2)

$$H_d(z) = \frac{1+4z^{-1}}{\left(1-\frac{1}{3}e^{j\pi/4}\right)\left(1-\frac{1}{3}e^{-j\pi/4}\right)}$$

(i) Find the compensating system transfer function $H_c(z)$ that will produce output $s_c[n]$ from the $s_d[n]$ in such a way that $s_c[n]$ retains the spectral shape of s[n].

(ii) Sketch the frequency response of $H_c(z)$.

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2. (a) From the input output relationship of an LTI system, find the step response. Given that $y[-1]=6$ and $y[-2]=18$. **(15)**

$$y[n]-\frac{5}{6}y[n-1]+\frac{1}{6}y[n-2]=x[n]+3x[n-1]$$

(b) Consider the three sequences **(10)**

$$v[n]=u[n]-u[n-6]$$
$$w[n]=\delta[n]+2\delta[n-2]+\delta[n-4]$$
$$q[n]=v[n]*w[n]$$

Find and sketch r[n] such that $r[n]*v[n]=\sum_{k=-\infty}^{n-1}q[k]$

(c) Consider the system illustrated in Fig. for Q. No. 2(c). **(10)**

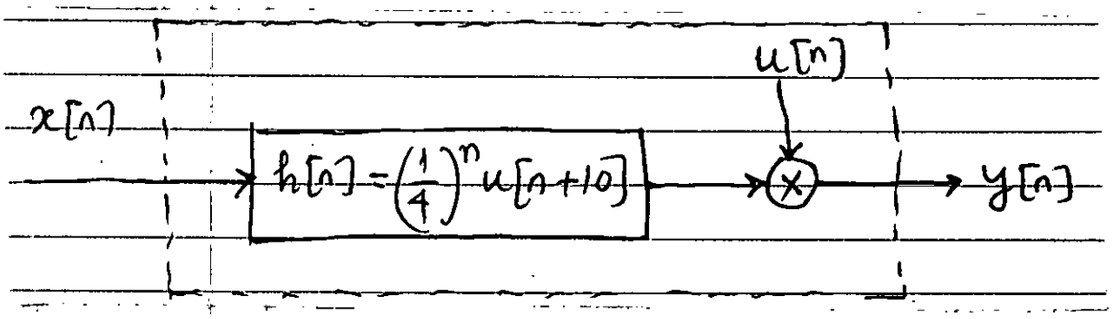

Fig. for Q. No. 2(c)

(i) Is the overall system LTI? Justify.

(ii) Is the overall system causal? Justify.

(iii) Is the overall system stable in the BIBO sense? Justify.

3. (a) Find the inverse Z-transform: **(10)**

(i) $X(z)=\dfrac{3z^{-3}}{\left(1-\frac{1}{4}z^{-1}\right)^2}$, $x[n]$ left sided

(ii) $X(z)=\dfrac{z^7-2}{1-z^{-7}}, |z|>1$

(b) When the input to a causal LTI system: **(15)**

$$x[n]=-\frac{1}{3}\left(\frac{1}{2}\right)^n u[n]-\frac{4}{3}2^n u[-n-1]$$

the z-transform of the output is $Y(z)=\dfrac{1+z^{-1}}{\left(1-z^{-1}\right)\left(1+\frac{1}{2}z^{-1}\right)\left(1-2z^{-1}\right)}$

(i) Find X(z).

(ii) What is the ROC of Y(z)?

(iii) Find the impulse response of the system.

(iv) Comment on stability of the system.

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Contd... Q. No. 3

(c) Find the one-sided z-transform. **(10)**

(i) $x_1[n]=\delta[n-2]$

(ii) $x_2[n]=\delta[n+2]$

(iii) $x_3[n]=x[n+2]$ where $x[n]=\frac{1}{3^n}u[n]$.

4. (a) In a certain design procedure, it is necessary to consider different systems which must have the same magnitude-squared response as that obtained for H(z) given by **(10)**

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

Each of these systems under consideration has three poles and three zeros.

(i) Draw the pole-zero plot for $C(z)=H(z)H^*\left(\frac{1}{z^*}\right)$

(ii) Mention possible ROCs when only stable systems are considered.

(ii) Sketch the magnitude response for the case of minimum-phase system $H_{min}(z)$.

(b) Consider an LTI system with frequency response **(15)**

$$H\left(e^{jw}\right)=e^{-j\left(w-\frac{\pi}{4}\right)}\left(\frac{1+e^{-j2w}+4e^{-j4w}}{1+\frac{1}{2}e^{-j2w}}\right)$$

Determine the output y[n] for all n if the input for all n is $x[n]=\cos\left(\frac{3\pi n}{2}+\frac{\pi}{4}\right)$

(c) The overall system shown in the dotted box in Fig. for Q. No. 4(c) is linear and time invariant. Determine an expression for $H(e^{jw})$ in terms of $H_1(e^{jw})$. Plot $H(e^{jw})$ where $H_1\left(e^{jw}\right)=\begin{cases}1, & |\omega|<\omega_c\\ 0, & \omega_c<|\omega|\le\pi\end{cases}$. **(10)**

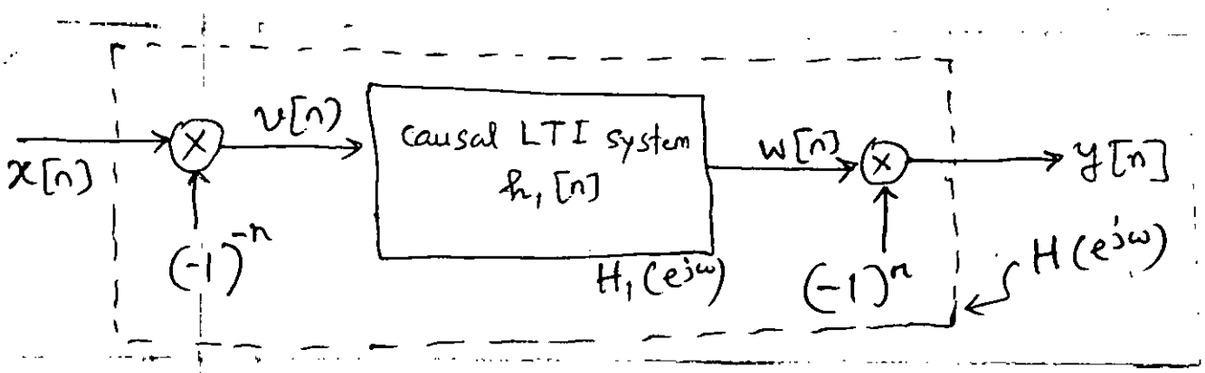

Fig. for Q. No. 4(c)

EEE 311

SECTION – B

There are **FOUR** questions in this section. Answer to **Question No. 5 is compulsory.**

Answer any TWO questions from Questions 6-8.

5. (a) Derive relevant Kaiser Window parameters for the FIR Highpass Filter with a maximum value of passband and stopband ripple, $\delta = 0.01$, stopband passband edge frequency, $\omega_S = 0.4\pi$, and passband edge frequency, $\omega_p = 0.554$. Given, **(20)** (CO3)

$$\beta = \begin{cases} 0.1102(A - 8.7), & A > 50, \\ 0.5842(A - 21)^{0.4} + 0.07886(A - 21), & 21 \le A \le 50, \\ 0.0, & A < 21. \end{cases}$$

(i) Is it a Type I or Type II filter?

(ii) Write an expression for $h_{hp}[n]$, where, $h[n] = h_{hp}[n]w[n]$, $w[n]$ is the Kaiser window.

(iii) Does this filter have any unexpected behavior at the frequency, $\omega = \pi$? If yes, how can that be resolved?

(b) Some well-known properties of commonly used window functions are presented in the Table for Q 5(b). **(15)** (CO3)

Type of Window	Peak Side-Lobe Amplitude (Relative)	Approximate Width of Main Lobe
Rectangular	−13	$4\pi/(M+1)$
Bartlett	−25	$8\pi/M$
Hann	−31	$8\pi/M$
Hamming	−41	$8\pi/M$
Blackman	−57	$12\pi/M$

Table for Q 5(b)

(i) Explain the numerical basis for the Bartlett window having the main lobe width twice as much that of the rectangular window.

(ii) Which window gives the optimum performance when multiplied with a FIR impulse response? Justify your answer.

6. (a) Calculate the M-point DFT, W[k] of the following signal $w[n]$. **(15)**

$$w[n] = \begin{cases} \frac{1}{2}\left(1 - \cos\frac{2\pi n}{M}\right), & 0 \le n \le M \\ 0, & \text{Otherwise} \end{cases}$$

Contd P/5

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Contd... Q. No. 6

(b) Consider the following sequences **(20)**

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

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

(i) Calculate and sketch the $X[k]$, the 4-point DFT of $x[n]$.

(ii) Calculate $w_4^{2k}H[k]$.

(iii) Calculate the 4-point circular convolution of $x[n]$ and $h[n]$ using DFT and IDFT.

7. (a) A moving average system is defined as **(10)**

$$y[n]=\frac{1}{M}\sum_{i=0}^{M-1}x[n].$$

(i) Sketch the structure showing a recursive implementation of this system.

(ii) Is this a FIR or IIR system?

(b) Consider the signal flow graph as shown in Fig for Q 7(b). **(25)**

(i) Is this a FIR or IIR system?

(ii) Derive the corresponding transfer function.

(iii) Sketch an equivalent cascade form implementation of this structure.

(iv) Calculate the total cost of each implementation (in terms of adder multiplier and delay elements). Comment on which implementation is preferable? Justify.

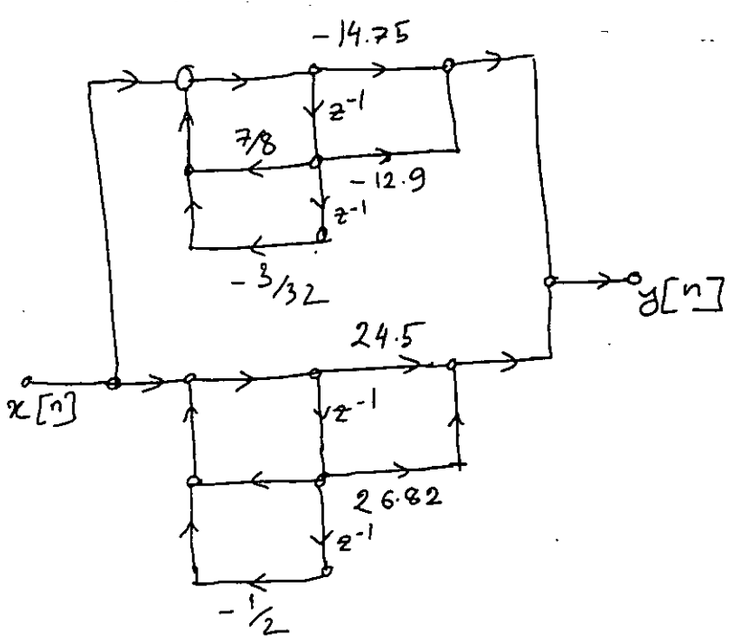

Fig for Q.7(b)

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8. (a) Suppose you have to design a discrete time high pass IIR filter from a continuous time filter. Which method will you choose between the impulse invariance and the bilinear transformation? Why? **(6)**

(b) Design a discrete-time (DT) low-pass filter (LPF) by applying the bilinear transformation method to a continuous time (CT) Butterworth filter with the following specifications: **(20)**

$$0.9 \leq |H(e^{j\omega})| \leq 1, \quad 0 \leq |\omega| \leq 0.22\pi$$

$$|H(e^{j\omega})| \leq 0.18, \quad 0.32\pi \leq |\omega| \leq \pi$$

(i) What is the filter order, *N*?

(ii) Show all the poles of the CT filter in s-plane.

(iii) Show all the poles of the DT filter in z-plane.

(c) Show that, stability in continuous time filters is equivalent to stability in discrete time filters, if bilinear transformation is used. **(9)**

Course Outcomes of EEE 311

CO No.	CO Statement
1	**apply** the digital signal processing principles to solve problems relevant to the time and frequency domain operations
2	**analyse** the signal processing techniques applied to real-life applications based on the underlying principles
3	**design** digital filters and systems such that specified performance characteristics are attained

L-3/T-1/EEE

Date: 19/05/2024 ~~18/04/2024~~

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2022-2023

Sub: **CSE 109** (Computer Programming)

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. Question No. 1 is **MANDATORY**.

Answer any **TWO** of the remaining **THREE** questions.

1. **MANDATORY**

(a) Describe two different ways a function can be overloaded. Explain each way with an example. (10)

(b) Analyze the following code and write the output of it. (10)

```
#include<iostream>
using namespace std;
class Account{
    int accNo; double balance;
    public:
    Account(){
        cout<<"In the default constructor.\n";
        accNo=-1; balance=0;
    }
    Account(int a, double b){
        cout<<"In the parameterized constructor of "<<a<<"\n";
        accNo=a; balance=b;
    }
    ~Account(){
      cout<<"In the destructor of "<<accNo<<"\n";
    }
    Account transferFrom(Account a, double b){
        balance=balance+b;
        a.balance=a.balance-b;
        return a;
    }
    void print(){
        cout<<"Acc No: "<<accNo<<", Balance: "<<balance<<endl;
    }
};

int main(){
  Account a[2] = {{1,1000}, {2,2000}};
  for(int i = 0 ; i < 2 ; i++){
    a[i].print();
  }
  a[0] = a[1].transferFrom(a[0],500);
  for(int i = 0 ; i < 2 ; i++){
    a[i].print();
  }
}
```

(c) Create necessary functions in the two classes **Line** and **Rectangle** in such a way that the following code is executable. (15)

```
#include<iostream>
```

Contd..... P/2

```
using namespace std;

class Shape
{
    int length, width;
public:
    Shape(int length, int width){
        this->length = length;
        this->width = width;
    }
    int perimiter(){return -1;}
    int area(){return -1;}
    int getLength(){return length;}
    int getWidth(){return width;}
    void setWidth(int width){ this->width = width;}
};
class Line: public Shape
{
public:
    // your code
};
class Rectangle: public Line
{
public:
    // your code
};
int main()
{
    Line l(5); // length is 5
    cout << l.area() << endl; // outputs 0
    cout << l.perimeter() << endl; // outputs -1

    Rectangle r( 5, 2); // length is 5, width is 2
    cout << r.area() << endl; // outputs 10
    cout << r.perimeter() << endl; // outputs 14

}
```

2. You are given the following two structures where the **Rectangle** is denoted by two endpoints of any of its diagonal. Note, each edge of the **Rectangle** is always parallel to the x or y axis.

```
struct point {
    float x;
    float y;
};
typedef struct point Point;

struct rect {
    struct point pt1;
    struct point pt2;
};
typedef struct rect Rectangle;
```

(a) Create necessary functions that will calculate the area of the rectangle. (10)

(b) Create two more functions that will - (10)

i. Check if a point is inside or outside a rectangle. If inside return 1, else return 0.

Contd..... P/3

```
    float real;
    float imag;
public:
    Complex(float r, float i){
        real = r; imag = i;
    }
};

int main() {
    Complex complex1(4, 5), complex2(6, 7), result(0, 0);
    result = complex1 + complex2;
}
```

(c) Analyze the following code and write the output of it. (15)

```
class base {
public:
    base(){
        cout << "Inside base constructor" << endl;
    }
   virtual void show() {
      cout << "base\n";
   }
};
class derived1 : public base {
public:
    derived1(){
        cout << "Inside derived1 constructor" << endl;
    }
   void show() {
      cout << "derived-1\n";
   }
};

int main() {
   base *pb1, *pb2;
   base b1; derived1 d1;
   pb1 = &b1; pb2 = &d1;
   pb1->show(); pb2->show();
}
```

SECTION – B

There are **FOUR** questions in this section. Question No. 5 is **MANDATORY**.

Answer any **TWO** of the remaining **THREE** questions.

5. **MANDATORY**

a. Describe the structure of a C program. Demonstrate how conditional execution and repeated execution are done in C programming. **(5+5=10)**

b. Explain what the following C program does. Also, write down its output.

```
#include <stdio.h>
int main() {
    int n = 8;
    for (int y = n - 1; y >= 0; --y) {
        for (int i = 0; i < y; ++i) {
            printf(" ");
        }
        for (int x = 0; x + y < n; ++x) {
            printf("%c", x & y ? '*' : ' ');
            printf(" ");
        }
        printf("\n");
    }
}
```

(10)

Contd..... P/5

ii. Check if a rectangle is completely inside, outside or overlapping with another rectangle and print "Inside" or "Outside" or "Overlapping" accordingly.

You may or may not implement additional functions for ease of calculation.

(c) (3 + 3 + 9)

```
int **array;
int rows = 3, cols = 3, i;
array = (int**) malloc( rows * sizeof(int*) );
for (i = 0; i < rows; i++) {
    array[i] = (int*) malloc( cols * sizeof(int) );
    printf("value at address %d: %d\n",
            array + i, *(array + i) );
}
```

The above code outputs the following lines:

```
value at address 2036736: 2036768
value at address 2036744: 2036800
value at address 2036752: 2036832
```

i. Explain the difference between *(array + i)* and ***(array + i)***?

ii. Explain why is there a difference of 8 between *(array + 0)* and *(array + 1)*?

iii. Analyze the above code and then write down the memory address of each array[i][j] where $0 <= i, j < 3$.

3. (a) Using bitwise operators, design a function called **left_extract(unsigned int x, int n)** that extracts the leftmost n bits of a 32-bit unsigned integer x. (10)

(b) Using bitwise operators, design a function to identify numbers whose binary representation consists solely of 1s. For instance, if 'n' is taken as an input and happens to be 3, 7, 15, 31, etc., the code should output 'Yes'; otherwise, it should output 'No'. Consider, n is a non negative integer and its binary representation does not exceed 32 bits. (10)

Explanation: The binary representation of 1 is 1, 3 is 11, 7 is 111, and 15 is 1111, making them valid. However, the binary representation of 2 is 10, and 5 is 101, both of which contain zeros and are therefore considered invalid..

(c) Imagine you are the CR and have been given a file named **copy_checker_result** containing information about ten students in your class who copied in the last offline. The file is in binary format, and your lab instructor wrote the data using the following structure: (15)

```
struct Student{
    int id;
    float copy_percentage;
    float penalty;
};
```

You attempted to open **copy_checker_result** in a text editor only to find gibberish. Now, as a responsible CR, your task is to create a C program that correctly reads the student information from the file so that you can announce it to your peers. However, your lab instructor has imposed a constraint on you - you are not allowed to use any loops inside your code to read the file (you may use one to print information only). Construct a proper C code to read the data of the **copy_checker_result** file within the constraints.

4. (a) i. Explain how the size of a Union is determined with an example. (5+5)

ii. Explain the importance of the base type of a pointer with an example.

(b) Complete the **Complex** class of the following code in such a way that the main function is executable and **result** is updated in such a way that the value of result.real is 10 and result.imag is 12. (10)

```
class Complex {
```

Contd..... P/4

c. A Mersenne prime is a prime number that is one less than a power of two. For example, $(2^2-1=)$ 3, $(2^3-1=)$ 7, $(2^5-1=)$ 31 are Mersenne primes. Write down a C program that lists all Mersenne primes between 1 and $2^{64}-1$. **(15)**

6.

a. Write a C program that takes as inputs 20 strings from the console and prints them out in lexicographical order. The strings can have both uppercase and lowercase English letters and have a maximum length of 80 characters. You cannot use any functions from the string.h library. **(20)**

b. Write down a *recursive* function that finds a^n. The prototype for the function is given below. For the function, you can assume n is a non-negative integer. You cannot use loops or any library functions.:

```
double power(double a, unsigned int n);
```

(10)

c. What will be the output when the following C program is run?

```
#include <stdio.h>
void pattern(int n) {
    if (n == 0) return;
    pattern(n-1);
    for (int i = 0; i < n; ++i) printf("%d ", n);
    printf("\n");
    pattern(n-1);
}
int main() {
    pattern(4);
}
```

(5)

7.

a. Suppose, you want to write a function in C that provides two floating point numbers back to the calling function. Show two ways in which you can do this. **(10)**

b. Write a C function that finds the k-th largest element of an array. For the function, 0 <= k < n, where n is the size of the array. The prototype of the function should be as follows:

```
int find_kth_largest_element(int arr[], int n, int k);
```

Some example inputs and outputs of the function are as follows:

Input with Explanation	Output
arr = [1,2,3,4,5], n = 5, k = 0	1
arr = [1,2,3,4,5], n = 5, k = 4	5
arr = [1,5,2,3,4], n = 5, k = 2	3

(10)

c. What will be the output for the following C program? Provide reasoning for your answer.

```
#include <stdio.h>
int fib(int n) {
    int a = 0;
    static int b = 0;
    printf("%d %d %d\n", ++a, b++, n);
    if (n <= 1) return 1;
    return fib(n-1) + fib(n-2);
}
int main() {
    printf("%d\n", fib(4));
}
```

(10)

Contd..... P/6

d. Your friend wants to write a C program that takes 5 integer numbers from the console, sorts them in non-decreasing order and then prints them out to the console in sorted order. Your friend wrote the following C program, but it is not working as expected. Explain what your friend did wrong.

```
#include<stdio.h>
void swap(int a, int b) {
    int temp = b;
    b = a;
    a = temp;
}
int main() {
    int arr[5];
    for (int i = 0; i < 5; ++i) scanf("%d", &arr[i]);
    // sorting the array
    for (int i = 0; i < 5; ++i) {
        for (int j = i+1; j < 5; ++j) {
            if (arr[i] > arr[j]) swap(arr[i], arr[j]);
        }
    }
    for (int i = 0; i < 5; ++i) printf("%d ", arr[i]);
}
```

(5)

8.

a. Write a C function that takes two strings str1 and str2 as input and returns 1 if str2 is a subsequence of str1 and 0 otherwise. A subsequence is a sequence of characters taken from a string appearing in the same order as they appear in the original sequence, but not necessarily consecutively. For example "ace" is a subsequence of "abcde" and "acb" is not a subsequence of "abcde". The function prototype should be as follows:

```
int is_subsequence(char* str1, char* str2);
```

(10)

b. Write a C function that takes a 2D square matrix and its size as input and returns 1 if the matrix is orthogonal and 0 otherwise. An n x n matrix A is considered orthogonal if and only if $A^T = A^{-1}$ or $AA^T = A^TA = I$, where I is an n x n identity matrix. The function prototype should be as follows:

```
int is_orthogonal(int** matrix, int n);
```

* A^T is the transport of matrix A
* A^{-1} is the inverse of matrix A

(15)

c. Analyse the following C program and provide its output.

```
char* decrypt(char* str) {
    for(int i = 0; str[i]; ++i) {
        switch(i % 3) {
            case 0: str[i] = (str[i] - 'a' - 3) % 26 + 'a';
            case 1: str[i] = (str[i] - 'a' - 2) % 26 + 'a'; break;
            default: str[i] = (str[i] - 'a' - 1) % 26 + 'a';
        }
    }
    return str;
}
int main() {
    char str[] = "skdjnziqoj";
    printf("%s", decrypt(str));
}
```

(10)