KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

B.Sc. Engineering 2nd year 2nd Term Examination, 2015

Department of Electronics and Communication Engineering

ECE-2201

(Analog Communications)

TIME: 3 hours FULL MARKS: 210

N.B. i) Answer **ANY THREE** questions from each section in separate scripts,
ii) Figures in the right margin indicate full marks.

SECTION A

(Answer **ANY THREE** questions from this section in Script A)

1. a) What is the technical definition of communication? Why do we need to use high carrier frequency for communication system? (04+04)
   b) Prove that the sidebands power in an AM wave is 1/3 rd of the total power for 100% modulation. Calculate the sideband power in an AM wave for 50% modulation. (12+04)
   c) Explain the simple transistor modulator circuit. What is the function of LC tuned circuit in the simple transistor modulator? (04+02)
   d) Draw an AM wave for 50% modulation of the modulating signal shown in fig. 1(d) (05)

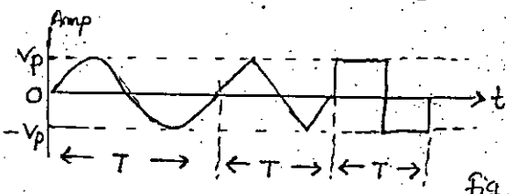

fig. for Q.1(d)

2. a) What are the comparisons between the tuned and superhetrodyne radio receivers? (06)
   b) What do you mean by SSBSC modulation? Explain the frequency and phase discrimination methods for generating a SSB modulated wave. (02+12)
   c) Compare between DSB and SSB modulation. Explain the VSB modulation and its generation principle from DSB using necessary diagrams. (04+06)
   d) A 100V, 100KHz carrier is modulated with the help of a 10V, 1KHz signal to the extent of 50%. Write down the equation for the AM wave. (05)

3. a) Explain the generation of FM from PM and vice versa. (08)
   b) What is meant by linear diode detection? Explain why the time constant RC of load circuit in linear diode detector cannot be kept too low or too high. (10)
   c) Given $m(t) = sin2000\pi t, K_f = 200000\pi, and\ K_p = 10$ (05+05)
      a. Estimate the bandwidths of $\varphi_{FM}(t) and\ \varphi_{PM}(t)$.
      b. Repeat part (a) if the message signal amplitude is doubled.
   d) What are the comparisons between the narrow band FM and full AM? (07)

4. a) Prove that the bandwidth of FM wave is infinity. (08)
   b) Why is Armstrong method called indirect method? Explain the indirect method of Armstrong for FM. (02+10)
   c) What are the requirements of commercial FM radio? (05)
   d) An angle modulated signal with carrier frequency $\omega_c = 2\pi \times 10^6$ is described by the equation $\varphi_{EM}(t) = 10\cos(\omega_c t + 0.1sin2000\pi t)$ (10)
      i) Find the power of the modulated signal
      ii) Find the frequency deviation Δf
      iii) Find the deviation ratio β, and
      iv) Estimate the bandwidth of $\varphi_{EM}(t)$

SECTION B

(Answer **ANY THREE** questions from this section in Script B)

5. a) What is meant by the term "Noise" as used in communication system? Under what conditions the quantity noise temperature is more useful than noise figure to evaluate the performance of a receiver? (06)

Discuss the effects of partition noise and flicker noise in microwave receivers? Explain the reasons why mixers in receiver produces more noise than the amplifier? (08)

c) Discuss the term equivalent input noise resistance R_{eq}. In a multistage amplifier shown in fig. 5(c), derive expressions for the net equivalent noise resistance in terms of resistances and the voltage gains of the individual stages. (11)

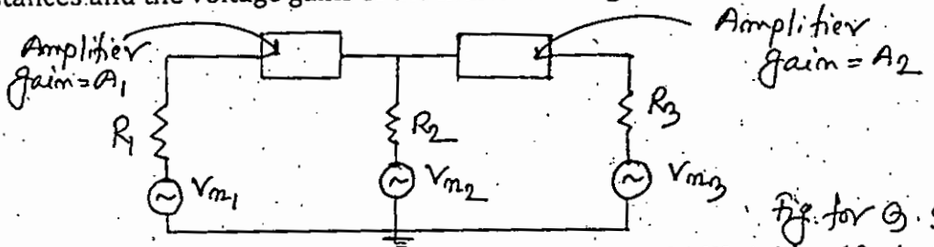

Fig. for Q. 5(c)

d) A parallel tuned circuit, having a Q of 20, is resonated to 200 MHz with a 10-picofarad capacitor. If this circuit is maintained at 17^0C, what noise voltage will a wideband voltmeter measure when placed across it? (10)

6. a) What are energy and power signals? A signal cannot both be an energy and a power signal, explain the statement. (06)

b) What is meant by PSD? What are the properties of PSD. (02+05)

c) For multistage amplifier in cascade shown in fig. 6(c), derive the Friis's formula. With the help of Friis's formula describe how the effects of mixer noise can be reduced to negligible levels? (12)

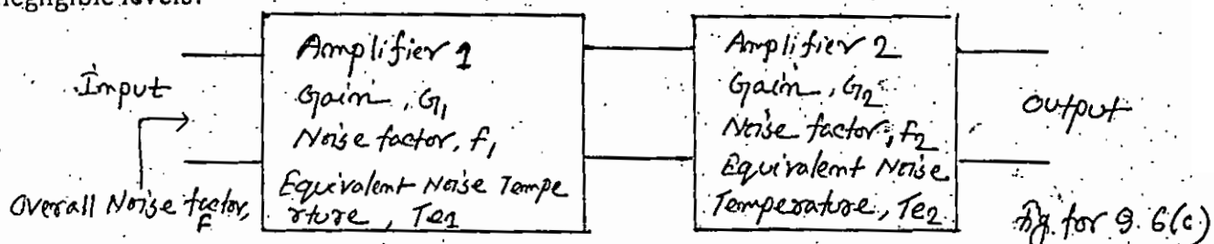

Fig. for Q. 6(c)

d) A mixer circuit has a noise figure of 12dB. It is preceded by an amplifier that has an equivalent noise temperature, of 200K and a power gain of 30dB. Calculate the equivalent noise temperature of the combination referred to the amplifier input. (10)

7. a) Define signal to noise ratio (SNR). Show that the output SNR for a DSB-SC system can be expressed as $S_0/N_0 = \frac{S_i}{\eta f_m}$, S_i=input signal power, η=white noise PSD and f_m=baseband bandwidth. (10)

b) Explain the FDM technique. What are the disadvantages of FDM? (07+03)

c) Design a FDM system for telephone based voice communication considering following requirements: (10)

- Number of users= 12
- FDM output signal bandwidth= 48 KHz
- Modulation technique= AM (SSB-SC)
- Should have "Guard Band"

d) Consider a cable television operator needs to multiplex 80 TV channels, each having 6MHz bandwidth. What is the minimum bandwidth of the link (black co-axial cable connected to your TV set) if there is a need for a guard band of 250 KHz between the channels to prevent interference? (05)

8. a) What is compatibility? Explain the three color theory of color TV system. (04+04)

b) What type of scanning is used in color TV system? Explain that the interlaced scanning reduces flicker and conserve bandwidth. (02+08)

c) Show that a total channel bandwidth of 7 MHz is necessary for successful transmission of both picture and sound signals in the monochrome TV system. Sketch frequency distribution of the channel and mark the location of picture and sound signal carrier frequency. (07)

d) Explain additive three colour mixing theory. Describe with suitable diagrams the gun arrangement and constructional details of a delta gun color picture tube. (10)

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

B.Sc. Engineering 2nd Year 2nd Term Examination, 2015

Department of Electronics and Communication Engineering

ECE 2205

(Electromagnetic Fields and Waves)

TIME: 3 hours FULL MARKS: 210

N.B. i) Answer **ANY THREE** questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.

SECTION A

(Answer **ANY THREE** questions from this section in Script A)

1. a) Write and explain the differential form of the fundamental postulates of electrostatics in free space. Also explain the integral form of the fundamental postulates. (10)
   b) State and explain Gauss's law. Using this law, determine the electric field intensity of sheet charge. (11)
   c) Deduce the equations of Poisson's and Laplace expressing the relationship of the space rate of variation of electric field component with the distributed charge field. (08)
   d) Define homogeneous, linear and isotropic media. (06)

2. a) State the principle of conservation of charge. Based on this principle, derive the continuity equation, $\vec{\nabla} \cdot \vec{J} = -\partial \rho_v / \partial t$, where the symbols have their usual meanings. Also write down the physical significance of this equation. (09)
   b) Consider a plane boundary between two dielectric media (with zero conductivities) and establishes a relationship between the tangential and normal components of the electric field on both sides. What happens when one of the media is a conductor? (07)
   c) A cylindrical capacitor consists of an inner conductor of radius '*a*' and outer conductor whose inner radius is '*b*'. The space between the conductors is filled with a dielectric of permittivity ε, and the length of the capacitor is *L*. Determine the capacitance of this capacitor. (10)
   d) Write down the differential and integral form of Maxwell's equations with their physical significance. (09)

3. a) Deduce the homogeneous wave equations for both scalar and vector potentials. How would these equations turn out to be non-homogeneous? (12)
   b) What is meant by polarization of a wave? Show that the reflection and transmission coefficients are related with the following expression (11)
   $1 + T = \tau$, where the symbols have their usual meaning.
   c) What do you mean by loss tangent? Discuss the characteristics of i) good conductor, ii) lossy dielectric and iii) skin depth. (12)

4. a) State the mode of propagation for each of the following services and explain the reason. (10)
      i) FM radio broadcasting
      ii) SW radio broadcasting
      iii) Cellular telephones
      iv) Satellite communication
   b) A y-polarized uniform plane wave ($\vec{E}_i, \vec{H}_i$) with a frequency of 100 MHz propagates in air in the +*x* direction and impinges normally on a perfectly conducting plane at *x*=0. Assuming the amplitude of $\vec{E}_i$ to be 6 mV/m, write the phasor and instantaneous expression for a) $\vec{E}_i$ and $\vec{H}_i$ of the incident wave; b) $\vec{E}_r$ and $\vec{H}_r$ of the reflected wave, and c) $\vec{E}_1$ and $\vec{H}_1$ of the total wave in air, d) Determine the location nearest to the conducting plane where $\vec{E}_1$ is zero. (19)
   c) Define i) Virtual height, ii) skip distance, iii) maximum usable frequency (MUF)- as used in radio wave propagation. (06)

SECTION B

(Answer **ANY THREE** questions from this section in Script B)

5. a) State and explain Ampere's circuital law and Biot-Savart law. Also compare the usefulness of these laws in determining magnetic flux density. (10)
   b) A direct current I flows in a straight wire of length L. Find the magnetic flux density at a point located at a distance r from the wire in the bisecting plane. (15)
   c) Distinguish between vector magnetic potential and scalar magnetic potential. (10)

6. a) Define magnetic dipole. How do you calculate magnetic dipole moment? What are the dissimilarities between electric dipole and magnetic dipole? (13)
   b) Find the magnetic flux density at a distant point of a small circular loop of radius b that carries current I in terms of dipole moment. (12)
   c) Explain Doppler effect with proper mathematical illustration. (10)

7. a) Define magnetization vector. Relate this parameter with equivalent current and charge densities. (10)
   b) What is the role of magnetic susceptibility? Explain briefly. (12)
   c) Mention the boundary conditions at an interface between magnetic medium and air. Also calculate magnetic field intensity at an arbitrary point on the interface between these two media. (13)

8. a) State and explain Poynting's theorem. (09)
   b) Upon what condition a wave is said to be i) elliptically polarized? ii) circularly polarized? (09)
   c) Consider two closed loops C_1 and C_2 carrying current I_1 and I_2 respectively. Find the expression of energy stored in the magnetic field. Also show that Newton's third law holds here. (17)

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

B.Sc. Engineering 2nd year 2nd Term Examination, 2015

Department of Electronics and Communication Engineering

CSE-2209

(Data Structure & Algorithm)

TIME: 3 hours FULL MARKS: 210

N.B. i) Answer **ANY THREE** questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.

SECTION A

(Answer **ANY THREE** questions from this section in Script A)

1. a) Given two sorted arrays, A with n elements & B with m elements. Write a procedure merging the elements of B into A in sorted order without adding any extra space. Assume, A has a large enough buffer at the end to hold all of B's elements. (10)
   b) Suppose $p(n)=a_0+a_1n+a_2n^2+.....+a_mn^m$; that is suppose degree p(n)=m. Prove that $p(n)=O(n^m)$. (08)
   c) Define data structure. Give some examples of linear & nonlinear data structure. (07)
   d) Suppose A is a two dimensional array declared in C language. The location of A[0][0] is 200 and the declaration is A[5][6]. (10)
      i) where is the location of A[1][2] if row-major representation is used?
      ii) where is the location of A[4][5] if column-major representation is used?

2. a) Discuss the complexity of linear search algorithm. (06)
   b) Suppose P and T are strings with length R and S respectively and are sorted as arrays with one character per element. Write an algorithm that finds the index of P in T. (08)
   c) How can infix expressions be transformed into postfix expressions? Show the steps for the infix expression: A+(B*C-(D/E↑F)*G)*H while considering stack content at each step. (10)
   d) What do you mean by recursion? Write an algorithm that can find the Fibonacci sequence recursively. (11)

3. a) Write down the algorithms to insert and delete items from QUEUE. (10)
   b) "Header linked lists are frequently used for maintaining polynomial in memory", explain briefly. (07)
   c) Write an algorithm; (08)
   COPY(INFO,LINK, NAME1,NAME2, AVAIL) which makes a copy of a linked list NAME1 using NAME2 as the list pointer variable of the new list.
   d) What are the moves allowed by the solution of Towers of Hanoi problem when n=4 disks? (10)

4. a) Propose a solution to minimize overflow in case of stacks. (06)
   b) Consider the following memory representation of linked list: START=4, AVAIL=3. (12)

	1	2	3	4	5	6	7	8
INFO	A	B		C	D		E	F
LINK	2	8	6	7	0	0	1	5

Fig. 1

   i) Find the sequence of characters in the list.
   ii) Suppose F & then C are deleted from the list and G is inserted at the beginning of the list. Find the final structure.
   iii) Suppose C & then F are deleted from the list and G is inserted at the beginning of the list. Find the final structure.
   iv) Suppose G is inserted at the beginning of the list and then F & C are deleted from the list. Find the final structure.
   c) When do overflow and underflow occur in stack? How can you minimize stack overflow? Can you minimize underflow problem? (10)
   d) Give an example of a situation where Bubble sort is faster than Quicksort. (07)

SECTION B

(Answer **ANY THREE** questions from this section in Script B)

5. a) Sort out the following items using Heapsort: (13)
   25,02, 60, 50,75, 86, 100, 90 and 12
   Show your sorted data in increasing order using max-heap.

b) Consider the following binary search tree T. Show stepwise, the post-order traversal using STACK on T after key 17 is deleted. (14)

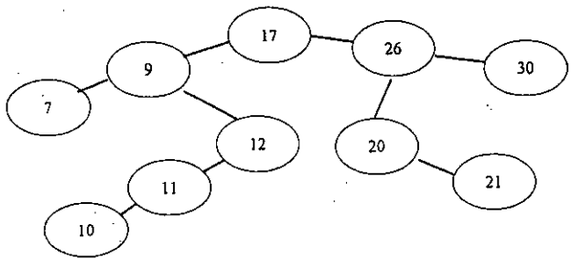

Fig. 2

c) Draw a binary tree from the following expression; ((a+b)*c-d)/(2+e^f) / (p+q). Then give the post order traversal of its nodes. (08)

6. a) Define graph. Why is linked representation of a graph better than array representation? (05)

b) A graph G is stored in memory as follows: (14)

NODE	A	B		E		D	C	
NEXT	7	4	0	6	8	0	2	3
ADJ	1	2		5		7	9	
	1	2	3	4	5	6	7	8

START = 1, AVAILN = 5

DEST	2	6	4		6	7	4		4	6
LINK	10	3	6	0	0	0	0	4	0	0
	1	2	3	4	5	6	7	8	9	10

AVAILE = 8

Fig. 3

Draw the graph G. Find the changes in the linked representation of graph G if the following operations occur:

i) Node F is added to G
ii) Edge (B,E) is deleted from G
iii) Edge (A,F) is added to G

Draw the resultant graph G.

c) Find the weight matrix W and find the matrix Q of shortest paths using modified Warshall's algorithm for graph shown in figure below. (16)

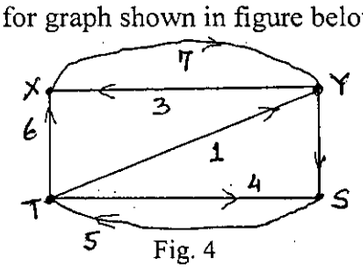

Fig. 4

7. a) Suppose a hash table has 11 memory locations. A file consists of 8 records with following hash addresses: (11)

Record:	A	B	C	D	E	F	G	X
Hash address H(k):	2	8	4	11	5	1	11	1

How will the records appear in the memory if linear problem technique is used? Find the average number of comparisons needed for a successful and unsuccessful search.

b) Show the steps if you apply merge sort algorithm for the following data: (10)
66, 33, 40, 22, 53, 88, 60, 11, 80 and 20

c) Using radix sort method, sort the data elements 9, 159, 59, 113 and 26 in decreasing order. Then calculate the total no. of comparisons needed to sort the data. (10)

d) Define: i) Collinon, and ii) load factor. (04)

8. a) Suppose a hash table has 7 memory locations and a has function h2(k)=5-(K mod 5) where k is the key value. Now arrange the following key values to the hash table using double hashing and find the successful and unsuccessful search: 76, 93, 40, 47, 10, 55 (15)

b) Define the terms: i) labeled graph, ii) directed graph, and iii) complete graph (05)

c) How can you traverse DFS using stack in the graph shown in the following figure? Start for the node A. (10)

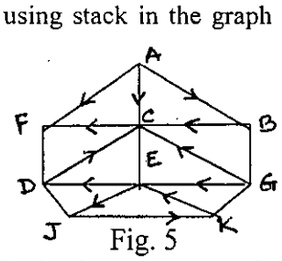

Fig. 5

d) What is topological sorting? Write down the steps of topological sorting. (05)

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

B.Sc. Engineering 2nd Year 2nd Term Examination, 2015
Department of Electronics and Communication Engineering
EEE 2209
(Electrical Drives & Instrumentation)

TIME: 3 hours FULL MARKS: 210

N.B. i) Answer **ANY THREE** questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.

SECTION A

(Answer **ANY THREE** questions from this section in Script A)

1. a) State the necessity of electrical drives in industries and daily life activities. (05)
   b) Explain the construction of a dc generator with the functions of each essential parts in brief. (12)
   c) Derive that the generated emf of a dc generator is $E_g=(Z/a)\varphi pN$, where the symbols have their usual meanings. (08)
   d) A 440V, 50A dc motor is supplied at rated voltage and current by a short-shunt compound dc generator. The generator has armature, series-field and shunt-field resistance of 0.05, 0.2 and 225 ohms respectively. Calculate the induced emf and armature current of the generator if contact drop per brush is 1 V. (10)

2. a) What is back emf? Show that the electrical power converted to mechanical power, Pm will be maximum when back emf will be half of the applied voltage. (10)
   b) What are the factors controlling motor speed? Explain the flux control method with relevant diagrams. (12)
   c) Why is starter necessary? What are the drawbacks of 3-point starter? How does 4-point starter overcome those drawbacks of 3-point starter? (13)

3. a) Why is induction motor called asynchronous motor? Explain how rotating magnetic field (with constant magnitude) is produced when 3-phase supply is connected across the 3-phase induction motor. (11)
   b) Clarify the elementary theory of an ideal transformer and obtain the emf equation. (14)
   c) In no-load test, a single phase transformer gives: (10)
   Primary voltage: 240 V; Secondary voltage: 120 V
   Primary current: 0.5 A; Power input: 35 W.
   Calculate: i) Turns ratio, ii) Components of no-load currents and iii) Iron loss

4. a) Mention the basic differences between dc generator and an alternator. What are the conditions for parallel operation of alternators? (07)
   b) Explain the principle of operation and characteristics of a universal motor in brief. (08)
   c) What are the applications of electric braking? Define plugging and show that in this case the braking torque never become zero even the speed is zero. (10)
   d) Why is synchronous not self starting? Explain the starting arrangement of synchronous motor together with its applications. (10)

SECTION B

(Answer **ANY THREE** questions from this section in Script B)

5. a) Define measurement and instrumentation. Show the input-output configuration of a measurement system and describe in brief. (12)
   b) Define i) drift, ii) reproducibility, iii) resolution of measurement system. Discuss different types of errors in measurements. (11)
   c) Define active and passive transducer with proper example. Explain the operation and characteristics of a potentiometer. (12)

6. a) What are the basic differences between sensor and transducer? Explain using suitable examples. (07)

b) Define piezoresistive effect. (10)

A compressive force is applied to a structural member. The strain is 5 micro-strain. Two separate strain gauges are attached to the structural member, one is a nickel wire strain gauge having a gauge factor of -12.1 and the other is nichrome wire strain gauge having a gauge factor of 2. Calculate the value of resistance of the gauges after they are strained. The resistance of strain gauges before being strained is 120 ohm.

c) Show the charge sensitivity of piezoelectric transducer is $d = \varepsilon_0 \varepsilon_r g$, where the symbols have their usual meaning. (08)

d) Describe the operating principle of LVDT. Also mention some advantages and disadvantages of it. (10)

7. a) Explain the principle of operation of a thermoelectric transducer. (10)
   b) Describe the relative advantages and disadvantages of LED display over LCD display. (10)
   c) Why is recording needed? Classify the recording systems. (05)
   d) Explain the operation of ramp type digital voltmeter. (10)

8. a) Define CRO. For a CRO, show that the electrostatic deflection is directly proportional to the deflecting voltage. (12)
   b) What is spectrum analyzer? Draw and explain the block diagram of a typical spectrum analyzer. (08)
   c) Define Lissajous pattern. Calculate the frequency of vertical plates if the applied frequency to the horizontal plate is 100 Hz for the following patterns shown in Fig. 1 below. (07)

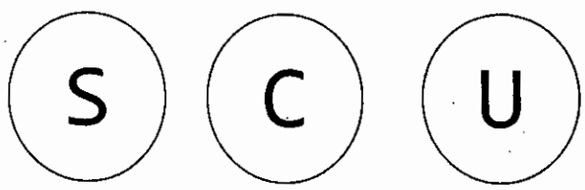

Fig. 1

d) A meter has an internal resistance of 100 ohm and requires 1 mA for full scale deflection. It is to be converted to a 10 V ac voltmeter using circuit shown ion Fig. 2. The shunt resistor placed across the meter has a value of 100 ohm. Rectifiers D1 & D2 each have a forward resistance of 400 ohm and are assumed to have infinite resistance in reverse direction. Calculate i) value of multiplier Rs and ii) voltmeter sensitivity. (08)

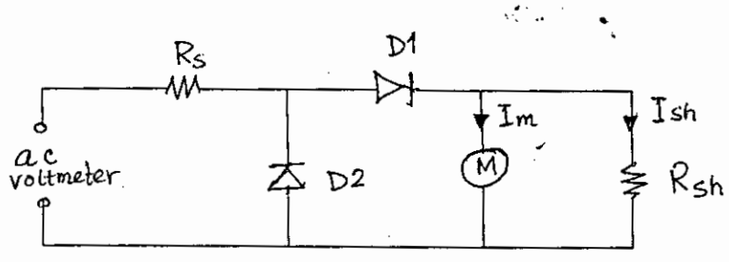

Fig. 2

KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

B.Sc. Engineering 2nd year 2nd Term Examination, 2015

Department of Electronics and Communication Engineering

Math-2209

(Mathematics-IV)

TIME: 3 hours FULL MARKS: 210

N.B. i) Answer **ANY THREE** questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.
iii) Standard Normal Distribution Table will be provided if necessary.

SECTION A

(Answer **ANY THREE** questions from this section in Script A)

1. a) For any complex number z, show that $\mathrm{Re}(iz) = |z|^2 . \mathrm{Im}\left(\frac{1}{z}\right)$. If the modules and argument of a complex number z are 1 and $\frac{3\pi}{4}$ respectively, find z. (06)

b) Describe the region $|z-3|+|z+3| \le 5$ geometrically in the finite z-plane. (05)

c) Determine the analytic function $f(z)$ whose real part is $u(x,y) = e^x\left[\left(x^2-y^2\right)\cos y - 2xy\sin y\right]$. Hence find its imaginary part $v(x,y)$. (15)

d) Locate and name the singular points of the functions: i) $\frac{1}{z\sin 2z}$, ii) $\frac{e^z}{(z-1)^4}$, iii) $(z-3)^{1/2}$. (09)

2. a) State Cauchy's theorem and verify this theorem for the integral of z^3 taken over the boundary C of the rectangle with vertices -1, 1, -1+i and 1+i. (12)

b) Evaluate $\oint_c \frac{z^3}{(2z^2-5z+2)^2} dz$, where c is a unit circle with center at the origin. (11)

c) State Laurent's theorem. Expand $\frac{3z-3}{(2z-1)(z-2)}$ in a Laurent series valid for $\frac{1}{2} < |z-1| < 1$. (12)

3. a) Find a Taylor series expansion of $f(z) = e^{-z}$ about the point $z = 0$. (05)

b) Evaluate any **Two** of the followings: (30)

i) $\int_0^{2\pi} d\theta/(3+4\sin\theta)$ ii) $\int_0^{2\pi} d\theta/(a+b\cos\theta)^2$, where a and b are real and a>b>0.

iii) $\int_{-\infty}^{\infty} \frac{dx}{2x^2+2x+7}$

4. a) A slightly stretched string of length l with fixed end points $x = 0$ and $x = l$ is initially at rest in its equilibrium position. If it starts vibrating by giving to each of its points with a velocity $\lambda_x(l-x)$, find the displacement $y(x, t)$ of the string at any distance x at any time $t > 0$. (18)

b) Using variable separation technique show that the general solution of $u_{tt} = c^2(u_{xx} + u_{yy})$ is (17)

$$u(x,y,t) = \sum_{m=1}^{\infty}\sum_{n=1}^{\infty}\left[P_{mn}\cos(ck_{mn}t) + Q_{mn}\sin(ck_{mn}t)\right]\sin\frac{m\pi x}{a}\sin\frac{n\pi y}{b}$$ Where,

$$k_{mn}^2 = \frac{m^2}{a^2} + \frac{n^2}{b^2}$$

$$u(a,y,t) = 0 = u(0,y,t) = u(x,a,t) = u(x,b,t)$$

SECTION B

(Answer **ANY THREE** questions from this section in Script B)

5. a) Write the Bessel's differential equation of order 3. Using the method of Frobenius, obtain the indicial roots of this equation. Also show that the solution corresponding the roots are not linearly independent. (18)

   b) Write the generating function for the Bessel's function of 1st kind. Derive Jacobi's series and hence obtain the Fourier-Bessel series for $f(x)=\sin x$ i.e, a series representation of $f(x)=\sin x$ in terms of Bessel functions. (12)

   c) Write the Legendre differential equation and its generating function. (05)

6. a) Express $f(x) = x^4 + 3x^3 - x^2 + 5x - 2$ in terms of Legendre polynomials. (11)

   b) Show that Legendre polynomials are orthogonal. (12)

   c) Mean marks of certain examination was 72 with variance 36. Assuming the marks to be normally distributed, determine the minimum and maximum marks of the top and bottom 10% of the students. (12)

7. a) Derive the moment generating function of the normal distribution. Hence, otherwise show that all odd moments about mean for this distribution is zero. (13)

   b) Two fair dice are thrown together 7 time. What is the probability of getting a sum of 8, 3 times? (08)

   c) Obtain the moment coefficient of skewness of the following distribution. (14)

x	13	22	30	40	49	58	67
f	5	15	27	28	26	20	14

8. a) What is Benoulli's process? Obtain an expression for the standard deviation of a binomial distribution. (12)

   b) Prove that the Poisson's distribution is a limiting case of the negative binomial distribution. (13)

   c) From the following data-set obtain the mode and third quartile (Q_3). (10)

x	41-50	51-60	61-70	71-80	81-90	91-100
F	12	15	17	16	18	14