Khandesh College Education Society's

Moolji Jaitha College, Jalgaon

An "Autonomous College" Affiliated to

KBC North Maharashtra University, Jalgaon

SYLLABUS

Mathematics

S.Y.B. Sc.

(Semester III & IV)

Under Choice Based Credit System (CBCS)

[w. e. f. Academic Year: 2020-21]

Course Structure: SYBSc (Mathematics)

Duration: The duration of B.Sc. (Mathematics) degree program shall be three years.

Semester	Course Module	Subject code	Title of Paper	Credit	Hours per week
III	DSC	MTH-231	Calculus of several variables	2	2
	DSC	MTH-232(A)	Abstract algebra	2	2
	DSC	MTH-232(B)	Computational algebra	2	2
	DSC	MTH-233	Practical course based on MTH-231 and MTH-232	2	4
	SEC	MTH-230	Set theory and logic	2	2
IV	DSC	MTH-241	Complex variables	2	2
	DSC	MTH-242(A)	Differential equations	2	2
	DSC	MTH-242(B)	Applied differential equations	2	2
	DSC	MTH-243	Practical course based on MTH-241 and MTH-242	2	4
	SEC	MTH-240	Graph theory	2	2

DSC : Discipline Specific Elective Core Course
SEC : Skill Enhancement Course
MTH-YSC : Mathematics (Y-year; S-Semester; C-Course number)

Examination Pattern for S.Y.B.Sc.

Examination	Marks
External Marks	**40**
Internal Marks	**10**
Total Marks	**50**

S.Y. B.Sc. (Mathematics): Semester-III

MTH-231: Calculus of several variables

Total Hours: 30 Credits: 2

Course objectives:

- To know scope and importance of functions of two and more variables.
- To study series expansions and extreme values.
- To know integration techniques as well as applications of integrals.

Course outcomes:

Student will be able to

- Understand limit and continuity of functions of several variables.
- Explain fundamental concepts of multivariable Calculus and series expansion of functions.
- Explain extreme points of function and their maximum, minimum values at those points.
- Understand meaning of definite integral as limit as sums.
- Learn how to solve double and triple integration and use them to find area by double integration and volume by triple integration.

Unit I: Functions of Two and Three Variables 10h

- Explicit and implicit functions, Continuity, Partial derivatives, Differentiability, Necessary and sufficient conditions for differentiability, Partial derivatives of higher order, Schwarz's theorem, Young's theorem.

Unit II: Composite Functions and Mean Value Theorems 10h

- Composite functions (chain rule), Homogeneous functions, Euler's theorem on homogeneous functions, Mean value theorem for functions of two variables.

Unit III: Taylor's Theorem and Extreme Values 10h

- Taylor's theorem for functions of two variables, Maclaurin's theorem for functions of two variables, Absolute and relative maxima & minima, Necessary condition for extrema, Critical point, Saddle point, Sufficient condition for extrema.

Unit IV: Double and Triple Integrals 10h

Double integrals by using Cartesian and polar coordinates, Change of order of integration, Area by double integral, Evaluation of triple integral as repeated integrals, Volume by triple integral.

References

1. Malik S.C. and Arora Savita (1992), Mathematical Analysis, Wiley Eastern Ltd, New Delhi.
2. Rogers Robert C. (2011), Calculus of Several Variables by Schaum's Outline Series.
3. Apostol T. M.(1985), Mathematical Analysis, Narosa Publishing House, New Delhi.

S.Y. B.Sc. (Mathematics): Semester-III

MTH-232(A): Abstract algebra

Total Hours: 30 **Credits: 2**

Course objectives:

- To know scope and importance of algebraic structures and their properties.
- To study problems in many branches of Mathematics such as theory of equations, theory of numbers, Geometry etc.
- To know properties of algebraic structures.

Course outcomes:

Student will be able to

- Understand group and their types which is one of the building blocks of pure and applied mathematics.
- Explain Lagrange, Euler and Fermat theorem.
- Explain concepts of homomorphism, isomorphism and automorphism of groups.
- Learn basic properties of rings and their types such as integral domain and field.

Unit I : Groups **10h**

- Definition and examples of a group, Simple properties of group, Abelian group, Finite and infinite groups, Order of a group, Order of an element and its properties.

Unit II: Subgroups **10h**

- Definition and examples of subgroups, Simple properties of subgroup, Criteria for a subgroup, Cyclic groups, Coset decomposition, Lagrange's theorem for finite group, Euler's theorem and Fermat's theorem.

Unit III: Homomorphism and Isomorphism of Groups **10h**

- Definition and examples of group homomorphism, Properties of group homomorphism, Kernel of a group homomorphism and it's properties, Definition and examples of isomorphism and properties, Definition and examples of automorphism of groups

Unit IV: Rings **10h**

- Definition and simple properties of a ring, Commutative ring, Ring with unity, Boolean ring, Ring with zero divisors and without zero divisors, Integral domain, Division ring & field and their simple properties.

References

1. Gopalakrishnan N. S.(2018), University Algebra, Wiley Eastern Limited, New Delhi.
2. Herstein I. N. (1975), Topics in Algebra, John Wiley and Sons, New Delhi.
3. Fraleigh J. B.(2003), A first Course in Abstract Algebra, Pearson.
4. Khanna Vijay K and Bhambri S. K. (2003), A course in Abstract Algebra, Vikas Publishing House Pvt. Ltd., Noida.

S.Y. B.Sc. (Mathematics): Semester-III

MTH-232(B): Computational algebra

Total Hours: 30 **Credits: 2**

Course objectives:

- To know scope and importance of algebraic structures and their properties
- To study problems in many branches of Mathematics and computer science such as theory of equations, theory of numbers, theory of computations, cryptography etc.
- To know properties of algebraic structures.

Course outcomes:

Student will be able to

- Understand group and their types which is one of the building blocks of pure and applied mathematics.
- Explain Lagrange, Euler and Fermat theorem.
- Explain concepts of homomorphism, isomorphism and automorphism of groups.
- Learn basic concepts in coding theory.

Unit I: Groups **10h**

- Definition and examples of a group, Simple properties of group, Abelian group, Finite and infinite groups, Order of a group, Order of an element and its properties.

Unit II: Subgroups **10h**

- Definition and examples of subgroups, Simple properties of subgroup, Criteria for a subgroup, Cyclic groups, Coset decomposition, Lagrange's theorem for finite group, Euler's theorem and Fermat's theorem.

Unit III: Homomorphism and Isomorphism of Groups **10h**

- Definition and examples of group homomorphism, Properties of group homomorphism, Kernel of a group homomorphism and it's properties, Definition and examples of isomorphism and properties, Definition and examples of automorphism of groups

Unit IV: Group Codes **10h**

- Message, word, (m, n)-encoding function, Code words, Detection of k or fewer errors, Weight, Parity check code, Hamming distance, Properties of the distance function, Minimum distance of an encoding function, Group codes, (n, m)-decoding function, Maximum likelihood decoding function, Decoding procedure for a group code given by a parity check matrix.

References

1. Gopalakrishnan N. S.(2018), University Algebra, Wiley Eastern Limited, New Delhi.
2. Kolman Bernard, Busby Robert C. and Ross, Discrete Mathematical Structures, Prentice Hall of India (Eastern Economy Edition), New Delhi.
3. Herstein I. N. (1975), Topics in Algebra, John Wiley and Sons, New Delhi.
4. Fraleigh J. B.(2003), A first Course in Abstract Algebra, Pearson.
5. Jones G. A. and Jones J. M., (2000), Information and Coding Theory , Springer.

S.Y. B.Sc. (Mathematics): Semester-III

MTH-233: Practical course based on MTH-231 and MTH-232

Total Hours: 60 **Credits: 2**

Course objectives:

- To know problem solving skills in Calculus of several variables.
- To know problem solving skills in group theory.
- To know problem solving skills in coding theory.

Course outcomes:

Student will be able to

- Understand and solve problems on Functions of Two and Three Variables , Composite Functions and Mean Value Theorems, Taylor's Theorem and Extreme Values, Double and Triple Integrals
- Apply theorems of Lagrange, Euler and Fermat to solve problems.
- Explain concepts and solve problems on homomorphism, isomorphism and automorphism of groups.
- Apply concepts of coding theory to solve problems.

S.Y. B.Sc. (Mathematics): Semester-III

MTH-233: Practical course based on MTH-231 and MTH-232

Practical No.	Title of the Practical
1.	Functions of two and three Variables
2.	Composite Functions and Mean Value Theorems
3.	Taylor's Theorem and Extreme Values
4.	Double and Triple Integrals
5.	Groups
6.	Subgroups
7.	Homomorphism and Isomorphism of Groups
8(A).	Rings
8(B).	Group Codes

Practical No.-1: Functions of two and three variables

1) Evaluate: $\lim_{(x,y)\to(0,0)} \frac{xy^3}{x^2+y^3}$.
2) If $u = x^2y + y^2z+z^2x$, then show that $\frac{\partial u}{\partial x} + \frac{\partial u}{\partial y} + \frac{\partial u}{\partial z} = (x + y + z)^2$.
3) Let $(x, y) = \begin{cases} xy\frac{x^2-y^2}{x^2+y^2} & , if\ (x, y) \neq (0,0) \\ 0 & , if\ (x, y) = (0,0) \end{cases}$. Prove that $f_{xy}(0,0) \neq f_{yx}(0,0)$.

4) Show that the function $f(x,y) = \sqrt{|xy|}$ has first partial derivative at the origin but not differentiable there.
5) Using differentials, find the approximate value of $\sqrt{(1.02)^2 + (1.97)^3}$.
6) Evaluate: $\lim_{(x,y)\to(0,0)} \frac{x^2y^4}{(x^2+y^4)^2}$.
7) Examine the continuity of the function $f(x,y) = \begin{cases} \frac{xy}{\sqrt{x^2+y^2}} & ,if\ (x,y) \neq (0,0) \\ 0 & ,if\ (x,y) = (0,0) \end{cases}$.
8) If $u = x^2 \tan^{-1}\frac{y}{x} - y^2 \tan^{-1}\frac{x}{y}$, prove that $\frac{\partial^2 u}{\partial x \partial y} = \frac{x^2-y^2}{x^2+y^2}$.
9) If $u = \frac{x^2+y^2}{x+y}$, then prove that $\left(\frac{\partial u}{\partial x} - \frac{\partial u}{\partial y}\right)^2 = 4\left(1 - \frac{\partial u}{\partial x} - \frac{\partial u}{\partial y}\right)$.
10) Using differentials, find the approximate value of $(2.01)(3.02)^2$.

Practical No.-2: Composite functions and Mean value theorems

1) Let $z = f(u,v)$, where $u = 2x - 3y$ and $v = x + 2y$. Prove that $\frac{\partial z}{\partial x} + \frac{\partial z}{\partial y} = 3\frac{\partial z}{\partial v} - \frac{\partial z}{\partial u}$.
2) If $u = f(x,y)$, where $x = r\cos\theta$ and $x = r\sin\theta$. Show that
$$\left(\frac{\partial u}{\partial x}\right)^2 + \left(\frac{\partial u}{\partial y}\right)^2 = \left(\frac{\partial u}{\partial r}\right)^2 + \frac{1}{r^2}\left(\frac{\partial u}{\partial \theta}\right)^2.$$
3) If $u = \sin^{-1}\left[\frac{x^2+2xy}{\sqrt{x-y}}\right]^{\frac{1}{5}}$, then find the value of (1) $x\frac{\partial u}{\partial x} + y\frac{\partial u}{\partial y}$, (2) $x^2\frac{\partial^2 u}{\partial x^2} + 2xy\frac{\partial^2 u}{\partial x \partial y} + y^2\frac{\partial^2 u}{\partial y^2}$.
4) If $u = \tan^{-1}\left[\frac{x^3+y^3}{x-y}\right]$, then find the value of (1) $x\frac{\partial u}{\partial x} + y\frac{\partial u}{\partial y}$, (2) $x^2\frac{\partial^2 u}{\partial x^2} + 2xy\frac{\partial^2 u}{\partial x \partial y} + y^2\frac{\partial^2 u}{\partial y^2}$.
5) If $f(x,y) = x^3 - xy^2$, then show that θ used in the mean value theorem applied to the points $(2,1)$ and $(4,1)$ satisfy the quadratic equation $3\theta^2 + 6\theta - 4 = 0$.
6) If $z = f(x,y) = \tan^{-1}\frac{x}{y}$, where $x = u + v$ and $y = u - v$, then show that $\frac{\partial z}{\partial u} + \frac{\partial z}{\partial v} = \frac{u-v}{u^2+v^2}$.
7) Find $\frac{dz}{dt}$ when $z = xy^2 + x^2y$, $x = at^2$, $y = 2at^2$.
8) If $z = x^2 + y^2$ where $x = t^2 + 1$, $y = 2t$, then find $\frac{dz}{dt}$ at $t = 1$.
9) Verify Euler's theorem for the function $f(x,y) = x^3 + y^3 - 3x^2y$.
10) If u = $\sin^{-1}\sqrt{x^2 + y^2}$, then prove that $x^2\frac{\partial^2 u}{\partial x^2} + 2xy\frac{\partial^2 u}{\partial x \partial y} + y^2\frac{\partial^2 u}{\partial y^2} = tan^3 u.$

Practical No.-3: Taylor's theorem and Extreme values

1) Expand $x^3 + y^3 + xy^2$ in powers of $(x-1)$ and $(y-2)$.
2) Expand $f(x,y) = x^2 + xy - y^2$ by Taylor's theorem in powers of $(x-1)$ and $(y+2)$.
3) Prove that $\sin(x+y) = (x+y) - \frac{(x+y)^3}{3!} + \cdots$

4) Expand $f(x, y) = \sin xy$ in powers of $(x-1)$ and $\left(y - \frac{\pi}{2}\right)$ up to and including terms of second degree.
5) Discuss the maxima and minima of the function $f(x, y) = x^2 + y^2 + \frac{2}{x} + \frac{2}{y}$.
6) Find the stationary points and determine the nature of the following function $f(x, y) = x^3 + y^3 - 3x - 12y + 20$.
7) A rectangular box open at the top is to have a volume 108 cubic unit. Find the dimension of the box if the total surface area is minimum.
8) Divide 24 in to three positive numbers such that their product is maximum.
9) Determine the minimum distance from origin to the plane $3x + 2y + z - 12 = 0$.
10) Expand $f(x, y) = \sin x \sin y$ about origin up to and including terms of third degree.

Practical No.-4: Double and Triple Integrals

1) Evaluate $\iint_R xy(x+y)dxdy$ where R is the region bounded by $y = x^2$ and $y = x$.
2) Evaluate $\iint ydxdy$ over the region bounded by $y = x^2$ and $x + y = 2$.
3) Using double integration, find the area of the region bounded by $y^2 = 4x$ and $x^2 = 4y$.
4) Using double integration, find the area of the circle $x^2 + y^2 = a^2$.
5) Evaluate $\iiint (x+y+z)dxdydz$ over the tetrahedron $x = 0, y = 0, z = 0$ and $x + y + z = 1$.
6) Using triple integration, find the volume of sphere having radius a.
7) Find the area bounded by the parabola $y^2 = 2x$ and $x^2 = 2y$.
8) Evaluate $\iint xydxdy$ over the region $x = 0, y = 0$ and $x + y = 1$.
9) Evaluate $\int_0^1 \int_0^2 \int_0^3 (x+y+z)dxdydz$.
10) Evaluate $\int_0^1 \int_0^{\sqrt{1-x^2}} \int_0^{\sqrt{1-x^2-y^2}} \frac{dxdydz}{\sqrt{1-x^2-y^2-z^2}}$.

Practical No.-5: Groups

1) Let $\mathbb{Q}^+$ denotes the set of all positive rational numbers and for any $a, b \in \mathbb{Q}^+$, define $a * b = \frac{ab}{3}$. Show that $(\mathbb{Q}^+, *)$ is an abelian group.
2) Show that $G = \mathbb{R} - \{1\}$ is an abelian group under the operation $a * b = a + b - ab$ $\forall\, a, b \in G$.
3) Let $G = \{(a, b): a, b \in \mathbb{R},\ a \neq 0\}$. Show that $(G, \odot\odot)$ is a non-abelian group, where $(a, b)\odot\odot(c, d) = (ac, ad + b)$.
4) Let G = GL(2, ℝ) = $\left\{\begin{bmatrix} a & b \\ c & d \end{bmatrix} : a, b, c, d \in \mathbb{R},\ ad - bc \neq 0\right\}$. Prove that G is a non-abelian group under usual matrix multiplication.
5) Prove that $G = \left\{\begin{bmatrix} x & x \\ x & x \end{bmatrix} : x \in \mathbb{R},\ x \neq 0\right\}$ is a group under matrix multiplication.
6) Let $G = \{\pm 1, \pm i, \pm j, \pm k\}$ where $i^2 = j^2 = k^2 = -1,\ ij = k, jk = i, ki = j,$ $ji = -k, kj = -i$ and $ik = -j$. Show that G is a non-abelian group under usual multiplication.
7) Prove that $G = \{\bar{2}, \bar{4}, \bar{6}, \bar{8}\}$ is a group under usual multiplication modulo 10.

8) Find order of every element in the group $(\mathbb{Z}_7, \times_7)$.
9) In the group $(\mathbb{Z}_{11}, \times_{11})$, find i) $(\bar{4})^3$ ii) $(\bar{5})^{-1}$ iii) $(\bar{6})^{-5}$ iv) $(\bar{3})^4$
10) If in a group G, $a^5 = e$ & $aba^{-1} = b^2$ where $a, b \in G$, then find order of an element b.

Practical - 6: Subgroups

1) If G is a group, then show that the center of G, $Z(G)$ is a subgroup of G where $Z(G) = \{a \in G : ax = xa, \forall x \in G\}$.
2) Let G be a group of all non-zero complex numbers under multiplication. Show that $H = \{a + ib : a^2 + b^2 = 1\}$ is a subgroup of G.
3) Let $G = \mathrm{GL}(2, \mathbb{R})$ be the group under usual matrix multiplication. Prove that $H = \mathrm{SL}(2, \mathbb{R}) = \left\{\begin{bmatrix} a & b \\ c & d \end{bmatrix} \in G : ad - bc = 1\right\}$ is a subgroup of G.
4) Let H be a subgroup of a group G and $gHg^{-1} = \{ghg^{-1} : h \in H\}$ is a subgroup of G.
5) Let $G = \{1, -1, i, -i, j, -j, k, -k\}$ be a group under multiplication and $H = \{1, -1, i, -i\}$ be its subgroup. Find all the left and right cosets of H in G.
6) Show that $(\mathbb{Z}_7, \times_7)$ is a cyclic group. Find all its generators and all its proper subgroups.
7) Let A and B be two subgroups of a finite group G whose orders are relatively prime. Show that $A \cap B = \{e\}$.
8) Show that every proper subgroup of a group of order 77 is cyclic.
9) Find the remainder obtained when 15^{27} is divided by 8.
10) Find the remainder obtained when 33^{19} is divided by 7.

Practical – 7: Homomorphism and Isomorphism of Groups

1) Let $G = \{A : A \text{ is } n \times n \text{ matrix over } \mathbb{R} \text{ and } |A| \neq 0\}$, the group under matrix multiplication and $\mathbb{R}^* = \mathbb{R} - \{0\}$, the group under multiplication. Define $f : G \to \mathbb{R}^*$ by $f(A) = |A|$, for all $A \in G$. Show that f is an onto group homomorphism and find its kernel.
2) Prove that the mapping $f : (\mathbb{C}, +) \to (\mathbb{C} - \{0\}, \cdot)$ such that $f(z) = e^z$ is a homomorphism. Find its kernel.
3) If $G = \{1, -1, i, -i\}$ is a group under multiplication and $G_1 = \{\bar{2}, \bar{4}, \bar{6}, \bar{8}\}$ is a group under usual multiplication modulo 10, then show that G and G_1 are isomorphic.
4) Let G be a group and $a \in G$. Show that $f_a : G \to G$ defined by $f_a(x) = axa^{-1}$ for all $x \in G$ is an automorphism.
5) Let G be a group and $f : G \to G$ be a map defined by $f(x) = x^{-1}$ for all $x \in G$. If G is an abelain group, then prove that f is an isomorphism.
6) Let G be a group and $f : G \to G$ be a map defined by $f(x) = x^{-1}$ for all $x \in G$. If f is a group homomorphism, then prove that G is abelian.
7) Let $G = \{a, a^2, a^3, \dots, a^{11}, a^{12} = e\}$ be a cyclic group of order 12 generated by a. Show that $f : G \to G$ defined by $f(x) = x^4$, $\forall x \in G$ is a group homomorphism. Find the kernel of f.

8) Let f and g be group homomorphisms from the group G into G. Show that $H = \{x \in G : f(x) = g(x)\}$ is a subgroup of G.
9) Let $G = \left\{\begin{bmatrix} a & b \\ -b & a \end{bmatrix} : a, b \in \mathbb{R},\ a^2 + b^2 = 1\right\}$ be a group under usual matrix multiplication and $\mathbb{C}^*$ be a group of non-zero complex numbers under multiplication. Show that $f : G \to \mathbb{C}^*$ defined by $f\left(\begin{bmatrix} a & b \\ -b & a \end{bmatrix}\right) = a + ib$ is an isomorphism.
10) Show that the groups $G = \{1, -1, i, -i\}$ under usual multiplication and $\mathbb{Z}_8' = \{\bar{1}, \bar{3}, \bar{5}, \bar{7}\}$ under multiplication modulo 8 are not isomorphic.

Practical – 8(A): Rings

1) Show that $R = \{a + b\sqrt{2} : a, b \in \mathbb{Z}\}$ is an integral domain under usual addition and multiplication.
2) Show that $\mathbb{Z}[i] = \{a + ib : a, b \in \mathbb{Z}\}$, the set of Gaussian integers, forms an integral domain under usual addition and multiplication of complex numbers.
3) Show that $\mathbb{Z}_7 = \{\bar{0}, \bar{1}, \bar{2}, \bar{3}, \bar{4}, \bar{5}, \bar{6}\}$ forms a ring under addition and multiplication modulo 7.
4) In the ring $(\mathbb{Z}_7, +_7, \times_7)$, find (i) $-(\bar{4} \times_7 \bar{6})$ (ii) $\bar{3} \times_7 (-\bar{6})$ (iii) $(-\bar{5}) \times_7 (-\bar{5})$ (iv) Units in $\mathbb{Z}_7$ (v) Additive inverse of $\bar{6}$.
5) Find all zero divisors in the ring $(\mathbb{Z}_6, +_6, \times_6)$.
6) Show that $\mathbb{R}\times\mathbb{R}$ forms a field under the following addition and multiplication: $(a, b) + (c, d) = (a + c, b + d)$ and $(a, b) \cdot (c, d) = (ac - bd, ad + bc)$.
7) If p is a prime number, then show that $\mathbb{Z}_p$ is an integral domain.
8) Which of the following rings are integral domains?
   (i) $\mathbb{Z}_{187}$ (ii) $\mathbb{Z}_{61}$ (iii) $\mathbb{Z}_{2\times 2}$ (iv) $(\mathbb{Z}, +, \cdot)$
9) Show that every Boolean ring is commutative.
10) Give an example of a division ring which is not a field.

Practical – 8(B): Group Codes

1) Consider the (3,9) encoding function $e : B^3 \to B^9$ defined by $e(abc) = abcabcabc$ for all $(abc) \in B^3$. Determine whether an error will be detected for each of the following received words:
   (a) 011111011 (b) 111110110.
2) How many errors will e detect? Consider the (3,8) encoding function $e : B^3 \to B^8$ defined by $e(000) = 00000000$, $e(001) = 10111000$, $e(010) = 00101101$, $e(011) = 10010101$, $e(100) = 10100100$, $e(101) = 10001001$, $e(110) = 00011100$, $e(111) = 00110001$.
   (a) Find the minimum distance of e.
   (b) How many errors will e detect?
3) Show that the (3,6) encoding function $e : B^3 \to B^6$ defined by $e(000) = 000000$, $e(001) = 001100$, $e(010) = 010011$, $e(011) = 011111$, $e(100) = 100101$,

$e(101) = 101001, e(110) = 110110, e(111) = 111010$ is a group code. Also find the minimum distance of e.

4) Compute: (a) $\begin{bmatrix} 1 & 0 & 1 \\ 1 & 1 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \oplus \begin{bmatrix} 1 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 1 & 0 \\ 0 & 1 & 0 \end{bmatrix}$ (b) $\begin{bmatrix} 1 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix} * \begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix}$.

5) Consider the $(2\,,5)$ encoding function defined by $e(00) = 00000, e(10) = 10110\,, e(01) = 01011\,, e(11) = 11101$. Show that $e : B^2 \to B^5$ is a group code.

6) Let $H = \begin{bmatrix} 0 & 1 & 1 \\ 0 & 1 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ be a parity check matrix. Determine the (2 , 5) group code $e_H : B^2 \to B^5$.

7) Consider the (3,5) encoding function $e : B^3 \to B^5$ defined by $e(000) = 00000$, $e(001) = 00110$, $e(010) = 01001$, $e(100) = 10011$, $e(101) = 10010$, $e(110) = 11010$, $e(011) = 01111$, $e(111) = 11100$. Decode the following words relative to a maximum likelihood decoding function :

a) 11001 b) 01010 c) 00111.

8) Consider the parity check matrix: $H = \begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$. Decode the following words relative to a maximum likelihood decoding function associated with e_H :

a) 10100 b) 01101 c) 11011.

9) Consider the parity check matrix: $H = \begin{bmatrix} 1 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$. Determine the coset leaders for $N = e_H(B^3)$. Also compute the Syndrome for each coset leader and decode the code 001110 relative to maximum likelihood decoding function.

10) Let the (9, 3) decoding function $d : B^9 \to B^3$ be defined by $d(y) = z_1 z_2 z_3$, where for all i, $z_i = \begin{cases} 1, & \text{if } \{y_i, y_{i+3}, y_{i+6}\} \text{ has at least two 1's} \\ 0, & \text{if } \{y_i, y_{i+3}, y_{i+6}\} \text{ has less than two 1's} \end{cases}$.

If $y \in B^9$, then determine $d(y)$, where $(i)\; y = 101111101$ $(ii)\; y = 100111100$.

(a) Find the minimum distance of e.

(b) How many errors will e detect?

S.Y. B.Sc. (Mathematics): Semester-III
MTH-230: Set theory and logic

Total Hours: 30 **Credits: 2**

Course objectives:

- To acquire concepts of sets, relations, countable and uncountable sets.
- To know scope and importance of statements and truth values, tautology, contradiction.
- To know concepts of quantifiers.

Course outcomes:

Student will be able to

- Understand the issues associated with different types of finite and infinite sets via countable uncountable sets.
- Explain the language of set theory, designing issues in different subjects of mathematics.
- Explain the concepts and methods of mathematical logic, set theory, relation calculus, and concepts concerning functions which are included in the fundamentals of various disciplines of mathematics.
- Understand the role of propositional and predicate calculus.

Unit I: Sets and Subsets **10 h**

- Finite set and infinite set, Equality of two sets, Null set, Subset, Proper subset, Symmetric difference of two sets, Universal set, Power set, Disjoint sets, Operation on sets such as union and intersection, Venn diagram, Equivalent sets, Countable and uncountable sets.

Unit II: Relations and Functions **10 h**

- Product of sets, Relations, Types of relations, Reflexive, Symmetric, Transitive relations and equivalence relations, Function, Types of functions, One-one, Onto, Even, Odd and inverse function, Composite functions.

Unit III: Algebra of Propositions **10h**

- Statements, Conjunction, Disjunction, Negation, Conditional and bi-conditional statements, Propositions, Truth table, Tautology and contradiction, Logical equivalence, Logical equivalent statements.

Unit IV: Quantifiers **10h**

- Propositional functions and truth sets, Universal quantifier, Existential quantifier, Negation of proposition which contain quantifiers, Counter examples.

References

1. Halmos P. R.(1974), Naïve Set Theory, Springer.
2. Kamke E. (1950), Theory of Sets, Dover Publishers.
3. Lipschutz S. (1998), Set Theory and Related Topics , Schaum’s outline Series, McGraw-Hill.

S.Y. B.Sc. (Mathematics): Semester-IV

MTH-241: Complex variables

Total Hours: 30 **Credits: 2**

Course objectives:

- To know the concept of analytic function, harmonic function.
- To study generalization of real number system and calculus.
- To know integration techniques as well as applications of integrals.

Course outcomes:

Student will be able to

- Understand the theory for functions of complex variables.
- Explain fundamental concepts of analytic function and Cauchy Riemann Equations.
- Explain extreme points of function and their maximum, minimum values at those points.
- Understand meaning of complex integration.
- Learn how to solve problems on calculus of residues and contour integrations.

Unit I: Complex numbers **10h**

- Complex numbers, Modulus and amplitude, Polar form, Triangle inequality and Argand's diagram, Riemann Sphere, De-Moivre's theorem for rational indices and applications, n^{th} roots of a complex number.

Unit II: Functions of complex variables **10h**

- Limits, Continuity and derivative, Analytic functions, Necessary and sufficient conditions for analytic functions, Cauchy-Riemann equations, Laplace equations and Harmonic functions, Construction of analytic functions.

Unit III: Complex integrations **10h**

- Line integral and theorems on it, Statement and verification of Cauchy-Gaursat's theorem, Cauchy's integral formulae (for simple connected domain) for $f(a)$, $f'(a)$ and $f^n(a)$, Taylor's and Laurent's series.

Unit IV: Calculus of Residues **10h**

- Zeros, poles and singularities of a function, Residue of a function, Cauchy's residue theorem, Evaluation of integrals by using Cauchy's residue theorem, Contour integrations of the type $\int_0^{2\pi} f(\cos\theta, \sin\theta)d\theta$ and $\int_{-\infty}^{\infty} f(x)dx$.

References

1. Brown J. W. and Churchill R. V. (2009), Complex Variables and Applications, McGraw-Hill; 8^{th} Edition.
2. Narayan Shanti and Mittal P.K (2005), Theory of Functions of Complex Variables, S. Chand and Company New Delhi.
3. Spiegel Murray R, (2009), Complex variables, Schaum's Outline Series, The McGraw-Hill, New York.

S.Y. B.Sc. (Mathematics): Semester-III
MTH-242(A): Differential equations

Total Hours: 30 **Credits: 2**

Course objectives:

- To know the techniques of formation of differential equations and their solutions
- To study method of variation of parameters for second order L.D.E.
- To know Pfaffian differential equations and method of their solutions.

Course outcomes:

Student will be able to

- Understand formation of differential equations and their solutions, concept of Lipschitz condition.
- Explain method of variation of parameters for second order L.D.E.
- Explain concepts of simultaneous linear differential equations and method of their solutions.
- Learn Pfaffian differential equations, difference equations and method of their solutions.

Unit I: Theory of ordinary differential equations **10h**

- Lipschitz condition, Existence and uniqueness theorem, Linearly dependent and independent solutions, Definition of Wronskian and properties related to solution of L.D.E., Super position principle. Method of variation of parameters for second order L.D.E.

Unit II: Simultaneous Differential Equations **10h**

- Simultaneous linear differential equations of first order, Simultaneous D.E. of the form $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$, Rule I: Method of combinations, Rule II: Method of multipliers, Rule III: Properties of ratios.

Unit III: Total Differential or Pfaffian Differential Equations **10h**

- Pfaffian differential equations, Necessary and sufficient conditions for the integrability, Conditions for exactness, Method of solution by inspection, Solution of homogenous equation.

Unit IV: Difference Equations **10h**

- Introduction, Order of difference equation, Degree of difference equations, Solution to difference equation and formation of difference equations, Linear difference equations, Linear homogeneous difference equations with constant coefficients, Non-homogenous linear difference equation with constant coefficients viz. a^x and $f(x)$ (a polynomial of degree m).

References

1. Raisinghania M. D. (2017), *Ordinary and Partial Differential Equation*, S. Chand & Co. 19th Edition.
2. Simmons G. F. (1972), *Differential equations*, Tata Mcgrawhill.
3. Murray D. A. (1997), *Introductory course in Differential Equations*,(5th Edition) Longmans Green and co. London and Mumbai.
4. Coddington E. A. (1981), *An Introduction to Ordinary Differetial Equations*, Dover Publications, INC.

S.Y. B.Sc. (Mathematics): Semester-III

MTH-242(B): Applied differential equations

Total Hours: 30 **Credits: 2**

Course objectives:

- To know the techniques of formation of differential equations and their solutions
- To study method of variation of parameters for second order L.D.E.
- To know Pfaffian differential equations and method of their solutions.

Course outcomes:

Student will be able to

- Understand formation of differential equations and their solutions, concept of Lipschitz condition.
- Explain method of variation of parameters for second order L.D.E.
- Explain concepts of simultaneous linear differential equations and method of their solutions.
- Learn Pfaffian differential equations, numerical differentiation and method of their solutions.

Unit I: Theory of ordinary differential equations **10h**

- Lipschitz condition, Existence and uniqueness theorem, Linearly dependent and independent solutions, Definition of Wronskian and properties related to solution of L.D.E., Super position principle. Method of variation of parameters for second order L.D.E.

Unit II: Simultaneous Differential Equations **10h**

- Simultaneous linear differential equations of first order, Simultaneous D.E. of the form $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$, Rule I: Method of combinations, Rule II: Method of multipliers, Rule III: Properties of ratios.

Unit III: Total Differential or Pfaffian Differential Equations **10h**

- Pfaffian differential equations, Necessary and sufficient conditions for the integrability, Conditions for exactness, Method of solution by inspection, Solution of homogenous equation.

Unit IV: Numerical differentiation **10h**

- Numerical Differentiation, First and second order derivatives using Newton's forward interpolation formula, Newton's backward interpolation formula and Stirling's interpolation formula.

References

1. Raisinghania M. D. (2017), Ordinary and Partial Differential Equation, S. Chand & Co. 19^{th} Edition.
2. Simmons G. F. (1972), Differential equations, Tata Mcgrawhill.
3. Murray D. A. (1997), Introductory course in Differential Equations, (5^{th} Edition) Longmans Green and co. London and Mumbai.
4. Coddington E. A. (1981), An Introduction to Ordinary Differetial Equations, Dover Publications, INC.
5. Vedamurthy V. N. and Iyengar N. (1998), Numerical Methods, Vikas Publishing House, New Delhi.
6. Sastry S. S. (2012), Introductory methods of Numerical Analysis, Prentice Hall, New Delhi.

S.Y. B.Sc. (Mathematics): Semester-III

MTH-243: Practical course based on MTH-241 and MTH-242

Total Hours: 60 **Credits: 2**

Course objectives:

- To know problem solving skills in theory of Complex variables.
- To know problem solving skills in Differential Equations.
- To know problem solving skills in Applied Differential Equations.

Course outcomes:

Student will be able to

- Understand and solve problems on Functions of complex Variables , Complex integration and calculus of residues.
- Apply theory of ordinary differential equations and Simultaneous Differential Equations to solve problems.
- Explain concepts and solve problems on Total Differential or Pfaffian Differential Equations and Difference Equations.
- Apply concepts of differential equations to solve problems on Numerical differentiation.

S.Y. B.Sc. (Mathematics): Semester-III

MTH-243: Practical course based on MTH-241 and MTH-242

Practical No	Title of the Practical
1	Complex Numbers
2	Function of Complex Variables
3	Complex Integration
4	Calculus of Residues
5	Theory of ordinary differential equations
6	Simultaneous Differential Equations
7	Total (Pfaffian) Differential Equations
8(A)	Difference Equations
8(B)	Numerical Differentiation

Practical No.-1: Complex Numbers

1) If $|z_1| = |z_2| = |z_3| = 5$ and $z_1 + z_2 + z_3 = 0$ then, Show that $\frac{1}{z_1} + \frac{1}{z_2} + \frac{1}{z_3} = 0$.
2) Prove that for any two complex numbers z_1 and z_2 $|z_1 + z_2|^2 + |z_1 - z_2|^2 = 2|z_1|^2 + 2|z_2|^2$.

3) Find cube root of unity.
4) Solve the equation $x^4 - x^3 + x^2 - x + 1 = 0$.
5) Solve the equation $x^4 + x^3 + x^2 + x + 1 = 0$.
6) Solve the equation $x^9 - x^5 + x^4 - 1 = 0$.
7) Find all the values of $(1+i)^{1/5}$. Shw that their contineous product is $1+i$.
8) Show that $\cos^6\theta = \frac{1}{32}[\cos 6\theta + 6\cos 4\theta + 15\cos 2\theta + 10]$.
9) Using Demoivre's theorem to prove the following
   $\cos 5\theta = \cos^5\theta - 10\cos^3\theta\sin^2\theta + 5\cos\theta\sin^4\theta$ and
   $\sin 5\theta = 5\cos^4\theta\sin\theta - 10\cos^2\theta\sin^3\theta + \sin^5\theta$.
10) Using Demoivre's theorem to prove the following
   $\cos 6\theta = \cos^6\theta - 15\cos^4\theta\sin^2\theta + 15\cos^2\theta\sin^4\theta - \sin^6\theta$ and
   $\sin 6\theta = 6\cos^5\theta\sin\theta - 20\cos^3\theta\sin^3\theta + 6\cos\theta\sin^5\theta$.

Practical No.-2: Function of Complex Variables

1) Evaluate $\lim_{z\to 1+i} \frac{z^4+4}{z-1-i}$
2) Evaluate $\lim_{z\to 1+i} \frac{(z^4+4)(1+i-z)}{(z^2-2iz+2i-2z)}$
3) Examine the following functions for continuity at $z = i$
   $$f(z) = \begin{cases} \frac{3z^4-2z^3+8z^2-2z+5}{z-i} & , if\ z \neq i \\ 2+3i & , if\ z = i \end{cases}$$
4) Discuss the continuity of the following function at $z = 2i$
   $$f(z) = \begin{cases} \frac{z^2+4}{z-2i} & , if\ z \neq 2i \\ 3+4i & , if\ z = 2i \end{cases}$$
5) Let $f(z) = \begin{cases} \frac{xy^2(x+iy)}{x^2+y^4} & , if\ z \neq 0 \\ 0 & , if\ z = 0 \end{cases}$
   Show that $f(z)$ satisfies the C-R equations at origin and not differentiable at origin.
6) Show that the function $f(z) = \sqrt{|xy|}$ is not differentiable at origin even though the C-R equations satisfies there.
7) Using Milne-Thomson method, find the analytic function $f(z) = u + iv$
   if $u = x^3 - 3xy^2 + 3x^2 - 3y^2 + 1$.
8) Using Milne-Thomson method, find the analytic function $f(z) = u + iv$
   if $v = e^{-y}\sin x$ such that $f(0) = 1$.
9) Show that if $u = \frac{1}{2}\log(x^2 + y^2)$ satisfy the Laplace equation. Find it's harmonic conjugate.
10) If $f(z)$ is analytic function with constant modulus. Show that $f(z)$ is constant function.

Practical No.-3: Complex Integration

1) Evaluate $\int_c (y - x - 3x^2 i)dz$, where c is the line segment joining from $z = 0 \; to \; z = 1 + i$.
2) Use Cauchy's integral theorem to evaluate $\int_c e^z dz$, where c : $|z| = 1$ and hence deduce
   a) $\int_0^{2\pi} e^{\cos\theta} \sin(\theta + \sin\theta)\, d\theta = 0$
   b) $\int_0^{2\pi} e^{\cos\theta} \cos(\theta + \sin\theta)\, d\theta = 0$.
3) Evaluate $\int_c \frac{e^z}{z-2} dz$, $c: |z - 2| = 1$, by Cauchy's integral formula.
4) Evaluate $\int_c \frac{dz}{z^3(z+4)} dz$, $c: |z| = 2$, by Cauchy's integral formula.
5) Evaluate $\int_c \frac{e^{2z}}{(z-1)^4} dz$, $c: |z| = 2$, by Cauchy's integral formula.
6) Evaluate $\int_{|z|=1} \frac{e^z}{z} dz$ and hence deduce that
   a) $\int_0^{2\pi} e^{\cos\theta} \cos(\sin\theta)\, d\theta = 2\pi$
   b) $\int_0^{2\pi} e^{\cos\theta} \sin(\sin\theta)\, d\theta = 0$.
7) Evaluate $\int_c \frac{ze^z}{(z-1)^3} dz$, $c: |z - 1| = 2$.
8) Evaluate $\int_c \frac{sin^6 z}{\left(z-\frac{\pi}{6}\right)^3} dz$, $c: |z| = 1$.
9) Expand $f(z) = \frac{z^2-4}{z^2+5z+4}$, for the region $1 < |z| < 4$.
10) Expand $f(z) = \frac{1}{z-2}$ in Laurent's series valid for $|z| > 2$.

Practical No.-4: Calculus of Residues

1) Find the poles and residues of $f(z) = \frac{1}{z(z-1)^2}$ also find the sum of residue.
2) Find the residue of $f(z) = \frac{z^2}{(z-1)(z-2)(z-3)}$ at its poles.
3) Find the residue of $f(z) = \frac{ze^z}{(z-1)^3}$ at its poles.
4) Evaluate $\int_c \frac{5z-2}{z(z-1)} dz$, where $c: |z| = 2$, by Cauchy's residue theorem.
5) Evaluate $\int_c \frac{z^2}{(z-2)(z+3)} dz$, where $c: |z| = 4$, by Cauchy's residue theorem.
6) Evaluate $\int_c \frac{3z^2+2}{(z^2+9)(z-1)} dz$, where $c: |z - 2| = 2$, by Cauchy's residue theorem.
7) Use Contour integration to evaluate $\int_0^{2\pi} \frac{d\theta}{5+\cos\theta}$.
8) Evaluate $\int_0^{\pi} \frac{d\theta}{3+2\cos\theta}$.
9) Evaluate by Contour integration $\int_{-\infty}^{\infty} \frac{1}{x^4+13x^2+36} dx$.
10) Evaluate $\int_0^{\infty} \frac{x^2}{(x^2+1)(x^2+4)} dx$.

Practical No.-5: Theory of ordinary differential equations

1) Show that $f(x, y) = xy^2$ satisfies the Lipchitz condition on the rectangle $|x| \leq 1$, $|y| \leq 1$ but does not satisfy the Lipchitz condition $|x| \leq 1, |y| \leq \infty$.
2) Show by an example that continuous function may not satisfies the Lipchitz condition on a rectangle.
3) If S is defined on the rectangle $|x| \leq a, |y| \leq b$ show that the function $f(x, y) = x \sin y + y \cos x$ satisfies the Lipchitz condition find Lipchitz constant.
4) Show that the following function x^2, e^x, e^{-x} are linearly independent.
5) Show that x and xe^x are linearly independent.
6) Examine whether the set of function $x^2 - x + 1, x^2 - 1, 3x^2 - x - 1$ are linearly independent or not.
7) Show that $\sin 2x$ and $\cos 2x$ are solution of differential equation $y'' + 4y = 0$ and these are linearly independent.
8) Show that $y_1 = \sin x$ and $y_2 = \sin x - \cos x$ are linearly independent solution of $y'' + y = 0$.
9) Using method of variation of parameters, solve $y'' - 2y' + y = e^x$.
10) Using method of variation of parameters, solve $\frac{d^2y}{dx^2} + a^2y = \operatorname{cosec} ax$.

Practical No.-6: Simultaneous Differential Equation

1) Solve: $\frac{dx}{zy} = \frac{dy}{zx} = \frac{dz}{xy}$.
2) Solve: $\frac{dx}{\tan x} = \frac{dy}{\tan y} = \frac{dz}{\tan z}$.
3) Solve: $\frac{dx}{y^2z} = \frac{dy}{x^2} = \frac{dz}{x^2y^2z^2}$.
4) Solve: $\frac{dx}{z} = \frac{dy}{-z} = \frac{dz}{z^2+(x+y)^2}$.
5) Solve: $\frac{dx}{y} = \frac{dy}{x} = \frac{dz}{xyz^2(x^2-y^2)}$.
6) Solve: $\frac{dx}{1} = \frac{dy}{3} = \frac{dz}{3z+\tan(y-3x)}$.
7) Solve: $\frac{dx}{x(y-z)} = \frac{dy}{y(z-x)} = \frac{dz}{z(x-y)}$.
8) Solve: $\frac{yzdx}{(y-z)} = \frac{zxdy}{(z-x)} = \frac{xydz}{(x-y)}$.
9) Solve: $\frac{dx}{x(2y^4-z^4)} = \frac{dy}{y(z^4-2x^4)} = \frac{dz}{z(x^4-y^4)}$.
10) Solve: $\frac{dx}{y^2z} = \frac{dy}{zx} = \frac{dz}{y^2}$.

Practical No.-7: Total (Pfaffian) Differential Equation

1) Show that $(2x + y^2 + 2xz)dx + 2xydy + x^2dz = 0$ is integrable.
2) Show that the equation $(yz + 2x)dx + (zx - 2z)dy + (xy - 2y)dz = 0$ is exact.
3) Solve: $(x^2 - yz)dx + (y^2 - zx)dy + (z^2 - xy)dz = 0$.
4) Verify that the differential equation $(y + z)dx + (z + x)dy + (x + y)dz = 0$ is exact and find the solution.

5) Solve: $yz \log z\, dx - zx \log z\, dy + xydz = 0$.
6) Solve: $x(y^2 - a^2)dx + y(x^2 - z^2)dy - z(y^2 - a^2)dz = 0$.
7) Solve: $xdy - ydx - 2x^2zdz = 0$.
8) Solve: $yz\,(y + z)dx + zx(z + x)dy + xy(x + y)dz = 0$, by homogenous method.
9) Solve: $(yz + z^2)dx - xydy + xydz = 0$, by homogenous method.
10) Solve: $(x - y)dx - xdy + zdz = 0$, by homogenous method.

Practical No.-8(A): Difference Equations

1) Solve the difference equation $3y_{x+2} - 6y_{x+1} + 4y_x = 0$.
2) Solve the difference equation $y_{x+3} - 3y_{x+2} - 10y_{x+1} + 24y_x = 0$.
3) Solve: $y_{x+2} - 7y_{x+1} + 12y_x = 0$.
4) Solve: $y_{x+4} - 4y_{x+3} + 6y_{x+2} - 4y_{x+1} + y_x = 0$.
5) Solve: $y_{x+4} - 8y_{x+3} + 18y_{x+2} - 27y_x = 0$.
6) Solve: $9y_{x+2} - 6y_{x+1} + y_x = 0$, also find the particular solution when $y_0 = 0$ and $y_1 = 1$.
7) Solve: $y_{x+2} - 3y_{x+1} + 2y_x = 1$.
8) Solve: $y_{x+2} - 4y_{x+1} + 4y_x = 3^x + 2^x + 4$.
9) Solve: $y_{x+2} - 4y_{x+1} + 3y_x = 3^x + 1$.
10) Solve: $y_{x+2} - 4y_{x+1} + 4y_x = 3x + 2^x$.

Practical No.-8(B): Numerical Differentiation

1) Find the first, second and third derivative of $f(x)$ at $x = 1.5$ if

x	1.5	2.0	2.5	3.0	3.5	4.0
y	3.375	7.000	13.625	24.000	38.875	59.000

2) The population of a certain town is shown in the following table

Year	1951	1961	1971	1981	1991
Population (in thousands)	19.96	36.65	58.81	77.21	94.61

Find the rate of growth of the population in the year 1981.

3) Obtain the value of $f'(90)$ using stirling's formula to the following data

x	60	75	90	105	120
$y = f(x)$	28.2	38.2	43.2	40.9	37.7

4) From the following table of values of x & y. Obtain $\frac{dy}{dx}$ and $\frac{d^2y}{dx^2}$ at $x = 1.2$

x	1.0	1.2	1.4	1.6	1.8	2.0	2.2
y	2.7183	3.3201	4.0552	4.9530	6.0496	7.3891	9.0250

5) From the following table, Correct to two decimal places for which y is maximum and find this value of y.

x	1.2	1.3	1.4	1.5	1.6
y	0.9320	0.9636	0.9855	0.9975	0.9996

6) Find the first and second derivative of the function tabulated below at the point $x = 1.9$

x	1.0	1.2	1.4	1.6	1.8	2.0
$y = f(x)$	0	0.128	0.544	1.296	2.432	4.00

7) From the values in the table given below, find the value of $\sec 31°$ using numerical differentiation

$\theta°$	31	32	33	34
$\tan\theta$	0.6008	0.6249	0.6494	0.6745

8) Use Stirling formula to compute $f'(0.5)$ from the following data

x	0.35	0.40	0.45	0.50	0.55	0.60	0.65
$f(x)$	1.521	1.506	1.488	1.467	1.444	1.418	1.389

9) Find $\frac{dy}{dx}$ at $x = 0.1$ from the following table

x	0.0	0.1	0.2	0.3	0.4
y	1.000	0.9975	0.9900	0.9776	0.9604

10) From the following values of x and y, find $\frac{dy}{dx}$ when $x = 6$

x	4.5	5.0	5.5	6.0	6.5	7.0	7.5
y	9.69	12.90	16.71	21.18	26.37	32.34	39.15

S.Y. B.Sc. (Mathematics): Semester-III

MTH-240: Graph theory

Total Hours: 30 **Credits: 2**

Course objectives:

- To acquire concepts of graphs, connected graphs.
- To know scope and importance of trees and directed graphs
- To know applications of the graphs.

Course outcomes:

Student will be able to

- Understand the uses of the graph theory, designing issues in different problems like Konigsberg Seven Bridge Problem, Travelling salesman Problem.
- Understand the issues associated with different types of graphs viz connected graphs, disconnected graphs.
- Find the minimal Spanning trees.
- Form flowchart using rooted trees.

Unit I: Graphs **10h**

- Graph, Simple graph, Multigraph, Hand shaking lemma, Types of graphs, Operations on graphs, Subgraphs, Isomorphism of graphs, Walk, Path, Cycles (circuits).

Unit II: Connected Graphs **10h**

- Connected and disconnected graphs, Bridges, Cut vertices, Edge connectivity and vertex connectivity, Eulerian graph, Hamiltonian graph, Planer graph, Euler's formula for planer graphs, Kuratowski's second graph, Geometrical dual.

Unit III: Trees and Directed Graphs **10h**

Definition and some properties of trees, Distance and centre in a tree, Definitions of rooted and binary trees, Spanning trees, Minimal spanning trees, Directed graphs, Eulerian digraphs.

Unit IV: Applications of the Graphs **10h**

- Existence of graphs for given number of vertices and edges, Coloring of the graphs, Konigsberg seven bridge problem, Travelling salesman problem, Dijkstra's algorithm, Warshall's algorithm, Formation of flowchart using rooted trees.

References

1. Deo Narsingh (1979), Graph Theory with Applications to Engineering and Computer science, Prentice Hall of India Pvt. Ltd.
2. Lipschitz Seymour and Lipson Marc Lars (2007), Theory and Problems of Discrete Mathematics, Schaum's outline series, McGraw-Hill Ltd., New York.
3. Liu C. L. (1986), Elements of Discrete Mathematics, Mc Graw Hill, International Edition, Computer science series; Second Edition.
4. Harary F. (1969), Graph Theory, Addison-Wesley Publishing Company.
5. Bhave N. S. and T. T. Raghunathan (1990), Elements of Graph Theory, Goal Publications.