# KAVAYITRI BAHINABAI CHAUDHARI NORTH MAHARASHTRA UNIVERSITY, JALGAON

**SYLLABUS FOR**

**T.Y. B. Sc. (MATHEMATICS)**

**UNDER CHOICE BASED CREDIT SYSTEM (CBCS)**

**Effective from June 2020-2021**

**KAVAYITRI BAHINABAI CHAUDHARI**
**NORTH MAHARASHTRA UNIVERSITY, JALGAON**

# Syllabus for T. Y. B. Sc. (Mathematics)
## Under Choice Based Credit System (CBCS)
## Effective from June 2020

**Course Structure:** Six semester course with continuous evaluation of external and internal examinations in 60:40 pattern.

| Discipline | Course Type | Course code | credits | Hours per week | Total Teaching Hours |
|---|---|---|---|---|---|
| **Semester-V** | | | | | |
| DSC | Core I | MTH – 501 | 3 | 3 | 45 |
| | Core II | MTH – 502 | 3 | 3 | 45 |
| | Core III | MTH – 503 | 3 | 3 | 45 |
| | Core IV | MTH – 504 | 3 | 3 | 45 |
| DSC Skill Enhancement course (SEC) | Skill based | MTH – 505 | 3 | 3 | 45 |
| DSC Elective course | Elective course (Any one) | MTH – 506(A) | 3 | 3 | 45 |
| | | MTH – 506(B) | 3 | 3 | 45 |
| DSC | DSC Practical | MTH – 507 | 2 | 4 (Per batch) | 60 |
| | | MTH – 508 | 2 | 4 (Per batch) | 60 |
| | | MTH – 509 | 2 | 4 (Per batch) | 60 |
| Non-Credit Course | Elective Audit Course (Any one) | AC-601(A) | Non-credit | 2 | 30 |
| | | AC-601(B) | Non-credit | 2 | 30 |
| | | AC-601(C) | Non-credit | 2 | 30 |
| **Semester-VI** | | | | | |
| DSC | Core I | MTH – 601 | 3 | 3 | 45 |
| | Core II | MTH – 602 | 3 | 3 | 45 |
| | Core III | MTH – 603 | 3 | 3 | 45 |
| | Core IV | MTH – 604 | 3 | 3 | 45 |
| DSC Skill Enhancement course (SEC) | Skill based | MTH – 605 | 3 | 3 | 45 |
| DSC Elective course | Elective course(Any one) | MTH – 606(A) | 3 | 3 | 45 |
| | | MTH – 606(B) | 3 | 3 | 45 |
| DSC | DSC Practical | MTH – 607 | 2 | 4 (Per batch) | 60 |
| | | MTH – 608 | 2 | 4 (Per batch) | 60 |
| | | MTH – 609 | 2 | 4 (Per batch) | 60 |

**Medium of instruction**: The medium of instruction for the courses shall be English.

**Credit to contact hour:** 1 credit = 15 teaching hour

**Attendance:** At least 75% per semester

**Examination pattern**

- Each theory and practical course will be of 100 marks comprising of 40 marks internal and 60 marks external examinations.
- Theory examination (60 marks) will be of two hours duration for each theory course. There shall be 5 questions each carrying equal marks (12 marks each). The pattern of question papers shall be:

| Question Pattern | Q.1 | Q.2 | Q.3 | Q.4 | Q.5 | Total Questions |
|---|---|---|---|---|---|---|
| Question Type | Any 6 out of 9 | Any 4 out of 6 | Any 3 out of 4 | Any 2 out of 3 | Any 1 out of 2 | 16 out of 24 |
| Marks | 2 marks each | 3 marks each | 4 marks each | 6 marks each | 12 marks | -- |
| Maximum Total Marks | 18 | 18 | 16 | 18 | 24 | 94 marks |

## Semester-V

<table>
<tr><td colspan="3" align="center">DSC Core Course</td></tr>
<tr><td colspan="3" align="center">MTH - 501: Metric Spaces.</td></tr>
<tr><td>Total Hours: 45</td><td></td><td>Credits: 3</td></tr>
<tr><td></td><td colspan="2">Course objectives<br>1. Introduction of metric as a generalization of distance function and basic concepts in metric spaces.<br>2. To explain the concept of sequence and complete metric space with their properties.<br>3. To discuss compactness, and sequential compact spaces and their properties along with continuity.</td></tr>
<tr><td></td><td colspan="2">Learning outcomes<br>After studying this course, student should be able to:<br>1. Understand the Euclidean distance function on $\mathbb{R}^n$ and appreciate its properties, and state and use the Triangle and Reverse Triangle Inequalities for the Euclidean distance function on $\mathbb{R}^n$<br>2. Explain the definition of continuity for functions from $\mathbb{R}^n$ to $\mathbb{R}^m$ and determine whether a given function from $\mathbb{R}^n$ to $\mathbb{R}^m$ is continuous<br>3. Explain the geometric meaning of each of the metric space properties (M1) – (M3) and be able to verify whether a given distance function is a metric<br>4. Distinguish between open and closed balls in a metric space and be able to determine them for given metric spaces<br>5. Define convergence for sequences in a metric space and determine whether a given sequence in a metric space converges<br>6. State the definition of continuity of a function between two metric spaces.</td></tr>
<tr><td align="center">Unit</td><td align="center">Topics</td><td align="center">Lectures</td></tr>
<tr><td align="center">UNIT-1</td><td>Metric Spaces.<br>1.1 Equivalence and Countability<br>1.2 Metric Spaces<br>1.3 Limits in Metric Spaces</td><td align="center">09</td></tr>
<tr><td align="center">UNIT-2</td><td>Continuous functions on Metric Spaces.<br>2.1 Reformulation of definition of continuity in Metric Spaces.<br>2.2 Continuous function on Metric Spaces.<br>2.3 Open Sets<br>2.4 Closed Sets<br>2.4 Homeomorphisms.</td><td align="center">09</td></tr>
<tr><td align="center">UNIT-3</td><td>Connected Metric Spaces<br>3.1 More about Sets<br>3.2 Connected Set<br>3.3 Bounded and Totally bounded sets</td><td align="center">09</td></tr>
<tr><td align="center">UNIT-4</td><td>Complete of Metric Spaces<br>4.1 Complete Metric Spaces<br>4.2 Properties of Complete Metric Spaces<br>4.3 Contraction Mapping on Metric Spaces.</td><td align="center">09</td></tr>
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|---|---|---|
| UNIT-5 | **Compactness of Metric Spaces**<br>4.1 Compact Metric Spaces.<br>4.2 Continuous function on compact Metric Spaces .<br>4.3 Continuity of inverse function<br>4.4 Uniform Continuity | 09 |
| **Recommended Book (s):** | | |
| 1 | R.R. Goldberg, Methods of Real Analysis, Oxford & IBH Publishing Co. PVT. LTD, 2nd Edition, 1976<br>Chapter I : 1.5 ,1.6 , Chapter IV : 4.2, 4.3, Chapter V : 5.2,5.3, 5.4, 5.5<br>Chapter VI : 6.1,6.2,6.3.6.4,6.5,6.6,6.7,6.8 | |
| **Reference Book (s):** | | |
| 1 | S. C. Malik and Savita Arora, Mathematical Analysis, Second Edition, New Age International Pvt. Ltd., New Delhi , 2010. | |
| 2 | A First Course in Mathematical Analysis by D. Somsundaram and B. Chaudhari, Narosa Publishing House, New Delhi. 2018 | |

| DSC Core Course | | |
|---|---|---|
| **MTH - 502: Real Analysis –I** | | |
| **Total Hours: 45** | | **Credits: 3** |
| | **Course objectives**<br>1. To study the Riemann Integration.<br>2. To study the Mean value theorems of integral calculus<br>3. To study Improper integrals with finite limit and infinite limit<br>4. To study the concept of Riemann integration and its properties.<br>5. To study Beta and Gamma Integrals | |
| | **Learning outcomes**<br>After successful completion of this course, students are expected to:<br>1. Understand the structure of Riemann Integration<br>2. Represent lattice in diagrammatic form.<br>3. Understand the Improper integrals with finite limit and infinite limit their properties.<br>4. Learn the concepts of Beta and Gamma Integrals. | |
| **Unit** | **Topics** | **Lectures** |
| **UNIT-1** | **Riemann Integration**<br>1.1 Definition and Existence of the Integral, The meaning of $\int_a^b f dx$ when $a \le b$, Inequalities for integrals<br>1.2 Refinement of partitions<br>1.3 Darboux's Theorem ( without proof )<br>1.4 Conditions of integrability<br>1.5 Integrability of the sum and difference of integrable functions.<br>1.6 The integral as a limit of sum ( Riemann Sums ) and the limit of sum as the integral and its applications<br>1.7 Some Integrable functions. | **09** |
| **UNIT-2** | **Mean value theorems of integral calculus**<br>2.1 The First mean value theorem<br>2.2 The generalized First mean value theorem<br>2.3 Abel's lemma (without proof)<br>2.4 Second mean value theorem. Bonnets form and Karl Weierstrass form | **09** |
| **UNIT-3** | **Improper integrals with finite limit**<br>3.1 Integration of unbounded functions with finite limits of Integral<br>3.2 Comparison Test for convergence at $a$ of $\int_a^b f dx$<br>3.3 Convergence of the improper integrals $\int_a^b \frac{dx}{(x-a)^n}$<br>3.4 Cauchy's general test for convergence at the point $a$ of $\int_a^b f dx$<br>3.5 Absolute convergence of the improper integrals | **09** |

| | | |
|---|---|---|
| | $\int_a^b f dx$ | |
| **UNIT-4** | **Improper integrals with infinite limit**<br>4.1 Convergence of the integral with infinite range of Integration<br>4.2 Comparison Test for convergence at $\infty$<br>4.3 Convergence at $a$ of $\int_a^\infty \frac{dx}{x^n}$, $( a > 0 )$<br>4.4 Cauchy's General Test for convergence at $\infty$<br>4.5 Absolute convergence of $\int_a^\infty f dx$<br>4.6 Test for absolute convergence of $\int_a^\infty f dx$<br>4.7 Abel's Test and Dirichlet's Test for convergence of $\int_a^\infty f dx$ | **09** |
| **UNIT-5** | **Beta and Gamma Integrals**<br>5.1 Convergence of Beta and Gamma Integrals<br>5.2 Properties of Beta and Gamma Functions<br>5.3 Relation between Beta and Gamma Functions<br>5.5 Duplication Formula<br>5.6 Evaluation of integrals using Beta and Gamma Integrals | **09** |
| **Recommended Book (s):** | | |
| **1** | S. C. Malik and Savita Arora, Mathematical Analysis, second Edition New Age International Pvt. Ltd., New Delhi, 2000.<br>Chapter 9: 1 to 13, Chapter 11: 1 to 5. | |
| | | |
| **Reference Book (s):** | | |
| **1** | R.R. Goldberg, Methods of Real Analysis, Oxford & IBH Publishing Co. PVT. LTD, 2nd Edition, 1976. | |

| DSC Core Course | | |
|---|---|---|
| **MTH - 503: Algebra** | | |
| **Total Hours: 45** | | **Credits: 3** |
| | **Course objectives**<br>1) To gain the basic concepts of groups like subgroups, normal, isomorphism of groups.<br>2) To understand basic concepts of rings like ideals, isomorphism of rings and polynomial rings. | |
| | Learning outcomes<br>After successful completion of this course, students are expected to:<br>1) know the use Permutation Groups<br>2) know normal Subgroups and group isomorphisms<br>3) Know Ideals in rings, Quotient Rings and Isomorphism of Rings<br>4) Know polynomial Rings and irreducibility of polynomials | |
| **Unit** | **Topics** | **Lectures** |
| **UNIT-1** | **Permutation Groups**<br>1.1 Definitions: Permutation, Cycle, Transposition<br>1.2 Permutations as a product of disjoint cycles and transpositions<br>1.3 Even and odd permutations<br>1.4 Permutation Groups, Alternating Groups | **09** |
| **UNIT-2** | **Normal Subgroups**<br>2.1 Normal Subgroup<br>2.2 Criterions for a subgroup to be a normal subgroup<br>2.3 Union and Intersection of normal subgroups<br>2.4 Quotient Group<br>2.5 Simple Group<br>2.6 Cyclic group<br>2.7 Commutator subgroup<br>2.8 Group homomorphism | **09** |
| **UNIT-3** | **Isomorphism Theorems for Groups**<br>3.1 Revision of Homomorphism and Isomorphism of Groups.<br>3.2 Isomorphism theorems for groups and examples<br>3.3 Cayley's theorem, Theorem: $o(A_n) = \frac{o(S_n)}{2}$<br>3.4 Automorphism and inner Automorphism | **09** |
| **UNIT-4** | **Ideals, Quotient Rings and Isomorphism of Rings**<br>4.1 Revision of Ring, integral domain, field and basic properties<br>4.2 Characteristics of a ring<br>4.3 Subrings, ideals, left ideals, right ideals, principal ideals, prime and maximal ideals.<br>4.4 Quotient rings<br>4.5 Quotient Field (Definition & Examples only)<br>4.6 Homomorphism and isomorphism of rings | **09** |

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|---|---|---|
| UNIT-5 | **Polynomial Rings**<br>5.1 Definition and Properties of polynomial rings<br>5.2 Roots of Polynomials<br>5.3 Factorization of Polynomials<br>5.4 Division Algorithm for Polynomials<br>5.5 Eisenstein's Criterion<br>5.6 Other irreducibility criterion | 09 |
| **Recommended Book(s):** | | |
| 1 | N.S. Gopalakrishnan, University Algebra, 2nd Revised Edition, New Age International Publishers, 2003.<br>Chapter-1 : Art.-1.7, 1.8, 1.9, 1.11;<br>Chapter-2 : Art.- 2.2, 2.3,2.4,2.5, 2.6, 2.7,2.8,2.9,2.14,2.15 | |
| 2 | J.B. Fraleigh, A First Course in Abstract Algebra , 3rd Edition, Narosa Publishing House, Tenth Reprint 2003.<br>Chapter-30: Art.-30.1, 30.2, 30.3; Chapter-31: Art.-31.1, 31.2. | |
| **Reference Book(s):** | | |
| 1 | I.N. Herstein, *Topics in Algebra* ,2nd Edition, Vikas Publishing House Pvt. Ltd. New Delhi. 2018. | |
| 2 | V. K. Khanna and S. K. Bhambri, *A course in Abstract Algebra* (3rd Edition), Vikas Publishing House Pvt. Ltd. New Delhi, 2008. | |
| 3 | P.B. Bhattacharya, S. K. Jain and S. R. Nagpaul, *Basic Abstract Algebra* (2nd Edition), Cambridge University Press, 2003. | |

| DSC Core Course | | |
|---|---|---|
| **MTH - 504: Lattice Theory** | | |
| **Total Hours: 45** | | **Credits: 3** |
| | **Course objectives**<br>1) To study the structure of poset and lattice.<br>2) To study the diagrammatic representation of lattice.<br>3) To study the terms Maximal element, Minimal element, Greatest element, Least elements.<br>4) To study the concept of ideals and its properties.<br>5) To study homomorphism of lattices.<br>6) To study modular and distributive lattice and their inter-relation.<br>7) To study complemented and relatively complemented lattice. | |
| | **Learning outcomes**<br>After completing this syllabus students will able to<br>1) Understand the structure of poset and lattice.<br>2) Represent lattice in diagrammatic form.<br>3) Understand the terms Maximal element, Minimal element, Greatest element, Least elements.<br>4) Learn the concepts of ideals and their properties.<br>5) Learn the concepts of homomorphism.<br>6) Understand modular and distributive lattice and their inter-relation.<br>7) Understand complemented and relatively complemented lattice | |
| **Unit** | **Topics** | **Lectures** |
| **UNIT-1** | **Posets**<br>1.1. Posets and Chains<br>1.2. Diagrammatical Representation of posets<br>1.3. Maximal and Minimal elements of subset of a poset, Zorn's Lemma ( Statement only)<br>1.4. Supremum and infimum<br>1.5. Poset isomorphism<br>1.6. Duality Principle. | **09** |
| **UNIT-2** | **Lattices**<br>2.1. Two definitions of lattice and equivalence of two definitions<br>2.2. Modular and Distributive inequalities in a lattice.<br>2.3. Sublattice and Semilattice<br>2.4. Complete lattice | **09** |
| **UNIT-3** | **Ideals**<br>3.1. Ideals ,Union and intersection of Ideals<br>3.2. Prime Ideals<br>3.3. Principal Ideals<br>3.4. Dual Ideals<br>3.5. Principal dual Ideals<br>3.6. Complements , Relative Complements | **09** |

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| **UNIT-4** | **Homomorphisms and Modular Lattices**<br>4.1. Homomorphisms, Join and meet homomorphism<br>4.2. Definition of Kernel<br>4.3. Properties of Kernels<br>4.4. Modular lattice<br>4.5. Sublattice of Modular lattice<br>4.6. Homomorphic image of Modular lattice | **09** |
| **UNIT-5** | **Distributive lattices and Boolean Lattice**<br>5.1. Distributive lattice<br>5.2. Relation between Modular and Distributive Lattices<br>5.3. Sublattice of distributive lattice<br>5.4. Homomorphic image of distributive lattice<br>5.5. Complemented and Relatively complemented lattice<br>5.6. Definition Boolean Lattice<br>5.7. Properties of Boolean lattice | **09** |
| **Recommended Book(s):** | | |
| 1 | Vijay K. Khanna, Lattices and Boolean Algebra, Vikas Publ. Pvt. Ltd , 2nd edition 2004,<br>Chapter -2,3,4, | |
| Reference Book(s): | | |
| 1 | George Gratzer, General Lattice Theory, Birkhauser, 2nd Editon, 2013. | |

<table>
<tr><th colspan="3">DSC Skill Enhancement Course (SEC) SEC-III: Skill Based<br>DSC Elective Course</th></tr>
<tr><th colspan="3">MTH - 505: Integral Transforms</th></tr>
<tr><td>Total Hours: 45</td><td></td><td>Credits: 3</td></tr>
<tr><td></td><td colspan="2">Course objective<br>The goals for the course are<br>1. To gain a facility with using the transform, both specific techniques and general principles, and learning to recognize when, why, and how it is used.<br>2. Together with a great variety, the subject also has a great coherence, and the hope is students come to appreciate both.</td></tr>
<tr><td></td><td colspan="2">Learning outcomes<br>After successful completion of this course, students are expected to:<br>1. Know the use of Fourier transform in Wave equation,<br>2. Solve Boundary Value Problems, also problem on Heat-flow in semi-infinite bar.<br>3. Use Fourier transform in communication theory and signal analysis, image processing and filters, data processing and analysis, solving partial differential equations for problems on gravity.<br>4. Students will be able to use Z-transform in the characterization of Linear Time-Invariant system ( LTI ), in development of scientific simulation algorithms</td></tr>
<tr><th>Unit</th><th>Topics</th><th>Lectures</th></tr>
<tr><td>UNIT-1</td><td>Fourier Transforms :<br>1.1 Complex and exponential form of Fourier series<br>1.2 Fourier Integrals<br>1.3 Equivalent form of Fourier integral<br>1.4 Sine and cosine integrals<br>1.5 Fourier transforms<br>1.6 Fourier cosine transforms<br>1.7 Fourier sine transforms</td><td>09</td></tr>
<tr><td>UNIT-2</td><td>Inverse Fourier Transforms<br>2.1 Useful result for evaluating the integral in Fourier transforms<br>2.2 Inverse Fourier transforms<br>2.3 Inverse sine transforms<br>2.4 Inverse cosine transforms</td><td>09</td></tr>
<tr><td>UNIT-3</td><td>Theorems of Fourier Transforms<br>3.1 Modulation theorem<br>3.2 Convolution theorem<br>3.3 Finite Fourier transforms<br>3.4 Finite Fourier cosine transforms<br>3.5 Finite Fourier sine transforms<br>3.6 Fourier transform of the derivatives of a function.<br>3.7 Application of Fourier transform to boundary value problem.</td><td>09</td></tr>
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| **UNIT-4** | **Z – Transforms**<br>4.1 Basic preliminary Z-transforms<br>4.2 Inverse Z-transform<br>4.3 Z-transform pair<br>4.4 Uniqueness of inverse Z-transform<br>4.5 Properties of Z-transforms | **09** |
| **UNIT-5** | **Inverse Z-transforms**<br>5.1 Power series method<br>5.2 Partial fraction method<br>5.3 Inverse integral method.<br>5.4 Solution of difference equations with constant coefficients using Z-transform | **09** |
| **Recommended Book(s):** | | |
| **1** | Lokenath Debnath, Dambaru Bhatta, Integral Transforms and Their Applications, Third Edition, CRC Press, 2014.<br>Chapter 2 : 2.1 to 2.19<br>Chapter 12 : 12.1 to 12.8 | |
| **Reference Book(s):** | | |
| **1** | Davies, Brian, Integral Transforms and Their Applications, 3rd edition, Springer Verlag, New York, 2002.<br>Chapter 7 : 7.1 to 7.4. | |

<table>
<tr><th colspan="3">DSC Elective Course (Any one)</th></tr>
<tr><th colspan="3">MTH – 506(A): C Programming</th></tr>
<tr><td>Total Hours: 45</td><td></td><td>Credits: 3</td></tr>
<tr><td></td><td colspan="2">Course objectives<br>The course is oriented to those who want to advance structured and procedural programming understating and to improve C programming skills. The major objective is to provide students with understanding of code organization and functional hierarchical decomposition with using complex data types.</td></tr>
<tr><td></td><td colspan="2">Learning outcomes<br>After successful completion of this course, students are expected to:<br>• Understanding a functional hierarchical code organization.<br>• Ability to define and manage data structures based on problem subject domain.<br>• Ability to work with textual information, characters.<br>• Ability to work with arrays of complex objects.<br>• Understanding a concept of object thinking within the framework of functional model.<br>• Understanding a defensive programming concept. Ability to handle possible errors during program execution.</td></tr>
<tr><th>Unit</th><th>Topics</th><th>Lectures</th></tr>
<tr><td>UNIT-1</td><td>Basic concepts<br>1.1 Introduction<br>1.2 Character set<br>1.3 C tokens, keywords<br>1.4 Constants<br>1.5 Variables, data types<br>1.6 Variables, symbolic constants<br>1.7 Over flow, under flow<br>1.8 Operators of arithmetic, relational, logical, assignment, increment and decrement, conditional and special type.</td><td>09</td></tr>
<tr><td>UNIT-2</td><td>Expressions and conditional statements<br>2.1 Arithmetic expression and its evaluation precedence of arithmetic operators type<br>2.2 Conversion, operator precedence, mathematical functions<br>2.3 Reading and writing a character<br>2.4 Formatted input and out put<br>2.5 Decision making, if, is-else, else-if, switch and go to statements.</td><td>09</td></tr>
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| **UNIT-3** | **Loops: Decision making and Looping:**<br>3.1 Sentinel loops. While loop, do-while loop and for statements.<br>3.2 Jump in loops, continue, break and exit statements. | **09** |
| **UNIT-4** | **Arrays**<br>4.1 One dimensional array<br>4.2 Two dimensional and multidimensional arrays.<br>4.3 Declaration and initialization of arrays. | **09** |
| **UNIT-5** | **Functions**<br>5.1 Need for user defined functions, multi-function program<br>5.2 Elements of function, definition of functions, return values and their types<br>5.3 Function calls, function declaration, category of functions.<br>5.4 Functions that return multiple values. Recursion. | **09** |
| **Recommended Book (s):** | | |
| **1** | Programming in ANSI C , E. Balagurusamy, Mcgraw-Hill company, New York, 2012.<br>Chapter 1 to chapter 9 all points. | |
| **Reference Book (s):** | | |
| **1** | LET Us C, Yashwant Kanitkar, B.P.B. Publication, 14TH Edition, 2016<br>Chapter 1 to 8, Chapter 13 and 14. | |

<table>
<tr><td colspan="3" align="center">MTH – 506(B): Number Theory</td></tr>
<tr><td>Total Hours: 45</td><td></td><td>Credits: 3</td></tr>
<tr><td></td><td colspan="2">Course objectives:<br>To study prime numbers and Diophantine equations, Theory of congruence’s, Perfect numbers, Fibonacci sequence and finite continued fractions.</td></tr>
<tr><td></td><td colspan="2">Learning outcomes<br>After successful completion of this course, students are expected to:<br>1) solve Diophantine equations<br>2) use Fermat’s theorem, Euler’s theorem and Wilson’s theorem for finding remainders<br>3) understand perfect, Mersenne and Fermat’s numbers.<br>4) understand Fibonacci sequence<br>5) solve Diophantine equations by using finite continued fractions.</td></tr>
<tr><td align="center">Unit</td><td align="center">Topics</td><td align="center">Lectures</td></tr>
<tr><td align="center">UNIT-1</td><td>Prime numbers and Diophantine Equations<br>1.1 The Fundamental Theorem of Arithmetic<br>1.1 The Sieve of Eratosthenes<br>1.3 The Goldbach Conjecture<br>1.4 The Diophantine Equation $ax + by = c$</td><td align="center">09</td></tr>
<tr><td align="center">UNIT-2</td><td>The theory of congruence<br>2.1 Basic Properties of Congruence<br>2.2 Binary and decimal representations of integers.<br>2.3 Linear Congruences and the Chinese Remainder Theorem.</td><td align="center">09</td></tr>
<tr><td align="center">UNIT-3</td><td>Fermats Theorem<br>3.1 Fermat’s Factorization Method<br>3.2 The Little Theorem and pseudoprimes<br>3.3 Wilson’s Theorem</td><td align="center">09</td></tr>
<tr><td align="center">UNIT-4</td><td>Perfect Numbers<br>4.1 Perfect Numbers<br>4.2 Mersenne Numbers<br>4.3 Farmat’s Numbers</td><td align="center">09</td></tr>
<tr><td align="center">UNIT-5</td><td>Fibonacci sequence and finite continued fractions<br>5.1 The Fibonacci sequence<br>5.2 Certain Identities Involving Fibonacci Numbers.<br>5.3 Finite continued fractions</td><td align="center">09</td></tr>
<tr><td colspan="3">Recommended Book (s):</td></tr>
<tr><td align="center">1.</td><td colspan="2">Elementary Number Theory , David M. Burton, Sixth Edition, Tata McGraw-Hill Edition, New Delhi, 1998.<br>Ch.3 : 3.1 to 3.3, Ch . 2 : 2.5, Ch.4 : 4.2 to 4.4, Ch.5 : 5.2 to 5.4, Ch.11 : 11.2 to 11.4, Ch 14 : 14.2 to 14.3, Ch 15: 15.2</td></tr>
<tr><td colspan="3">Reference Book (s):</td></tr>
<tr><td align="center">1.</td><td colspan="2">Introduction to Analytic Number Theory ,T. M. Apostol, Springer International student Edition, 1972.</td></tr>
<tr><td align="center">2.</td><td colspan="2">Number Theory, Hari Kishan, Krishna Prakashan Media (p) Ltd, Meerat,, 2014.</td></tr>
</table>

| DSC Core (Practical) | | |
|---|---|---|
| MTH – 507: Practical Course based on (MTH-501& MTH-502) | | |
| Total Hours: 60 | | Credits: 2 |
| | **Course objectives**<br>• To develop analytical and computational skills<br>• To get hands on training for solving problems of Metric spaces and Riemann integrals. | |
| | **Learning outcomes**<br>After successful completion of this course, students are expected to:<br>• Students will develop problem solving problems on metric spaces and Riemann integrations. | |
| Unit | Topics | Lectures |
| UNIT-1 | Examples on unit -1 of (MTH-501 & MTH-502) | 12 |
| UNIT-2 | Examples on unit -2 of (MTH-501 & MTH-502) | 12 |
| UNIT-3 | Examples on unit -3 of (MTH-501 & MTH-502) | 12 |
| UNIT-4 | Examples on unit -4 of (MTH-501 & MTH-502) | 12 |
| UNIT-5 | Examples on unit -5 of (MTH-501 & MTH-502) | 12 |

## List of Practical's:

| MTH-507 | Practical Course based on MTH-501 & MTH-502 |
|---|---|

**MTH-501 : Metric Spaces**

**Practical No. 1 - Metric spaces**

1. If $A_1$ , $A_2$ , $\cdots$ , $A_n$ are countable sets, then show that $\bigcup_{n=1}^{\infty} A_n$ is countable.
2. Show that the intervals $(0,1)$ and $[0,1]$ are equivalent.
3. Show that the intervals $\left[-\frac{\pi}{2}\ ,\ \frac{\pi}{2}\right]$ and $(-\infty\ ,\ \infty)$ are equivalent.
4. Let $x = (x_1, x_2)$, $y = (y_1, y_2)$ be any two points in $\mathbb{R}^2$. Define $\rho : \mathbb{R}^2 \times \mathbb{R}^2 \to \mathbb{R}$ by $\rho(x,y) = \max\{|x_1 - y_1|, |x_2 - y_2|\}$. Show that $\rho$ is a metric on $\mathbb{R}^2$.
5. Let $d : \mathbb{R} \times \mathbb{R} \to \mathbb{R}$ be defined by $d(x, y) = \frac{|x-y|}{1+|x-y|}$ $\forall\, x, y \in \mathbb{R}$. Show that $d$ is a metric on $\mathbb{R}$.

**Practical No. 2 –Continuous Functions on Metric Spaces**

1. Which of the following subsets of $\mathbb{R}^2$ are open? Justify.
   a) $A = \{(x,y) \in \mathbb{R}^2 \mid x \text{ and } y \text{ are rationals}\}$
   b) $B = \{(x,y) \in \mathbb{R}^2 \mid x \text{ and } y \text{ are both irrationals}\}$
2. If $A$ and $B$ are open subsets of $\mathbb{R}$ then show that $A \times B$ is an open subset of $\mathbb{R}^2$.
3. Let $f$ and $g$ be two real valued continuous functions on metric space $M$ and $B = \{x \in M : f(x) \geq g(x)\}$. Prove that $B$ is closed.
4. Give an example of a sequence $A_1, A_2, A_3 \cdots$ of non empty closed subsets of $\mathbb{R}$ such that both of the following conditions hold :
   a) $A_1 \supset A_2 \supset A_3 \supset \cdots$
   b) $\bigcap_{n=1}^{\infty} A_n = \phi$
5. Show that $\mathbb{R}$ and $\mathbb{R}_d$ are not homeomorphic to each other.

**Practical No. 3 – Connected Metric Spaces**

1. If $A$ is a connected subset of a metric space $M$ and if $A \subset B \subset \bar{A}$ then prove that $B$ is connected.
2. Show that $(0, 1)$ is not complete but connected subset of the usual metric space $\mathbb{R}$ .
3. Let $A = [\,0, 1]$ be a metric space with absolute value metric $d$. Which of the following subsets of $A$ are open subsets of $A$ ?
   i) $(\,½, 1\,]$  ii) $(\,½, 1\,)$
4. Prove that the interval $[0, 1]$ is not connected subset of $\mathbb{R}_d$.
5. Let $A$ be a subset of $l^2$ space consisting of the points $e_1 = (1\,,0\,,0\,,\cdots), e_2 = (0\,,1\,,0\,,\cdots), e_3 = (0\,,0\,,1\,,\cdots)$ , then show that $A$ is a bounded subset of $l^2$ but it is not totally bounded.

**Practical No. 4 – Complete Metric Spaces**

1. Let $(M\,,\rho)$ be a metric space If $T: M \to M$ is a contraction on $M$ then prove that $T$ is continuous on $M$.
2. Prove that any discrete metric space is complete .
3. If $T: X \to X$ is define as $Tx = x^2$, where $x = \left[0, \frac{1}{3}\right]$, Then $T$ is a contraction on $\left[0, \frac{1}{3}\right]$.
4. If $T: [0,1] \to [01]$ and there is a real number $\alpha$ with $0 < \alpha < 1$ such that $|f'(x)| < \alpha$, where $f'$ is the derivative of $f$ , then $f$ is contraction on $[0,1]$
5. Show that any set with discrete metric space forms a complete metric space.

**Practical No. 5 – Compact Metric Spaces**

1. Let $f : \mathbb{R} \to \mathbb{R}$ be defined by $f(x) = sinx$, for all $x \in \mathbb{R}$ $f(x)$. Examine whether $f(x)$ is uniformly continuous or not.
2. Show that $f(x) = x^2$ , for all $x \in [0\,,1]$ is uniformly continuous on $[0,1]$ using definition of uniformly continuous function.
3. Show that every finite subset $E$ of any metric space $(M\,,\rho)$ is compact.
4. Give example of
   a) Complete, compact and connected metric space.
   b) Complete, compact but not connected metric space.
5. Let $f$ be a continuous function from the compact metric space $M_1$ into the metric space $M_2$. Then prove that range $f(M_1)$ of $f$ is bounded subset of $M_2$.

**MTH-502: Real Analysis**

**Practical No. 06 -**

1. Let $f(x) = x^2$ defined on $[0, k]$. Find $a)\ U(p, f)$, b) $L(p, f)$ and show that $f \in [0, k]$ and $\int_0^k f(x)dx = \frac{k^3}{3}$
2. Find the upper and lower integral for the function defined on $[0, 1]$ as
   $$f(x) = \begin{cases} \sqrt{1 - x^2} & , when\ x\ is\ rational \\ 1 - x & , when\ x\ is\ irrational \end{cases}$$
3. The function $f(x)$ defined on $\left[0, \frac{\pi}{4}\right]$ as $f(x) = \begin{cases} cosx, & when\ x\ is\ rational \\ sinx\ , & when\ x\ is\ irrational \end{cases}$
   Show that $f(x) \notin R\left[0, \frac{\pi}{4}\right]$
4. Show that the function defined as $f(x) = \frac{1}{2^n}$ , where $\frac{1}{2^{n+1}} < x \leq \frac{1}{2^n}$ , $n = 0, 1, 2, \cdots$ $f(x) = 0$ is integrable on $[0, 1]$ and evaluate $\int_0^1 f(x)dx$
5. A function defined on $[0, 1]$ as $f(x) = \frac{1}{a^{r-1}}\ , if\ \frac{1}{a^r} < x \leq \frac{1}{a^{r-1}}$, where a is an integer greater than 2, and $r = 1, 2, 3, \cdots$ Show that
   $a)\ \int_0^1 f(x)dx\ exists\ ,$  $b)\ \int_0^1 f(x)dx = \frac{a}{a+1}$

**Practical No. 07 : Mean Value Theorem**

1. Using Mean Value Theorem. Prove that $\frac{\pi^3}{24} \leq \int_0^{\pi} \frac{x^2}{5+3cosx} dx \leq \frac{\pi^3}{3}$
2. Show that $\frac{1}{2} \leq \int_0^1 \frac{dx}{\sqrt{4-x^2+x^3}} \leq \frac{\pi}{6}$
3. If $a > 0$, show that $ae^{-a^2} < \int_0^{-a^2} e^{-x^2} dx < tan^{-1}a$
4. Show that $\lim_{n\to\infty} \int_0^1 \frac{nf(x)}{1+n^2x^2} dx = \frac{\pi}{2} f(0)$
5. Verify second Mean Value Theorem for the function $f(x) = x$ and $g(x) = e^x$

**Practical No. 08 : Improper integral for finite limit**

1. Show that $\int_0^2 \frac{\log x}{\sqrt{2-x}} dx$ is convergent.
2. Discuss the convergence of $\int_1^2 \frac{\sqrt{x}}{logx} dx$ .
3. Test the convergence of $\int_0^1 \frac{dx}{x^{1/2}(1-x)^{1/2}}$ .
4. Show that the integral $\int_0^{\pi/2} logsinx\, dx$ is convergent and hence evaluate it.
5. Show that $\int_0^1 x^{m-1}(1-x)^{n-1}dx$ exists if and only if $m, n \geq 0$

**Practical No. 09 : Improper integral for infinite limit**

1. Examine the convergence of $\int_0^{\infty} \frac{x^2}{\sqrt{x^5+1}} dx$ .
2. Show that $\int_0^{\infty} \frac{sin^2 x}{x^2} dx$ is convergent.
3. Test the convergence of the integral $\int_0^{\infty} \frac{xtan^{-1}x}{(1+x^4)^{1/3}} dx$ .
4. Show that the integral $\int_0^{\infty} x^{m-1}e^{-x} dx$ is convergent if and only if $m > 0$.
5. Using Cauchy's Test, show that $\int_0^{\infty} \frac{sinx}{x} dx$ is convergent.

**Practical No. 10 : Beta and Gamma Integrals**

1. Show that $\int_0^{\infty} e^{-ax}x^{n-1}\, dx = \frac{n!}{a^n}$ , $a > 0$
2. Show that $\Gamma(n) = \int_0^1 \frac{\left(log\frac{1}{y}\right)^{n-1}}{x^2} dy$ .
3. Prove that $\int_0^{\infty} \frac{x^{m-1}}{(1+x)^{m+n}} dx = \beta(m, n)$.
4. Prove that $\int_0^1 \frac{x^{m-1}+x^{n-1}}{(1+x)^{m+n}} dx = \beta(m, n)$.
5. Show that $m > 0, n > 0, \int_a^b (x-a)^{m-1}(b-x)^{n-1}dx = (b-a)^{m+n-1}\beta(m, n)$.

| DSC Core (Practical) | | |
|---|---|---|
| MTH – 508 :Practical Course based on (MTH-503 & MTH-504) | | |
| **Total Hours: 60** | | **Credits: 2** |
| | **Course objectives**<br>• To develop analytical and computational skills<br>• To get hands on training in solving problems of groups, rings and Lattice Theory. | |
| | **Learning outcomes**<br>After successful completion of this course, students are expected to:<br>• develop problem solving skills | |
| **Unit** | **Topics** | **Lectures** |
| **UNIT-1** | Examples on unit -1 of (MTH-503 & MTH-504) | **12** |
| **UNIT-2** | Examples on unit -2 of (MTH-503 & MTH-504) | **12** |
| **UNIT-3** | Examples on unit -3 of (MTH-503 & MTH-504) | **12** |
| **UNIT-4** | Examples on unit -4 of (MTH-503 & MTH-504) | **12** |
| **UNIT-5** | Examples on unit -5 of (MTH-503 & MTH-504) | **12** |

## List of Practical's:

| MTH-508 | Practical Course based on MTH-503 & MTH-504 |
|---|---|

**MTH-503 : Algebra**

**Practical No. 1 - Permutations**

1) Prepare a multiplication table of the permutations on set $A = \{1, 2, 3\}$ and show that $S_3$ is a group under the operation of permutation multiplication.
2) Find all even permutations in the permutation group $S_4$.
3) If $\sigma = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 \\ 5 & 4 & 1 & 6 & 3 & 2 \end{pmatrix}$ and $\mu = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 \\ 2 & 3 & 4 & 1 & 6 & 5 \end{pmatrix}$ in $S_6$, then find
   i) $\sigma^2$ ii) $\mu^2$ iii) $\sigma\mu$ iv) $\mu\sigma$ v) $\sigma^{-1}$ vi) $\mu^{-1}$.
4) If $\sigma = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 \\ 6 & 4 & 7 & 5 & 2 & 3 & 1 \end{pmatrix}$ in $S_7$, then express $\sigma$ as a product of transpositions. Is it an even permutation? Also find order of $\sigma$.
5) If $\mu = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \\ 4 & 6 & 2 & 5 & 8 & 9 & 3 & 1 & 7 \end{pmatrix}$ in $S_9$, then find order of $\mu^{-1}$.

**Practical No.-2 Normal Subgroups**

1) Show by an example that union of two normal subgroups of a group $G$ need not be a normal subgroup.
2) Find all normal subgroups of the group of quaternions $Q = \{\pm 1, \pm i, \pm j, \pm k\}$.
3) Show that $A_n$ is a normal subgroup of the permutation group $S_n$.
4) Give an example of subgroups $H, K$ of $G$ such that $H$ is normal in $K$ and $K$ normal in $G$ but $H$ is not normal in $G$.

5) Let $G = \mathrm{GL}(2,\mathbb{R}) = \{A : A \text{ is non-singular } 2\times 2 \text{ matrix over } \mathbb{R}\}$, a group under usual matrix multiplication and $H = \mathrm{SL}(2,\mathbb{R}) = \{A \in G: |A| = 1\}$ a subgroup of $G$. Show that $H$ is normal in $G$.

**Practical No.-3 Isomorphism Theorems for Groups**

1) Let $\mathbb{R}^*$ be the multiplicative group of non-zero reals. Show that $\frac{\mathrm{GL}(2,\mathbb{R})}{\mathrm{SL}(2,\mathbb{R})} \cong \mathbb{R}^*$.
2) If $G, H, K$ are groups such that $G \cong H$ and $H \cong K$, then prove that $G \cong K$.
3) Let $G = \{1, -1\}$ be the group under multiplication. Show that the function $f: S_n \to G$ defined by $f(\sigma) = \begin{cases} 1 & \text{if } \sigma \text{ is even} \\ -1 & \text{if } \sigma \text{ is odd} \end{cases}$, is an onto group homomorphism. Find its kernel.
4) Show that $\mathbb{Z}_9$ is not a homomorphic image of $\mathbb{Z}_{16}$.
5) Show that the group $(\mathbb{Q}, +)$ is not isomorphic to $(\mathbb{Q}^+, \cdot)$.

**Practical No.-4 Ideals, Quotient Rings and Isomorphism of Rings**

1) Show that characteristics of a Boolean ring is two.
2) Find the characteristics for the rings i) $(\mathbb{Z}_n, +_n, \times_n)$ ii) $(\mathbb{Z}, +, \cdot)$.
3) Let $R$ be a ring and $Z(R) = \{x \in R: xy = yx \ \forall y \in R\}$. Show that
   (a) $Z(R)$ is a subring of $R$.
   (b) If $R$ is a division ring, then $Z(R)$ is a field.
4) Give an example of a right ideal in a ring which is not a left ideal.
5) Find all ideals in the ring $(\mathbb{Z}_{12}, +_{12}, \times_{12})$.

**Practical No.-5 Polynomial Rings**

1) Let $f(x) = 2x^3 + 4x^2 + 3x + 2$ and $g(x) = 3x^4 + 2x + 4$ in $\mathbb{Z}_5[x]$. Find
   a) $f(x) + g(x)$ b) $f(x) \cdot g(x)$ c) $\deg(f(x) \cdot g(x))$.
2) Let $f(x) = x^6 + 3x^5 + 4x^2 - 3x + 2$ and $g(x) = x^2 + 2x - 3$ be polynomials in $\mathbb{Z}_7[x]$.
   a) Find $q(x), r(x) \in \mathbb{Z}_7[x]$ such that $f(x) = g(x).q(x) + r(x)$ with $\deg(r(x)) < 2$.
   b) Find all zeros of $f(x) = x^5 + 3x^3 + x^2 + 2x$ in $\mathbb{Z}_5$.
3) Examine whether the polynomial $x^3 + 3x^2 + x - 4$ is irreducible over the field $(\mathbb{Z}_7, +_7, \times_7)$.
4) Express the polynomial $x^4 + 4$ as a product of linear factors in $\mathbb{Z}_5[x]$.
5) Give an example of polynomials $f(x)$ and $g(x)$ in a ring $\mathbb{Z}_6[x]$ such that $\deg(f(x) \cdot g(x)) < \deg(f(x)) + \deg(g(x))$.

**MTH -504: Lattice Theory**

**Practical 6: Posets**

1) Show that set of natural numbers $N$ under usual $\leq$ forms a poset.
2) Show that in a poset $a < a$ for no $a$ and $a < a, b < c \Rightarrow a < c$.
3) Prove that a mapping $f: P \to Q$ is an isomorphism iff $f$ is isotone and has an isotone inverse.
4) Show that two chains $S = \left\{0, \dots, \frac{1}{n}, \dots, \frac{1}{3}, \frac{1}{2}, 1\right\}, \leq$ and $T = \left\{0, \frac{1}{2}, \frac{2}{3}, \dots, \frac{1}{3}, \frac{1}{2}, 1\right\}, \leq$ are dually isomorphic.
5) Let $A$ and $B$ be two posets. Show that $A \times B = \{(a, b) = a \in A, b \in B\}$ forms a poset under the relation defined by $(a_1, b_1) \leq (a_2, b_2) \Leftrightarrow a_1 \leq a_2$ in $A$ and $b_1 \leq b_2$ in $B$.

**Practical 7:Lattices**

1) Show that a lattice $L$ is a chain iff every non-empty subset of it is a sublattice.
2) Let $S$ be any set and $L$ be a lattice. Let T =set of all functions from $S \to L$. Define relation $\leq$ on T by $f \leq g \Rightarrow f(x) \leq g(x) \forall x \in S, f, g \in$ T. Show that (T, $\leq$) forms a lattice.

3) Draw the diagram of the lattice of factors of 20, under divisibility and show that it is same as that of the product of two chains with three and two elements.
4) Prove that a finite lattice has least and greatest elements.
5) Show that a lattice of factors of 12 under divisibility is a sublattice of the lattice $N$ of natural numbers under divisibility.

**Practical 8: Ideals**

1) Prove that an ideal is a sublattice. Is converse true? Justify.
2) Prove that, union of two ideals is an ideal iff one of them is contained in other.
3) Let $N$ be the lattice of all natural numbers under divisibility.

Show that $A = \{1, p, p^2, \dots,\}$, where $p$ is a prime, forms an ideal of $N$.

4) Show that an ideal of a lattice $L$ which is also a dual ideal is the lattice itself.
5) Prove that, a lattice $L$ is a chain iff all ideals in $L$ are prime.

**Practical 9: Homomorphisms and Modular Lattices**

1) Let $L, M$ be lattices. If $\theta: L \to M$ is onto homomorphism and $L$ has least element then prove that $M$ has least element.
2) Prove that homomorphic image of a relatively complemented lattice is relatively complemented.
3) If $\theta: L \to M$ is onto homomorphism, where $L, M$ are lattices and $o$' is least elemtnt of $M$, then $Ker\theta$ is an ideal of $L$.
4) If $\theta: L \to L$ is a homomorphism, where $L$ is a complete lattice then $\exists$ some $a \in L$, such that $\theta(a) = a$.
5) Prove that homomorphic image of modular lattice is modular.

**Practical 10: Distributive Lattices Boolean Lattice**

1) Prove that, every distributive lattice is always modular, but converse need not true.
2) A lattice $L$ is distributive iff $a \wedge (b \vee c) = (a \vee b) \wedge (a \wedge c), \forall a, b, c \in L$.
3) Prove that homomorphic image of distributive lattice is distributive.
4) Prove that a sublattice of a distributive lattice is distributive.
5) Prove that, a lattice is distributive iff $a \vee (b \wedge c) = (a \vee b) \wedge (a \vee c), \forall\ a, b, c \in L$.

| DSC Core (Practical) | | |
|---|---|---|
| **MTH – 509: Practical Course based on (MTH-505,MTH-506(A) or MTH- 506(B))** | | |
| **Total Hours: 60** | | **Credits: 2** |
| | **Course objectives**<br>• To develop analytical and computational skills<br>• To get hands on training in solving problems of Integral Transforms and either in C Programming or Number Theory. | |
| | **Learning outcomes**<br>After successful completion of this course, students are expected to:<br>• develop problem solving skills<br>• develop computer programs for problems of number theoretic problems. | |
| **Unit** | **Topics** | **Lectures** |
| **UNIT-1** | Examples on unit -1 of (MTH-505 & MTH-506(A or B) | **12** |
| **UNIT-2** | Examples on unit -2 of (MTH-505 & MTH-506(A or B) | **12** |
| **UNIT-3** | Examples on unit -3 of (MTH-505 & MTH-506 (A or B ) | **12** |
| **UNIT-4** | Examples on unit -4 of (MTH-505 & MTH-506 (A or B) | **12** |
| **UNIT-5** | Examples on unit -5 of (MTH-505 & MTH-506 (A or B) | **12** |

## List of Practical's:

| **MTH-509** | **Practical Course based on MTH-505 & MTH-506 (A or B)** |
|---|---|

**MTH-505 Integral Transforms**
**Practical 1 Fourier Transforms**

1) Find the Fourier integral for the function $f(x) = \begin{cases} 0, & if\ x < 0 \\ e^{-x}, & if\ x > 0 \\ \frac{1}{2}, & if\ x = 0 \end{cases}$

2) By considering Fourier sine and cosine integrals of $e^{-mx}$ $(m > 0)$, prove that
$(a) \int_0^\infty \frac{\lambda \sin \lambda x}{\lambda^2 + m^2}\, d\lambda = \frac{\pi}{2} e^{-mx}$ , $m > 0$ , $x > 0$ and
$$(b) \int_0^\infty \frac{\cos \lambda x}{\lambda^2 + m^2}\, d\lambda = \frac{\pi}{2m} e^{-mx} \ , \ m > 0 \, , x > 0$$

3) Find the Fourier cosine integral representation for the function
$$f(x) = \begin{cases} x^2, & if\ 0 < x < a \\ 0, & if\ x > a \end{cases}$$

4) Using Fourier integral representation, show that

$$\int_0^\infty \frac{\cos\left(\frac{\pi\lambda}{2}\right)\cos(\lambda x)}{1-\lambda^2}\, d\lambda = \begin{cases} \frac{\pi}{2}\cos x, & if\ |x| \le \frac{\pi}{2} \\ 0, & if\ |x| > \frac{\pi}{2} \end{cases}$$

5) Find the Fourier transform of $f(x) = \begin{cases} 1 - x^2, & if\ |x| \le 1 \\ 0, & if\ |x| > 1 \end{cases}$

and hence evaluate $\int_0^\infty \left(\frac{x\cos x - \sin x}{x^3}\right)\cos\left(\frac{x}{2}\right) dx$.

**Practical 2 Inverse Fourier Transforms**

1) Using inverse sine transform, find $f(x)$, if $F_s(\lambda) = \frac{1}{\lambda}e^{-a\lambda}$
2) What is the function f(x), whose Fourier cosine transform is $\frac{\sin a\lambda}{\lambda}$ ?
3) Solve the integral equation $\int_0^\infty f(x)\sin\lambda x\ dx = \begin{cases} 1-\lambda, & if\ 0 \le \lambda < 1 \\ 0, & if\ \lambda \ge 1 \end{cases}$
4) Solve the integral equation $\int_0^\infty f(x)\sin\lambda x\, dx = \begin{cases} 1, & if\ 0 \le \lambda < 1 \\ 2, & if\ 1 \le \lambda < 2 \\ 0, & if\ \lambda \ge 2 \end{cases}$
5) Solve the integral equation $\int_0^\infty f(x)\cos\lambda x\ dx = e^{-\lambda},\ \lambda > 0$

**Practical 3 Theorems of Fourier Transforms**

1) Find the finite sine and cosine transforms of $f(x) = 2x,\ \ 0 \le x \le 4$
2) If $f(x) = \sin kx$, where $0 \le x \le \pi$ and $k$ is an positive integer, then show that

$$F_s[f(n)] = \begin{cases} 0, & if\ n \ne k \\ \frac{\pi}{2}, & if\ n = k \end{cases}$$

3) Find$f(x)$ if $F_c[f(n)] = -\frac{l^3}{n^2\pi^2}(1+\cos n\pi)$ and $F_c(0) = \frac{l^3}{6}$, where $0 \le x \le l$
4) Find $f(x)$ if $F_c[f(n)] = \frac{2l^3}{n^3\pi^3}(1-\cos n\pi)$, where $0 \le x \le l$
5) Find $f(x)$ if $F_c[f(n)] = \frac{\cos\frac{2n\pi}{3}}{(2n+1)^2}$, where $0 \le x \le 1$

**Practical 4 Z – Transform**

1) Find $Z\{f(k)\}$ if $f(k) = \{8,\ 6,\ 4,\ 2, -1,\ 0,\ 1,\ 2,\ 3\}$
2) Find $Z\{f(k)\}$ if $f(k) = 2^k\cos(3k+2)$, $k \ge 0$
3) Find $Z\{f(k)\}$ if $f(k) = 3^k\sinh(\alpha k)$, $k \ge 0$
4) Find $Z\{f(k)\}$ if $f(k) = \sin\left(\frac{k\pi}{4} + \alpha\right)$, $k \ge 0$
5) Find $Z\{f(k)\}$ if $f(k) = e^{-ak}\sin(bk)$, $k \ge 0$

**Practical 5 Inverse Z-transform**

1) Find $Z^{-1}\left[\frac{z}{\left(z-\frac{1}{4}\right)\left(z-\frac{1}{5}\right)}\right]$, if $|z| > \frac{1}{4}$ by partial fraction method
2) Show that $Z^{-1}\left[\frac{z^2}{\left(z-\frac{1}{4}\right)\left(z-\frac{1}{5}\right)}\right] = \{x_k\}$for$|z| < \frac{1}{5}$, where $x_k = 4\left(\frac{1}{5}\right)^k - 5\left(\frac{1}{4}\right)^k$ , $k < 0$
3) Show that $Z^{-1}\left[\frac{z^3}{\left(z-\frac{1}{4}\right)^2(z-1)}\right] = \{x_k\}\ for\ |z| > 1$, where $x_k = \frac{16}{9} - \frac{4}{9}\left(\frac{1}{4}\right)^k - \frac{1}{3}(k+1)\left(\frac{1}{4}\right)^k, k \ge 0$
4) Find $Z^{-1}\left[\frac{10z}{(z-2)(z-1)}\right]$ by using inversion integral method.
5) Find $Z^{-1}\left[\frac{z^3}{(z-1)\left(z-\frac{1}{2}\right)^2}\right]$ by using inversion integral method.

## MTH -506(A) C Programming

### Practical No : 6(A) - Basic concept

1) Write a C program that will obtain the area and perimeter of a square when the length of side is given.
2) Write a C program that will obtain the area and perimeter of a rectangle when the length of width of rectangle is given.
3) Write a C program to calculate area and circumference of the circle, whose radius is given.
4) Write a C program to multiply two floating point numbers.
5) Write a C program to find the average of five given numbers.

### Practical No : 7(A) - Expressions and conditional statements

1) Write a C program that determines whether a given integer is odd or even and displays the number and description on the same line.
2) Write a C program that determines whether a given integer is divisible by 3 or not and displays the number and description on the same line.
3) Write a C program that determines the roots of the quadratic equation $ax^2 + bx + c = 0,\ a \neq 0$.
4) Write a C program to print the largest of the three numbers using nested if . . .else statement.
5) Write a program to check whether given year is leap or not.

### Practical No : 8(A) - Looping

1) Write a C program to find the sum of odd natural numbers from 100 to 500.
2) Write a C program that determines whether a given integer is prime or not.
3) Write a program of triangular number.
4) Write a C program to prepare multiplication table from 21 to 30.
5) Write a C program to generate and print first n Fibonacci numbers.

### Practical No : 9(A) - Arrays

1) Write a C program to sort N numbers in ascending order.
2) Write a C program to sort N numbers in descending order.
3) Write a C program to read two matrices and perform addition of these matrices.
4) Write a C program to read two matrices and perform subtraction of these matrices.
5) Write a C program to find transpose of given matrix.

### Practical No : 10(A)- Functions

1) Write a C-program to find GCD of two numbers by using function.
2) Write a C program of addition of two numbers by user defined function
3) Write a C program to display all prime numbers between two integer.
4) Write a C program to check integer as a sum of two prime numbers.
5) Write a program to check whether a number is prime or not, by using function

## MTH-506 (B) Number Theory

### Practical No : 6(B) -

1) Prove that:
   a) Any prime of the form $3n + 1$ is also of the form $6m + 1$.
   b) The only prime $p$ for which $3p + 1$ is a perfect square is $p = 5$.
2) Find all prime divisors of 50!
3) Obtain all prime numbers between 100 and 200 by using Sieve of Eratosthenes method.

4) a) Find all pairs of prime numbers $p$ and $q$ satisfying $p - q = 3$

b) Three integers $p, p+2, p+6$ which are all primes is called a prime-triplet.

c) Find five prime-triplets.

5) Prove that $n^4 + 4^n$ is composite for all integers n > 1

**Practical No : 7(B) -**

1) a) Determine the last three digits of $7^{999}$

b) Find the remainder when $1^5 + 2^5 + 3^5 + \cdots + 100^5$ is divided by 4.

2) Solve the following linear congruences:

a) $25x \equiv 15 \ (mod 29)$,

b) $140x \equiv 133 \ (mod\ 301)$

3) Find all solutions of the linear congruence: $3x - 7y \equiv 11 (mod\ 23)$

4) 4 By using CRT, solve the following system of congruences: $x \equiv 1 \ (mod\ 3)$, $x \equiv 2 \ (mod\ 5), x \equiv 3 (mod\ 7)$.

5) a) Show that the number 5117247 is divisible by 9.

b) Test whether the number 67058902 is divisible by 7

**Practical No : 8(B) -**

1) a) Factorize 2047 by Fermat's Factorization method.

b) Use Fermat's method to factor 23449

2) a) Find the remainder when $5^{38}$ is divided by 11.

b)Find the unit digit of $3^{100}$

3) a) If $7 \nmid a$, prove that either $a^3 + 1$ or $a^3 - 1$ is divisible by 7.

b) If $gcd(a, 133) = gcd\ (b, 133) = 1$, show that $133 \ |(a)^{18} - b^{18})$.

4) If $p$ and $q$ are distinct primes, prove that $p^{q-1} + q^{p-1} \equiv 1 \ (mod\ pq)$.

5) Show that 341 is pseudoprime.

**Practical No : 9(B) -**

1) a) Show that 496 and 8128 are perfect numbers.

b) Show that the integer $n = 2^7 \ (2^8 - 1)$ is not a perfect number.

2) Show that if $a^k - 1$ is a prime $(a > 0, k \geq 2)$ then $a = 2$ and $k$ is a prime.

3) Show that every even perfect number has last digit either 6 or 8.

4) Show that every even perfect number $n = 2^{k-1} \ (2^k - 1)$ is the sum of first $2^{\frac{k-1}{2}}$ odd cubes.

5) Show that the Mersenne number $M_{17}$ is prime. Hence show that $n = 2^{16} \ (2^{17} - 1)$ is perfect.

**Practical No : 10(B) -**

1) a)Represent the following numbers as a sum of distinct Fibonacci numbers:

i) 27 ii) 75 iii) 110 iv) 128 v) 150

b) Evaluate the following:

i) $gcd\ (u_8, u_{16})$ ii) $gcd\ (u_{15}, u_{27})$ iii) $gcd(u_{12}, u_{37})$.

2) For primes $p = 7,11,13,17$ verify that either $u_{p-1}\ or\ u_{p+1}$ is divisible by $p$.

3) For $n = 1, 2 \cdots, 10$ verify that $5u_n^2 + 4(-1)^n$ is always a perfect square.

4) a) Show that the sum of first $n$ Fibonacci numbers with odd indices is given by formula $u_1 + u_3 + u_5 + \cdots + u_{2n-1} = u_{2n}$.

b) Show that the sum of first $n$ Fibonacci numbers with even indices is given by formula $u_2 + u_4 + u_6 + \cdots + u_{2n} = u_{2n+1} - 1$.

5) a) Use induction to show that $u_{2n} \equiv n(-1)^{n+1} \ (mod\ 5),\ for\ n \geq 1$.

b) Derive the identity $u_{n+3} = 3u_{n+1} - u_{n-1}$.

- Syllabus of the Non-Credit Elective audit courses AC-601(A): Soft skill AC-601 (B): Yoga and AC-601(C): Practicing Cleanliness will be supplied by the university separately. Students have to opt any one of them. There are 2 credits for this course and has 30 clock hours teaching. For this course there will be internal examination of 100 Marks only.

## Semester VI

| DSC Core Courses | | |
|---|---|---|
| **MTH - 601: Measure Theory** | | |
| **Total Hours: 45** | | **Credits: 3** |
| | **Course objectives**<br>The aim of this course is to learn the basic elements of Measure Theory. It is useful as it provides a foundation for many branches of mathematics such as harmonic analysis, theory of partial differential equations and probability theory. | |
| | **Learning outcomes**<br>1) Learn measurable sets. Learn the concept of Sets of measure zero.<br>2) Understand why a more sophisticated theory of integration and measure is needed.<br>3) Show that certain functions are measurable.<br>4) Understand properties of the Lebesgue integrals. | |
| **Unit** | **Topics** | **Lectures** |
| **UNIT-1** | **Measurable Sets**<br>1.1 Length of open and closed sets<br>1.2 Inner and outer measure of a set<br>1.3 Measurable sets and Properties of measurable sets<br>1.4 Symmetric difference of two measurable sets<br>1.5 Cantor's ternary sets | **09** |
| **UNIT-2** | **Measurable functions**<br>2.1 Real valued measurable functions<br>2.2 Sequence of measurable functions<br>2.3 Supremum and infimum of measurable functions<br>2.4 Almost everywhere concept | **09** |
| **UNIT-3** | **Lebesgue integral for bounded functions**<br>3.1 Measurable partition, Refinement, Lower and Upper Lebesgue sum and Lebesgue integrals<br>3.2 Existence of Lebesgue integral for bounded function.<br>3.3 Properties of Lebesgue integral for bounded measurable functions<br>3.4 Lebesgue integral for bounded function over a set of finite measure | **09** |
| **UNIT-4** | **Lebesgue integral for unbounded functions**<br>4.1 Non-negative valued function<br>4.2 Positive and negative part of a function<br>4.3 Definition and properties of $\int_E f$ where $f$ is non-negative valued function in $L[a, b]$. | **09** |
| **UNIT-5** | **Some fundamental theorems and metric space $\boldsymbol{L^2[a,b]}$**<br>5.1 Lebesgue dominated convergence theorem<br>5.2 Fatou’s Lemma<br>5.3 Square integrable function<br>5.4 Schwartz inequality, Minkowski inequality. | **09** |

| **Recommended Book(s):** | |
|---|---|
| 1 | R.R. Goldberg, Methods of Real Analysis, Oxford & IBH Publishing Co. PVT. LTD, 2nd Edition, 1976<br>**Chapter 11** : 11.1,11.2,11.3, 11.4,11.5,11.6,11.7, 11.8, 11.9 |
| **Reference Book(s):** | |
| 1 | Measure Theory and Integration, G. D. Barra, Woodhead Publishing; 2 Edition, 2003. |
| 2 | Lebesgue Measure and integration, P. K. Jain and V. P. Gupta, New Age International Publishers; Third edition, 2019. |

<table>
<tr><td colspan="3" align="center">DSC Core Courses</td></tr>
<tr><td colspan="3" align="center">MTH - 602: Real Analysis – II</td></tr>
<tr><td>Total Hours: 45</td><td></td><td>Credits: 3</td></tr>
<tr><td></td><td colspan="2">Course objectives<br>1. To study Sequence of real numbers, series function.<br>2. To study of Fourier series. Theory of Uniform convergence of sequence of functions and Cauchy's criteria for uniform con. of sequence of function.</td></tr>
<tr><td></td><td colspan="2">Learning outcomes<br>After successful completion of this course, students are expected to:<br>1. solve Convergence and divergence<br>2. use Test for absolute convergence,<br>3. understand Fourier series for even and odd functions t,<br>4. understand Sine and cosine series in half range</td></tr>
<tr><td align="center">Unit</td><td align="center">Topics</td><td align="center">Lectures</td></tr>
<tr><td>UNIT-1</td><td>Sequence of real numbers<br>1.1 Definition of sequence and subsequence of real numbers.<br>1.2 Convergent Sequence.<br>1.3 Divergent Sequences.<br>1.4 Monotone sequence.<br>1.5 Operation on Convergent Sequences.<br>1.6 Cauchy Sequences.</td><td>09</td></tr>
<tr><td>UNIT-2</td><td>Series of real numbers<br>2.1 Convergence and divergence<br>2.2 Series with non-negative terms<br>2.3 Alternating series<br>2.4 Conditional convergence and absolute convergence<br>2.5 Test for absolute convergence<br>2.6 Series whose terms form non-increasing sequence</td><td>09</td></tr>
<tr><td>UNIT-3</td><td>Sequence of functions<br>3.1 Pointwise convergence of sequence of functions<br>3.2 Uniform convergence of sequence of functions<br>3.3 Cauchy's criteria for uniform con. of seq. of fun.<br>3.4 Consequences of uniform convergence</td><td>09</td></tr>
<tr><td>UNIT-4</td><td>Series of functions<br>4.1 Pointwise convergence of series of functions<br>4.2 Uniform convergence of series of functions<br>4.3 Integration and differentiation of series of functions<br>4.4 Abel's sum ability.</td><td>09</td></tr>
<tr><td>UNIT-5</td><td>Fourier series in the range (-π , π)<br>5.1 Fourier series and Fourier coefficients<br>5.2 Dirichlet's condition of convergence (Statement only)<br>5.3 Fourier series for even and odd functions<br>5.4 Sine and cosine series in half range</td><td>09</td></tr>
</table>

| Recommended Book(s): | |
|---|---|
| 1 | R.R. Goldberg, Methods of Real Analysis, Oxford & IBH Publishing Co. PVT. LTD, 2nd Edition, 1976: Unit 1:- 2.1, 2.3, 2.4, 2.6, 9.1, 9.2 Unit 2:- 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7 Unit 3 and 4:- 9.4, 9.5, 9.6 |
| 2 | Laplace Transform and Fourier series, M. R. Spigel ,Schaum series, Mc Graw Hill, 1965, Unit – 4 |
| **Reference Book(s):** | |
| 1 | Mathematical Analysis by S.C. Malik and Savita Arora. |
| 2 | Mathematical Analysis by S.K. Chatterjee |

| DSC Core Courses | | |
|---|---|---|
| **MTH - 603: Linear Algebra** | | |
| **Total Hours: 45** | | **Credits: 3** |
| | **Course objectives**<br>1) To study vector spaces, basis and dimensions.<br>2) To study Linear transformation also Eigen value and eigen values<br>3) To study diagonalization of matrices, congruences, Perfect numbers, | |
| | **Learning outcomes**<br>After successful completion of this course, students are expected to:<br>1) solve Rank and nullity theorem<br>2) use Cayley Hamilton theorem, Euler's theorem and finding Eigen values and Eigen vectors of linear transformation.<br>3) understand Kernel and image of linear transformations.<br>4) understand Singular and non-singular linear transformations | |
| **Unit** | **Topics** | **Lectures** |
| **UNIT-1** | **Vector Spaces**<br>1,1 Vector spaces, Subspaces, Examples.<br>1.2 Necessary and sufficient conditions for a subspace.<br>1.3 Addition, Intersection and union of subspaces.<br>1.4 Quotient space.<br>1.5 Linear Combinations.<br>1.6 Linear span and properties. | **09** |
| **UNIT-2** | **Basis and Dimensions**<br>2.1 Linear dependence and independence.<br>2.2 Basis and dimension of finite dimensional vector spaces.<br>2.3 Co-ordinates of a vector.<br>2.4 Existence theorem and its applications, Extension theorem.<br>2.5 Theorems on basis and dimensions. | **09** |
| **UNIT-3** | **Linear Transformations**<br>3.1 Introduction<br>3.2 Linear transformation,<br>3.3 Kernel and image of linear transformations<br>3.4 Range space and null space of linear transformations.<br>3.5 Rank and nullity theorem.<br>3.6 Algebra of linear transformations.<br>3.7 Invertible linear transformations.<br>3.8 Singular and non-singular linear transformations. | **09** |
| **UNIT-4** | **Eigen values and Eigen vectors**<br>4.1 Matrix polynomial.<br>4.2 Eigen values and Eigen vectors of linear transformation.<br>4.3 Diagonalization and Eigen vectors<br>4.4 Cayley Hamilton theorem. | **09** |

| | | |
|---|---|---|
| | 4.5 Characteristics polynomial and minimum polynomial. | |
| **UNIT-5** | **Matrices and Linear Transformation**<br>5.1 Matrix representation of linear operator.<br>5.2 Matrix representation of linear transformation.<br>5.3 Change of basis<br>5.4 Similarity<br>5.5 Diagonalisation of Matrix | **09** |
| **Recommended Book(s):** | | |
| 1 | Linear Algebra, S. Lipschutz and Marc Lars Lipson, 4th Edition, Schaum's outline series, McGraw Hill Book Company, New York, 2009. Cha. -4 4.1 to 4.14 cha.-5 5.1 io 5.6 Cha. -6 6.1 to 6.5 Cha- 9, 9.1 to 9.4 9.7 9.8. | |
| **Reference Book(s):** | | |
| 1 | N. S. Gopalkrishnan, University Algebra(2015), New Age Int. Pvt.Ltd | |
| 2 | A. R. Vasishtha and J.N. Sharma, Linear Algebra (2014), Krishna Publication, Meerut. | |
| 3 | K. P. Gupta J. K. Goyal, Advanced Course in Modern Algebra | |
| 4 | V. K. Khanna and S. K. Bhambri, Course in Abstract Algebra (2013),Vikas Publishing House Pvt. Ltd. New Delhi. | |

<table>
<tr><td colspan="3">DSC Core Courses</td></tr>
<tr><td colspan="3">MTH - 604: Ordinary and Partial Differential Equations</td></tr>
<tr><td>Total Hours: 45</td><td></td><td>Credits: 3</td></tr>
<tr><td></td><td colspan="2">Course objectives.<br>The main objective of this course is to provide the student with an understanding of the solutions and applications of ordinary differential equations. By using this theory and models students can apply their knowledge in real world.<br>Prerequisite: F.Y.B.Sc. and S.Y.B.Sc. Mathematics.</td></tr>
<tr><td></td><td colspan="2">Learning outcomes<br>1) Know the exact differential equation and its solution.<br>2) Solve the exact differential equations by using integrating factor.<br>3) Solve the linear differential equation of second order by using various methods.</td></tr>
<tr><td>Unit</td><td>Topics</td><td>Lectures</td></tr>
<tr><td>UNIT-1</td><td>Exact Differential Equation<br>1.1 Definition, condition of exactness of a linear differential equation of order $n$, examples of type-1<br>1.2 Integrating factor, examples of type-2<br>1.3 Exactness of non-linear equation by inspection, examples of type-3<br>1.4 Equation of the form $\frac{d^2y}{dx^2} = f(y)$</td><td>09</td></tr>
<tr><td>UNIT-2</td><td>Linear Differential Equation of Second Order<br>2.1 The standard form of linear differential equation of second order<br>2.2 Complete solution in terms of one known integral belonging to C.F.<br>2.3 Rules for getting an integral belong to C.F., working rule for finding complete solution when an integral of C.F. is known<br>2.4 Removal of first derivative (reduction to normal form) working rule for solving problem by using normal form<br>2.5 Transformation of the equation by changing the independent variable, working rule.</td><td>09</td></tr>
<tr><td>UNIT-3</td><td>Linear Partial Differential Equations of the First Order<br>3.1 Definition of partial differential equation, order and degree of partial differential Equation<br>3.2 Derivation of partial differential equation by elimination of arbitrary constants and arbitrary functions.<br>3.3 Lagrange's equations and Lagrange's method of solving $Pp + Qq = R$<br>3.4 Integral surface passing through a given curve</td><td>09</td></tr>
</table>

| | | |
|---|---|---|
| UNIT-4 | **Compatible System**<br>4.1 Surfaces orthogonal to a given system of surfaces and examples<br>4.2 Compatible system of first order equations<br>4.3 Condition for system of two first order partial differential equation to be compatible and examples<br>4.4 Particular case and examples | 09 |
| UNIT-5 | **Non-Linear partial Differential Equation of order one**<br>5.1 Charpit's method and examples<br>5.2 Special type (a)Involving only $p$ and $q$ (b)Equation not containing the independent variable (c) Separable equation,<br>5.3 Examples on (a), (b) and(c)<br>5.4 Jacobi's method and examples | 09 |
| **Recommended Book (s):** | | |
| 1 | Advanced Differential Equations, M D Raisinghania, S. Chand and Company Pvt Ltd. , 1988.<br>Part-I: 3.1, 3.2, 3.4, 3.5, 3.6, 3.7, 3.8, 3.11, and 3.12. Part-I: 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 4.10, 4.11, and 4.12. Part-II: 1.1, 1.2, 1.3, 1.4, 1.5, and 1.6. | |
| 2 | Ordinary and partial differential equations, M D Raisinghania, S. Chand and Company Pvt Ltd, 2017.<br>Part-III: 2.16, 2.17, 3.4, 3.5, and 3.6.<br>Part-III: 3.7, 3.8, 3.9, 3.10, 3.11, 3.14, 3.15, 3.16, 3.17, 3.18, 3.19, and 3.21. | |
| **Reference Book (s):** | | |
| 1 | Elements of Partial Differential Equations, Ian Naismith Sneddon, McGraw Hill Publication Company Ltd., 1957 | |
| 2 | Differential Equations, Richard Bronson, Schaum's Outline Series. McGraw Hill Education; 3 edition, 2017. | |

| DSC Skill Enhancement Course (SEC) SEC-III: Skill Based<br>DSC Elective Course | | |
|---|---|---|
| **MTH - 605: Graph Theory** | | |
| **Total Hours: 45** | | **Credits: 3** |
| | **Course objective**<br>1. The course is oriented to those who want to advance structured and procedural programming understating and to improve operation on graphs.<br>2. The major objective is to provide students with understanding of graph, Trees. Matrix representation of graphs. | |
| | **Learning outcomes**<br>After successful completion of this course, students are expected to:<br>1. Understanding a functional hierarchical code organization. Ability to define and manage graphs, connected graphs.<br>2. Understanding a concept of Cut set and cut vertices. | |
| **Unit** | **Topics** | **Lectures** |
| **UNIT-1** | **Graphs**<br>1.1 Definition, Handshaking lemma<br>1.2 Type s of graph<br>1.3 Subgraphs<br>1.4 Operations on graphs<br>1.5 Isomorphism of graphs | **09** |
| **UNIT-2** | **Connected graphs**<br>2.1 Walk path cycles, (circuit)<br>2.2 Connected and disconnected graphs<br>2.3 Eulerian graphs ,Konigsberg seven bridge problem<br>2.4 Hamiltonian graph<br>2.5 Traveling salesman problem | **09** |
| **UNIT-3** | **Trees**<br>3.1 Definition and properties of a tree<br>3.2 Distance and center in a tree<br>3.3 Rooted and binary trees<br>3.4 Spanning tree | **09** |
| **UNIT-4** | **Cut set and Cut vertices**<br>4.1 Cut sets ,edge connectivity ,vertex connectivity<br>4.2 Fundamental Cut set, fundamental circuits<br>4.3 Planar graph, Eulers formula for planar graph<br>4.4 Geometrical dual<br>4.5 Coloring of a graph | **09** |
| **UNIT-5** | **Matrix representation of graphs**<br>5.1 Incidence matrix<br>5.2 Adjacency matrix<br>5.3 Types of diagraph<br>5.4 Incidence matrix of a diagraph<br>5.5Adjacency matrix of a diagraph | **09** |

| Recommended Book(s): | |
|---|---|
| 1 | Discrete mathematics by S. Lipschutz and M. L. Lipson, Schaum's Outline Series ,McGraw Hill, New York, 2007.<br>Unit 1: (Chapter 8) 8.1, to 8.13, (Chapter 9) 9.1 to 9.6, |
| **Reference Book(s):** | |
| 1 | Graph Theory with Applications to Engineering and Computer Science, Narsingh Deo , Prentice Hall Pvt, Ltd. 1976. |
| 2 | Graph Theory , F. Harary, Narosa Publishing House, 2001. |

<table>
<tr><td colspan="3">DSC Elective Course (Any one)</td></tr>
<tr><td colspan="3">MTH – 606(A): Introduction to SciLab</td></tr>
<tr><td>Total Hours: 45</td><td></td><td>Credits: 3</td></tr>
<tr><td></td><td colspan="2">Course Objective:<br>1) Understand the fundamentals of SciLab and its utilization.<br>2) Familiarization of the syntax of numerical computing language-SciLab.<br>3) Application of SciLab for implementation/simulation and visualization of basic mathematical computations</td></tr>
<tr><td></td><td colspan="2">Course Outcomes :<br>After successful completion of this course students are expected to<br>1) Understand the main features/tools of SciLab.<br>2) Implement and determine simple mathematical computations in SciLab.<br>3) Interpret and visualize simple mathematical functions using SciLab tools.<br>4) Analyze the mathematical problem with simulation environment in SciLab.<br>5) Understand the need for simulation/implementation for the verification of mathematical functions.</td></tr>
<tr><td>Unit</td><td>Topics</td><td>Lectures</td></tr>
<tr><td>UNIT-1</td><td>Introduction to SciLab<br>1.1 Introduction to SciLab<br>1.2 What is SciLab, Downloading & Installing SciLab, A quick taste of SciLab.<br>1.3 The SciLab environment – manipulating the command line, working directory, comments<br>1.4 Variables in memory, recording sessions, the SciLab menu bar, demos</td><td>09</td></tr>
<tr><td>UNIT-2</td><td>Elementary Mathematics Through SciLab<br>2.1 Scalars & Vectors–introduction, initializing vectors in SciLab<br>2.2 Mathematical operations on vectors, relational operations on vectors, logical operations on vectors, built-in logical functions<br>2.3 Elementary mathematical functions, mathematical functions on scalars, complex numbers, trigonometric functions, inverse trigonometric functions, hyperbolic functions.</td><td>09</td></tr>
<tr><td>UNIT-3</td><td>Matrices and Polynomials Through SciLab<br>3.1 Matrices – introduction, arithmetic operators for matrices, basic matrix processing<br>3.2 Polynomials–introduction, creating polynomials,</td><td>09</td></tr>
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| | | |
|---|---|---|
| | basic polynomial commands, finding roots of polynomial, polynomial arithmetic, miscellaneous polynomial handling. | |
| **UNIT-4** | **Programming in SciLab**<br>4.1 Variables and variables names, assignment statements and arithmetic, relational and logical operators,<br>4.2 Branching: Conditional (if, if-else, nested and ladder if-else, switch constructs), Unconditional (break and continue statements)<br>4.3 Looping: Entry controlled (for and while)<br>4.4 Handling matrices with loops, scripts, functions. | **09** |
| **UNIT-5** | **Graphics and Applications in SciLab**<br>5.1 Graphic Output – Introduction, 2d plotting, 3d plotting, other graphic primitives.<br>5.2 Applications: Linear Algebra-Solving linear equations, Eigen values etc.<br>5.3 Numerical Analysis–Iterative methods ODE-Plotting solution curves | **09** |
| **Recommended Book(s):** | | |
| 1 | Computer SCILAB–A Free Software to MATLAB, Er. Hema Ramachandran, Dr. Achuthsankar S. Nair, S Chand & Company, 2011. Chapter 1 to 8. | |
| 2 | | |
| **Reference Book(s):** | | |
| 1 | Programming in Scilab, Rajan Goyal, Mansi Dhingra, Narosa Publishing House, New Delhi, 2019. | |

| DSC Elective Course (Any one) | | |
|---|---|---|
| **MTH – 606(B): Operations Research** | | |
| **Total Hours: 45** | | **Credits: 3** |
| | **Course objectives**<br>1. To study linear programming problem (LPP).<br>2. To study the simplex method to solve linear programming problem.<br>3. To study the simplex method for unbounded, alternative and infeasible solutions of LPP.<br>4. To study the initial basic feasible solution of transportation problem (TP).<br>5. To study the saddle point, maximin-minimax principal, two person zero sum game.<br>6. To study $2 \times 2$ games without saddle point.<br>7. To study graphical method to solve $m \times 2$ and $2 \times n$ games.<br>8. To study dominance property. | |
| | **Learning outcomes**<br>After successful completion of this course, students are expected to:<br>1. solve the linear programming problem by graphical method and simplex method.<br>2. learn the unbounded, alternative and infeasible solutions of LPP by graphical and simplex method.<br>3. understand the standard and canonical form of LPP.<br>4. find the optimal solution of TP by MODI method.<br>5. solve the solution of assignment problems by Hungerian Method.<br>6. Understand the unbalanced, balanced, maximization, restricted AP and alternative solution of AP.<br>7. understand the saddle point, maximin-minimax principal, two person zero sum game.<br>8. use of dominance property to find the solution games | |
| **Unit** | **Topics** | **Lectures** |
| **UNIT-1** | **Linear Programming Problem (LPP)**<br>1.1 Formation of LPP<br>1.2 Solution of LPP by graphical method<br>1.3 Special cases in LPP: a) Unbounded solution b) Alternative solution c) Infeasible solution<br>1.4 Standard and Canonical forms of LPP | **09** |
| **UNIT-2** | **Simplex Methods**<br>2.1 Simplex Algorithm<br>2.2 Solution of LPP by simplex method<br>2.3 Artificial variable technique (Big M method)<br>2.4 Special cases in LPP: (a) Unbounded solution (b) Alternate solution ( c) Infeasible solution | **09** |

| | | |
|---|---|---|
| **UNIT-3** | **Transportation Problem (TP)**<br>3.3 General Transportation Problem<br>3.4 Transportation Table. Methods for finding IBFS: (a) North –West corner rule (b) Matrix minima method (Least cost method) (c) Vogel's approximation method (VAM)<br>3.5 Optimality test and optimization of solution to TP by U-V method (MODI). Special cases in TP: (a) Alternate solution (b) Maximization TP (c) Unbalanced TP (d) Restricted TP<br>3.6 Degeneracy in TP | **09** |
| **UNIT-4** | **Assignment Problem (AP)**<br>4.1 Mathematical Formulation of Assignment problem<br>4.2 Hungerian method for solving AP<br>4.3 Special cases in AP: (a) Alternate solution (b) Maximization AP (c) Unbalanced AP (d) Restricted AP. | **09** |
| **UNIT-5** | **Game Theory**<br>5.1 Two person-zero sum games<br>5.2 Pure and mixed strategies, value of a game<br>5.3 Maxmin and Minimax principles and saddle point<br>5.4 Solution of $2 \times 2$ game by algebraic method and oddment method<br>5.5 Game without saddle points-mixed strategies Graphical solution of $m \times 2$ and $2 \times n$ games<br>5.6 Dominance Property | **09** |
| **Recommended Book(s):** | | |
| 1 | Operations Research, Kanti Swarup, P. K. Gupta, Man Mohan, S. Chand and Sons, Educational Publishers, New Delhi. Twelfth Edition,2004 Chapter No. 3, 4, 10, 11. | |
| **Reference Book(s):** | | |
| 1 | Operation Research by S. D. Sharma and K.Ramnath, Meerut Publication, 2012. | |
| 2 | Operation Research by Prem Kumar Gupta,S. Chand and Company pvt Ltd. New Delhi 7th Edition-2014. | |

| DSC Core (Practical) | | |
|---|---|---|
| MTH – 607: Practical Course based on (MTH-601, MTH-602) | | |
| Total Hours: 60 | | Credits: 2 |
| | **Course objectives**<br>• To develop analytical and computational skills<br>• To get hands on training for solving problems of measure theory and sequences and series of functions in Real analysis. | |
| | **Learning outcomes**<br>After successful completion of this course, students are expected to:<br>• Students will develop problem solving skills | |
| Unit | Topics | Lectures |
| UNIT-1 | Examples on unit -1 of (MTH-601 & MTH-602) | 12 |
| UNIT-2 | Examples on unit -2 of (MTH-601 & MTH-602) | 12 |
| UNIT-3 | Examples on unit -3 of (MTH-601 & MTH-602) | 12 |
| UNIT-4 | Examples on unit -4 of (MTH-601 & MTH-602) | 12 |
| UNIT-5 | Examples on unit -5 of (MTH-601 & MTH-602) | 12 |

## List of Practical's:

| MTH-607 | Practical Course based on MTH-601 & MTH-602 |
|---|---|

**MTH-601 : Measure Theory**

**Practical No. 1 - Measurable Sets**

1. If $I_1, I_2 \cdots, I_k$ are open subintervals of $[a,b]$ .Show that
   $|I_1 + I_2 + \cdots + I_k| \le |I_1| + |I_2| + \cdots + |I_k|$
2. Show that for any set $A$, $\overline{m}(A) = \overline{m}(A + x)$ where $A + x = \{y + x : x \in A\}$
3. If $E \subseteq [a,b]$, show that $\overline{m}(E) + \underline{m}(E') = (b - a)$ .
4. a) If $E_1$ is a measurable subset of $[a,b]$ and if $mE_2 = 0$, then prove that $E_1 \cup E_2$ is measurable.
   b) If $E_1$ and $E_2$ are measurable subsets of $[0,1]$ and if $mE_1 = 1$, then show that $m(E_1 \cap E_2) = mE_2$.
5. If If $E_1$ and $E_2$ are measurable subsets of $[0,1]$, prove that the symmetric difference of $E_1$ and $E_2$ is also measurable.

**Practical No. 2 Measurable Functions.**

1. If $f(x) = \begin{cases} \frac{1}{x}, & for < 0 < x < 1 \\ 5, & x = 0 \\ 7, & x = 1 \end{cases}$ , then
   Show that $f$ is measurable on $[0,1]$.
2. Show that the subset $E$ of $[a,b]$ is measurable if and only if the characteristic function $\chi_E$ is measurable.

3. If $F'(x)$ exists for every $x$ in $[a,b]$ and $f(x) = F'(x) \quad (a \le x \le b)$. Prove that $f$ is a measurable function.
4. If $f = g$ almost everywhere and $f$ is measurable function then show that $g$ is also measurable.
5. Show that the function $f$ defined on $\mathbb{R}$ by

$$f(x) = \begin{cases} x+5, & x < -1 \\ 2, & -1 \le x \le 0 \\ x^2, & x > 0 \end{cases}$$

is measurable function.

**Practical No. 3 Lebesgue Integral for Bounded Functions.**

1. The Dirichilet function $f:[0,1] \to \mathbb{R}$ defined by

$$f(x) = \begin{cases} 1, & if\ x\ is\ rational \\ 0, & if\ x\ is\ irrational \end{cases}$$

Show that $f(x)$ is Lebesgue integrable but not Riemann integrable.
2. Let $f$ be a bounded function on $[a,b]$. Let $P$ and $Q$ are any two measurable partitions of $[a,b]$. Show that $L[f\,;Q] \le U[f;\,P]$.
3. If $E_1$ and $E_2$ are disjoint measurable subsets of $[a,b]$ and $f$ is bounded function in $L[a,b]$ then prove that $\int_{E_1 \cup E_2} f = \int_{E_1} f + \int_{E_2} f$.
4. Let $\chi$ be the characteristic function of the irrational number in $[0,1]$. Show that $\chi \in L[0,1]$ and $\int_0^1 \chi = 1$.
5. a) If $E$ is measurable subset of $[a,b]$, then show that $\int_E k = k.m(E)$ where $k$ is a positive constant.

   b) Let $E_1, E_2, \cdots, E_n$ be measurable subsets of $[0,1]$. If each point of $[0,1]$ belongs to at least three of these sets. Show that at least one of the sets has measure $\ge \frac{3}{n}$.

**Practical No. 4 Lebesgue Integral for Unbounded Functions**

1. Let $f(x) = \begin{cases} \frac{1}{x^{2/3}}, & if\ \ 0 < x \le 1 \\ 0, & if\ \ x = 0 \end{cases}$

   Calculate ${}^n f$, also prove that $f$ is L-integrable on $[0,1]$ and $\int_0^1 f dx = 3$.

2.a) If $f(x) = log\frac{1}{x}$ for $0 < x \le 1$ find ${}^3 f$.

b) If $f(x) = (\frac{1}{x})^{1/3}$ for $0 < x \le 1$ find ${}^4 f$.

3. If $f(x) = \begin{cases} 1/x, & if\ \ 0 < x \le 1 \\ 19, & if\ x = 0 \end{cases}$ then prove that $f$ is not L-integrable on $[0,1]$.
4. If $f(x) = \frac{1}{x^p}$ for $0 < x \le 1$, then prove that $f \in L[0,1]$, if $p < 1$ and $L\int_0^1 f = \frac{1}{1-p}$.
5. Let $f(x) = 0$ for every $x$ in the Cantor set $K$ and $f(x) = n$, for $x$ in each of the interval of length $\frac{1}{3^n}$ in $K'$. Prove that $f$ is L-integrable on $[0,1]$ and that $\int_0^1 f = 3$.

**Practical No. 5 Some Fundamental Theorems**

1. Let $f \in L[0,1]$ and $F(x) = \int_a^x f(t)dt$, for $a \le x \le b$. Prove that $F$ is continuous on $[0,1]$.
2. Using Lebesgue dominated convergence theorem evaluate $\lim_{n\to\infty} \int_0^1 f_n(x)dx$, where

   $f_n(x) = \frac{n^{\frac{3}{2}}.x^{\frac{3}{2}}}{1+n^2+x^2}$, $\ 0 \le x \le 1,\ n = 1, 2, 3, \cdots ....$

3. For $n \in I$, let $f_n(x) = \begin{cases} 2n, & \frac{1}{2n} \le x \le \frac{1}{n} \\ 0, & x \in (0, \frac{1}{2n}) \cup (\frac{1}{n}, 1) \end{cases}$

calculate $\int_0^1 \lim_{n\to\infty} f_n(x)dx$ & $\lim_{n\to\infty} \int_0^1 f_n(x)dx$. Show that Fatou's lemma applies but that Lebesgue dominated convergence theorem does not.

4. For each positive integer $n$ and $x \in [0,2]$ define $f_n(x)$ to be,

$$f_n(x) = \begin{cases} \sqrt{n}\,, & \frac{1}{n} \le x \le \frac{2}{n} \\ 0\,, & x \in [0,\frac{1}{n}) \cup (\frac{2}{n},1] \end{cases}$$

then show that $\lim_{n\to\infty} \int_0^2 f_n(x) = 0$.

5. Let $g(x) = \begin{cases} 0, & 0 \le x \le \frac{1}{2} \\ 1, & \frac{1}{2} \le x \le 1 \end{cases}$, $f_{2k}(x) = g(x)$, $f_{2k+1}(x) = g(1-x), 0 \le x \le 1$. Then show that $\lim_{n\to\infty} \inf \int_0^1 f_n(x)dx > \int_0^1 \lim_{n\to\infty} \inf f_n(x)dx$

**MTH-602 Real Analysis-II**

**Practical No. 06 : Sequence of real numbers**

1. Prove that a sequence of real numbers is Cauchy if and only if it is convergent.
2. Discuss the convergence of sequence whose $n^{th}$ term is $a_n = \left(1+\frac{1}{n}\right)^n$.
3. If $\{S_n\}_{n=1}^{\infty}$ is Cauchy's sequence of real numbers which has a subsequence converges to L, then show that $\{S_n\}_{n=1}^{\infty}$ itself converges to L.
4. If $\{S_n\}_{n=1}^{\infty}$ is sequence of real numbers which converges to L, then show that $\{S_n\}_{n=1}^{\infty}$ converges to $L^2$.
5. If $\{a_n\}_{n=1}^{\infty}$ is Cauchy's sequence of real numbers, then show that $\{a_n\}_{n=1}^{\infty}$ is also Cauchy.

**Practical No. 07 : Series of real numbers**

1. Discuss the convergence of series $\sum_{n=1}^{\infty} \frac{n+1}{n+2}$, does the $\sum_{n=1}^{\infty} \frac{n+1}{10^{10}(n+2)}$ converges or diverges?
2. Examine the convergence of the series $1 + x + x^2 + x^3 + -$
3. Discuss the convergence of series $\sum_{n=1}^{\infty} \frac{1}{(2n-1)!}$
4. Test the convergence of series
$$(1-2) - (1-2^{1/2}) + (1-2^{1/3}) - (1-2^{1/4}) + \cdots$$
5. Examine the convergence of the series $a)\ \sum_{n=1}^{\infty} \frac{5^n}{2^n+5}$ $b)\ \sum_{n=1}^{\infty} \frac{n!}{n^n}$

**Practical No. 08 : Sequence of functions**

1. Let $f_n(x) = \frac{x^n}{1+x^n}$, $0 \le x \le 1$. Show that $\{f_n\}_{n=1}^{\infty}$ converges pointwise on [0, 1]. If $\lim\limits_{n\to\infty} f_n(x) = f(x)$. Does there $N \in x$ such that $|f_n(x) - f(x)| < \frac{1}{4}$, $\forall n \in N$, for all $x \in [0,1]$.
2. If $f_n(x) = \frac{n}{n+x}$, $n \ge x$, then show that $\{f_n(x)\}_{n=1}^{\infty}$ is uniformly convergent in any finite interval.
3. Let $f_n(x) = \frac{\sin nx}{n}$, $0 \le x \le 1$. Show that $\{f_n\}_{n=1}^{\infty}$ converges uniformly to 0 but that $\{f_n\}_{n=1}^{\infty}$ does not converges even pointwise to 0 on [0, 1].
4. Let $f_n(x) = \frac{nx}{1+n^2x^2}$, $x \in R$. Show that $\{f_n\}_{n=1}^{\infty}$ is not uniformly convergent in [0, 1] although it converges pointwise to 0.
5. Let $f_n(x) = \frac{x}{1+nx}$, $0 \le x \le 1$. Then show that $\{f_n\}_{n=1}^{\infty}$ converges uniformly to 0.

**Practical No. 09 : Series of functions**

1. Show that the series $\sum_{n=1}^{\infty}\frac{sin(x^2+n^2x)}{n(n+2)}$ is uniformly convergent for all values of x.
2. Using Weierstress M-test, show that the series $\sum_{n=1}^{\infty}\frac{cos(x^2+n^2x)}{n(n^2+2)}$ is uniformly convergent.
3. Test the uniform convergence of the series $\sum_{n=0}^{\infty} xe^{-nx}$ on [0, 1].
4. Show that $\sum_{n=1}^{\infty}\frac{1}{n^p+n^qx^2}$ is uniformly convergent for all values of x if p>1.
5. Show that $\sum_{n=1}^{\infty}\frac{x}{n^p+n^qx^2}$ is uniformly convergent for all values of x if p+q>2.

**Practical No. 10 : Fourier Series in range $[-\pi,\pi]$**

1. If f is bounded and integrable on $[-\pi,\pi]$ and if $a_n,\ b_n$ are its fourier coefficients then prove that $\sum_{n=1}^{\infty}\left({a_n}^2+{b_n}^2\right)$ converges.
2. Obtain the Fourier series for $f(x)=\begin{cases}0 & for -\pi\le x\le 0\\ x & for\ \ 0\le x\le\pi\end{cases}$
3. Let $\frac{1}{2}a_0+\sum_{n=1}^{\infty}(a_n cosnx+b_n sinnx)$ be Fourier series which converges uniformly to f(x) on $[-\pi,\pi]$. Show that $\frac{1}{2}{a_0}^2+\sum_{n=1}^{\infty}\left({a_n}^2+{b_n}^2\right)=\frac{1}{\pi}\int_{-\pi}^{\pi}\{f(x)\}^2dx$
4. Obtain the Fourier series of the function $f(x)=nsinx$ in $[-\pi,\pi]$. Hence deduce that $\frac{\pi}{4}=\frac{1}{2}+\frac{1}{1.2}+\frac{1}{3.5}+\frac{1}{5.7}+\cdots$
5. Expand $f(x)=|x|$ in Fourier series in $[-\pi,\pi]$ and hence deduce that $\frac{\pi^2}{9}=\frac{1}{1^2}+\frac{1}{3^2}+\frac{1}{5^2}+\cdots$

| DSC Core (Practical) | | |
|---|---|---|
| **MTH – 608: Practical Course based on (MTH-603 & MTH-604)** | | |
| **Total Hours: 60** | | **Credits: 2** |
| | **Course objectives**<br>• To develop analytical and computational skills<br>• To get hands on training in solving problems of linear spaces and ordinary as well as partial differential equations. | |
| | **Learning outcomes**<br>After successful completion of this course, students are expected to:<br>• Understand basics of vector spaces and method of solving differential equations. | |
| **Unit** | **Topics** | **Lectures** |
| **UNIT-1** | Examples on unit -1 of (MTH-603 & MTH-604) | **12** |
| **UNIT-2** | Examples on unit -2 of (MTH-603 & MTH-604) | **12** |
| **UNIT-3** | Examples on unit -3 of (MTH-603 & MTH-604) | **12** |
| **UNIT-4** | Examples on unit -4 of (MTH-603 & MTH-604) | **12** |
| **UNIT-5** | Examples on unit -5 of (MTH-603 & MTH-604) | **12** |

## List of Practical's:

| MTH-608 | Practical Course based on MTH-603 & MTH-604 |
|---|---|

**MTH-603 : Linear Algebra**

**Practical No. 1 - Vector Spaces**

1. Let V be the set of all ordered pair $(p, q)$ of real numbers. Examine whether $V$ is a vector space over $\mathbb{R}$ or not with respect to the addition and scalar multiplication defined below:
   $(i)$ $(p,q)+(p',q')=(0,q+q'),\ \alpha(p,q)=(\alpha p,\alpha q)$.
   $(ii)$ $(p,q)+(p',q')=(p+p',q+q'),\ \alpha(p,q)=(0,\alpha q)$.
   $(iii)$ $(p,q)+(p',q')=(p+p',q+q'),\ \alpha(p,q)=(\alpha^2 p,\alpha^2 q)$.
2. If $V_3(\mathbb{R})$ be a vector space of all ordered triads $(x, y, z)$. Determine which of the following subsets of $V_3(\mathbb{R})$ are subspaces
   $(i)$ $W=\{(x,y,z) \mid x,y,z\in\mathbb{R}\ and\ x-3y+4z=0\}$
   $(ii)$ $W=\{(x,y,z) \mid x,y,z\in\mathbb{Q}\}$
   $(iii)$ $W=\{(x,y,z) \mid x\geq 0\}$
3. (a) Write the vector $v=(1,-2,5)$ as linear combination of the vectors
   $e_1=(1,1,1),\ e_2=(1,2,3),\ e_3=(2,-1,1)$
   (b) For which value of k will the vector $u=(1,-2,k)$in $\mathbb{R}^3$ be a linear combinations of the vectors $v=(3,0,-2)$ and $w=(2,-1,-5)$?

4. Show that the vectors $u = (1, 2, 3),\ v = (0, 1, 2)$ and $w = (0, 0, 1)$ generates $\mathbb{R}^3$.
5. Find the condition on a, b and c so that $(a, b, c) \in \mathbb{R}^3$ belongs to the space generated by $u = (2, 1, 0),\ v = (0, 1, 2)$ and $w = (0, 3, -4)$.

**Practical No. 2 Basis and Dimension**

1. If $x, y, z$ are linearly independent vectors over the field $\mathbb{C}$ of complex numbers then prove that $(i)\ x + y,\ y + z,\ z + x$ are also linearly independent over $\mathbb{C}$.
   $(ii)\ x + y,\ y - yz,\ x - 2y + z$ are linearly independent.
2. Find the co-ordinate vector of $v = (3, 5, -2)$ relative to the basis
   $e_1 = (1, 1, 1),\ e_2 = (0, 2, 3),\ e_3 = (0, 2, -1)$
3. Find the basis and dimension of solution space $W$ of the following system of equations
   $x + 2y - 4z + 3s - t = 0,\ \ x + 2y - 2z + 2s + t = 0,\ \ 2x + 4y - 2z + 3s + 4t = 0.$
4. Show that the vectors $(0, 1, -1), (1, 1, 0) and\ (1, 0, 2)$ is basis of a vector space $\mathbb{R}^3(\mathbb{R})$.
5. Let $W_1$ and $W_2$ be two subspaces of $\mathbb{R}^4$ given by $W_1 = \{(a, b, c, d) \mid b + d = 2c\}$, $W_2 = \{(a, b, c, d) \mid a = b, b = 2c\}$ . Find the basis and dimension of $(i)\ W_1,\ (ii)\ W_2,\ (iii)\ W_1 + W_2,\ (iv)\ W_1 \cap W_2$.

**Practical No. 3 Linear Transformations**

1. Let $T: \mathbb{R}^3 \to \mathbb{R}^3$ be the linear map defined by $T(x, y, z) = (x + 2y - z,\ y + z,\ x + y - 2z)$. Find the basis and dimension of the image of $T$.
2. Find the linear map $T: \mathbb{R}^3 \to \mathbb{R}^4$ whose image is generated by $(1, 2, 0, -4)$ and $(2, 0, -1, -3)$.
3. Show that the linear operator on $\mathbb{R}^3$ defined by $T(a, b, c) = (a + b + c,\ b + c,\ c)$ is non singular and find its inverse.
4. Let $T: \mathbb{R}^3 \to \mathbb{R}^3$ be the linear transformation defined by $T(x, y, z) = (3x,\ x - y,\ 2x + y + z)$. Prove that $T$ is invertible and find the formula for $T^{-1}$.
5. Let $T: \mathbb{R}^4 \to \mathbb{R}^3$ be the linear mapping defined by $T(x, y, s, t) = (x - y + s + t,\ x + 2s - t,\ x + y + 3s - 3t)$ . Find the basis and dimension of the kernel of $T$.

**Practical No. 4 Eigen Values and Eigen Vectors**

1. Find the eigen values and corresponding eigen vectors of the matrix $A = \begin{bmatrix} 1 & 2 \\ 3 & 2 \end{bmatrix}$.
2. Find the characteristics roots, their corresponding vectors and the basis for the vector space of the matrix $A = \begin{bmatrix} 2 & 1 & 0 \\ 0 & 1 & -1 \\ 0 & 2 & 4 \end{bmatrix}$.
3. Verify Cayley-Hamilton theorem for the matrix $A = \begin{bmatrix} 1 & 3 & 7 \\ 4 & 2 & 3 \\ 1 & 2 & 1 \end{bmatrix}$.
4. Find all eigen values and basis of each eigen space of linear operator $T: R^3 \to R^3$ defined by $T(x, y, z) = (2x + y,\ y - z,\ 4y + 4z)$.
5. Verify Cayley-Hamilton theorem for the matrix $A = \begin{bmatrix} 1 & 2 & 0 \\ 2 & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix}$ and hence obtain $A^{-1}$.

**Practical No. 5 Matrices and Linear Transformations**

1. Let $T$ be linear operator on $\mathbb{R}^3$ defined by $T(x, y, z) = (x - y,\ y - x,\ x - z)$. Find the matrix of $T$ with respect to basis $Q = \{(1, 0, 0),\ (0, 1, 1),\ (1, 1, 0)\}$.
2. Let $T$ be linear operator on $\mathbb{R}^2$ defined by $T(x, y) = (x + y,\ -2x + 4y)$. Compute the matrix of $T$ relative to basis $\{(1,1),\ (1, 2)\}$.

3. Let $T: \mathbb{R}^2 \to \mathbb{R}^3$ be a linear transformation defined by $T(x, y) = (y,\ 5x - 13y,\ 7x + 16y)$. Obtain the matrix of $T$ in the following basis of $\mathbb{R}^2$ and $\mathbb{R}^3$ where $B_1 = \{(3,1),\ (5,2)\}$ and $B_2 = \{(1,0,-1),\ (-1,2,2),\ (0,1,2)\}$ respectively.
4. Show that the matrix $A = \begin{bmatrix} 1 & -1 & 4 \\ -3 & 2 & 1 \\ 2 & 1 & -1 \end{bmatrix}$ is diagonalizable.
5. Find the matrix $P$ if exists which diagonalize matrix $A = \begin{bmatrix} 3 & 2 & 4 \\ 2 & 0 & 2 \\ 4 & 1 & 3 \end{bmatrix}$.

**MTH-604: Ordinary and Partial Differential Equation**

**Practical No. 6 - Exact Differential Equation**

1. Solve $(x^3 - 2x)\frac{d^3y}{dx^3} + 3(3x^2 - 2)\frac{d^2y}{dx^2} + 18x\frac{dy}{dx} + 6y = 24x$
2. Show that $\frac{d^3y}{dx^3} + cosx\frac{d^2y}{dx^2} - 2sinx\frac{dy}{dx} - ycosx = sin(2x)$ is exact and find its first integral.
3. Find $m$ , if $x^m$ is an integrating factor of the differential equation $x^2\frac{d^3y}{dx^3} + 4x\frac{d^2y}{dx^2} + (x^2 + 2)\frac{dy}{dx} + 3xy = 1$ and obtain its first integral.
4. Show that the equation $y + 3x\frac{dy}{dx} + 2y\left(\frac{dy}{dx}\right)^3 + \left(x^2 + 2y^2\frac{dy}{dx}\right)\frac{d^2y}{dx^2} = 0$ is exact and find its first integral.
5. Solve i) $\frac{d^2y}{dx^2} = a^2y$ ii) $\frac{d^2y}{dx^2} = \frac{a}{y^3}$

**Practical No. 7 - Linear Differential Equation of Second Order**

1. Find the general solution of $sin^2x\frac{d^2y}{dx^2} = 2y$ given that $y = cotx$ is a one integral.
2. Solve $(sinx - xcosx)y'' - xsinxy' + ysinx = 0$ if $y = sinx$ is solution of it.
3. Solve by using normal form $\frac{d^2y}{dx^2} - 2tanx\frac{dy}{dx} + 5y = 0$
4. Solve by removing the first derivative $x\frac{d}{dx}\left(x\frac{dy}{dx} - y\right) - 2x\frac{dy}{dx} + 2y + x^2y = 0$
5. Solve by changing the independent variable $x\frac{d^2y}{dx^2} + (4x^2 - 1)\frac{dy}{dx} + 4x^3y = 2x^3$

**Practical No. 8 - Linear Partial Differential Equations of First Order**

1. Form a partial differential equation by eliminating the arbitrary function $f$ from $f(x + y + z, x^2 + y^2 - z^2) = 0$
2. Find partial differential equation by eliminating the constants
   i) $x^2 + y^2 - (z - 1)^2 = a^2$ ii) $ax^2 + by^2 + z^2 = 1$
3. Find the general integral of
   i) $\left(\frac{y^2z}{x}\right)p + xzq = y^2$
   ii) $z(xp - yq) = y^2 - x^2$
4. Find the integral surface of the linear partial differential equation $x(y^2 + z)p - y(x^2 + z)q = (x^2 - y^2)z$ which contains the straight line $x + y = 0,\ z = 1$
5. Find the surface which is orthogonal to one parameter surface $z = cxy(x^2 + y^2)$ and which passes through the hyperbola $x^2 - y^2 = a^2$ and $z = 0$

**Practical No. 9 - Non-Linear Partial Differential Equations of Order one**

1. Show that the equations $xp - yq = x$ and $x^2p + q = xz$ are compatible.
2. Show that equations $xp = yq$ and $z(xp + yq) = 2xy$ are compatible and solve them.
3. Using Charpit's method find the complete integral if
   i) $(p^2 + q^2)y = qz$
   ii) $p^2x + q^2y = z$

4. Find the complete integral of the equations
   i) $p + q = pq$ ii) $zpq = p + q$ iii) $p^2y(1 + x^2) = qx^2$
5. Find the complete integral of the equations by using Jacobi's method
   i) $p^2x + q^2y = z$ ii) $z^2 = pqxy$

**Practical No. 10 - Non-linear Partial differential equation of order One**

1. Using Charpit's method find the complete integral of $(p^2 + q^2)y = qz$ .
2. Find the complete integral of the equations
   i) $p + q = pq$ ii) $zpq = p + q$ iii) $p^2y(1 + x^2) = qx^2$
3. Find the complete integral of $p^2x + q^2y = z$ by using Charpit's method .
4. Using Jacobi's method find complete integral of $p^2x + q^2y = z$

5. Find complete integral of $z^2 = pqxy$ by using Jacobi's method.

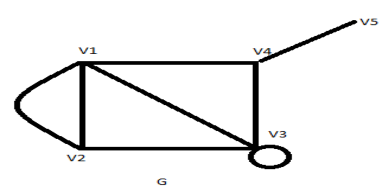
| DSC Core (Practical) | | |
|---|---|---|
| **MTH – 609: Practical Course based on (MTH-605, MTH-606(A) or MTH- 606(B))** | | |
| **Total Hours: 60** | | **Credits: 2** |
| | **Course objectives**<br>• To develop analytical and computational skills<br>• To get hands on training in solving problems of graph theory and either of SciLab or operations research. | |
| | **Learning outcomes**<br>After successful completion of this course, students are expected to:<br>• Students will develop problem solving analytical and computational skills. | |
| **Unit** | **Topics** | **Lectures** |
| **UNIT-1** | Examples on unit -1 of (MTH-605, MTH-606(A orB) | **12** |
| **UNIT-2** | Examples on unit -2 of (MTH-605, MTH-606(A orB) | **12** |
| **UNIT-3** | Examples on unit -3 of (MTH-605, MTH-606(A orB) | **12** |
| **UNIT-4** | Examples on unit -4 of (MTH-605, MTH-606(A orB) | **12** |
| **UNIT-5** | Examples on unit -5 of (MTH-605, MTH-606(A orB) | **12** |

## List of Practical's:

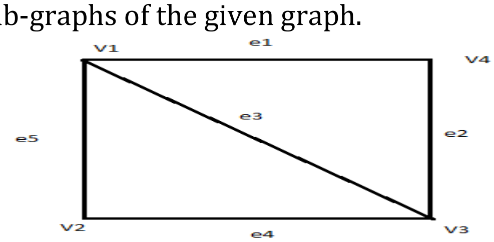
| MTH-609 | Practical Course based on (MTH-605, MTH-606(A) or MTH- 606(B)) |
|---|---|

**MTH-605 : Graph Theory**
**Practical no. 1 - Graph**

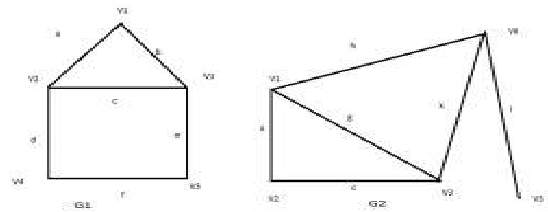
1. Verify Handshaking lemma for the following graph G. And also Find order and size of G.



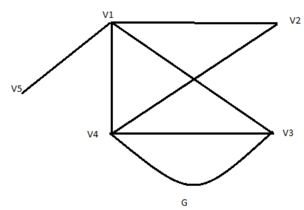

2. Find ten different sub-graphs of the given graph.



3. Find the Union, Intersection and ring sum for the graphs $G_1$ and $G_2$.

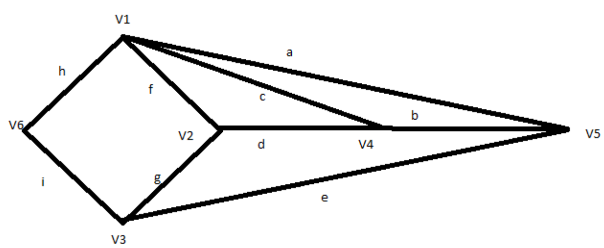


4. If G1 and G2 are regular graphs, is G1 + G2 regular? Justify.
5. Find six spanning sub graphs of following graph G.

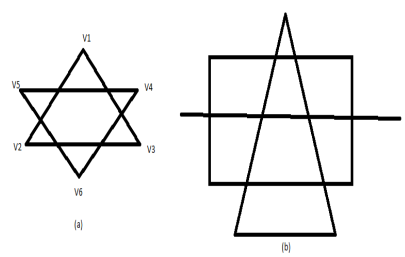



**Practical No. 2 - Connected Graph.**

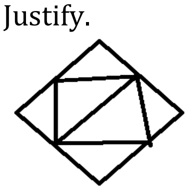
1. Find six different paths between vertices $V_5$ and $V_6$ in the following graph. Also give the length of these paths.




2. Which of the following graphs are connected? If not, then find components of the graphs.



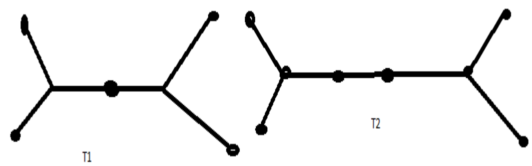

3. Is the following graph Eulerian? Justify.



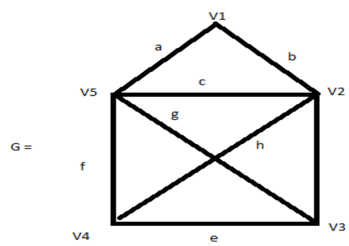
4. Draw two graphs in each case.
   i) Which is Hamiltonian but not Eulerian.
   ii) Which is Eulerian but not Hamiltonian.
4. Draw graph which is neither Eulerian nor Hamiltonian.

**Practical No. 3 - Trees**

1. Construct the tree on six vertices such that
   a) Which has minimum number of pendent vertices.
   b) Which has maximum number of pendent vertices.
2. Draw five non-isomorphic trees on six vertices.
3. construct a tree whose diameter is not equal to twice its radius.
4. Find eccentricity of each vertex. Also find centre, radius and diameter of the following graph.

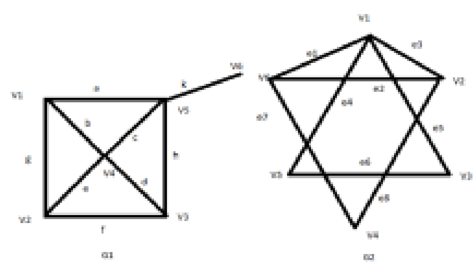



5. Draw six distinct spanning tree of the given graph G,

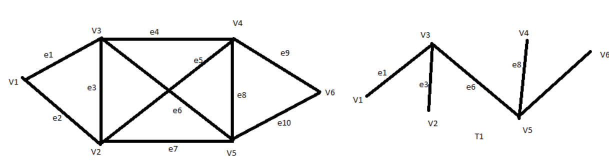



**Practical No. 4 - Cut Sets and Cut Vertices.**

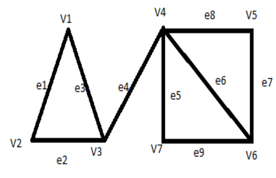
1. Find six different cut-set of the following graphs.



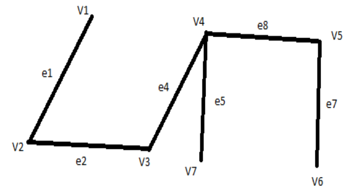
2. Construct a graph on 8 vertices, 16 edges and of vertex connectivity four.
3. With usual notations , construct a graph
   a) $K(G) = \lambda(G) = \delta(G)$
   b) $K(G) < \lambda(G) < \delta(G)$
4. Find fundamental cut-set and fundamental circuit for given graph and its given spanning tree.
   a)



b)

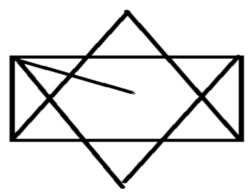



G1

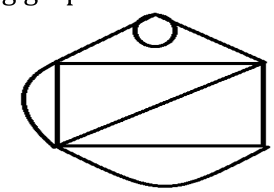



T1

5.Construct the geometrical dual of the following graphs



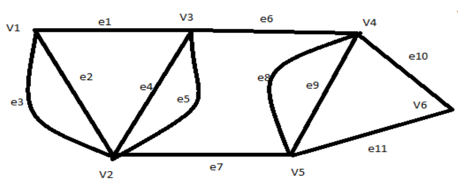
G1



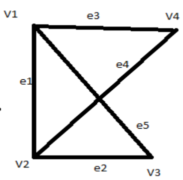
G2

**Practical No. 5 - Matrix Representation of a Graph.**

1. Find the incidence matrix of the following graphs.




G




G1

2. For the given incidence matrix, draw the graph.

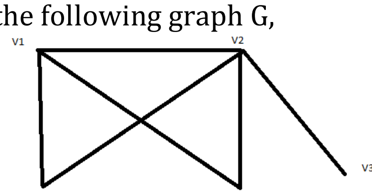
a)

| | e1 | e2 | e3 | e4 | e5 | e6 | e7 |
|---|---|---|---|---|---|---|---|
| V1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 |
| V2 | 1 | 0 | 1 | 0 | 1 | 0 | 0 |
| V3 | 0 | 1 | 1 | 0 | 1 | 0 | 1 |
| V4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| V5 | 0 | 0 | 0 | 1 | 0 | 1 | 1 |

b)

| | e1 | e2 | e3 | e4 | e5 | e6 | e7 | e8 |
|---|---|---|---|---|---|---|---|---|
| V1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| V2 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| V3 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| V4 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 |
| V5 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |

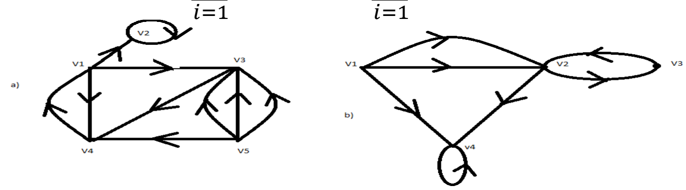
3. Find the adjancy matrix of the following graph G,



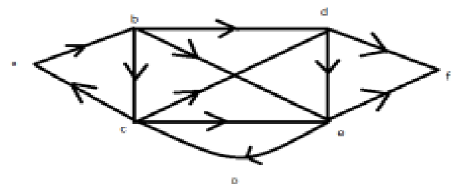

G

4. Find the indegree and outdegree of each vertex in the following digraphs and also verify handshaking Dilemma.

$$\sum_{i=1}^{n} d^{-}(Vi) = \sum_{i=1}^{n} d^{+}(Vi)$$



5. In digraph D given below , find five directed paths from vertex a to f and two directed circuits starting from vertex d.



**MTH: 365(A) Introduction to SciLab**

**Practical No. 6(A) - Introduction to SciLab**

1. Answer the following questions.
   a. What is the command to clear the screen?
   b. What is the short cut key to clear the screen?
   c. What is command history? What are the shortcut keys to use the command history?
   d. Is there a command to record all commands that you type and save them to a file so that you can see them later?
2. What are the rules for choosing names for variables in Scilab? Can you use a numeric character as the first character? Can you use underscore (_) as the first character? Can you use special characters, such as -, +, /, ? in a variable name?
3. Write a SciLab program for the following.
   a. Display your country name, university name, college name etc.
   b. Factorial of a single digit number.
   c. Absolute value of a number.
4. Write a SciLab program for the following problems
   a. Compute the area and circumference of a circle given the radius.
   b. Largest of three numbers.
   c. Logarithm of a number.
5. Write a SciLab program for the following problems
   a. Compute simple interest given the interest rate, principal and duration.
   b. Compute compound interest given the interest rate, principal, compounding nature and duration.

**Practical No. 7(A) -Elementary Mathematics through SciLab**

1. Define the complex numbers $z_1$ and $z_2$ in Scilab and perform the following mathematical operations on it. Also, try to plot the result in the Re-Im plane.
   a. Extract the real part and imaginary part of complex numbers.
   b. Define conjugate of complex number.
   c. Define addition of complex numbers.

2. Define the complex numbers $z_1$ and $z_2$ in Scilab and perform the following mathematical operations on it. Also, try to plot the result in the Re-Im plane.
   a. Define subtraction of complex numbers.
   b. Define multiplication of two complex numbers.
   c. Define division of two complex numbers.
3. Define the complex numbers $z_1$ and $z_2$ (Cartesian form) in Scilab and convert them into polar form.
4. Plot the following function in Scilab in the range of $-2\pi \le x \le 2\pi$
   a. $y = \sin(x)$
   b. $y = \cos(x)$
   c. $y = \tan(x)$
5. Plot the following function in Scilab in the range of $-2\pi \le x \le 2\pi$
   a. $y = \sinh(x)$
   b. $y = \cosh(x)$
   c. $y = \tanh(x)$

**Practical No. 8(A) -Matrices and Polynomials through SciLab**

1. Answer the following questions in Scilab.
   a. Create a $2 \times 3$ matrix of real values.
   b. Describe the addition of two matrices.
   c. Describe the multiplication of two matrices.
   d. Describe the scalar multiplication of matrix.
   e. Describe the power of a matrix.
   f. Describe the transpose of a matrix.
2. Discuss the following functions which generate matrices.

| | |
|---|---|
| eye | identity matrix |
| linspace | linearly spaced vector |
| Ones | matrix made of ones |
| Zeros | matrix made of zeros |

3. Discuss the solution of the system of linear equations in Scilab.
4. Write a Scilab program for the following.
   a. Define the polynomial $p_1(x)$ which has the following roots: $x_1 = -1, x_2 = 2$
   b. Define the polynomial which has the following coefficients: $a_1 = 3$, $a_2 = -3, a_3 = -8, a_4 = 7$.
5. Write a Scilab program for the addition, subtraction, multiplication, and division of the above two polynomials. (Refer the previous example)

**Practical no. 9(A) - Programming in SciLab**

1. List the rules to define variables in SciLab program.
2. Explain conditional statements: if, if-else, nested and ladder if-else, switch constructs
3. Write a note on break and continue statements
4. Explain in detail loops in SciLab
5. Describe the concept of functions and user defined functions in SciLab

**Practical No. 10(A) - Graphics and Applications in SciLab**

1. a. Write a Scilab program to plot 2d graph for a given set of data.
   b. Write a Scilab program to plot 3d graph for a given set of data.

2. Write a Scilab program to find an approximate solution of given transcendental equation using Bisection/Regula-Falsi/Newton Raphson method. Also plot its solution curve.
3. a. Write a Scilab program to find the solution of given system of linear equations.
   b. Write a Scilab program to find an eigen values of a given matrix.
4. Write a Scilab program to solve the given ODE using suitable method and plots its solution.
5. Write a Scilab program to solve the given definite integral using suitable method.

**MTH 606 (B): Operations Research**

**Practical No. 6(B): Linear Programming Problem (LPP)**

1. Use graphical method to solve the LPP
   Min $Z = x_1 + 0.5x_2$ subject to the constraints
   $3x_1 + 2x_2 \leq 12,\ 5x_1 \leq 10,\ x_1 + x_2 \geq 8, -x_1 + x_2 \geq 4,\ x_1, x_2 \geq 0.$
2. Use graphical method to solve the LPP
   Max. $Z = 2x_1 + 4x_2$subject to the constraints $x_1 + 2x_2 \leq 5,\ x_1 + x_2 \leq 4,\ x_1, x_2 \geq 0$. Is this LPP has alternative solution? If yes, find it.
3. Using graphical method show that the following LPP has unbounded solution.
   Max. $Z = 6x_1 + x_2$subject to the constraints $2x_1 + x_2 \geq 3,\ x_2 - x_1 \geq 0,\ x_1, x_2 \geq 0.$
4. Using graphical method show that the following LPP has infeasible solution.
   Max. $Z = x_1 + x_2$subject to the constraints $x_1 + x_2 \leq 1,\ -3x_1 + x_2 \geq 3,\ x_1, x_2 \geq 0.$
5. Reduce the following LPP to its standard form:
   Max $Z = x_1 + x_2 + 4x_3$ subject to the constraints
   $-2x_1 + 4x_2 \leq 4,\ \ x_1 + 2x_2 + x_3 \geq 5,\ \ 2x_1 + 3x_2 \leq 2$and$x_1, x_2, x_3 \geq 0.$

**Practical No. 7(B): Simplex Methods**

1. Use simplex method to solve the LPP
   Max $Z = 4x_1 + 10x_2$ subject to the constraints $2x_1 + x_2 \leq 50,\ \ 2x_1 + 5x_2 \leq 100,$ $2x_1 + 3x_2 \leq 90\ \ and\ \ x_1 \geq 0,\ x_2 \geq 0.$
2. Using Big-M method show that the following LPP does not possess any feasible solution.
   Max $Z = 3x_1 + 2x_2$ subject to the constraints $2x_1 + x_2 \leq 2,\ \ 3x_1 + 4x_2 \geq 12,$ $and\ \ x_1 \geq 0,\ x_2 \geq 0.$
3. Using Big-M method show that the following LPP has alternative solution.
   Max $Z = 6x_1 + 4x_2$ subject to the constraints $2x_1 + 3x_2 \leq 30,\ \ 3x_1 + 2x_2 \leq 24,$ $x_1 + x_2 \geq 3\ and\ \ x_1 \geq 0,\ x_2 \geq 0.$
4. Using simplex method solve the LPP
   Max $Z = 3x_1 + 4x_2$ subject to the constraints $x_1 + x_2 \leq 4,\ \ 2x_1 + x_2 \leq 5,$ $and\ \ x_1 \geq 0,\ x_2 \geq 0.$
5. Use simplex method to solve the LPP, Max$Z = 3x_1 + 2x_2$ subject to the constraints $x_1 + x_2 \leq 4,\ \ x_1 - x_2 \leq 2\ \ and\ \ x_1 \geq 0,\ x_2 \geq 0.$

**Practical No. 8 (B): Transportation Problem (TP)**

1. Obtain IBFS of TP by using North-West Corner rule

| | D | E | F | G | Available |
|---|---|---|---|---|---|
| A | 11 | 13 | 17 | 14 | 250 |
| B | 16 | 18 | 14 | 10 | 300 |
| C | 21 | 24 | 13 | 10 | 400 |
| Requirements | 200 | 225 | 275 | 250 | |

2. Obtain IBFS of TP by using Matrix Minima Method

| | $D_1$ | $D_2$ | $D_3$ | $D_4$ | Capacity |
|---|---|---|---|---|---|
| $O_1$ | 1 | 2 | 3 | 4 | 6 |
| $O_2$ | 4 | 3 | 2 | 0 | 8 |
| $O_3$ | 0 | 2 | 2 | 1 | 10 |
| Demand | 4 | 6 | 8 | 6 | |

3. Obtain IBFS of TP by using Vogel's Approximation Method

| | D | $E$ | $F$ | $G$ | Available |
|---|---|---|---|---|---|
| A | 11 | 13 | 17 | 14 | 250 |
| B | 16 | 18 | 14 | 10 | 300 |
| C | 21 | 24 | 13 | 10 | 400 |
| Demand | 200 | 225 | 275 | 250 | |

4. Convert the following unbalanced TP into balanced TP.

| | Destinations | | | | | | |
|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | V | Supply |
| Sources | A | 4 | 3 | 26 | 38 | 30 | 160 |
| | B | 3 | 2 | 34 | 34 | 198 | 280 |
| | C | 3 | 3 | 24 | 28 | 30 | 240 |
| | Demand | 1 | 1 | 200 | 120 | 240 | |

5. Obtain IBFS by VAM and solve the transportation problem for minimum cost.

| | $D_1$ | $D_2$ | $D_3$ | Supply |
|---|---|---|---|---|
| $S_1$ | 2 | 7 | 4 | 5 |
| $S_2$ | 3 | 3 | 1 | 8 |
| $S_3$ | 5 | 4 | 7 | 7 |
| $S_4$ | 1 | 6 | 2 | 14 |
| Demand | 7 | 9 | 18 | |

**Practical No. 9 (B): Assignment Problem (AP)**

1. Solve following AP.

| | I | II | III | IV |
|---|---|---|---|---|
| A | 2 | 3 | 4 | 5 |
| B | 4 | 5 | 6 | 7 |
| C | 7 | 8 | 9 | 8 |
| D | 3 | 5 | 8 | 4 |

Is there exist alternative solution? If Yes, Find it.

2. A departmental head has four subordinates and four tasks to be performed. The subordinates differs in efficiency and the tasks differ in their intrinsic difficulty. His estimate, of the time each man would take to perform each task, is given in the matrix below:

| Tasks | Men | | | |
|---|---|---|---|---|
| | E | F | G | H |
| A | 18 | 26 | 17 | 11 |
| B | 13 | 28 | 14 | 26 |
| C | 38 | 19 | 18 | 15 |
| D | 19 | 26 | 24 | 10 |

How should the tasks be allocated, one to a man, so as to minimize total man-hours?

3. Solve the following assignment problem for maximum profit.

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| A | 16 | 10 | 14 | 11 |
| B | 14 | 11 | 15 | 15 |
| C | 15 | 15 | 13 | 12 |
| D | 13 | 12 | 14 | 15 |

4. The following is the cost matrix of assigning 4 clerks to 4 key punching jobs. Find the optimal assignment if clerk I cannot be assigned to job 1:

| Clerk | Job | | | |
|---|---|---|---|---|
| | I | II | III | IV |
| 1 | --- | 5 | 2 | 0 |
| 2 | 4 | 7 | 5 | 6 |
| 3 | 5 | 8 | 4 | 3 |
| 4 | 3 | 6 | 6 | 2 |

What is the minimum total cost?

5. Convert the following unbalanced AP into balanced AP and solve it for minimization.

| | A | B | C |
|---|---|---|---|
| W | 9 | 26 | 15 |
| X | 13 | 27 | 6 |
| Y | 35 | 20 | 15 |
| Z | 18 | 30 | 20 |

**Practical No. 10 (B): Game Theory**

1. Find the best strategy of each player and the value of game.

| | Player B | | | | | |
|---|---|---|---|---|---|---|
| | | A | B | C | D | E |
| Player A | I | 9 | 3 | 1 | 8 | 0 |
| | II | 6 | 5 | 4 | 6 | 7 |
| | III | 2 | 4 | 3 | 3 | 8 |
| | IV | 5 | 6 | 2 | 2 | 1 |

2. A and B play a game in which each has three coins 5p ,10p and 20p each player selects the point without the knowledge of coin, if the sum of coin is an odd amount, A wins B's coin and if the sum of coin is even then B wins A's coin. Find the best strategy for player A &B and the value of game.
3. Find the ranges of values of $p$ &$q$ which will render the entry $(2,2)$a saddle point for the game

| | Player B | | | |
|---|---|---|---|---|
| Player A | | I | II | III |
| | I | 2 | 4 | 5 |
| | II | 10 | 7 | Q |
| | III | 4 | P | 6 |

4. Solve the following 2×4 game by graphical method.

| Player B | | | | | |
|---|---|---|---|---|---|
| Player B | | I | II | III | IV |
| | I | 3 | 3 | 4 | 0 |
| | II | 5 | 4 | 3 | 7 |

5. Solve the following game by graphical method.

| | Player B | | | | |
|---|---|---|---|---|---|
| Player A | | I | II | III | IV |
| | I | 19 | 6 | 7 | 5 |
| | II | 7 | 3 | 14 | 6 |
| | III | 12 | 8 | 18 | 4 |
| | IV | 8 | 7 | 13 | -1 |

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# Equivalence for T. Y. B. Sc. (Mathematics) Courses

| Old Syllabus (June 2017) (Semester pattern 60:40) | | New Syllabus (June 2020) CBCS pattern (Semester pattern 60:40) | |
|---|---|---|---|
| **Course code** | **Paper** | **Course code** | **Paper** |
| **Semester-V** | | | |
| MTH-351 | Topics in Metric Spaces | MTH-501 | Metric Spaces |
| MTH-352 | Integral Calculus | MTH-502 | Real Analysis- I |
| MTH-353 | Modern Algebra | MTH-503 | Algebra |
| MTH-354 | Lattice Theory | MTH-504 | Lattice Theory |
| MTH-355(A) | C-Programming | MTH-506(A) | C-Programming |
| MTH-355(B) | Elementary Number Theory | MTH-506(B) | Number Theory |
| MTH-356(A) | Vector Analysis | MTH-505 | Integral Transforms |
| MTH-356(B) | Integral Transforms | MTH-505 | Integral Transforms |
| MTH-357 | Practical Course based on MTH-351 & MTH-352 | MTH-507 | Practical Course based on MTH-501 & MTH-502 |
| MTH-358 | Practical Course based on MTH-353 & MTH-354 | MTH-508 | Practical Course based on MTH-503 & MTH-504 |
| MTH-359 | Practical Course based on MTH-355 & MTH-356 | MTH-509 | Practical Course based on MTH-505 & MTH-506 |
| **Semester-VI** | | | |
| MTH-361 | Measure and Integration Theory | MTH-601 | Measure Theory |
| MTH-362 | Method of Real Analysis | MTH-602 | Real Analysis- II |
| MTH-363 | Linear Algebra | MTH-603 | Linear Algebra |
| MTH-364 | Ordinary and Partial Differential Equations | MTH-604 | Ordinary and Partial Differential Equations |
| MTH-365(A) | Optimization Techniques | MTH-606(B) | Operations Research |
| MTH-365(B) | Dynamics | MTH-606(A) | Introduction to SciLab |
| MTH-366(A) | Applied Numerical Methods | MTH-605 | Graph Theory |
| MTH-366(B) | Differential Geometry | MTH-605 | Graph Theory |
| MTH-367 | Practical Course based on MTH-361 & MTH-362 | MTH-607 | Practical Course based on MTH-601 & MTH-602 |
| MTH-368 | Practical Course based on MTH-363 & MTH-364 | MTH-608 | Practical Course based on MTH-603 & MTH-604 |
| MTH-369 | Practical Course based on MTH-365 & MTH-366 | MTH-609 | Practical Course based on MTH-605 & MTH-606 |