5th Meeting of the Department Council
Tuesday, November 28, 2017

Proposed Scheme of Studies
B.Sc, BS, M.Sc, M.Phil, PhD Programs

Prepared By:
Dr Shah Muhammad, Assistant Professor,
Department of Mathematics, MUST, Mirpur

Mirpur University of Science and Technology (MUST)
Allama Iqbal Road, Mirpur-10250
Mirpur, Azad Jammu & Kashmir
### Members of the Department Council

The following members attended the meeting:

<table>
<thead>
<tr>
<th>Sr. #</th>
<th>Name</th>
<th>Designation</th>
<th>Signature</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Dr. Rashida Hussain</td>
<td>Chairperson, Department of Mathematics, MUST, Mirpur AJ&amp;K</td>
<td>Convener/Member</td>
</tr>
<tr>
<td>2</td>
<td>Prof. Dr. Rehana Asghar</td>
<td>Dean, Faculty of Sciences, MUST, Mirpur, AJK</td>
<td>Observer</td>
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<tr>
<td>3</td>
<td>Prof. Dr. Malik Zawwar Hussain, Department of Mathematics, University of Punjab, Lahore</td>
<td></td>
<td>Member</td>
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<td>4</td>
<td>Prof. Dr. Muhammad Mushtaq</td>
<td>Dept. of Mathematics, UET Lahore</td>
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<tr>
<td>5</td>
<td>Dr. Muhammad Munir</td>
<td>Associate Professor, Department of Mathematics, Post Graduate College, Abbottabad, KPK</td>
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<td>6</td>
<td>Mr. Suleman Khan</td>
<td>Assistant Prof. Dept. of Mathematics, MUST, Mirpur AJK</td>
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<tr>
<td>7</td>
<td>Dr. Shah Muhammad</td>
<td>Assistant Prof. Dept. of Mathematics, MUST, Mirpur AJK</td>
<td>Member/Secretary</td>
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<td>8</td>
<td>Director AS &amp; RB, MUST, Mirpur AJK</td>
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<td>Observer</td>
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<td>The Registrar, MUST, Mirpur AJK</td>
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<td>Observer</td>
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<tr>
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<td>The Controller of Examinations, MUST, Mirpur AJK</td>
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<td>Observer</td>
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<td>Director QEC, MUST, Mirpur AJK</td>
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<td>Observer</td>
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Introduction

The department of mathematics at MUST, Mirpur, AJ&K, was established in 2009. The first intake of the M.Sc program was inducted in the Spring 2010. The M.Phil program was launched in the Spring 2011. In the Fall 2012, the department launched its BS program. The PhD program was started in the Spring 2015.

Mission Statement: The department of mathematics is committed to provide a supportive and conducive academic environment for learning through its various programs. The focus of these programs is to produce intellectual mathematicians equipped with critical thinking, problem solving skills, innovation, and high professional ethics who could bring positive changes in our society.

Faculty Buildup:

The faculty build up chart since the start of this program is given below.

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<th>Year</th>
<th>PhD</th>
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<td>2016-2017</td>
<td>6</td>
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<td>2010-2011</td>
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Year-wise Enrolment Data:

The year-wise enrollement datails for each program are given below.

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<td>M.Sc</td>
</tr>
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<td></td>
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<td>Female</td>
</tr>
<tr>
<td>2017</td>
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<td>2011</td>
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<td>2010</td>
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1. **Scheme of Studies of BS Mathematics Program: General Breakup**

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<th>Remarks</th>
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<td>1.1</td>
<td>Awarding Institute/Body</td>
<td>Mirpur University of Science and Technology (MUST)</td>
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<tr>
<td>1.2</td>
<td>Teaching Institute</td>
<td>Department of Mathematics, Mirpur University of Science and Technology (MUST), and affiliated colleges</td>
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<td>1.3</td>
<td>Final Award</td>
<td>Bachelor Studies in Mathematics</td>
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<td>Starting Time for Program</td>
<td>Fall/Spring semester of each academic year</td>
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<td>1.6</td>
<td>Duration of the Program</td>
<td>8-12 Semesters</td>
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<td>1.7</td>
<td>Entrance Requirements</td>
<td>Intermediate or equivalent degree with mathematics (Min 45% marks)</td>
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<tr>
<td></td>
<td></td>
<td>No D-grade/3rd Division in matric and intermediate</td>
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<tr>
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<td></td>
<td>Entry Test conducted by the University with the following breakup: Mathematics: 30 %, English: 10%, two other subjects which the candidate have studied in intermediate with 30% weightage for each</td>
</tr>
<tr>
<td>1.8</td>
<td>Merit Formula</td>
<td>Merit shall be determined on 20% of SSC, 50% of Intermediate and 30% of Entry Test marks.</td>
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<tr>
<td>1.9</td>
<td>Total Credit Hours</td>
<td>Course Work: 127 Credit Hrs</td>
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<td>Project (Compulsory): 6 Credit Hrs</td>
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<td></td>
<td>Conference/Seminar/Reading- I &amp; II: S/U</td>
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1.10 **Program Educational Objectives:**

The BS Mathematics program is aimed at imparting quality education of mathematics to the youth of Mirpur division and the surrounding districts, at an affordable cost. The program will give an opportunity to the talented youth to satiate their desire to learn and excel in mathematics. The program will meet the demand of skilled mathematicians in the local job market. The objectives of the BS program also include: to teach students basic concepts of mathematics, to empower them with analytical and computational skills, to develop critical thinking, and to develop professional approach and work ethics. Moreover, the program is designed in such a way that the students can learn advanced mathematical concepts through the course work and the semester projects.

1.11 **Program Learning Outcomes (PLOs):**

The curriculum of the BS program is very diverse. During the first 4 semesters, beside some of the fundamental mathematics courses, the students also take many general and compulsory courses like
Physics, Mathematical Statistics, English, HR management, etc. These courses are so designed that students get useful knowledge and skills which will help them towards completion of their degrees.

1.12 Scope of the Program:
The mathematical experts are in demand across all kind of industries, the world over. Our graduates will be able to seek career opportunities in:

a). Teaching at school, college, or higher level  
b). R&D and strategic organizations like PAEC, NESCO, SUPARCO, etc.  
c). Banking sector, trading, and stock exchange businesses  
d). Higher studies in national and international universities and institutes  
e). Armed forces, civil services, oil and gas sector,

1.13 Program Structure and Features, Curriculum Units, Credit and Award Requirements

<table>
<thead>
<tr>
<th>Sr. No.</th>
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<td>Electives Courses</td>
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<td>06</td>
<td>Conference/Seminar/Reading I &amp; II</td>
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<tr>
<td>07</td>
<td>Project/Report</td>
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<td>06</td>
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<td>08</td>
<td>Comprehensive Oral Examination</td>
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Total 48 133

1.14 Layout/Framework

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<td></td>
<td>Introduction to Computers and Its Applications</td>
<td>03</td>
<td></td>
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<td>Islamic Studies/Ethics</td>
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<td>Introduction to Sociology/HR Management</td>
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### 1.15 Semester-Wise Breakdown

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<td>HUM-2410</td>
<td>Entrepreneurship</td>
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**3rd Year**

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<th>Course Title</th>
<th>Credits</th>
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<th>Year</th>
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<tr>
<td>MAT-3501</td>
<td>Real Analysis-I</td>
<td>3</td>
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<td>MAT-3502</td>
<td>Differential Equations II</td>
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<tr>
<td>MAT-3503</td>
<td>Differential Geometry-I</td>
<td>3</td>
<td>0</td>
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<td>MAT-3504</td>
<td>Analytical Mechanics</td>
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<td>MAT-3505</td>
<td>Topology</td>
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<td>MAT-3506</td>
<td>Abstract Algebra</td>
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**Semester-VI**

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<tr>
<td>MAT-3601</td>
<td>Real Analysis-II</td>
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<td>MAT-3602</td>
<td>Partial Differential Equations</td>
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<td>MAT-3603</td>
<td>Numerical Methods-I</td>
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<td>MAT-3604</td>
<td>Complex Analysis</td>
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<td>MAT-3605</td>
<td>Tensor Analysis</td>
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<td>MAT-3606</td>
<td>Scientific Programming</td>
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**4th Year**

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<tr>
<td>MAT-4702</td>
<td>Mathematical Physics</td>
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<td>MAT-4704</td>
<td>Functional Analysis</td>
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<td>MAT-4715</td>
<td>Conference/Seminar/Reading-I</td>
<td>S/U</td>
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<tr>
<td>MAT-4716</td>
<td>Project/Report</td>
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**Two Optional Courses**

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<th>Course Title</th>
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<tr>
<td>MAT-4701</td>
<td>Measure Theory</td>
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<td>MAT-4703</td>
<td>Numerical Methods II</td>
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<td>MAT-4705</td>
<td>Fluid Mechanics I</td>
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<tr>
<td>MAT-4706</td>
<td>Operation Research</td>
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<td>MAT-4707</td>
<td>Discrete Structures</td>
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<td>MAT-4709</td>
<td>Quantum Mechanics-I</td>
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<td>MAT-4710</td>
<td>Ring Theory</td>
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<td>MAT-4711</td>
<td>Analytical Dynamics</td>
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<td>MAT-4712</td>
<td>Introduction to Difference Equations</td>
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<td>0</td>
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<tr>
<td>MAT-4713</td>
<td>Differential Geometry-II</td>
<td>3</td>
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<tr>
<td>MAT-4714</td>
<td>Electromagnetic Theory-I</td>
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**Semester-VIII**

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<th>Course Code</th>
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<tr>
<td>MAT-4803</td>
<td>Integral Equations</td>
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<tr>
<td>MAT-4815</td>
<td>Conference/Seminar/Reading-II</td>
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<td>S/U</td>
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<tr>
<td>MAT-4816</td>
<td>Comprehensive Oral Examination</td>
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**Three Optional Courses**

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<tr>
<td>MAT-4801</td>
<td>Mathematical Systems Theory</td>
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<tr>
<td>MAT-4802</td>
<td>Mathematical Modeling</td>
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<td>MAT-4804</td>
<td>Optimization Theory</td>
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<td>MAT-4805</td>
<td>Fluid Mechanics II</td>
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<td>MAT-4806</td>
<td>Algebraic Topology</td>
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<td>MAT-4807</td>
<td>Special Functions</td>
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<td>MAT-4808</td>
<td>Financial Mathematics</td>
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<td>MAT-4809</td>
<td>Quantum Mechanics-II</td>
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<tr>
<td>MAT-4810</td>
<td>Introduction to Combinatorics</td>
<td>3</td>
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<tr>
<td>MAT-4811</td>
<td>Dynamical Systems</td>
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<td>MAT-4812</td>
<td>Theory of Elasticity</td>
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<td>MAT-4813</td>
<td>Special Theory of Relativity</td>
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<tr>
<td>MAT-4814</td>
<td>Electromagnetic Theory-II</td>
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1.16 Detail of Courses

Semester-I

Course Code: MAT-1105
Title: Calculus-I
Credit Hrs: 04

Course Outline:


Text and Reference Books
Course Code: MAT-1106  
Title: Foundation of Mathematics  
Credit Hrs: 03

Course Outline:  
Sets and its Subsets, Operations on Sets, Some Fundamental Results, Cartesian Products of Sets, Binary Relations, Equivalence Relations, Partially Ordered Relations, Functions and Their Graph, Countable and Uncountable Sets, Upper Bounds, Lower Bounds, Supremum and Infimum, Complex Numbers, Algebra of Complex Numbers, Modulus and Argument, Polar Form of a Complex Number, De Moivre’s Theorem, Roots, Complex-Valued Functions Binary Operations, Groups, Subgroups, Cyclic Groups, Groups of Permutations, Cycles, Transpositions, Order of a Permutation, Rings

Text and Reference Books

Course Code: MAT-1205  
Title: Calculus-II  
Credit Hrs: 04

Course Outline:
Conic section, parameterized curves and polar coordinates: Curves defined by parametric equations. Calculus with parametric curves: tangents, areas, arc length. Polar coordinates. Polar curves, tangents to polar curves. Area and arc length in polar coordinates.

Text and Reference Books

Course Code: MAT-1206  
Title: Linear Algebra-I  
Credit Hrs: 03


Text and Reference Books
Course Code: MAT-2303
Title: Mathematical Statistics I
Credit Hrs: 03

Course Outline: The postulates of probability, Some elementary theorems, Addition and multiplication rules, Baye’s rule and future Baye’s theorem, Random variables and probability functions, Uniform, Bernoulli and Binomial distribution, Hypergeometric and geometric distribution, Negative binomial and Poisson distribution, Uniform and exponential distribution, Gamma and beta distributions, Normal distribution, Moments and moment generating functions
Moments of binomial, hypergeometric, Poisson, gamma, beta and normal distributions

Text and Reference Books:

Course Code: MAT-2304
Title: Mechanics-I
Credit Hrs: 03

Course Outline:
Forces: Fundamental concepts and principles, Newtonian Mechanics, Inertial-non-inertial frames, Resultant of several concurrent forces, The parallelogram law of forces, Resolution of a forces, triangle of forces, Lamy’s theorem, polygon of forces, Conditions of equilibrium for a particle, External and internal forces, principle of transmissibility, Resultant of like and unlike parallel forces, Moment of forces about a point, Varignon’s theorem, Moment of a couple, equivalent couples, composition of couples, Reduction of coplanar forces to a force or a couple
Friction: Dry friction and fluid friction, Laws of dry friction, coefficients of friction, angle of friction, Equilibrium of a particle on a rough inclined plane, Particle on a rough inclined plane acted on by an external force, Conditions for sliding or titling
Virtual Work: Principle of virtual work, Problems involving tensions and thrust

Text and Reference Books:
1. A. Bedford and W. Fowler, Dynamics Engineering Mechanics, Addision-Wesley, Reading, USA.
Course Code: MAT-2305  Title: Calculus-III  Credit Hrs: 04

Course Outline:


Vectors and analytic geometry in space: Coordinate system. Rectangular, cylindrical and spherical coordinates. The dot product, the cross product. Equations of lines and planes. Quadric surfaces.


Text and Reference Books

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Course Code: MAT-2306  Title: LinearAlgebra-II  Credit Hrs: 02

Course Outline: Linear Transformations and the Matrix of Linear Transformations, Eigenvectors and eigenvalues, Diagonalization, Complex Eigenvalues, Inner Product Spaces, Length and Orthogonality, Orthogonal Sets and Orthogonal Projections, Gram-Schmidt Process, Symmetric Matrices, Diagonalization of Symmetric Matrices, Quadratic Forms

Text and Reference Books
Semester-IV

Course Code: MAT-2402  Title: Differential Equations I  Credit Hrs: 02

Course Outline:

Preliminaries: Introduction (Formulation and classifications of differential equations), existence and uniqueness of solutions, introduction of initial value and boundary value problems

First order ordinary differential equations: Basic concepts, Separable variables, Exact Equations, Homogeneous Equations, Linear equations, integrating factors. Some nonlinear first order equations with known solution, differential equations of Bernoulli and Ricaati type, Clairaut equation, modeling with first-order ODEs.

Second and higher order Linear differential equations: Initial value and boundary value problems, Homogeneous and non-homogeneous equations, Superposition principle, homogeneous equations with constant coefficients, Linear independence and Wronskian, Nonhomogeneous equations, undetermined coefficients method, variation of parameters, Cauchy-Euler equation, Modeling.

Text and Reference Books


Course Code: MAT-2403  Title: Mathematical Statistics II  Credit Hrs: 03

Course Outline: Distribution function technique, Transformation technique: One variable, several variables, Moment-generating function technique, The distribution of the mean, The distribution of the mean: Finite populations, The Chi-Square distribution., The t distribution, The F distribution, Regression and Correlation, Linear regression, The methods of least squares, Normal regression analysis, Normal correlation analysis, Multiple linear regression, Multiple linear regression (matrix notation)

Text and Reference Books

Course Code: MAT-2404  
Title: Mechanics-II  
Credit Hrs: 03

Course Outline:
Planer Motion of Rigid Bodies: Introduction to rigid and elastic bodies, degree of freedom, translations, rotations, instantaneous axis and center of rotation, Rotation of a rigid body about a fixed axis, moments and products of inertia. Parallel and perpendicular axis theorem.  

Text and Reference Books
1. A. Bedford and W. Fowler, Dynamics Engineering Mechanics, Addision-Wesley, Reading, USA.

Course Code: MAT-2405  
Title: Metric Spaces  
Credit Hrs: 02

Course Outline: Preliminary Concepts, Definition and Examples of Metric Spaces, Open and Closed Spheres and Sets, Convergent Sequences, Cauchy Sequences, Cantor’s Intersection Theorem, Complete Metric Spaces, Dense and Nowhere Dense Subsets, Continuous and Uniform Continuous Functions and Their Properties,

Text and Reference Books
Course Code: MAT-2406  Title: Number Theory  Credit Hrs: 02


Text and Reference Books

Semester-V

Course Code: MAT-3501  Title: Real Analysis-I  Credit Hrs: 03


Text and Reference Books

Course Code: MAT-3502  Title: Differential Equations II  Credit Hrs: 03

Course Outline:
Review of first order linear and nonlinear odes and higher order linear odes and their solution techniques. Basic theory of systems of first order linear equations, Homogeneous linear system with constant coefficients, Non homogeneous linear system, Series Solution and its Limitations, The Frobenius Method, Sturm-Liouville (S-L) System and Boundary-Value Problems, Solution of the Bessel, The Hypergeometric, The Legendre and the Hermite Equations, Properties of the Bessel, the Legendre and the Hermite Functions

Text and Reference Books
Course Code: MAT-3503    Title: Differential Geometry-I    Credit Hrs: 03


Text and Reference Books

---

Course Code: MAT-3504    Title: Analytical Mechanics    Credit Hrs: 03


Text and Reference Books
Course Code: MAT-3505  Title: Topology  Credit Hrs: 03

Course Outline: Overview of Metric Spaces, Convergence, and Continuity in Metric Spaces, Topological Spaces, Sub-Spaces, Closed Sets, Closures and Interiors of Sets, Boundary of a Set, Limit Point, Bases and Sub-bases, Neighborhood Base, First and Second Countable Spaces, Continuous Functions and Homeomorphism, Product Topology
$T_0$, $T_1$, $T_2$ Spaces and Their Characterizations and Basic Properties, Regular and Completely Regular Spaces, Normal and Completely Normal Spaces, Compact / Countable Spaces and Their Properties, Connected Spaces

Text and Reference Books

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Course Code: MAT-3506  Title: Abstract Algebra  Credit Hrs: 03

Course Outline: Sets and Structures, Basic Axioms and Order of a Group, Subgroups, Subgroups Generated by Subset of a Group, System of Generators, Cyclic Group, Cosets, Lagrange’s Theorem, Permutations, Even and Odd Permutations, Cycles, Lengths of Cycles, Transpositions, Symmetric and Alternating Group, Normalizers and Centralizers of a Subset of a Group, Centre of a Group, Normal Subgroup, Quotient Groups, Conjugacy Relation between Elements and Subgroups, Homomorphism and Isomorphism between Groups, Homomorphism and Isomorphism Theorems,

Text and Reference Books
Semester-VI

**Course Code:** MAT-3601  **Title:** Real Analysis-II  **Credit Hrs:** 03

**Course Outline:**


**Text and Reference Books**


**Course Code:** MAT-3602  **Title:** Partial Differential Equations  **Credit Hrs:** 03

**Course Outline:**

**First order PDEs:** Introduction, formation of PDEs, solutions of PDEs of first order, The Cauchy’s problem for quasilinear first order PDEs, First order nonlinear equations, Special types of first order equations. **Second order PDEs:** Basic concepts and definitions, Mathematical problems, Linear operators, Superposition, Mathematical models: The classical equations, the vibrating string, the vibrating membrane, conduction of heat solids, canonical forms and variable, PDEs of second order in two independent variables with constant and variable coefficients, Cauchy’s problem for second order PDEs in two independent variables. **Methods of separation of variables and Green’s Functions:** Solutions of elliptic, parabolic and hyperbolic PDEs in Cartesian and cylindrical coordinates.

**Text and Reference Books**

Course Code: MAT-3603  
Title: Numerical Methods-I  
Credit Hrs: 03


Text and Reference Books

Course Code: MAT-3604  
Title: Complex Analysis  
Credit Hrs: 03


Text and Reference Books
Course Code: MAT-3605  Title: Tensor Analysis  Credit Hrs: 02


Text and Reference Books

Course Code: MAT-3606  Title: Scientific Programming  Credit Hrs: 2+1

Course Outline (Matlab, Maple, and Mathematica): A list of contents is given below. However the instructor may add or remove some of the contents depending on the need of the students.
Curve sketching (only graphs of functions of one variable in Cartesian Coordinates) by using standard procedure, Intro to MATLAB (history, installation, interface, using product help, etc), MATLAB vs Maths syntax, sketching plane curves and surfaces in MATLAB, use of MATLAB in linear algebra, symbolic computations using MATLAB, creating script and function m-files, MATLAB codes for Bisection, Newton-Raphson, secant, Regula-Falsi, Jacobi, GS, Euler, and RK-4 methods. A brief introduction to Maple/Mathematica, comparison between similar features of MATLAB and Maple/Mathematica.
The following points are important for teaching this course:
1. The course should be taught in a computer lab setting
2. At the completion of this course, the students must be able to utilize the software to solve computationally difficult problems
3. The students should have a good command on at least two of the three programs mentioned above

Text and Reference Books
Course Code: MAT-4701 Title: Measure Theory Credit Hrs: 03

Course Outline: Definition and Examples of Algebra and σ-Algebra, Basic Properties of Measurable Spaces, Definition and Examples of Measure Spaces, Outer Measure, Lebesgue Measure, Measurable Sets, Complete Measure Spaces, Measurable Functions: Some Equivalent Formulations of Measurable Functions, Examples of Measurable Functions, Various Characterizations of Measurable Functions, Properties that Hold Almost Everywhere, Definition of Lebesgue Integral, Basic Properties of Lebesgue Integrals, Comparison between Riemann Integration and Lebesgue Integration, L²-Spaces

Text and Reference Books

Course Code: MAT-4702 Title: Mathematical Physics Credit Hrs: 03

Course Outline: Definition and Properties of Laplace and Inverse Laplace Transforms, s-shifting property of LT, existence and uniqueness theorem, LT of derivatives and integrals and solution of ivps, unite step function and t-shifting property of LT, solution of circuit problems by using LT, Dirac Delta Function and its properties, LT of periodic functions, Convolution Theorem, Convolution of discontinuous functions, solution of integral equations by LT, differentiation and integration of LT, Laguerre’s equation and polynomials, Applications of Laplace Transforms to systems of ODEs and PDEs, Fourier Series of 2pi and 2L periodic functions, Convergence and sum of FS, even and odd functions and half-range expansions of FS, solution of odes and pdes by using FS, Fourier Integrals, Fourier Sine and Cosine integrals, Fourier sine and cosine transforms, Fourier sine and cosine transforms of derivatives, existence of FT, FT of derivatives, Convolution theorem, Discrete and Fast Fourier Transforms, solution of odes and pdes by using FT.

Text and Reference Books
Course Code: MAT-4703 Title: Numerical Methods-II Credit Hrs: 03


Text and Reference Books

Course Code: MAT-4704 Title: Functional Analysis Credit Hrs: 03


Text and Reference Books
Course Code: MAT-4705  Title: Fluid Mechanics-I  Credit Hrs: 03


Irrotational Fluid Motion: Velocity Potential from an Irrotational Velocity Field, Streamlines, Vortex Lines and Vortex Sheets, Kelvins Minimum Energy Theorem, Conservation of Linear Momentum, Bernoullis Theorem and Its Applications, Circulations, Rate of Change of Circulation (Kelvins Theorem), Axially Symmetric Motion, Stokes Stream Function

Two-Dimensional Motion: Stream Function, Complex Potential and Complex Velocity, Uniform Flows, Sources, Sinks and Vortex Flows, Flow in a Sector, Flow Around a Sharp Edge, Flow Due to a Doublet

Text and Reference Books

Course Code: MAT-4706  Title: Operation Research  Credit Hrs: 03


Text and Reference Books
4. W. L. Winston, Practical Management Science: Spreadsheet Modeling and Applications
Course Code: MAT-4707  
Title: Discrete Structures  
Credits: 3

Course Outlines: Set and Relations: Basic Notions, Set Operations, Venn Diagrams, Extended-Set Operations, Indexed Family of Sets, Countable and Uncountable Sets, Relations, Cardinality, Equivalence Relations, Congruence, Partitions, Partial Order, Representation of Relations, Mathematical Induction

Elementary Logic: Logics of Order Zero and One, Propositions and Connectives, Truth Tables, Conditionals and Bi-Conditionals, Quantifiers, Methods of Proof, Proofs Involving Quantifiers

Text and Reference Books


Course Code: MAT-4708  
Title: Special Functions  
Credit Hrs: 03

Course Outline: Infinite Products: introduction, Definition of an infinite product, A necessary condition for convergence, Associated series of logarithms, Convergences types, The Gamma and Beta Functions: The Euler constant, The Gamma function, A series for logarithmic differential of Gamma function, The order symbols o and O, Evaluation of certain infinite products, The Beta Function, Factorial function, Asymptotic Series: Definition of an asymptotic expansion, Algebraic properties, Term by term integration, Uniqueness, The Hypergeometric function: Simple integral form, The function $F(a, b; c, z)$ and its properties, The Hypergeometric differential equation, Logarithmic solution of the hypergeometric function, $F(a, b; c, z)$ as a function of parameters, Elementary series manipulation, Kummer Theorem, Generalized Hypergeometric functions, the exponential and binomial functions, A differential equation, Saalschutz theorem, Contour integral integrals of Barnes’ type, the Barnes integrals and the generalized hypergeometric function, Bessel Functions and its properties, The Confluent Hypergeometric functions and its properties, Generating Functions.

Text and Reference Books

Course Code: MAT-4709  Title: Quantum Mechanics-I  Credit Hrs: 03

Function Spaces and Hermitian Operators: Particle in a Box, Dirac Notation, Hilbert Space. Hermitian Operators, Properties of Hermitian Operators, Additional One-Dimensional Problems: Bound and Unbound States: General Properties of the One Dimensional Schrodinger Equation, Unbound States, One-Dimensional Barrier Problems, The Rectangular Barrier, Tunneling

Text and Reference Books

Course Code: MAT-4710  Title: Ring Theory  Credit Hrs: 03

Course Outline:
The fundamental theorem of symmetric polynomials.

Text and Reference Books
Course Code: MAT-4711
Title: Analytical Dynamics
Credit Hrs: 03

Course Outline: Constraints, Generalized Coordinates, Generalized Forces, General Equation of Dynamics, Lagrange’s Equations, Conservation Laws, Ignorable Coordinates, Explicit Form of Lagrange’s Equation in Terms of Tensors. Hamilton’ Principle of Least Action, Hamilton’s Equations of Motion, Hamilton-Jacobi Method, Poisson Brackets (P.B’s); Poisson’s Theorem; Solution of Mechanical Problems by Algebraic Technique Based on (P.B’s) Small Oscillations and Normal Modes, Vibrations of Strings, Transverse Vibrations Normal Modes, Forced Vibrations and Damping, Reflection and Transmission at a Discontinuity, Longitudinal Vibrations, Rayleigh’s Principle

Text and Reference Books

MAT-4712
Introduction to Difference Equations
Credit Hrs: 3


Recommended Books:
Course Code: MAT-4713  Title: Differential Geometry-II  Credit Hrs: 03


Text and Reference Books

Course Code: MAT-4714  Title: Electromagnetic Theory-I  Credit Hrs: 03


Text and Reference Books
**Course Code:** MAT-4715  
**Title:** Conference/Seminar/Reading-I  
**Credit Hrs:** S/U

**Course Outline:** The purpose of this activity is to introduce students with the importance of conferences, seminars, and reading in scientific and academic development. Through various activities, students will be encouraged and trained to develop reading habits, especially of reference books and scientific articles. They will also trained on preparing papers and presentations for conferences and seminars.

**Text and Reference Books**
As per requirement of the students taking the course.

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**Course Code:** MAT-4716  
**Title:** Project/Report  
**Credit Hrs:** 06

**Course Outline:**
The objective of this course is to train students to learn and use the tools required for writing their project reports and the tools for doing their research work. They will do the literature survey, work on some research problem (theoretical or practical) and write a project or review report by the end of the course.

**Text and Reference Books**
As per requirements of the topic of the Project.
**Course Code:** MAT-4801  
**Title:** Mathematical Systems Theory  
**Credit Hrs:** 03

**Course Outline:** Conservation laws and phenomenological principles, some principles and laws of thermodynamics, mechanics, and electromagnetism and their applications in modelling, Linearization, matrix exponentials and solution of linear differential equations, LTV systems, Impulse and step responses, Stability, controllability, and observability of LTI systems, Realization theory and Hankel matrices, Feedback and stabilizability, observers and state reconstruction, detectability, separation principle and compensation, disturbance rejection, Laplace transforms and LTI systems, transfer functions and transfer matrices, transfer functions and minimal realizations of SISO and MIMO systems, Abstract systems description and behavioral modeling, polynomial representations of systems, brief discussion of nonlinear, descriptor, stochastic, distributed system, and discrete event systems, optimal control theory, parameter estimation, filter theory, model reduction, and adaptive and robust control.

**Text and Reference Books**

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**Course Code:** MAT-4802  
**Title:** Mathematical Modeling  
**Credit Hrs:** 03

**Course Outline:** Introduction to modeling. Basic Guide line of mathematical modeling, Collection and interpretation of data, Technique of mathematical modeling, Classification of mathematical modeling, modeling through algebra, modeling through Geometry, modeling through Trigonometry, modeling through Calculus, Limitation of modeling, Development of Models’, , Discrete and Continuous models,, Linear Growth and Decay Model, Non-linear Growth and decay models, Mathematical modeling in population dynamic, Traffic flow models.

**Text and Reference Books**
4. S. Banerjee, *Mathematical modeling (Modell analysis and Application)*
Course Code: MAT-4803  
Title: Integral Equations  
Credit Hrs: 03


Text and Reference Books

Course Code: MAT-4804  
Title: Optimization Theory  
Credit Hrs: 03

Course Outline: Linear Programming: Simplex Method, Duality Theory, Dual and Primal-Dual Simplex Methods Unconstrained Optimization: Optimality Conditions, One-Dimensional Problems, Multi-Dimensional Problems and the Method of Steepest Descent, Constrained Optimization with Equality Constraints, Optimality Conditions, Lagrange Multipliers, Hessians and Bordered Hessians, Inequality Constraints, the Kuhn-Tucker Theorem and Applications

Text and Reference Books
Course Code: MAT-4805  
Title: Fluid Mechanics-II  
Credit Hrs: 03

Course Outline: Circular Cylinder without Circulation, Circular Cylinder with Circulation Blasius Theorem, Kutta Condition and the Flat-Plate Airfoil, Joukowski Airfoil, Vortex Motion, Karman’s Vortex Street, Method of Images, Velocity Potential, Stoke’s Stream Function, Solution of the Potential Equation, Uniform Flow Source and Sink, Flow Due to A Doublet Viscous Flows of Incompressible Fluids: Constitutive Equations, Navier-Stokes’s Equations, Exact Solutions of Navier-Stokes’s Equations, Steady Unidirectional Flow, Poiseuille Flow, Coquette Flow, Flow between Rotating Cylinders, Stoke’s First Problem, Stoke’s Second Problem  
Simplified Approach to Fluid Flow Problems: Similarity from Differential Equations, Dimensional Analysis, One Dimensional Steady Compressible Flow

Text and Reference Books

Course Code: MAT-4806  
Title: Algebraic Topology  
Credit Hrs: 03

Course Outline: Path Wise Connectedness with Examples, Notion of Homotopy, Homotopy Classes and its Application, Path Homotopy, Path Homotopy Classes, Fundamental Groups, Covering Mapping with Examples, Covering Spaces, Lifiting Properties of Covering Spaces and its Application, Fundamental Group of a Circle (s)

Text and Reference Books
Course Code: MAT-4807  Title: Special Functions  Credit Hrs: 03

Course Outline: Infinite Products: introduction, Definition of an infinite product, A necessary condition for convergence, Associated series of logarithms, Convergences types, The Gamma and Beta Functions: The Euler constant, The Gamma function, A series for logarithmic differential of Gamma function, The order symbols o and O, Evaluation of certain infinite products, The Beta Function, Factorial function, Asymptotic Series: Definition of an asymptotic expansion, Algebraic properties, Term by term integration, Uniqueness, The Hypergeometric function: Simple integral form, The function F(a,b;c,z) and its properties, The Hypergeometric differential equation, Logarithmic solution of the hypergeometric function, F(a,b;c,z) as a function of parameters, Elementary series manipulation, Kummer Theorem, Generalized Hypergeometric functions, the exponential and binominal functions, A differential equation, Saalschütz theorem, Contour integral integrals of Barnes’ type, the Barnes integrals and the generalized hypergeometric function, Bessel Functions and its properties, The Confluent Hypergeometric functions and its properties, Generating Functions.

Text and Reference Books

Course Code: MAT-4808  Title: Financial Mathematics  Credit Hrs: 03


Text and Reference Books
**Course Code:** MAT-4809  **Title:** Quantum Mechanics-II  **Credit Hrs:** 03


**Text and Reference Books**


**Course Code:** MAT-4810  **Title:** Introduction to Combinatorics  **Credit Hrs:** 03


**Text and Reference Books**

**Course Code:** MAT-4811  
**Title:** Dynamical Systems  
**Credit Hrs:** 03


**Text and Reference Books**


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**Course Code:** MAT-4812  
**Title:** Theory of Elasticity  
**Credit Hrs:** 03

**Course Outline:** Cartesian Tensors, Analysis of Stress and Strain, Generalized Hooke’s Law, Crystalline Structure, Point Groups of Crystals, Reduction in the Number of Elastic Moduli Due to Crystal Symmetry, Equations of Equilibrium, Boundary Conditions, Compatibility Equation, Plane Stress and Plane Strain Problems, Two Dimensional Problem in Rectangular and Polar Coordinates, Torsion of Rods and Beams

**Text and Reference Books**

Course Code: MAT-4813  
Title: Special Theory of Relativity  
Credit Hrs: 03

Course Outline: Historical Background and Fundamental Concepts of Special Theory of Relativity, Lorentz Transformations (for Motion Along One Axis), Length Contraction, Time Dilation and Simultaneity, Velocity Addition Formulae, 3-Dimensional Lorentz Transformation, Introduction to 4-Vector Formalism, Lorentz Transformations in the 4-Vector Formalism, The Lorentz and Poincare Groups, Introduction to Classical Mechanics, Minkowski Space-Time and Null Cone, 4-Velocity, 4-Momentum and 4-Force, Application of Special Relativity to Doppler Shift and Compton Effect, Particle Scattering, Binding Energy, Particle Production and Decay, Electromagnetism in Relativity, Electric Current, Maxwell’s Equations and Electromagnetic Waves, The 4-Vector Formulation of Maxwell’s Equations, Special Relativity with Small Acceleration

Text and Reference Books

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Course Code: MAT-4814  
Title: Electromagnetic Theory-II  
Credit Hrs: 03


Text and Reference Books
Course Code: MAT-4815  Title: Conference/Seminar/Reading-I  Credit Hrs: S/U

Course Outline: The purpose of this activity is to introduce students with the importance of conferences, seminars, and reading in scientific and academic development. Through various activities, students will be encouraged and trained to develop reading habits, especially of reference books and scientific articles. They will also trained on preparing papers and presentations for conferences and seminars.

Text and Reference Books
As per requirement of the students taking the course.

Course Code: MAT-4816  Title: Comprehensive Oral Exam  Credit Hrs: S/U

Course Outline: This exam will be conducted at the end of the 8th semester. One external examiners and two internal examiners will conduct this exam from each student.
9- Details of Allied Courses BS-4 Years Program

Course Code: ISL-1101  
**Title:** Islamic Studies  
**Credit Hrs:** 02


**Text and Reference books:**

Course Code: ENG-1102  
**Title:** English-I  
**Credit Hrs:** 03

**Contents:** Basics of Grammar, Parts of Speech and Use of Articles, Sentence Structure, Active and Passive Voice, Practice in Unified Sentence, Analysis of Phrase, Clause and Sentence Structure, Transitive and Intransitive Verbs, Punctuation and Spelling, **Comprehension:** Answers to questions on a given text, **Discussion:** General topics and every-day conversation (topics for discussion to be at the discretion of the teacher keeping in view the level of students), **Listening:** To be improved by showing documentaries/films carefully selected by subject teachers, Translation Skills: Urdu to English, **Paragraph Writing:** Topics to be chosen at the discretion of the teacher, **Presentation skills:** Introduction

**Text and Reference books:**
**Course Code:** COM-1103    **Title:** Introduction to Computer and Its Applications    **Credit Hrs:** 03

**Contents:** Content will be determined by the teacher with the following points in view: At the end of the semester student must be equipped with the following:

1. Basics of the hardware and operating system
2. MS Word, Excel, Power Point
3. Use of Internet
4. Installation of Softwares
5. Handling Emails

**Text and Reference books:**


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**Course Code:** PHY-1104    **Title:** Physics-I    **Credit Hrs:** 03

**Contents:** Work and Energy, Impulse and Momentum, Circular Motion, Mass and Energy, Collisions, Center of Mass, Moment, Center of Gravity, Couples, Angular Motion, Kinetic Energy of Rotation, Moment of Inertia, Parallel Axis Theorem, Momentum, Angular Momentum and Energy, Elastic Restoring Forces, Circle of Reference, Harmonic Motion Density, Pressure in a Fluid, Pressure Gauges, Pumps, Archimedes’ Principle, Forces against a Dam, Surface Tension, Pressure Difference across a Surface Film, Contact Angle and Capillarity Equation of Continuity, Bernoulli’s Equation, Applications of Bernoulli’s Equation, Viscosity, Poiseuilles’s Law, Stokes’ Law, Reynolds Number Waves and Mathematical Description, Speed of a Transverse Wave and Longitudinal Wave, Adiabatic Character of a Longitudinal Wave, Water Waves, Superposition and Standing Waves, Longitudinal Standing Waves, Vibrations of Organ Pipes, Vibrations of Rods and Plates, Interference of Longitudinal Waves, Resonance, Sound Waves, Doppler Effect, Radiation from a Piston, Applications of Acoustic Phenomena

**Text and Reference books:**

Course Code: HUM-1201  
Title: Arabic  
Credit Hrs: 02  

Course Contents: Arabic to Urdu Translation, Urdu to Arabic Translation, Grammar, Comprehension.


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Course Code: ENG-1202  
Title: English-II (Communications Skills)  
Credit Hrs: 03  

Contents: Paragraph Reading (Practice in writing a good, unified, and coherent paragraph), Essay Writing, CV and Job Application, Translation Skills, Study Skills (Skimming and Scanning, intensive and extensive, and speed reading, summary and précis writing, and comprehension), Academic Skills, Personality development (emphasis on content, style, and pronunciation)

Text and Reference Books:

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Course Code: HUM-1203  
Title: Pak-Studies  
Credit Hrs: 02  


Text and Reference Books:
Course Code: PHY-1204  Title: Physics-II  Credit Hrs: 03


Text and Reference books:

Course Code: HUM-2301  Title: Introduction to Sociology  Credit Hrs: 03

Contents: Introduction, Scope and Subject Matter, Sociology as a Science, Historical back ground, Basic Concepts, Social Interaction: Levels of Social Interaction, Social Groups, Culture, Norms and Social Sanctions, Socialization & Personality, Deviance and Social Control, Collective Behavior

Text and Reference books:
Course Code: ENG-2302  
Title: English-II  
Credit Hrs: 03  

Contents: Presentation Skills, Essay Writing (Descriptive, narrative, discursive, argumentative), Academic Writing (How to write a proposal for research paper/term paper, how to write a research/term paper with emphasis on style, contents, language, form, clarity, consistency), Technical Report Writing, Progress report Writing.

Text and Reference Books:

Course Code: HUM-2308  
Title: HR Management  
Credit Hrs: 03  

Course Contents:

Text and Reference Books:

Course Code: PSY-2401  
Title: Educational Psychology  
Credit Hrs: 03  


Text and Reference Books:
Course Code: HUM-2408  Title: Organizational Behavior  Credit Hrs: 03

Course Contents: An overview of the field of organizational behavior, Individual behaviour and learning in organizations, Theories of employee motivation and reward system, Communications in Organizations, Group Dynamics, Teambuilding and Decision Making, Organizational Conflict & Resolution strategies, Organizational change and development, Organizational culture and Organizational structure and design.

Text and Reference books:

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Course Code: ENG-2409  Title: Business Mathematics  Credit Hrs: 03

Contents: Basic mathematical concepts and their application in various business real numbers, Linear equations and their applications, System of linear equations, Functions (linear functions, quadratic and polynomial functions, exponential and logarithmic functions), Matrix algebra, Differentiation and Integration, Mathematics of finance, Ratios, Proportions and Percentages, Principle of simple Interest, Principle of compound Interest, Annuities, Loans and Mortgages, Investment decisions, Discrete and continuous variables, Linear equations and inequalities and graphs, Progression of Sequence and Series and their applications in business, Permutations, Combination and their applications in business and finance.

Text and Reference books:
Course Code: HUM-2410  
Title: Entrepreneurship  
Credit Hrs: 03

Course Contents:

Recommended Books:

2. Scheme of Studies for MSc Mathematics: General Breakup

<table>
<thead>
<tr>
<th>Content</th>
<th>Description</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Awarding Institute/Body</td>
<td>Mirpur University of Science and Technology (MUST)</td>
<td></td>
</tr>
<tr>
<td>2.2 Teaching Institute</td>
<td>Department of Mathematics, Mirpur University of Science and Technology (MUST).</td>
<td></td>
</tr>
<tr>
<td>2.3 Final Award</td>
<td>Master of Science in Mathematics</td>
<td></td>
</tr>
<tr>
<td>2.4 Program Title</td>
<td>M.Sc in Mathematics</td>
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</tr>
<tr>
<td>2.5 Starting Time for Program</td>
<td>Fall/Spring Semester of each academic year</td>
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<tr>
<td>2.6 Duration of the Program</td>
<td>4-6 Semesters</td>
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</tr>
<tr>
<td>2.7 Entrance Requirement</td>
<td>Bachelor or Equivalent Degree with Mathematics (Min 45% Marks)</td>
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</tr>
<tr>
<td></td>
<td>No D-grade in academic career</td>
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<tr>
<td></td>
<td>Entry Test conducted by the University with the following breakup: Mathematics: 60 % (Maths A &amp; B), English: 10%, 30% for one subject which the candidate have studied in B.Sc/B.A.</td>
<td></td>
</tr>
<tr>
<td>2.8 Merit Formula</td>
<td>Merit shall be determined on 10% of HSSC, 10% of Intermediate, 50% Bachelor Degree and 30% of Entry Test marks.</td>
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<tr>
<td>2.9 Total Credit Hours</td>
<td>Course Work: 59 Credit Hrs</td>
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<td>Project (Compulsory): 6 Credit Hrs</td>
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<td></td>
<td>Comprehensive Oral Examination: S/U</td>
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</tr>
<tr>
<td></td>
<td>Conference/Seminars/Reading- I &amp; II: S/U</td>
<td></td>
</tr>
</tbody>
</table>

2.10 Program Educational Objectives:
The M.Sc Mathematics program is aimed at imparting quality education of mathematics to the youth of Mirpur division and the surrounding districts, at an affordable cost. The program will give an opportunity to the talented youth to satiate their desire to learn and excel in mathematics. The program will meet the demand of skilled mathematicians in the local job market.
The specific objectives of the M.Sc program include: to teach students basic concepts of mathematics, to empower them with analytical and computational skills, to develop critical thinking, and to develop professional approach and work ethics. Moreover, the program is designed in such a way that the students can learn advanced mathematical concepts through the course work and the semester projects.

2.11 Program Learning Outcomes (PLOs):
The curriculum of the two year M.Sc program is so designed that students learn analytical and computational skills for solving mathematical problems. The students are so trained through the class
room activities and assessments that can confidently do industrial, managerial, and teaching assignments.

2.12 Scope of the Program:

The mathematical experts are in demand across all kind of industries, the world over. Our graduates will be able to seek career opportunities in:

a). Teaching at school, college, or higher level
b). R&D and strategic organizations like PAEC, NESCOM, SUPARCO, etc.
c). Banking sector, trading, and stock exchange businesses
d). higher studies in national and international universities and institutes
e). armed forces, civil services, oil and gas sector

2.13 Program Structure and Features: Curriculum Units, Credit and Award Requirements

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Category</th>
<th>No. of Courses</th>
<th>Credit Hrs</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>01</td>
<td>Core Courses</td>
<td>15</td>
<td>44</td>
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<tr>
<td>02</td>
<td>Electives Courses</td>
<td>05</td>
<td>15</td>
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<tr>
<td>03</td>
<td>Conference?Seminar/Reading I &amp; II</td>
<td>02</td>
<td>S/U</td>
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<tr>
<td>04</td>
<td>Project</td>
<td>01</td>
<td>06</td>
<td></td>
</tr>
<tr>
<td>05</td>
<td>Comprehensive Oral Examination</td>
<td>01</td>
<td>S/U</td>
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<td></td>
<td>Total</td>
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2.14 Layout/Framework

<table>
<thead>
<tr>
<th>Category</th>
<th>Course Title</th>
<th>Credit Hrs</th>
<th>Remarks</th>
</tr>
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<tbody>
<tr>
<td>Core Courses</td>
<td>Ordinary Differential Equations</td>
<td>03</td>
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<tr>
<td></td>
<td>Abstract Algebra</td>
<td>03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Real Analysis-I</td>
<td>03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Complex Analysis</td>
<td>03</td>
<td></td>
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<tr>
<td></td>
<td>Topology</td>
<td>03</td>
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<td></td>
<td>Scientific Programming</td>
<td>2+1</td>
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<td></td>
<td>Tensor Analysis</td>
<td>02</td>
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<tr>
<td></td>
<td>Differential Geometry-I</td>
<td>03</td>
<td></td>
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<tr>
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<td>Real Analysis-II</td>
<td>03</td>
<td></td>
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<tr>
<td></td>
<td>Partial Differential Equations</td>
<td>03</td>
<td></td>
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<tr>
<td></td>
<td>Analytical Mechanics</td>
<td>03</td>
<td></td>
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<tr>
<td></td>
<td>Numerical Methods I</td>
<td>03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mathematical Physics</td>
<td>03</td>
<td></td>
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<tr>
<td></td>
<td>Functional Analysis</td>
<td>03</td>
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<td>Integral Equations</td>
<td>03</td>
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<tr>
<td></td>
<td>Project</td>
<td>06</td>
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<td></td>
<td>Comprehensive Oral Examination</td>
<td>S/U</td>
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<td>Conference/Seminar/Reading- I and II</td>
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<td>Elective Courses</td>
<td>Elective-I</td>
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<td>Elective-II</td>
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<td>Elective-V</td>
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### 2.15 Semester-Wise Breakdown

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Lec. Hrs.</th>
<th>Lab. Hrs.</th>
<th>Credit Hrs</th>
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</thead>
<tbody>
<tr>
<td>MAT-5101</td>
<td>Real Analysis-I</td>
<td>3</td>
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<tr>
<td>MAT-5102</td>
<td>Ordinary Differential Equations</td>
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<tr>
<td>MAT-5103</td>
<td>Differential Geometry-I</td>
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<td>MAT-5104</td>
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<td>MAT-5106</td>
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**Semester-II**

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<tr>
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<th>Course Title</th>
<th>Lec. Hrs.</th>
<th>Lab. Hrs.</th>
<th>Credit Hrs</th>
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</thead>
<tbody>
<tr>
<td>MAT-5201</td>
<td>Real Analysis-II</td>
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<tr>
<td>MAT-5202</td>
<td>Partial Differential Equations</td>
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<td>MAT-5203</td>
<td>Numerical Methods I</td>
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<td>3</td>
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<td>MAT-5204</td>
<td>Complex Analysis</td>
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<td>MAT-5206</td>
<td>Scientific Programming</td>
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**Semester-III**

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<th>Lec. Hrs.</th>
<th>Lab. Hrs.</th>
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<tr>
<td>MAT-6302</td>
<td>Mathematical Physics</td>
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<tr>
<td>MAT-6304</td>
<td>Functional Analysis</td>
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<tr>
<td>MAT-6316</td>
<td>Project</td>
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<td>MAT-6315</td>
<td>Conference/Seminar/Reading-I</td>
<td>S/U</td>
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</table>

**Two Optional Courses**

<table>
<thead>
<tr>
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<th>Course Title</th>
<th>Lec. Hrs.</th>
<th>Lab. Hrs.</th>
<th>Credit Hrs</th>
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<tbody>
<tr>
<td>MAT-6301</td>
<td>Measure Theory</td>
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<td>3</td>
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<tr>
<td>MAT-6303</td>
<td>Numerical Methods II</td>
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<tr>
<td>MAT-6305</td>
<td>Fluid Mechanics-I</td>
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<td>MAT-6306</td>
<td>Operation Research</td>
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<td>MAT-6307</td>
<td>Number Theory</td>
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<td>MAT-6308</td>
<td>Mathematical Statistics</td>
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<tr>
<td>MAT-6309</td>
<td>Quantum Mechanics-I</td>
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<td>MAT-6310</td>
<td>Ring Theory</td>
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<td>Analytical Dynamics</td>
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<td>MAT-6312</td>
<td>Introduction to Difference Equations</td>
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<td>MAT-6313</td>
<td>Differential Geometry-II</td>
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<td>MAT-6314</td>
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**Three Optional Courses**

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<thead>
<tr>
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<tr>
<td>MAT-6401</td>
<td>Mathematical Systems Theory</td>
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<td>MAT-6402</td>
<td>Mathematical Modeling</td>
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<tr>
<td>MAT-6404</td>
<td>Optimization Theory</td>
<td>3</td>
</tr>
<tr>
<td>MAT-6405</td>
<td>Fluid Mechanics-II</td>
<td>3</td>
</tr>
<tr>
<td>MAT-6406</td>
<td>Algebraic Topology</td>
<td>3</td>
</tr>
<tr>
<td>MAT-6407</td>
<td>Special Functions</td>
<td>3</td>
</tr>
<tr>
<td>MAT-6408</td>
<td>Financial Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>MAT-6409</td>
<td>Quantum Mechanics-II</td>
<td>3</td>
</tr>
<tr>
<td>MAT-6410</td>
<td>Introduction to Combinatorics</td>
<td>3</td>
</tr>
<tr>
<td>MAT-6411</td>
<td>Dynamical Systems</td>
<td>3</td>
</tr>
<tr>
<td>MAT-6412</td>
<td>Theory of Elasticity</td>
<td>3</td>
</tr>
<tr>
<td>MAT-6413</td>
<td>Special Theory of Relativity</td>
<td>3</td>
</tr>
<tr>
<td>MAT-6414</td>
<td>Electromagnetic Theory-II</td>
<td>3</td>
</tr>
<tr>
<td>MAT-6416</td>
<td>Special Functions</td>
<td>3</td>
</tr>
</tbody>
</table>

**Note**: Elective course mentioned above without any pre-requisite can be taught in 3rd or 4th semester. These courses can only be offered on the availability of the relevant teacher.
2.16 Details of the Courses in M.Sc Mathematics

Semester-I

Course Code: MAT-5101  Title: Real Analysis-I  Credit Hrs: 03


Text and Reference Books

Course Code: MAT-5102  Title: Ordinary Differential Equations  Credit Hrs: 03

Course Outline: Review of first order linear and nonlinear odes and higher order linear odes and their solution techniques. Basic theory of systems of first order linear equations, Homogeneous linear system with constant coefficients, Non homogeneous linear system, Sturm-Liouville (S-L) System and Boundary-Value Problems, Series Solution and its Limitations, The Frobenius Method, Solution of the Bessel, The Hypergeometric, The Legendre and the Hermite Equations, Properties of the Bessel, the Legendre and the Hermite Functions

Text and Reference Books
Course Code: MAT-5103  
Title: Differential Geometry-I  
Credit Hrs: 03


Text and Reference Books


Course Code: MAT-5104  
Title: Analytical Mechanics  
Credit Hrs: 03


Text and Reference Books

Course Code: MAT-5105                Title: Topology                Credit Hrs: 03

Course Outline: Overview of Metric Spaces, Convergence, and Continuity in Metric Spaces, Topological Spaces, Sub-Spaces, Closed Sets, Closures and Interiors of Sets, Boundary of a Set, Limit Point, Bases and Sub-bases, Neighborhood Base, First and Second Countable Spaces, Continuous Functions and Homeomorphism, Product Topology, $T_0$, $T_1$, $T_2$ Spaces and Their Characterizations and Basic Properties, Regular and Completely Regular Spaces, Normal and Completely Normal Spaces, Compact / Countable Spaces and Their Properties, Connected Spaces

Text and Reference Books

Course Code: MAT-5106                Title: Abstract Algebra                Credit Hrs: 03

Course Outline: Sets and Structures, Basic Axioms and Order of a Group, Subgroups, Subgroups Generated by Subset of a Group, System of Generators, Cyclic Group, Cosets, Lagrange’s Theorem, Permutations, Even and Odd Permutations, Cycles, Lengths of Cycles, Transpositions, Symmetric and Alternating Group, Normalizers and Centralizers of a Subset of a Group, Centre of a Group, Normal Subgroup, Quotient Groups, Conjugacy Relation between Elements and Subgroups, Homomorphism and Isomorphism between Groups, Homomorphism and Isomorphism Theorems,

Text and Reference Books
Semester-II

Course Code: MAT-5201         Title: Real Analysis-II         Credit Hrs: 03


Text and Reference Books

Course Code: MAT-5202         Title: Partial Differential Equations         Credit Hrs: 03

Course Outline: Review of ODEs in More than One Variable, First order PDEs: Introduction, formation of PDEs, solutions of PDEs of first order, The Cauchy’s problem for quasilinear first order PDEs, First order nonlinear equations, Special types of first order equations, Second order PDEs: Basic concepts and definitions, Mathematical problems, Linear operators, Superposition, Mathematical models: The classical equations, the vibrating string, the vibrating membrane, conduction of heat solids, canonical forms and variable, PDEs of second order in two independent variables with constant and variable coefficients, Cauchy’s problem for second order PDEs in two independent variables

Methods of separation of variables and Green’s Functions: Solutions of elliptic, parabolic and hyperbolic PDEs in Cartesian and cylindrical coordinates

Text and Reference Books
Course Code: MAT-5203  
Title: Numerical Methods I  
Credit Hrs: 03


Numerical Solution of Systems of Algebraic Linear Equations: Gauss-Elimination Method, Gauss-Jordan Method, Matrix Inversion, LU-Factorization, Doolittle’s, Crout’s, Cholesky’s Methods, Gauss-Seidel and Jacobi Methods, Matrix Norms, Method of Least Squares, Eigenvalues and Eigenvectors: Power Method

Text and Reference Books

Course Code: MAT-5204  
Title: Complex Analysis  
Credit Hrs: 03


Text and Reference Books
Course Code: MAT-5205  Title: Tensor Analysis  Credit Hrs: 02

Course Outline

Text and Reference Books

Course Code: MAT-5206  Title: Scientific Programming  Credit Hrs: 2+1

Course Outline (MATLAB, Maple, Mathematica): A list of contents is given below. However the instructor may add or remove some of the contents depending on the need of the students.
Curve sketching (only graphs of functions of one variable in Cartesian Coordinates) by using standard procedure, Intro to MATLAB (history, installation, interface, using product help, etc), MATLAB vs Maths syntax, sketching plane curves and surfaces in MATLAB, use of MATLAB in linear algebra, symbolic computations using MATLAB, creating script and function m-files, MATLAB codes for Bisection, Newton-Raphson, secan, Regula-Falsi, Jacobi, GS, Euler, and RK-4 methods. A brief introduction to Maple/Mathematica, comparison between similar features of MATLAB and Maple/Mathematica.
The following points are important for teaching this course:
1. The course should be taught in a computer lab setting
2. At the completion of this course, the students must be able to utilize the software to solve computationally difficult problems
3. The students should have a good command on at least two of the three programs mentioned above

Text and Reference Books
Semester-III

Course Code: MAT-6301  Title: Measure Theory  Credit Hrs: 03

Course Outline: Definition and Examples of Algebra and σ-Algebra, Basic Properties of Measurable Spaces, Definition and Examples of Measure Spaces, Outer Measure, Lebesgue Measure, Measurable Sets, Complete Measure Spaces
Measurable Functions: Some Equivalent Formulations of Measurable Functions, Examples of Measurable Functions, Various Characterizations of Measurable Functions, Properties that Hold Almost Everywhere
Definition of Lebesgue Integral, Basic Properties of Lebesgue Integrals, Comparison between Riemann Integration and Lebesgue Integration, L^2-Spaces

Text and Reference Books

Course Code: MAT-6302  Title: Mathematical Physics  Credit Hrs: 03

Course Outline: Definition and Properties of Laplace and Inverse Laplace Transforms, s-shifting property of LT, existence and uniqueness theorem, LT of derivatives and integrals and solution of ivps, unite step function and t-shifting property of LT, solution of circuit problems by using LT, Dirac Delta Function and its properties, LT of periodic functions, Convolution Theorem, Convolution of discontinuous functions, solution of integral equations by LT, differentiation and integration of LT, Laguerre’s equation and polynomials, Applications of Laplace Transforms to systems of ODEs and PDEs, Fourier Series of 2pi and 2L periodic functions, Convergence and sum of FS, even and odd functions and half-range expansions of FS, solution of odes and pdes by using FS, Fourier Integrals, Fourier Sine and Cosine integrals, Fourier sine and cosine transforms, Fourier sine and cosine transforms of derivatives, existence of FT, FT of derivatives, Convolution theorem, Discrete and Fast Fourier Transforms, solution of odes and pdes by using FT.

Text and Reference Books
Course Code: MAT-6303  Title: Numerical Methods-II  Credit Hrs: 03

**Course Outline:** IVP for ODEs: Elementary theory of ivps, Introduction to Single-Step Numerical Methods for solution of ivps, Picard’s method, Euler's Method, Second and higher order Taylor’s methods, RK-methods (mid-point, modified Euler, Heun’s, and RK-4 methods), Multi-Step methods for numerical solutions of odes (2-, 3-, 4-, and 5-step Adam-Bashforth and Adam-Moulton methods), Extension of Euler and RK-4 methods for numerical solutions of higher order odes and system of first order odes, stability, consistency, and convergence of SS and MS methods, stiff odes, region of absolute stability and A-Stability, BVPs for odes: Discussion on Problem Behavior and Stability, Shooting method and finite difference methods for Linear and Nonlinear BVPs, Rayleigh-Ritz method for Linear and Non-Linear BVPs.

**Text and Reference Books**

Course Code: MAT-6304  Title: Functional Analysis  Credit Hrs: 03

**Course Outline:** Definition and Examples of Normed Spaces, Banach Spaces, Characterization of Banach Spaces, Bounded Linear Transformations, Bounded Linear Operators, Functional and Their Examples, Various Characterization of Bounded (Continuous) Linear Operator, The Space of All Bounded Linear Operators, The Open Mapping and Closed Graph Theorems, The Dual (Conjugate) Spaces, Reflexive Spaces, Hahn-Banach Theorem (Without Proof), Some Important Consequences of the Hahn- Banach Theorem. Inner Product Spaces, Hilbert Spaces, Orthonormal Bases, Convexity in Hilbert Spaces, Operators in Hilbert Spaces, Invariant Sub-Spaces, Decomposition of Hilbert Spaces, Finite Dimensional Spectral Theory and Spectral Mapping Theorem.

**Text and Reference Books**
Course Code: MAT-6305  Title: Fluid Mechanics-I  Credit Hrs: 03


Irrotational Fluid Motion: Velocity Potential from an Irrotational Velocity Field, Streamlines. Vortex Lines and Vortex Sheets, Kelvins Minimum Energy Theorem, Conservation of Linear Momentum, Bernoullis Theorem and Its Applications, Circulations, Rate of Change of Circulation (Kelvins Theorem), Axially Symmetric Motion, Stokes Stream Function

Two-Dimensional Motion: Stream Function, Complex Potential and Complex Velocity, Uniform Flows, Sources, Sinks and Vortex Flows, Flow in a Sector, Flow Around a Sharp Edge, Flow Due to a Doublet

**Text and Reference Books**


Course Code: MAT-6306  Title: Operation Research  Credit Hrs: 03

**Course Outline:** Introduction to Operation Research and Real Life Phases, Introduction to Linear Programming (LP) with Examples, Graphical Solutions to Mathematical Model with Special Cases, Simplex Algorithm and its Different Cases, Big M Method and Two Phase Method, Scheduling and Blending Problems, The Transportation Problems, The Transshipment Problems, The Assignment Problems, Integer Programming, Network Models, Inventory Models

**Text and Reference Books**

Course Code: MAT-6307  Title: Number Theory  Credit Hrs: 03


Text and Reference Books

Course Code: MAT-6308  Title: Mathematical Statistics  Credit Hrs: 03

Course Outline: Set and Algebra of sets, Some elementary theorems of probability, Addition and multiplication rules, Baye’s rule and future Baye’s theorem, Random variables, probability functions, Cumulative distribution Function, Discrete and Continuous probability distribution, Moments and moment generating functions, Moments of binomial, hypergeometric, Poisson, gamma, beta and normal distributions and their characterizations. Joint probability functions and their properties, Bivariate Normal distribution, Transformation; Distribution function technique, Transformation technique: One variable, several variables, Moment-generating function technique, Sampling distributions and their properties, Regression and Correlation, Linear regression, The methods of least squares, Normal regression analysis, Normal correlation analysis, Multiple linear regression, Multiple linear regression (matrix notation)

Text and Reference Books
**Course Code:** MAT-6309  
**Title:** Quantum Mechanics-I  
**Credit Hrs:** 03


**Text and Reference Books**


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**Course Code:** MAT-6310  
**Title:** Ring Theory  
**Credit Hrs:** 03

**Course Outline:**


**Text and Reference Books**

Course Code: MAT-6311  
Title: Analytical Dynamics  
Credit Hrs: 03

Course Outline: Constraints, Generalized Coordinates, Generalized Forces, General Equation of Dynamics, Lagrange’s Equations, Conservation Laws, Ignorable Coordinates, Explicit Form of Lagrange’s Equation in Terms of Tensors. Hamilton’ Principle of Least Action, Hamilton’s Equations of Motion, Hamilton-Jacobi Method, Poisson Brackets (P.B’s); Poisson’s Theorem; Solution of Mechanical Problems by Algebraic Technique Based on (P.B’s) Small Oscillations and Normal Modes, Vibrations of Strings, Transverse Vibrations Normal Modes, Forced Vibrations and Damping, Reflection and Transmission at a Discontinuity, Longitudinal Vibrations, Rayleigh’s Principle

Text and Reference Books

MAT-6312  
Introduction to Difference Equations  
Credit Hrs: 3

Course Outlines: First, second and higher order differences, Some properties of operators \( E \) and \( \Delta \), Equivalence of operators, Infinite Summations, The operator \( \Delta^{-1} \), Analogies between the Difference and Differential calculus, Generating functions and approximate summation, Difference equations, Linear and nonlinear difference equations, Homogenous and Non-homogenous difference equations, solutions of a Difference Equations, An existence and Uniqueness Theorem, Sequences, Solutions as sequences, Simple and Compound interest, Inventory Analysis, Approximating a Differential equations by a Difference equations, General results for linear Difference Equations, Applications, Linear Difference Equations with constant coefficients , Fundamental set of solutions, General solution of Homogenous equations, Particular solutions of complete difference equations, Limiting behavior of solutions, Examples from Social Sciences, General case of order \( n \), Difference equation with variable coefficients, Linearizeable Nonlinear difference equations, Methods for solving Difference Equations, Equilibrium and stability of Solutions, First-order Equations and Cobweb Cycles, A Characteristic-Value Problem.

Recommended Books:
Course Code: MAT-6313  Title: Differential Geometry-II  Credit Hrs: 03


Text and Reference Books

Course Code: MAT-6314  Title: Electromagnetic Theory-I  Credit Hrs: 03


Text and Reference Books
2. J. D. Jackson, Classical Electrodynamics, Wiley, 1999
Course Code: MAT-6315
Title: Conference/Seminar/Reading-I
Credit Hrs: S/U

Course Outline: The purpose of this activity is to introduce students with the importance of conferences, seminars, and reading in scientific and academic development. Through various activities, students will be encouraged and trained to develop reading habits, especially of reference books and scientific articles. They will also be trained on preparing papers and presentations for conferences and seminars.

Text and Reference Books
As per requirement of the students taking the course

Course Code: MAT-6316
Title: Project
Credit Hrs: 3+3

Course Outline:
The objective of this course is to train students to learn and use the tools required for writing their project report and the tools for doing their research work. They will do the literature survey, work on some research problem and write a project report by the end of the 4th semester.

Text and Reference Books
As per requirements of the topic of the project.
Course Code: MAT-6401  
Title: Mathematical Systems Theory  
Credit Hrs: 03

Course Outline: Conservation laws and phenomenological principles, some principles and laws of thermodynamics, mechanics, and electromagnetism and their applications in modelling, Linearization, matrix exponentials and solution of linear differential equations, LTV systems, Impulse and step responses, Stability, controllability, and observability of LTI systems, Realization theory and Hankel matrices, Feedback and stabilizability, observers and state reconstruction, detectability, separation principle and compensation, disturbance rejection, Laplace transforms and LTI systems, transfer functions and transfer matrices, transfer functions and minimal realizations of SISO and MIMO systems,

Text and Reference Books

Course Code: MAT-6402  
Title: Mathematical Modeling  
Credit Hrs: 03

Course Outline: Introduction to modeling. Basic Guide line of mathematical modeling, Collection and interpretation of data, Technique of mathematical modeling, Classification of mathematical modeling, modeling through algebra, modeling through Geometry, modeling through Calculus, Limitation of modeling, Development of Models’, Discrete and Continuous models,. Linear Growth and Decay Model, Non-linear Growth and decay models, Mathematical modeling in population dynamic, Traffic flow models.

Text and Reference Books
1. Banerjee, Mathematical modeling (Modell analysis and Application)
2. J. J. Batzel, M. Bachar, and F. Kappel, Mathematical Modeling and Validation in Physiology, 2013
Course Code: MAT-6403  
Title: Integral Equations  
Credit Hrs: 03


Text and Reference Books

Course Code: MAT-6404  
Title: Optimization Theory  
Credit Hrs: 03


Text and Reference Books
Course Code: MAT-6405  
Title: Fluid Mechanics-II  
Credit Hrs: 03

Course Outline: Circular Cylinder without Circulation, Circular Cylinder with Circulation Blasius Theorem, Kutta Condition and the Flat-Plate Airfoil, Joukowski Airfoil, Vortex Motion, Karman’s Vortex Street, Method of Images, Velocity Potential, Stoke’s Stream Function, Solution of the Potential Equation, Uniform Flow Source and Sink, Flow Due to A Doublet
Viscous Flows Of Incompressible Fluids: Constitutive Equations, Navier-Stokes’s Equations, Exact Solutions of Navier-Stokes’s Equations, Steady Unidirectional Flow, Poiseuille Flow, Coquette Flow, Flow between Rotating Cylinders, Stoke’s First Problem, Stoke’s Second Problem
Simplified Approach to Fluid Flow Problems: Similarity from Differential Equations, Dimensional Analysis, One Dimensional Steady Compressible Flow

Text and Reference Books

Course Code: MAT-6406  
Title: Algebraic Topology  
Credit Hrs: 03

Course Outline: Path Wise Connectedness with Examples, Notion of Homotopy, Homotopy Classes and its Application, Path Homotopy, Path Homotopy Classes, Fundamental Groups, Covering Mapping with Examples, Covering Spaces, Lifiting Properties of Covering Spaces and its Application, Fundamental Group of a Circle (s)

Text and Reference Books
Course Code: MAT-6404  
Title: Special Functions  
Credit Hrs: 03

Course Outline: Infinite Products: introduction, Definition of an infinite product, A necessary condition for convergence, Associated series of logarithms, Convergences types, The Gamma and Beta Functions: The Euler constant, The Gamma function, A series for logarithmic differential of Gamma function, The order symbols o and O, Evaluation of certain infinite products, The Beta Function, Factorial function, Asymptotic Series: Definition of an asymptotic expansion, Algebraic properties, Term by term integration, Uniqueness, The Hypergeometric function: Simple integral form, The function \( F(a,b;c,z) \) and its properties, The Hypergeometric differential equation, Logarithmic solution of the hypergeometric function, \( F(a,b;c,z) \) as a function of parameters, Elementary series manipulation, Kummer Theorem, Generalized Hypergeometric functions, the exponential and binomial functions, A differential equation, Saalschutz theorem, Contour integral integrals of Barnes’ type, the Barnes integrals and the generalized hypergeometric function, Bessel Functions and its properties, The Confluent Hypergeometric functions and its properties, Generating Functions.

Text and Reference Books

Course Code: MAT-6408  
Title: Financial Mathematics  
Credit Hrs: 03


Text and Reference Books
Course Code: MAT-6409  Title: Quantum Mechanics-II  Credit Hrs: 03


Text and Reference Books

Course Code: MAT-6410  Title: Introduction to Combinatorics  Credit Hrs: 03

Linear Homogeneous Recurrence Relations, Algebraic Solutions of Linear Recurrence Relations and Constant Functions, The Method of Generating Functions, A Non-Linear Recurrence Relation and Catalaan Numbers

Text and Reference Books
Course Code: MAT-6411  Title: Dynamical Systems  Credit Hrs: 03


Text and Reference Books


Course Code: MAT-6412  Title: Theory of Elasticity  Credit Hrs: 03

Course Outline: Cartesian Tensors, Analysis of Stress and Strain, Generalized Hooke’s Law, Crystalline Structure, Point Groups of Crystals, Reduction in the Number of Elastic Moduli Due to Crystal Symmetry, Equations of Equilibrium, Boundary Conditions, Compatibility Equation, Plane Stress and Plane Strain Problems, Two Dimensional Problem in Rectangular and Polar Coordinates, Torsion of Rods and Beams

Text and Reference Books

Course Code: MAT-6413  Title: Special Theory of Relativity  Credit Hrs: 03

Course Outline: Historical Background and Fundamental Concepts of Special Theory of Relativity, Lorentz Transformations (for Motion Along One Axis), Length Contraction, Time Dilation and Simultaneity, Velocity Addition Formulae, 3-Dimensional Lorentz Transformation, Introduction to 4-Vector Formalism, Lorentz Transformations in the 4-Vector Formalism, The Lorentz and Poincare Groups, Introduction to Classical Mechanics, Minkowski Space-Time and Null Cone, 4-Velocity, 4-Momentum and 4-Force, Application of Special Relativity to Doppler Shift and Compton Effect, Particle Scattering, Binding Energy, Particle Production and Decay, Electromagnetism in Relativity, Electric Current, Maxwell’s Equations and Electromagnetic Waves, The 4-Vector Formulation of Maxwell’s Equations, Special Relativity with Small Acceleration

Text and Reference Books
Course Code: MAT-6414  
Title: Electromagnetic Theory-II  
Credit Hrs: 03


Text and Reference Books

Course Code: MAT-6415  
Title: Conference/Seminar/Reading-II  
Credit Hrs: S/U

Course Outline: The purpose of this activity is to introduce students with the importance of conferences, seminars, and reading in scientific and academic development. Through various activities, students will be encouraged and trained to develop reading habits, especially of reference books and scientific articles. They will also be trained on preparing papers and presentations for conferences and seminars.

Text and Reference Books
As per requirement of the students taking the course.

Course Code: MAT-6416  
Title: Comprehensive Oral Examination  
Credit Hrs: S/U

Course Outline: There will be a comprehensive oral examination at the end of the 4th semester. This examination will be conducted by an external examiner and 2 internal examiners together. Questions may be asked from any course which the student has studied during M.Sc.
### 3. Scheme of Studies for M.Phil in Mathematics: General Breakup

<table>
<thead>
<tr>
<th>Content</th>
<th>Description</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1 Awarding Institute/Body</td>
<td>Mirpur University of Science and Technology (MUST)</td>
<td></td>
</tr>
<tr>
<td>3.2 Teaching Institute</td>
<td>Department of Mathematics, Mirpur University of Science and Technology (MUST),</td>
<td></td>
</tr>
<tr>
<td>3.3 Final Award</td>
<td>Master of Philosophy in Mathematics</td>
<td></td>
</tr>
<tr>
<td>3.4 Program Title</td>
<td>M.Phil in Mathematics</td>
<td></td>
</tr>
<tr>
<td>3.5 Starting Time for Program</td>
<td>Fall/Spring Semester</td>
<td></td>
</tr>
<tr>
<td>3.6 Duration of the Program</td>
<td>4-8 Semesters</td>
<td></td>
</tr>
<tr>
<td>3.7 Eligibility Criteria</td>
<td>BS or MSc or Equivalent Degree in Mathematics with CGPA 2.50 or above (for semester system degree) or 2nd division (for annual system)</td>
<td>No D-grade in academic career</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NTS/GAT General Test with minimum cumulative score of 50%</td>
</tr>
<tr>
<td></td>
<td>Qualify Entry Test conducted by the University: 90 minutes duration, MCQs from BS/MSc mathematics syllabus</td>
<td></td>
</tr>
<tr>
<td>3.8 Merit Formula</td>
<td>Merit formulas are the following: <strong>For M.Sc:</strong> 15% of Intermediate, 20% of B.Sc, 20% of M.Sc, 35% of Entry Test marks, and 10% of interview conducted by the department. <strong>For BS:</strong> 15% of Intermediate, 40% of BS, 35% of Entry Test marks, and 10% of interview conducted by the department.</td>
<td></td>
</tr>
<tr>
<td>3.9 Total Credit Hours</td>
<td>Course Work: 24 Credit Hrs</td>
<td>Seminar: 1 Credit Hrs</td>
</tr>
<tr>
<td></td>
<td>Thesis (Compulsory): 6 Credit Hrs</td>
<td></td>
</tr>
</tbody>
</table>

### 3.10 Program Educational Objectives:

After graduation, our students will be equipped not only with advanced mathematical tools but will also acquire skill set needed to apply mathematics towards engineering problems. Moreover, our graduates will be able to:

i. Collaborate with engineers, scientists and other professionals from industry and academia on research/projects.

ii. Promote the culture of interdisciplinary novel research and produce fundamental & applied quality research in Pakistan.
iii. Contribute through publishing fundamental research in the emerging areas of science and engineering, like, systems and control, computational fluid dynamics, mathematical modelling, and complex analysis etc.

3.12 Program Learning Outcomes (PLOs):

The curriculum for MPhil program is so designed that the students undertaking research in this department will have a chance to learn not only the fundamental courses of mathematics but also advanced courses related to their area of specialization and interest. Fundamental and emerging specializations in the domain of mathematics, like systems and control, computational and theoretical fluid dynamics, advanced complex analysis, mathematical modelling of biological systems, and applied and theoretical statistics etc., will be offered as area of research for graduate students at this department. The mathematics department is also providing support to other engineering and sciences departments of MUST, so upon successful completion of the courses taught by mathematics faculty, students will be able to:

PLO-01: Apply knowledge of mathematics, science, and engineering fundamentals to the solution of complex problems involved in different areas of engineering and sciences.

PLO-02: Identify, formulate, search literature, and analyze mathematical models governing laws of physics and other engineering sciences.

PLO-03: Design solution strategy for mathematical models arising in aerospace engineering, electrical engineering, mechanical engineering, and other science and engineering disciplines.

PLO-04: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling the physical phenomena with an understanding of the limitations.

PLO-05: Communicate effectively on mathematical activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive instructions effectively.

PLO-06: Apply ethical principles and exhibit commitment to professional ethics, responsibilities and norms of the profession.

3.13 Scope of the Program:

The mathematical experts are in demand across all kind of industries, the world over. The curriculum of MPhil mathematics is so designed that students in this department will have a chance to learn not only the fundamental courses of mathematics but also advanced courses and tools related to the emerging areas of applied mathematics like systems and control, mathematical modelling, computational fluid dynamics, complex analysis, statistics, etc. Some of the career opportunities for our graduates are listed in the following.

a). Teaching at school, college, or higher level

b). R&D and strategic organizations like PAEC, NESCOM, SUPARCO, KRL, etc.

c). Banking sector, trading, and stock exchange businesses

d). Higher studies in national and international universities and institutes

e). Armed forces, civil services, oil and gas sector, etc.
3.14 Program Structure and Features, Curriculum Units, Credit and Award Requirements

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Category</th>
<th>No. of Courses</th>
<th>Credit Hrs</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Core Courses</td>
<td>04</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>02</td>
<td>Elective Courses</td>
<td>04</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>03</td>
<td>Seminar</td>
<td>01</td>
<td>01</td>
<td></td>
</tr>
<tr>
<td>04</td>
<td>Thesis</td>
<td>01</td>
<td>06</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>31</td>
<td></td>
</tr>
</tbody>
</table>

3.15 Semester-Wise Breakdown

**Semester-I**
Following advanced courses of Mathematics will be offered in this semester.
1. Core I
2. Core II
3. Elective I
4. Elective II

**Semester-II**
Following foundation courses of the specialized areas will be offered in this semester.
1. Core III
2. Core IV
3. Elective III
4. Elective IV

**Semester-III**
Students will start research work in this semester. Students will register in Thesis which will be concluded in Semester IV.

**Semester-IV**
Students will submit and defend their thesis at the end of this semester. The Seminar will also be graded in this semester. The students who can’t finish their thesis by the end of the 4th semester, will seek approval from the relevant authority (AS&RB) for an extension to complete their degree.
### 3.16 List of Courses for M.Phil Program

**A. Compulsory Requirements**

<table>
<thead>
<tr>
<th>Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT-7001</td>
<td>Seminar</td>
<td>01</td>
</tr>
<tr>
<td>MAT-7002</td>
<td>Thesis</td>
<td>06</td>
</tr>
<tr>
<td>MAT-7003</td>
<td>*Research Methodology and Scientific Writing</td>
<td>S/U</td>
</tr>
</tbody>
</table>

*This course will be a non-credit course. This will be offered in 3rd semester when students start their thesis. This will be an S/U based course but students have to pass it for completing the degree requirements. Its assessments will be based on home assignments.*

In the following, a list of core courses is given. A student will have to complete 12 credit hours (4 courses) of their course work from these courses.

<table>
<thead>
<tr>
<th>Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT-7004</td>
<td>Mathematical Analysis</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7005</td>
<td>Advanced Mathematical Physics</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7006</td>
<td>Riemannian Geometry</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7007</td>
<td>Advanced Complex Analysis</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7008</td>
<td>Mathematical Techniques</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7009</td>
<td>Advanced Topology</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7010</td>
<td>Advanced Abstract Algebra</td>
<td>03</td>
</tr>
</tbody>
</table>

**B. Elective Courses (12 credit hrs)**

In the following, a list of elective courses is given. A student will have to complete 12 credit hours of their course work from these courses.

<table>
<thead>
<tr>
<th>Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT-7011</td>
<td>Advanced Numerical Analysis</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7012</td>
<td>Geometric Functions Theory</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7013</td>
<td>Advanced Optimization Theory</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7014</td>
<td>Advanced Mathematical Modeling</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7015</td>
<td>Nonlinear Systems and Control</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7016</td>
<td>Optimal Control</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7017</td>
<td>Sampling Techniques</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7018</td>
<td>Multivariate Analysis</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7019</td>
<td>Finite Mixture Distributions</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7020</td>
<td>Mathematical Techniques for Boundary Value Problems</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7021</td>
<td>Non-Newtonian Fluid Mechanics</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7022</td>
<td>Fundamentals of the Theory of Fluids</td>
<td>03</td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
<td>Credits</td>
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<tr>
<td>-------------</td>
<td>--------------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>MAT-7023</td>
<td>Group Methods for Differential Equations</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7024</td>
<td>Computer Applications in Mathematics</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7025</td>
<td>Fundamentals of Finite Element Methods</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7026</td>
<td>Advanced Integral Equations</td>
<td>03</td>
</tr>
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<td>MAT-7027</td>
<td>Approximation Theory</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7028</td>
<td>Complex Analysis of Several Variables</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7029</td>
<td>Advanced Analytical Dynamics</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7030</td>
<td>Introduction to Robotics</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7031</td>
<td>Stochastic Processes</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7032</td>
<td>Estimation Theory</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7033</td>
<td>Time Series</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7034</td>
<td>Mathematical Ecology</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7035</td>
<td>Biomathematics</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7036</td>
<td>Advances in Discrete Mathematics and Applications</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7037</td>
<td>Graph Theory</td>
<td>03</td>
</tr>
<tr>
<td>MAT-7038</td>
<td>Lie Algebra</td>
<td>03</td>
</tr>
</tbody>
</table>
3.17 Details of the Courses/Contents

**Course Code:** MAT-7003  **Title:** Research Methodology and Scientific Writing  **Credit Hrs:** 03

**Course Outline:** Definition of Research, Types of Research, Selection of Problem, Formation of Hypothesis and Objective, Literature Review, Research Design: Experimental and Nonexperimental Research, Ethical issues in the Research Process, Components of Scientific Report, Various Methods of Data Presentation: Tables, Diagrams, Graphs and their interpretation; Citation and listing of references, Preparation of Scientific Reports by using a scientific writing tool (Latex, MS Word, Scientific workplace, etc), Plagiarism, Publication Procedures.

**Text and Reference Books**


**Course Code:** MAT-7004  **Title:** Advanced Mathematical Analysis  **Credit Hrs:** 03

**Course Outline:** Introduction to Fourier analysis: Lebesgue measure, Fubini Theorem, Convolutions, Introduction to the Fourier Transform, **Introduction to Function spaces:** Introduction to Sobolev spaces and distributions, Foundations of Harmonic analysis and theory of maximal operators, Lebesgue points, **Introduction to Geometric measure theory:** Hausdorff metric, Hausdorff measure, Fractals, Hausdorff dimensions, Box dimension,

**Text and Reference Books:**

**Course Code:** MAT-7005  
**Title:** Advanced Mathematical Physics  
**Credit Hrs:** 03


**Text and Reference Books**


---

**Course Code:** MAT-7006  
**Title:** Riemannian Geometry  
**Credit Hrs:** 03


**Text and Reference Books**

Course Code: MAT-7007       Title: Advanced Complex Analysis       Credit Hrs: 03


Text and Reference Books:

Course Code: MAT-7008       Title: Mathematical Techniques       Credit Hrs: 03


Text and Reference Books:
**Course Code:** MAT-7009  
**Title:** Advanced Topology  
**Credit Hrs:** 03

**Course Outline:** Convergence: Sequence and Nets, Filterbase in Space, Convergence, Properties of Filterbases, Closure in Terms of Filterbase, Continuity, Convergence in Cartesian Products, Adequacy of Sequences, Maximal Filterbase  
Compactness: Compact Spaces, Special Properties of Compact, Countable Compactness, Compactness in Metric Spaces, Perfect Maps, Local Compactness, O-Compact Spaces, Compactification, K-Space, Baire Space Category  
Function Spaces: The Compact Open Topology, Continuity of Composition, The Evaluation Map, Cartesian Products, Application to Identification Topologies, Basis for $Z^\alpha$, Compact Subsets of $Z^\alpha$  
Sequential Convergence in the C-Topology, Metric Topologies, Relation to the C-Topologies, Point-Wise Convergence, Comparison of Topologies in $Z^\alpha$  
The Spaces $C(Y)$: Continuity of the Algebraic Operations, Algebras in $C(Y; C)$, Stone-Weierstrass Theorem, The Metric Space $C(Y)$, Embedding of Y in $C(Y)$, The Ring $C(Y)$.

The Complete Spaces: Cauchy Sequences, Complete Metrics and Complete Spaces, Cauchy Filterbases, Total Boundedness, Baire’s Theorem for Complete Metric Spaces, Extension of Uniformly Continues Maps, Fixed Point Theorem for Complete Spaces, Complete Subspaces of Complete Spaces, Complete Gauge Structure.

**Text and Reference Books**

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**Course Code:** MAT-7010  
**Title:** Advanced Abstract Algebra  
**Credit Hrs:** 03

**Course Outline:** Endomorphism and Automorphism of Groups, Simple Groups (Definition and Examples), Direct Product of Groups, Sylow Groups and Sylow Theorems, Normal Series of a Group, Refinement Theorem, Composition Series and Jordan Holder Theorem, Solvable and Nilpotent Groups, Finitely Generated Abelian Groups.

**Text and Reference Books**
Course Code: MAT-7011  
Title: Advanced Numerical Analysis  
Credit Hrs: 03


Text and Reference Books


Course Code: MAT-7012  
Title: Geometric Functions Theory  
Credit Hrs: 03


Text and Reference Books

Course Code: MAT-7013  Title: Advanced Optimization Theory  Credit Hrs: 03

Course Outline: Intro to mathematical optimization, objective of constraint functions, basic optimization concepts, mathematical prerequisites, convexity, gradient vectors, Hessian matrix, global and local minima, saddle points, optimality conductions, general structure for line search method, Wolf conditions, Goldstein conditions, convergence of line search method, convergence of steepest decent method, Newton method, Quasi Newton method, Newton method with Hessian approximation, line search algorithm for Wolf conditions, conjugate gradient method, Trust Region Method and Cauchy point, Newton point, Dogleg method.

Text and Reference Books

Course Code: MAT-7014  Title: Advanced Mathematical Modeling  Credit Hrs: 03

Course Outline: Modeling through Differential Equations, Mathematical modeling through Ordinary Differential Equations, Mathematical modeling through system of Ordinary Differential equations of first order, Excursive of some modeling projects to demonstrate the variety of the require equations to formulate essential, control theory as modeling tool, Parameter estimation as optimization problem, Sensitivity analysis, Parameter estimation, Situation giving rise to Partial Differential Equations, Modeling through Delay differential and Differential–Difference equations

Text and Reference Books
Course Code: MAT-7015  
Title: Nonlinear Systems and Control  
Credit Hrs: 03

Course Outline:

**Analysis techniques for nonlinear systems:** phase portraits and their symmetries, singular points, phase plan analysis of linear and nonlinear systems, existence of limit cycles,

Fundamentals of Lyapunov Theory: Nonlinear systems and equilibrium points, concept of stability, linearization and local stability, Lyapunov’s direct method and stability analysis, Krasovskii and variable gradient methods, performance analysis, control design based on Lyapunov’s direct method

Advanced Stability Analysis: Stability of non-autonomous systems, Linearization and Lyapunov’s direct methods for nonlinear autonomous systems, Asymptotic properties of functions and their derivatives, Barbalat Lemma, positive real and strictly positive real transfer functions, Kalman-Yakubovich lemma, passivity of linear systems,

Describing Function Analysis: Fundamentals of describing function analysis, common nonlinearities in control systems and their describing functions, Nyquist criterion and its extensions, existence and stability of limit cycles, reliability of describing function analysis,

**Nonlinear Control Systems Design:** Feedback Linearization: Canonical form, Lie derivatives and Lie brackets, diffeomorphism and state transformations, the Frobenius theorem, input-state and input-output linearization of SISO systems, the normal forms and zero dynamics, local and global asymptotic stabilizations, tracking control and inverse dynamics, feedback linearization of multi-input systems,

**Adaptive Control:** Basic concepts in Adaptive Control, Adaptive control of first order systems, Adaptive control of linear systems of relative degree 1 and higher with full state-feedback and output feedback, Adaptive Control of nonlinear systems, robustness of adaptive control systems,

**Text and Reference Books**

Course Code: MAT-7016  Title: Optimal Control  Credit Hrs: 03

Course Outline: Calculus of Variation: Principle of calculus of variation, Euler Equation in Calculus of variation, some important theoretical results of calculus of variation and mathematical examples

Optimal Control and the Minimum Principle: Application of calculus of variation in optimal control, simplest problem in the Calculus of variation, Necessary condition for optimality, Lagrange multipliers, and Hamiltonian equations, The minimum principle, solution of Zermelo’s problem, Linear quadratic cost problem with finite and infinite horizon: theory and examples,

Optimal Control Theory and Dynamic Programming: Dynamic programming in discrete time, Principle of optimality and Bellman’s equation, linear quadratic cost problem with finite and infinite horizon in the dynamic programming perspective: theory and examples,

Differential Games: Introduction, continuous time differential games, intro to Nash and Stackleberg equilibrium solutions concepts, solutions of Nash differential games: theory and examples

Text and Reference Books

Course Code: MAT-7017  Title: Sampling Techniques  Credit Hrs: 03


Text and Reference Books
### Course Code: MAT-7018  
**Title:** Multivariate Analysis  
**Credit Hrs:** 03


**Text and Reference Books**


### Course Code: MAT-7019  
**Title:** Finite Mixture Distributions  
**Credit Hrs:** 03


**Text and Reference Books**


### Course Code: MAT-7020  
**Title:** Mathematical Techniques for BVPs  
**Credit Hrs:** 03

**Course Outline:** Green’s Function Method, Perturbation Method: Regular and Singular Perturbation Techniques with Application, Variational Methods, Wiener -Hopf Techniques with Applications to Diffraction Problems.

**Text and Reference Books**

Course Code: MAT-7021  Title: Non-Newtonian Fluid Mechanics  Credit Hrs: 03


Text and Reference Books

Course Code: MAT-7022  Title: Fundamentals of the Theory of Fluids  Credit Hrs: 03


Text and Reference Books
Course Code: MAT-7023  Title: Group Methods For Differential Equations  Credit Hrs: 03

Course Outline: Basic concept of groups of transformation, Parameter Lie group of transformation (LGT), infinitesimal transformation (I.T), Infinitesimal generators, Lie’s first fundamental theorem, Invariance, Canonical coordinates, Elongations, Multi-parameter Lie group of transformation (MLGT), Lie algebra, Solvable Lie algebra, Lie’s second and third fundamental theorems.
Invariance of ODE’s under (LGT) and (MLGT), Mapping solutions to other solutions from invariance of an ODE and PDE, Determining equations (I.T) of and \( n^{th} \) order ODE and system of PDE’s, Determination of \( n^{th} \) order ODE invariant under a given group, Reduction of order by canonical coordinates and differential invariants, invariant solutions of ODE’s and PDE’s Separacies and envelopes. Neother’s theorem and Lie-Backlund symmetries, Potential symmetries, Mapping of differential equations.

Text and Reference Books:


Course Code: MAT-7024  Title: Computer Applications in Mathematics  Credit Hrs: 03


Text and Reference Books:

Course Code: MAT-7025 Title: Fundamentals of Finite Element Methods Credit Hrs: 03


Text and Reference Books

Course Code: MAT-7026 Title: Advanced Integral Equations Credit Hrs: 03


Text and Reference Books
3. F. G. Tricomi, Integral Equations, Inter science, 1957.

Course Code: MAT-7027 Title: Approximation Theory Credit Hrs: 03


Text and Reference Books
Course Code: MAT-7028  Title: Complex Analysis of Several Variables  Credit Hrs: 03


Text and Reference Books

Course Code: MAT-7029  Title: Advanced Analytical Dynamics  Credit Hrs: 03


Text and Reference Books
2. E. T. Whittaker, A treatise on Dynamic of Rigid Bodies and Particles, At the University Press, 1927.
Course Code: MAT-7030  Title: Introduction to Robotics  Credit Hrs: 03

Course Outline: Fundamental Concepts: Introduction to Robot (Fundamental notions and Definitions), Jacobians: Transformations and Jacobians, Manipulator. Kinematics: Kinematics (Forward and Inverse) of manipulator, Manipulator Dynamics, Trajectory Generation, Manipulator Mechanism, Manipulator Design. Linear Control: Linear Control of Manipulator, Non-linear Control of Manipulator, Forced Control of Manipulator, Multivariable Control: Multivariable control, Feedback linearization, Variable structure and Adaptive Control.

Text and Reference Books

Course Code: MAT-7031  Title: Stochastics Processes  Credit Hrs: 03


Text and Reference Books

Course Code: MAT-7032  Title: Estimation Theory  Credit Hrs: 03


Text and Reference Books
Course Code: MAT-7033  Title: Time Series  Credit Hrs: 03


Text and Reference Books

Course Code: MAT-7034  Mathematical Ecology  Credit Hrs: 3

Course Outlines: Key models in Behavioral Ecology, Diet-choice and foraging, Evolutionarily Stable Strategies, Search and Predation, Stochastic models and statistics, Probability background and important distributions, Some applications to search and foraging, Bayesian methods, Host-parasitoid models, Nicholson-Bailey and extensions, Evolutionary models and stochastic dynamic programming, Disease models and Fishery models (may be included based on participant interest and available time), Basic SIR and extensions, Evolution of virulence, Vectors and disease, Fisheries bio-economic models, Stochastic population models, Sample paths and stochastic differential equations, General stochastic diffusion processes, Extinction time in density independent case, Extinction time in density-dependent case, Designing a model Cellular automata and IBMs, Formulating and implementing a model

Text and Reference Books:
Course Code: MAT-7035  
Biomathematics  
Credit Hrs: 3

Course Outlines: Biological applications of difference and differential equations, Biological applications of nonlinear differential equations, Biological applications of graph theory.

Text and Reference Books:


Course Code: MAT-7036  
Advances in Discrete Mathematics and Applications  
Credit Hrs: 3

Course Outlines: Introduction, Definitions of stability and linearized stability, Semi-cycle analysis, Full limiting sequences and Convergence theorems, Lyness equation, Todd equation, the generalized Lozi equation, the Gingerbreadman equation and the Riccati difference equation, analysis of semi-cycle of some special type of equations, Period-2 solutions, Global asymptotic stability of period-2 solutions, Existence of unbounded solutions and Boundedness of solutions, on the systems of rational difference equations.

Text and Reference Books:


Course Code: MAT-7037  
Title: Graph Theory  
Credit Hrs: 03


Text and Reference Books:

Course Code: MAT-7038  Title: Lie Algebra  Credit Hrs: 03


Text and Reference Books

### 4. Scheme of Studies for PhD in Mathematics: General Breakup

<table>
<thead>
<tr>
<th>Content</th>
<th>Description</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 Awarding Institute/Body</td>
<td>Mirpur University of Science and Technology (MUST)</td>
<td></td>
</tr>
<tr>
<td>4.2 Teaching Institute</td>
<td>Department of Mathematics, Mirpur University of Science and Technology (MUST)</td>
<td></td>
</tr>
<tr>
<td>4.3 Final Award</td>
<td>Doctor of Philosophy</td>
<td></td>
</tr>
<tr>
<td>4.4 Program Title</td>
<td>Ph.D. in Mathematics</td>
<td></td>
</tr>
<tr>
<td>4.5 Starting Time for Program</td>
<td>Fall/Spring Semester of Every Academic Year</td>
<td></td>
</tr>
<tr>
<td>4.6 Duration of the Program</td>
<td>3 to 8 years (6-16 Semesters)</td>
<td></td>
</tr>
<tr>
<td>4.7 Entrance Requirement</td>
<td>M.Phil or MS or Equivalent Degree in Mathematics with CGPA 3.0 or above (for semester system degree) or 1st division (for annual system)</td>
<td>No D-grade in academic career</td>
</tr>
<tr>
<td>4.8 Merit Formula</td>
<td>Merit formulas are the following:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>For M.Sc: 15% of Intermediate, 20% of B.Sc, 20% of M.Sc, 25% of M.Phil marks, 5% Publications, and 15% of interview conducted by the department.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>For BS: 15% of Intermediate, 40% of BS, 25% of M.Phil marks, 5% Publications, and 15% of interview conducted by the department.</td>
<td></td>
</tr>
<tr>
<td>4.9 Total Credit Hours</td>
<td>Course Work: 18 Credit Hrs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thesis (MAT-8000): 50 Credit Hrs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Seminar I &amp; II (MAT-7998, 7999): 1 Credit Hrs each</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Comprehensive Examination (Written and Oral): P/F</td>
<td></td>
</tr>
</tbody>
</table>

### 4.10 Program Educational Objectives:

Our students will be equipped not only with advanced mathematical tools but will also acquire skill set needed to apply mathematics towards real life problems in different fields of engineering, sciences, economics, business and finance, etc. Moreover, our graduates will be able to:

i. Collaborate with Engineers and scientists from industry and academia in their research/projects to promote the industry-academia linkages;

ii. Promote the culture of interdisciplinary novel research and produce fundamental & applied quality research in Pakistan;

iii. Contribute through active research in the emerging areas of science and engineering, for instance, systems and control, computational and theoretical fluid dynamics, advanced complex analysis, mathematical modelling of biological systems, and statistics etc.
4.11 Program Learning Outcomes (PLOs):

The curriculum for Ph.D program is so designed that the students undertaking research in this department will have a chance to learn not only the fundamental courses of mathematics but also advanced courses related to their area of specialization and interest. Fundamental and emerging specializations in the domain of mathematics, like systems and control, computational and theoretical fluid dynamics, advanced complex analysis, mathematical modelling of biological systems, and applied and theoretical statistics etc., will be offered as area of research for graduate students at this department. The mathematics department is also providing support to other engineering and sciences departments of MUST, so upon successful completion of the courses taught by mathematics faculty, students will be able to:

**PLO-01:** Apply knowledge of mathematics, science, and engineering fundamentals to the solution of complex problems involved in different areas of engineering and sciences.

**PLO-02:** Identify, formulate, search literature, and analyze mathematical models governing laws of physics and other engineering sciences.

**PLO-03:** Design solution strategy for mathematical models arising in aerospace engineering, electrical engineering, mechanical engineering, and other science and engineering disciplines.

**PLO-04:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling the physical phenomena with an understanding of the limitations.

**PLO-05:** Communicate effectively on mathematical activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive instructions effectively.

**PLO-06:** Apply ethical principles and exhibit commitment to professional ethics, responsibilities and norms of the profession.

4.12 Scope of the Program: The mathematical experts are in demand across all kind of industries, the world over. The curriculum of MPhil mathematics is so designed that students in this department will have a chance to learn not only the fundamental courses of mathematics but also advanced courses and tools related to the emerging areas of applied mathematics like systems and control, mathematical modelling, computational fluid dynamics, complex analysis, statistics, etc. Some of the career opportunities for our graduates are listed in the following

a). Teaching at school, college, or higher level

b). R&D and strategic organizations like PAEC, NESCOM, SUPARCO, KRL, etc.

c). Banking sector, trading, and stock exchange businesses

d). Higher studies in national and international universities and institutes

e). Armed forces, civil services, oil and gas sector, etc.
### 4.12 Program Structure and Features, Curriculum Units, Credit and Award Requirements

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Category</th>
<th>No. of Courses</th>
<th>Credit Hrs</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Core Courses</td>
<td>02</td>
<td>06</td>
<td></td>
</tr>
<tr>
<td>02</td>
<td>Elective Courses</td>
<td>04</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>03</td>
<td>Seminar</td>
<td>02</td>
<td>02</td>
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<tr>
<td>04</td>
<td>Thesis</td>
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</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>70</td>
<td></td>
</tr>
</tbody>
</table>

### 4.13 Semester-Wise Breakdown

**Semester-I**
Following advanced courses of Mathematics will be offered in this semester.
- 1. Core I
- 2. Elective I
- 3. Elective II

**Semester-II**
Following foundation courses of the specialized areas will be offered in this semester.
- 1. Core II
- 2. Elective III
- 3. Elective IV

**Semester-III and IV:**
Students will complete his/her course work (if it is not finished in the first two semesters) and clear the Comprehensive Examination (Written and Oral) by the end of the 4th semester.

**Semester-V and VI:**
Students will submit synopsis in the 5th semester to the relevant body and after approval of the synopsis, research work will start formally. The two Seminars will be evaluated after the submission of synopsis and before the public defense of the thesis. After completing the research work and the degree award requirements, the process for the public defense will be started. The students who can’t finish their thesis by the end of the 6th semester, will seek approval from the relevant authority (AS&RB) for an extension to complete their degree.
4.14 List of Courses for Ph.D Program

A. Compulsory Requirements

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT-7998</td>
<td>Seminar I</td>
<td>01</td>
</tr>
<tr>
<td>MAT-7999</td>
<td>Seminar II</td>
<td>01</td>
</tr>
<tr>
<td>MAT-8000</td>
<td>Thesis</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Comprehensive Examination (Written &amp; Oral)</td>
<td>P/F</td>
</tr>
</tbody>
</table>

B. Elective Courses* (18 credit hrs)

In the following, a list of elective courses is given. A student will have to complete 18 credit hours of his/her course work from these courses on the recommendation of his/her supervisor.

<table>
<thead>
<tr>
<th>Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>MAT-8001</td>
<td>Advanced Functional Analysis</td>
<td>03</td>
</tr>
<tr>
<td>MAT-8002</td>
<td>Advanced Partial Differential Equations</td>
<td>03</td>
</tr>
<tr>
<td>MAT-8003</td>
<td>Variational Inequalities</td>
<td>03</td>
</tr>
<tr>
<td>MAT-8004</td>
<td>Convex Analysis</td>
<td>03</td>
</tr>
<tr>
<td>MAT-8005</td>
<td>Parameter Estimation and Sensitivity Analysis</td>
<td>03</td>
</tr>
<tr>
<td>MAT-8006</td>
<td>Semigroups in Geometric Functions Theory</td>
<td>03</td>
</tr>
<tr>
<td>MAT-8007</td>
<td>Differential Subordination Theory and Applications</td>
<td>03</td>
</tr>
<tr>
<td>MAT-8008</td>
<td>Conformal Mappings</td>
<td>03</td>
</tr>
<tr>
<td>MAT-8009</td>
<td>Perturbation Methods</td>
<td>03</td>
</tr>
<tr>
<td>MAT-8010</td>
<td>Electro-dynamics</td>
<td>03</td>
</tr>
<tr>
<td>MAT-8011</td>
<td>Magneto-hydro-dynamics</td>
<td>03</td>
</tr>
<tr>
<td>MAT-8012</td>
<td>Fundamentals of Turbulence</td>
<td>03</td>
</tr>
<tr>
<td>MAT-8013</td>
<td>LIE Group Analysis of Differential Equations</td>
<td>03</td>
</tr>
<tr>
<td>MAT-8014</td>
<td>Selected Topics in Applied Mathematics</td>
<td>03</td>
</tr>
<tr>
<td>MAT-8015</td>
<td>Selected Topics in Pure Mathematics</td>
<td>03</td>
</tr>
<tr>
<td>MAT-8016</td>
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<td>MAT-8025</td>
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<tr>
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<td>Integral Inequalities</td>
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<td>MAT-8027</td>
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<td>MAT-8028</td>
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<td>MAT-8030</td>
<td>Bifurcation and Chaos</td>
<td>03</td>
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</table>

*Apart from this list, a student may also register in a course with M.Phil. class with the consent of his/her supervisor provided the student did not take this course already while doing M.Phil.*
4.15: Details of the Courses/Contents

Course Code: MAT-8001  Title: Advanced Functional Analysis  Credit Hrs: 03


Text and Reference Books

Course Code: MAT-8002  Title: Advanced PDEs  Credit Hrs: 03


Text and Reference Books
**Course Code:** MAT-8003  
**Title:** Variational Inequalities  
**Credit Hrs:** 03

**Course Outline:** Variational Inequalities in Fixed Points, The Characterization of the Projection onto a Convex Set, A First Theorem about Variational Inequalities, Some Problems about Variational Inequalities, Variational Inequalities in Hilbert Space, The Obstacle Problem, Variational Inequalities for Monotone Operators, A Variational Inequality with Mixed Boundary Conditions, Penalization

**Text and Reference Books**


**Course Code:** MAT-8004  
**Title:** Convex Analysis  
**Credit Hrs:** 03


**Text and Reference Books**

Course Code: MAT-7005  Title: Parameter Estimation and Sensitivity Analysis  Credit Hrs: 03

Course Outline:

Text and Reference Books

Course Code: MAT-7006  Title: Semigroups in Geometric Functions Theory  Credit Hrs: 03


Text and Reference Books
Course Code: MAT-8007  Title: Differential Subordination Theory and Applications  Credit Hrs: 03


Text and Reference Books

Course Code: MAT-8008  Title: Conformal Mappings  Credit Hrs: 03

Mapping Properties of Special Functions: Rational Functions of Second Degree, Exponential and Trigonometric Functions, Elliptic Functions, Domains Bounded by Arcs of Confocal Conics, The Schwarzian δ-Functions, the Elliptic Modular Functions

Text and Reference Books
Course Code: MAT-8009  
Title: Perturbation Methods  
Credit Hrs: 03


Text and Reference Books

Course Code: MAT-8010  
Title: Electro-dynamics  
Credit Hrs: 03


Text and Reference Books
Course Code: MAT-8011  Title: Magneto-hydro-dynamics  Credit Hrs: 03

Motion of an Incompressible Fluid: Motion of a Viscous Electrically Conducting Fluid with Linear Current Flow, Steady State Motion along a Magnetic Field, Wave Motion of an Ideal Fluid
Small Amplitude MHD Waves: Magneto-Sonic Waves, Alfven’s Waves, Damping and Excitations of MHD Waves, Characteristic Lines and Surfaces.

Text and Reference Books

Course Code: MAT-8012  Title: Fundamentals of Turbulence  Credit Hrs: 03


Text and Reference Books:
Course Code: MAT-8013  Title: LIE Group Analysis of Differential Equations  Credit Hrs: 03

Course Outline: Brief introduction to Lie group analysis of differential equations, preliminaries: heuristic approach in examples, finite differences and transformation groups in space of discrete variables, invariance of finite difference models, invariance difference models of ordinary differential equations, invariance difference models of partial differential equations, combined mathematical models and some generalizations, Lagrangian formalism for difference equations, Hamiltonian formalism for difference equations, symmetries and first integrals, discrete representation of ordinary differential equations with symmetries.

Text and Reference Books:

Course Code: MAT-8014  Title: Selected Topics in Applied Mathematics  Credits: 3

Course Outline: Course outlines of this course will be determined by the concerned teacher as per requirement of a student in connection with his/her research.

Course Code: MAT-8015  Title: Selected Topics in Pure Mathematics  Credit Hrs: 03

Course Outline: Course outlines of this course will be determined by the concerned teacher as per requirement of a student in connection with his/her research.
Course Code: MAT-8016  Title: Numerical Solutions of PDEs  Credit Hrs: 03

Course Outline: Preliminaries, Classification of PDEs, Canonical Forms and Well-Posed Problems, Behavior of Solutions, Characteristics, Introduction to Finite Difference Methods

Text and Reference Books

Course Code: MAT-8017  Title: Design Methods for Control Systems  Credit Hrs: 03

Course Outline:
Introduction to Feedback Control Theory: Basic feedback theory, closed loop stability, stability robustness, frequency response design goals, loop shaping, limits of performance,
Classical Control System Design: Steady state error behavior, integral control, frequency response plots, classical control system design, lead, lag, and lag-lead compensation, the root locus approach to parameter selection, quantitative feedback theory,
Multivariable Control System Design: Poles and zeros of multivariable systems, MIMO structural requirements and design methods,
LQ, LQG, and $H_2$ Control System Design: LQ theory, LQG theory, $H_2$ optimization, feedback system design by $H_2$ optimization, examples and applications
Uncertainty Models and Robustness: parameter robustness analysis, the basic perturbation model, the small gain theorem, stability robustness of feedback systems, structured singular value robustness analysis, combined performance and stability robustness,
$H_\infty$ – optimization and $\mu$-synthesis: The mixed sensitivity problem, the standard $H_\infty$ problem, suboptimal solutions and examples, state space solutions of standard $H_\infty$ problem, optimal solutions to the $H_\infty$ problem, integral control and high frequency roll-off, $\mu$-synthesis with applications

Text and Reference Books:
Course Code: MAT-8018          Title: Optimal State Estimation          Credit Hrs: 03

Course Outline: Least squares estimation, Wiener filtering, propagation of states and covariances for discrete and continuous time systems, the discrete and continuous time Kalman filters, the H-infinity filters, the extended and unscented Kalman filters.

Text and Reference Books

Course Code: MAT-8019          Title: Linear Matrix Inequalities          Credit Hrs: 03


Text and Reference Books

Course Code: MAT-8020          Title: Advanced Probability Theory          Credit Hrs: 03

Course Outline: Probability review, convergence of sequences, characteristic function, transformation of random variables, discrete and continuous probability models, Sets, Indicator functions and classes of sets, measure space and probability space, measurable functions, integration theory and Lebesque measure

Text and Reference Books
**Course Code:** MAT-8021  
**Title:** Advanced Finite Mixture Distributions  
**Credit Hrs:** 03

**Course Outline:** Components of a Mixture: Various Informal and Formal Techniques of Determining the Number of Components of a Mixture, The Structure of Modality, Assessment of Modality, Discriminate Analysis. Sequential Problems and Procedure: Introduction to Unsupervised Learning Problems, Approximate Solutions to Unknown Mixing Parameters, Unknown Component Distribution Parameters, Unknown Mixing and Component Parameters and Dynamic Linear Models.

**Texts and Reference Books**

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**Course Code:** MAT-8022  
**Title:** Advanced Sampling Techniques  
**Credit Hrs:** 03

**Course Outline:** Ratio and Regression Estimators with Application in Equal and Unequal Probabilities, Best Linear Unbiased Estimator (BLUE), Model Based Versus Design Based Estimator, Condition Under which Ratio Estimator Is BLUE, Derivation of Variance and Variance Estimator Under a Model for Ratio and Regression Estimator, Multistage Sampling, Derivation of Variance and Estimator for Equal and Unequal Probability Sampling for Two-Stage Sampling, Multistage Rules-Durbin’s Rule, Raj’s Rule, Raj’s Modified Rule, Brewer-Hanif Rule.

**Texts and Reference Books**
Course Code: MAT-8023  Title: Advanced Mathematical Statistics  Credit Hrs: 03


Text and Reference Books

Course Code: MAT-8024  Title: Stochastic Differential Equations  Credit Hrs: 03

Course Outline: Brief Introduction to Diffusion Processes and How They Arise as Natural Approximations to Certain Discrete Processes, Review of Some Basic Facts about Brownian Motion and Martingales, ITO Stochastic Integrals Construction and Martingale Properties, ITO's Formula, Integration by Parts, Comparison with Stieltjes Integrals and Ordinary Calculus, Stochastic Differential Equations, Existence and Uniqueness of Solutions, Markov Property, Generators, Martingale Problem Characterization of Weak Solutions, Diffusion Processes, Dynkin's Formula, Calculations of Expectations and Probabilities, Converting to the Natural Scale, Stationary Distributions, Examples from Biology: Wright-Fisher Diffusions, Branching Diffusions

Text and Reference Books
Course Code: MAT-8025  
Title: Fixed Point Theory and Applications  
Credit Hrs: 03

Course Outline:  Lipschitzian, Contraction, Contractive and Non-Expansive Mappings, Banach’s Contraction Principal with Application to Differential and Integral Equations, Brouwer’s Fixed Point Theorem with Applications, Schauder’s Fixed Point Theorem with Applications, Uniformly Convex and Strictly Convex Spaces, Properties of Non-Expansive Mappings, Extension’s of Banach’s Contraction Principal

Text and Reference Books
2. R. P. Agarwal, D. O. Regan and D. R. Sahu, Fixed Point Theory for Lipschitzian-type mappings with applications, Springer-Verlag, USA.

Course Code: MAT-8026  
Title: Integral Inequalities  
Credit Hrs: 03

Course Outline: Some Quadrature Rules and Their Applications Ostrowski Inequality in L₁ And Lp- and L∞ Spaces and Applications Gruss Inequality, Its Variant and Applications Ostrowski – Gruss Inequalities, Their Consequences and Applications Perturbed Results for Ostrowski and Ostrowski-Gruss Type Inequalities for Convex Functions, Hadmard, Sinequality, Hadmard,S Inequality for Convex Functions and Applications.

Text and Reference Books
**Course Code:** MAT-8027  
**Title:** Banach Algebras  
**Credit Hrs:** 03


**Text and Reference Books**

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**Course Code:** MAT-8028  
**Title:** Harmonic Functions Theory  
**Credit Hrs:** 03


**Text and Reference Books**
Course Code: MAT-8029  
Title: Cosmology  
Credit Hrs: 03


Text and Reference Books

Course Code: MAT- 8030  
Bifurcation and Chaos  
Credit Hrs: 3


Text and Reference Books:
5. Approval for the Updated Lists of External Examiners for Comprehensive Oral Exams of BS and MSc students, Thesis/Project Evaluation of BS, M.Sc, M.Phil and PhD Programs

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6. Scheme of Studies for BSc (Two Years Program) for affiliated colleges
There are three different courses of studies in Mathematics and each course has status of the subject
i) A-course of Mathematics (200 Marks)
ii) B-course of Mathematics (200 Marks)
iii) General Mathematics (200 Marks)

The following division is recommended:
6.1 A-Course of Mathematics
i) Differential and Integral Calculus (50 Marks)
ii) Complex Number and Analytic Geometry (50 Marks)
iii) Infinite Series, Differential Equation and Laplace Transform (50 Marks)
iv) Linear Programming and Application of Calculus (50 Marks)

6.2 B-Course of Mathematics
i) Group Theory and Linear Algebra (50 Marks)
ii) Number Theory, Topology and inner product space (50 Marks)
iii) Vector Analysis and Statics (50 Marks)
iv) Numerical Method and Dynamics (50 Marks)

6.3 General Mathematics
i) Complex Number and linear Algebra and Analytic Geometry (50 Marks)
ii) Differential and integral calculus (50 Marks)
iii) Application of calculus and Analytical Geometry of Three Dimension (50 Marks)
iv) Numerical Method, Infinite Series, Linear Programming and Differential Equation (50 Marks)

6.4 Course Contents of A-Course of Mathematics

6.4.1 Paper-I : DIFFERENTIAL AND INTEGRAL CALCULUS (3rd Year)
Students have to attempt five question out of eight: three from Section-I and two question from Section-II

Section-I Differential Calculus (5 out of 8)
A review of real number system, upper and lower bounds, Function and their Graphs, limits, continuity and related theorems, Tangents and the Derivative at a point, Differential rules and their Application, Derivative as a rate of change, Derivatives of trigonometry, exponential, logarithmic hyperbolic function and differentiation of their inverse, Implicit differentiation, Related rates, Linearization and differentials, Higher derivatives, Leibnitz’s theorem, Rolle’s theorem, Lagrange mean value theorem, increasing and decreasing function, Cauchy’s mean-value theorem, indeterminate forms and L’Hospital’s rule.

Section-II Integral calculus (3 out of 8)
Area and estimating with finite sums, sigma notations and limit of finite sums, definite integral as the limit of a sum, properties of definite integral, fundamental theorem of calculus, indefinite integrals and techniques of integration, reduction formulae, application of definite integral to area, arc length and other problems
Recommended Books
3. S.M.Yousaf ,Calculus
6. Prentice Hall, Inc.

6.4.2 Paper-II Complex Number and Analytical Geometry (3rd year)
Student have to attempt five question out of eight: two from section-I and three question from section-II

Section-I: Complex Numbers (3 out of 8)
Complex Numbers and algebra of complex number, polar representation, Euler's Formula, De- Moivres' theorem and its applications, Trigonometric and Hyperbolic function, Exponential and logarithmic function, Separation of complex valued functions and imaginary parts, Summation of series.

Section-II: Analytical Geometry (5 out of 8)
Two-dimensional Analytical Geometry (2 out of 8)
Translation and rotation of axes, General equation of the second degree and the classification of conic sections, Conic sections in polar coordinates, Tangents and normals, Pedal equation of curves, Tracing of polar curves.

Three-dimensional Analytical Geometry (3 out of 8)
Direction cosines and ratios, angle between two lines, Standard forms of equations of lines and planes, Distances between points, Lines and planes, Spherical polar and cylindrical coordinate systems, Standard form of the equation of sphere, Cylinder, Cone, ellipsoid, paraboloid and hyperboloid, symmetry, intercepts and sections of a surface, tangent planes and normals.

Recommended Books:
3. S. M. Yousaf, Muhammad Amin, Calculus with Analytical Geometry.
   a. Prentice Hall,Inc.

6.4.3 Paper.III: INFINITE SERIES, DIFFERENTIAL EQUATIONS AND LAPLACE TRANSFORMS (4th Year)
Students have to attempt five questions out of eight:two from section-I and three question from section-II
Section –I: Infinite serious (3 out of 8)
Sequence of numbers and their convergence, Algebra of convergent sequences, Infinite series and their convergences, Convergences tests for infinite series: Comparison, quotient, ratio, root and integral tests, Absolute and conditional convergences, Interval and radius of convergences, Taylors and Maclaurin’s theorems in finite and infinite form and their use in expansion of function.

Section-II: Differential Equations (5 out of 8)

Recommended Books
4. S.M. Yosaf, Mathematical Methods
5. Hamday A. Taha, Operations Research

6.4.4 PAPER-IV: LINEAR PROGRAMMING AND APPLICATIONS OF CALCULUS (4th Year)
Students have to attempt five questions out of eight: three from section-I and two from section-II.

Section-I: (5 out of 8)
(a) Applications of Differential Calculus 4/5
Curves and their Cartesian, polar and parametric representations, Asymptotes, Maxima and Minima, points of inflexion and their applications, singular points, curve tracing, Curvature, centre and radius of curvature, Functions of several variables, limits continuity and partial derivatives, Maxima and minima of functions of two variables with applications, Approximations, Equations of tangent plane and normal line to a surface.

(b) Linear programming 1/5
Introduction to Operations Research in general and in particular to linear programming simplex method, Assignment Models

Section-II: Applications of Integral Calculus (3/8)
Rectifications and Quadrature, Simple cases of double and triple integrals, Volumes and area of surfaces of revolutions.

Books Recommended
2. A. Sultan, Linear programming, Academic press.
3. W.A Spivey Linear programming, McMillan Co.
5. Hiller, Introduction to Operations Research
6.5 B-COURSE OF MATHEMATICS

6.5.1 PAPER-I: GROUP THEORY AND LINEAR ALGEBRA (3rd Year)
Students have to attempt five questions out of eight: three from section-I and two from section-II.

Section-I Group Theory (3 out of 8)
Definitions and examples of groups, Groups of residue classes, Cyclic group, Order of a group and order of an element of a group, subgroup, cosets, Lagrange’s theorem and its applications Permutations, even and odd permutations, Cycles and length, transpositions

Section-II: Linear Algebra (5 out of 8)
Fields, Vector spaces, subspaces and examples, Linear dependence and independence, Bases and dimensions, Linear transformation, Motivations of matrices through a system of linear homogenous and non-homogenous equations, Elementary row and column operations on matrices, Algebra of matrices Determinants of matrices, their properties and evaluation of various kinds of matrices, Matrix of a linear transformation, Rank of a matrix, Evaluation of ranks and inverses of matrices, solution of system of homogenous and non-homogenous linear equations (Elimination and Gauss Method)

Books Recommended
2. S.M. Yosaf, Mathematical Methods
3. A.Majeed, Group Theory

6.5.2 Paper-II: NUMBER THEORY, TOPOLOGY AND INNER PRODUCT SPACE(3rd Year)
Student have to attempt five question out of eight: two from section-I and three question from section-II

Section-I: Number Theory (3 out of 8)
Divisibility Euclid’s theorem (Division Algorithm), Greatest common divisor and latest common multiple, theory of primes, Linear Equations, Diophantine Equation.

Section-II: Topology & Inner Product Space (5 out of 8)
Definition and examples of metric space, open balls, open sets in a metric space, interior, exterior, boundary and closure of a set in a metric space, definition and example of topology and topological spaces, open and closed sets in topological spaces, Neighborhood, Limit Point, Interior, exterior, boundary and closure of sets in a topological spaces, Definition and example of inner product spaces, Orthogonality, orthogonal and orthogonal system, orthogonal matrices.

Books Recommended
2. S. M. Fahfa, Introduction to point set topology.
6.5.3 PAPER-III: VECTOR ANALYSIS AND STATICS (4th YEAR)
Students have to attempt five questions out of eight: two from section-I and three from section-II

**Section-I: Vector Analysis (3 out of 8)**
Vectors and there algebra, coordinate systems and bases, Scalar and vector triple products, Differentiation and integration of vectors, Scalar and vector point functions, Concepts of gradient, divergence and curl along with their applications.

**Section-II: Statics (5 out of 8)**
Composition and resolution of forces, Particles in equilibrium, Parallel forces, moments, Couples, General conditions of equilibrium of coplanar forces, Principle of virtual work, Friction, Centre of gravity.

**Books Recommended**
2. Q. K. Ghori, Introduction to Mechanics (West Pakistan Co., Ltd., Lahore)

6.5.4 PAPER-IV NUMERICAL METHODS AND DYNAMICS (4th Year)
Students have to attempt five questions out of eight: three from section-I and two questions from section-II.

**Section-I: Numerical Methods (3 out of 8)**

**Section-II: Dynamics of a Particle (5 out of 8)**
Motion in a straight line, Uniformly accelerated and resisted motion. Velocity, acceleration and their components in cartesian and polar coordinates, tangential and normal components, Conservative forces, Projectiles, Central forces and orbits, Simple harmonic motion, Damped and forced vibrations.

**Books Recommended**
4. S.A. Bhatti, N.A. Bhatti, Numerical Methods
6.6 GENERAL MATHEMATICS

6.6.1 PAPER-I: COMPLEX NUMBER, LINEAR ALGEBRA AND ANALYTICAL GEOMETRY (3rd Year)
Students have to attempt five questions out of eight: two from section-I and three questions from section-II.

Section-I: Complex Number System (3 out of 8)
Real number system and properties of real numbers, Real-valued functions and their graphs, Complex numbers their algebra and Polar form, De-Moivres’ theorem, n n th roots of complex numbers, Complex functions, Sum of trigonometric series.

Section-II: Linear Algebra and Analytical Geometry (5 out of 8)

6.6.2 PAPER-II: DIFFERENTIAL AND INTEGRAL CALCULAS (3rd Year)
Students have to attempt five questions out of eight: three from section-I and two questions from section-II.

Section-I: Differential Calculus (5 out of 8)
Techniques of finding limits, Continuity of a function, Differentiability, Indeterminate forms, Use of Rolle’s theorem, Mean value theorems (Lagrange and Cauchy), Taylor and Maclaurins series, Derivatives, Higher Derivatives and Partial Derivatives, Related rates.

Section-II: Integral Calculus (3 out of 8)
Techniques of integration, Definite integral as limit of a sum, Evaluation of a definite integral by definition, Improper integrals, reduction formulae.

6.6.3 PAPER-III: APPLICATION OF CALCULUS AND ANALYTICAL GEOMETRY OF THREE DIMENSIONS (4th Year)
Students have to attempt five questions out of eight: two from section-I and three questions from section-II.
Section-I: Application of differential and Integral Calculus (5 out of 8)
Asymptotes, maxima and minima of a function of one and two variables, Curvatures and centre of curvature, rectification, quadrate, Euler's theorem, Chain Rule, Total derivative, Equation of tangent, Plane and normal lines to surfaces volumes and surface area of revolution, Simple cases of double and triple integrals.

Section-II: Analysis Geometry (3 out of 8)
Direction cosines and ratios, Angle between two lines, Standard form of equations of planes and lines, Intersection of planes and lines, Distance between points, lines and planes, Spherical, polar and cylindrical coordinate systems, Standard form of the equations of a sphere, cylinder, cone, ellipsoid, paraboloid and hyperboloid, Symmetry and intercepts of a surface, Tangent planes and normal.

6.6.4 PAPER-IV: NUMERICAL METHODS, INFINITE SERIES, LINEAR PROGRAMMING AND DIFFERENTIAL EQUATIONS (4th Year)
Students have to attempt five questions out of eight: two from section-I and three questions from section-II.

Section-I: Numerical Methods and Infinite Series (3 out of 8)
Introduction to infinite series and tests for their convergence, Absolute and conditional convergence. Introduction to Numerical Analysis, Numerical Solution of algebraic and transcendental equations: bisection method, Newton-Raphson method.

Section-II: Linear Programming and Differential Equations (5 out of 8)
Introduction to linear programming, Simplex methods and their examples from real life, Differential equations of first order, Separable, Homogenous equation, Exact equation, Linear differential equation, Bernoulli’s equation, orthogonal trajectories, Differential equations 2nd and higher order Cauchy Euler equation, Method of variation of parameters, Method of undetermined Coefficient.

Books Recommended for General Mathematics (Papers I to IV)
   Ed. Inc., 2010.
2. S.T. Tan, Applied Mathematics. For the Managerial, life, and social sciences.
7. Fiaz Ahmad and M.A. Rana, Elements of Numerical Analysis, (Latest Edition), NBF.

Other Books
1. Calculus S.M. Yousaf
2. Introduction to Mechanics, S.M. Yousaf
3. Topology Ch. M. Amin
4. Introductions Set Topology S.M. Yousaf.
5. Metric Spaces by Z.R Bhatti
6. Elementary Theory of Numbers by Sayyed Manzoor Hussain
7. Elementary Numerical Analysis by Dr. M. Iqbal
8. Vector Analysis by Dr. Munawwar Hussain.
Any Other Item