POST GRADUATE SYLLABUS
Department of Mathematics

(Recommended by B.O.S. in Mathematics, M.D.U. in its meeting held on 24.07.2024)

Madhabdev University
Narayanpur, Assam

Graduate Attributes in Mathematics

The graduate attributes in mathematics are the summation of the expected course learning outcomes mentioned in the beginning of each course. Some of them are stated below.

- Disciplinary knowledge:

Capability of demonstrating comprehensive knowledge of mathematics and understanding of one or more disciplines.

- Communications skills:

  i. Ability to communicate various concepts of mathematics effectively using examples and their geometrical visualizations.
  ii. Ability to use mathematics as a precise language of communication in other branches of human knowledge.

- Critical thinking and analytical reasoning:

  i. Ability to employ critical thinking in understanding the concepts in every area of mathematics.
  ii. Ability to analyze the results and apply the various problems appearing in different branches of mathematics.

- Problem solving:

  i. Ability to solve linear system of equations, linear programming problems and network flow problems.
  ii. Ability to provide new solutions using the domain knowledge of mathematics acquired during this programme.

- Research-related skills:

  i. Capability for inquiring about appropriate questions relating to the concepts in various fields of mathematics.
  ii. To know about the advances in various branches of mathematics.

- Information/digital literacy:

  i. Capability to understand and apply the computer programming concepts to mathematical investigations and problem solving.

- Self-directed learning:

  Ability to work independently and do in-depth study of various notions of mathematics.

- Moral and ethical awareness/reasoning:

  Ability to identify unethical behaviour such as fabrication, falsification or misrepresentation of data and adopting objective, unbiased and truthful actions in all aspects.

- Life long learning:

  Ability to think, acquire knowledge and skills through logical reasoning and to inculcate the habit of self-learning.

Programme Learning Outcomes of M.Sc (Hons) Mathematics

Master's degree in mathematics is the culmination of in-depth knowledge of algebra, calculus, geometry, differential equations and several other branches of mathematics. This also leads to study of related areas like computer science and statistics. Thus, this programme helps learners in building a solid foundation for higher studies in mathematics.

1. The skills and knowledge gained has intrinsic beauty, which also leads to proficiency in analytical reasoning. This can be utilised in modelling and solving real life problems.

2. Students undergoing this programme learn to logically question assertions, to recognise patterns and to distinguish between essential and irrelevant aspects of problems. They also share ideas and insights while seeking and benefitting from knowledge and insight of others. This helps them to learn behave responsibly in a rapidly changing interdependent society.

3. Students completing this programme will be able to present mathematics clearly and precisely, make vague ideas precise by formulating them in the language of mathematics, describe mathematical ideas from multiple perspectives and explain fundamental concepts of mathematics to non-mathematicians.

4. Completion of this programme will also enable the learners to join teaching profession in higher, primary and secondary schools.

5. This programme will also help students to enhance their employability for government jobs, jobs in banking, insurance and investment sectors, data analyst jobs and jobs in various other public and private enterprises.

Course learning outcomes

Course learning outcomes of each course in M.Sc. (Hons) Mathematics have been enshrined in the beginning of course contents of each course.

	Courses with Credits				
	Core(Fixed)	**Elective(minimum)**		**AEC (minimum)**	**Total**
		DSE (Any one)	**GE**		
I	1. Abstract Algebra (**4 Credit**) 2. Differential Equations (**4 Credit**) **3.** Real Analysis (**4Credit)**	1. Classical Mechanics (**4 Credit**) 2. Combinatorics and Probability (**4 Credit**)	----------	1Course X 2 Credit=2	18
II	1. Complex Analysis 2. (**4 Credit**) 3. Linear Algebra (**4Credit**) 4. Numerical Analysis (**4 Credit**)	1. Fluid Dynamics (**4 Credit**). 2. Graph Theory (**4Credit**)	Foundation in Mathematics (**4 Credit**)	----------	20
III	1. Measure Theory (**4 Credit**) 2. Topology **(4 Credit**) **3.** Numerical Partial Differential Equation **(4 Credit)**	4. Number Theory (**4 Credit**) 5. Magneto Hydrodynamics (**4 Credit**)	Mathematical Modelling (**4Credit**)	Research Methodology Credit=2	22
IV	1. Mathematical Methods **(4Credit)** 2. Computer Programming **(4Credit)** 3. Functional Analysis **(4Credit)**	1. Research Project (8 Credit)	----------	----------	20
	Total Credit				80

<table>
<tr><td colspan="3">Department of Mathematics</td><td colspan="6">Madhabdev University</td></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="3">Abstract Algebra</td><td colspan="2">Paper Number</td><td></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">CORE</td><td>Year</td><td>1</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td>Course Code</td><td>PMTC 101</td></tr>
<tr><td>Semester</td><td>I</td><td></td><td></td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours (Per week)</td><td colspan="2">Lecture</td><td>Tutorial</td><td colspan="2">Lab Practical</td><td>Total</td></tr>
<tr><td colspan="2">3</td><td>1</td><td colspan="2"></td><td>4</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">The students are expected to develop a strong foundation in Algebra with special emphasis on finite groups and algebraic number theory.</td></tr>
<tr><td colspan="2">Learning Outcome</td><td colspan="6">After going through this course the students will be able to
(i) Describe the Group theoretic notions of class equation and the related results.
(ii) Discuss three important classes of Ring structures,viz., the Principal ideal Domain, Euclidean domain and the unique factorization domain.</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">Unit-1 Marks 8, L:5,T:3
External direct product of groups, properties of external direct products, internal direct products, fundamental theorem of finite Abelian groups and applications.
Unit-2 Marks 10, L:8,T:3
Group action, Properties of group action, Class equation of finite groups, Sylow's theorems, Applications of Sylow's theorems.
Unit-3 Marks 8, L:8,T:3
Subnornmal, normal series, derived group, solvable groups, composition series, nilpotent groups, Jordan-Holder theorem.
Unit-4 Marks 9, L:8,T:2
Ring Embedding, Polynomial rings, Rings of formal power series, field of fractions.
Unit-5 Marks10, L:8,T:2
Factorization theory in integral domains, PID, UFD and Euclidean domains.
Unit-6 Marks15, L:8,T:2
Field extensions, algebraic and transcendental elements, geometrical constructions, splitting field, finite fields, structure of finite fields, normal, separable and inseparable extension of fields.</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">1. Herstein, I. N.(1975).Topics in Algebra, Wiley Eastern Limited.
2. Dummit, D. S., Foote, R.M.(2004). Abstract Algebra, John Wiley & Sons, Inc.
3. Gallian, J. A. (2013). Contemporary Abstract Algebra, Cengage Learning, India.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. Hungerford, T. W., Algebra. (1974). Springer-Verlag. NewYork.
2. Bhattacharya, P. B., Jain, S.K., Nagpaul, S.R.(1994). Basic Abstract Algebra. Cambridge University Press.</td></tr>
<tr><td colspan="2">Website and E-learning Source</td><td colspan="6">www.algebra.com</td></tr>
</table>

Department of Mathematics							*Madhabdev University*
Title of the Course		**Differential Equations**			**Paper Number**		
Category	**core**	**Year**	**1**	**Credits**	**4**	**Course Code**	**PMTC 102**
		Semester	**I**				
Instructional Hours(Per week)		**Lecture**		**Tutorial**		**Lab Practical**	**Total**
		3		**1**			**4**
Prerequisites for the Course		Knowledge of ordinary differential equations of first order and second order and their General Solutions are essential. Knowledge of partial differential equations of first order is essential.					
Objectives of the Course		To learn the governing mathematical formulations and their solutions of various physical problems.					
Learning Outcome		After going through this course the students will be able to (i) Formulate the governing Mathematical equations of Physical Problems. (ii) Solve Differential Equations using various Mathematical tools.					
Course outline		**UnitI: Ordinary Differential Equations: Marks15,L:11,T:4** Series solutions of second order linear differential equations, Legendre equation and Legendre polynomials, Bessel equation and Bessel functions, Systems of first-order linear differential equations. **UnitII: Partial Differential Equations of Second Order: Marks15,L:12,T:4** Liner partial differential equations of second order with constant co-efficient, Characteristic curves of second–order equations, Reduction to canonical forms, Separation of variables, Solutions of nonlinear equations of the second order by Monge's method. **Unit III: Laplace's Equation, Wave Equation, Diffusion Equation: Marks15,L:12,T: 4** The occurrence of Laplace's equation in Physics, Elementary solutions of Laplace's equation ,Boundary value problems, Solution of Laplace's equation by separation of variables, The occurrence of the Wave equation in Physics, Elementary solutions of the one-dimensional Wave equation, Solution of the Wave equation by separation of variables, The occurrence of the Diffusion equation in Physics, Elementary solutions of the Diffusion equation, Solution of the Diffusion equation by separation of variables. **Unit IV: Methods of Green's Function: Marks15, L:10,T: 3** Green's Function, Green's function for the Laplace's equation, Green's function for the Wave equation, Green's function for the Diffusion equation.					
Recommended Text		1. Ross, S.L.(1984). Differential Equations,Wiley India. 2. Coddington, E. A.(2001). An Introduction to Ordinary Differential Equations, PHI. 3. Sneddon, I.N.(2006). Elements of Partial Differential Equations, Dover Publications, Inc. 4. Rao, K. S.(2010). Introduction to Partial Differential Equations, PHI Learning Pvt. Ltd..					
Reference Books		1. Boyce,W. E., Di Prima, R. C.(2009). Elementary Differential Equations and Boundary Value Problems, 9th Edition,Wiley India 2. Piaggio, E.T.H.(1985). Differential Equations, CBS Publishers and Distributors 3. Bhamra, K.S.(2010). Partial Differential Equations, PHI Learning Pvt. Ltd. 4. Ayres, F (Jr.). (1972). Theory and Problems of Differential Equations, SI (Metric) Edition, Schaum's Outline Series, McGraw Hill Book Co.					
Website and E-learning Source		http://mathforum.org,http://ocw.mit.edu/ocwweb/Mathematics,http://www.opensource.org					

<table>
<tr><td colspan="3">Department of Mathematics</td><td colspan="5">Madhabdev University</td></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="3">Real Analysis</td><td colspan="2">Paper Number</td><td></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">CORE</td><td>Year</td><td>1</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td>Course Code</td><td>PMTC 103</td></tr>
<tr><td>Semester</td><td>I</td><td></td><td></td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours (Per week)</td><td colspan="2">Lecture</td><td>Tutorial</td><td colspan="2">Lab Practical</td><td>Total</td></tr>
<tr><td colspan="2">3</td><td>1</td><td colspan="2"></td><td>4</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">To build up a strong analytical foundation of basic Real Analysis.</td></tr>
<tr><td colspan="2">Learning Outcome</td><td colspan="6">After going through this course the students will be able to
(i) Describe the properties of the Real numbers.
(ii) Analyze the properties of advanced differentiation and Integration of real valued functions in one or multiple variables.
(iii) Describe $\mathbb{R}$ as a metric space and identify its special metric properties.</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UnitI: Preliminaries: Marks:20 L:15 T:5
Metric spaces, continuity, compactness, completeness, Bolzano-Weierstrass theorem, Heine-Borel theorem; connectedness.

UnitII: Sequences of Functions: Marks:13 L:10 T:3
Sequences and series of functions, Pointwise and uniform convergence, Monotonic functions, types of discontinuity, Absolute continuity, functions of bounded variation.

UnitIII: Functions of Several Variables: Marks: 15 L: 11 T:4
Directional derivatives, Continuity, total derivatives, Jacobian matrix, the chain rule and its matrix form, the mean value theorem for differentiable functions, sufficient condition for differentiability, Inverse mapping Theorem, Implicit Mapping Theorem

UnitIV: Riemann-Stieltjes Integral: Marks:12 L:9 T:3
Riemann-Stieltjes integrals, The R-S integral as a limit of sum, Classes of R-S integrable functions, Algebra of R-S integrable functions, Relation between Riemann and Riemann-Stieltjes integral.</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">1. Bartle, R. G.(1991). Elements to real analysis. Wiley. (For Unit II&IV)
2. Fitzpatrick, P. M. (2010). Advanced Calculus. American Mathematical Society.(For Unit III)
4. Carothers, N. L. (2009). Real Analysis. Cambridge University Press.(For Unit I, II)</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. Rudin,W.(1964). Principles of mathematical analysis. NewYork: McGraw-hill.
2. Simmons, G.F.(1963). Introduction to Topology and Modern Analysis. Mc Graw Hill.
3. Kaczor, W. J., Nowak, M. T., Nowak, N. T. (2000). Problems in Mathematical Analysis: Integration. American Mathematical Soc.
4. Kumaresan, S. (2005). Topology of Metric Spaces. Narosa publishing House.
3. Apostol, T. M. (2008). Mathematical Analysis. Narosa Publishing House. (For Unit3 and 4).</td></tr>
<tr><td colspan="2">Website and E-learning Source</td><td colspan="6">http:/www.mathforum.org,http:/opensource.org</td></tr>
</table>

<table>
<tr><td colspan="2">Department of Mathematics</td><td colspan="6">Madhabdev University</td></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="3">Complex Analysis</td><td colspan="2">Paper Number</td><td></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">CORE</td><td>Year</td><td>1</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td>Course Code</td><td>PMTC 201</td></tr>
<tr><td>Semester</td><td>II</td><td></td><td></td></tr>
<tr><td colspan="2">Instructional Hours (Per week)</td><td colspan="2">Lecture</td><td>Tutorial</td><td colspan="2">Lab Practical</td><td>Total</td></tr>
<tr><td colspan="2"></td><td colspan="2">3</td><td>1</td><td colspan="2"></td><td>4</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">It is expected that the students will be exposed to an advanced course in Complex Analysis.</td></tr>
<tr><td colspan="2">Learning Outcome</td><td colspan="6">After going through this course, the students will be able to
(i) Define various functions of Complex variables.
(ii) Discuss the principles involved with Complex Integration.
(iii) Obtain the conformal mappings of standard complex valued functions.</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UnitI: Functions of Complex variable: Marks 12 L: 9 T: 3
Functions of Complex variables, Mappings by exponential functions, limits, continuity, derivatives, Cauchy-Riemann equations, Analytic functions, Harmonic functions, Reflection principles, The exponential functions, logarithmic function, Branches and derivatives of logarithm, Complex exponents, Trigonometric functions, Hyperbolic functions, Inverse trigonometric functions.

UnitII:Integration of Complex functions: Marks 12 L: 9 T: 3
Basic properties of Complex Integration, Cauchy's Theorem, Morera's Theorem, Cauchy Integral formula, Laurent's series,The Maximum modulus principle, Schewarz lemma, Liouville's theorem.

UnitIII: Series of Complex variables: Marks12 L:9 T:3
Convergence of sequences, Convergence of series, Taylor series, Laurent Series, Absolute and uniform convergence of Power series, Uniqueness of series representation.

Unit IV:Calculus of Residues: Marks 12 L:9 T:3
Residue at a finite point, Residue at the point at infinity, Residue Theorem, Number of zeros and poles, Argument principle, Rouche's theorem, evaluation of Integrals, Application of residues, Jordan’s lemma, Indented Paths.

UnitV: Conformal Mapping: Marks12 L:9 T:3
Linear Transformation, Linear fractional transformation, mappings of upper half plane, The transformation $w = \sin z$; mappings by z^2 and Branches of $z^{1/2}$, square roots of polynomials,preservationofangles,scalefactor,localinverses,harmonicconjugates,transformationof Harmonic functions, Applications.</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">1. Brown, J. W., Churchill, R. V. (2009). Complex variables and applications. Boston: McGraw-Hill Higher Education.
2. Ponnusamy, S.(2002). Foundations of Complex analysis. Narosa Publishing House.
3. Apostol, T.M. (2008). Mathematical Analysis. Narosa Publishing House.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. Karunakaran, V.(2005).Complex analysis. Alpha Science Int'l Ltd.
2. Rudin,W.(2006). Real and complex analysis. Tata Mc Graw-Hill Education.
3. Hahn, L. S., Epstein, B.(1996).Classical complex analysis. Royal Society of Chemistry.</td></tr>
</table>

<table>
<tr><td colspan="3">Department of Mathematics</td><td colspan="5">Madhabdev University</td></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="3">Linear Algebra</td><td colspan="2">Paper Number</td><td></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">CORE</td><td>Year</td><td>1</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td>Course Code</td><td>PMTC 202</td></tr>
<tr><td>Semester</td><td>II</td><td></td><td></td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours (Per week)</td><td colspan="2">Lecture</td><td>Tutorial</td><td colspan="2">Lab Practical</td><td>Total</td></tr>
<tr><td colspan="2">3</td><td>1</td><td colspan="2"></td><td>4</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">To build up a foundation of Linear algebra</td></tr>
<tr><td colspan="2">Learning outcome</td><td colspan="6">After going through this course, student will able to
(i) Give theoretical treatment to solve system of linear equations.
(ii) Discuss basic properties of inner products spaces and operators.</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">Unit I: Marks10 L:8, T:2
Matrix representation of a linear transformation, Annihilating polynomial of a linear transformation; Elementary Canonical forms: Diagonalization and triangulation of linear operators. Gerschgorin’s disk theorem.

UnitII: Marks8 L:8, T:2
Primary Decomposition theorem; rational and Jordan forms.

Unit III: Marks12 L:9, T:3
Inner product spaces: inner product, Cauchy-Schwarz inequality, Gram-Schmidt orthogonalization process, Orthogonal Linear Transform.

UnitIV: Marks16 L:10, T:4
Linear functionals and adjoints; self adjoint, positive definite, normal and unitary operators; orthogonal projections; spectral theorem for normal operators on a finite dimensional vector space, Singular value decomposition.

Unit V: Marks14L:10, T:4
Bilinear forms, Matrices of bilinear forms, Symmetric bilinear forms, Diagonalization of symmetric matrices, positive and quadratic forms, Sylvester’s law of inertia.</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">1. Axler.S.(1997). Linear Algebra Done Right. Springer.
2. Stephen H. F., Arnold J. I. and Lawrence E. S., (2003). Linear Algebra, 4th edition, Prentice Hall.
3. Hoffman, K. and Kunze, R., (1984). Linear Algebra, Prentice Hall.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. Artin, M.(2015).Algebra. Pearson Ed. India.
2. Saikia, P.K.(2014). Linear Algebra. Pearson Education India
3. Strang, G.(2005). Linear Algebra and its Applications. Cengage Learning.
4. Halmos, P. R.,(1987). Finite dimensional vector spaces, Springer Verlag, New York.
5. Bhattacharya, P. B., Jain, S. K., Nagpaul, S.R.(1994). Basic abstract algebra. Cambridge University Press.</td></tr>
<tr><td colspan="2">Website and E-learning Source</td><td colspan="6">MITOCW18.06SC: Linear Algebra by Gilbert Strang.
http://ocw.mit.edu/(AlsoavailableonYoutube)</td></tr>
</table>

<table>
<tr><td colspan="8">Department of Mathematics Madhabdev University</td></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="3">Numerical Analysis</td><td colspan="2">Paper Number</td><td></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">CORE</td><td>Year</td><td>1</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td>Course Code</td><td>PMTC 203</td></tr>
<tr><td>Semester</td><td>II</td><td></td><td></td></tr>
<tr><td colspan="2">Instructional Hours (Per week)</td><td colspan="2">Lecture</td><td>Tutorial</td><td colspan="2">Lab Practical</td><td>Total</td></tr>
<tr><td colspan="2"></td><td colspan="2">3</td><td>1</td><td colspan="2"></td><td>4</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">To give a theoretical treatment to the numerical methods used to solve various problems of science and engineering</td></tr>
<tr><td colspan="2">Learning out come</td><td colspan="6">After completing this course learners will be able to
(i) Use and analyze various numerical methods in solving scientific problem
(ii) Discuss various issues in a numerical techniques such as convergence and stability
(iii) Fit polynomial and exponential function to a given set of data.</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">Unit I:Floating point representation and Errors: Marks5 L:4,T:2
Review of Taylor series, floating point representation, loss of significance

Unit II: Solution of system of equations: Marks15 L:11,T:3
Doolittle and Crout’s Decomposition, Successive approximation by Gauss Jacobi, Gauss Seidal’s Methods, Convergence of successive approximations.

UnitIII: Numerical Integration: Marks15 L:11,T:4
General Newton’s quadrature formula, Weddle’s rule, Newton-Cotes formula, Gaussian quadrature.

UnitIV: Solution of Ordinary Differential Equations: Marks15 L:11,T:4
Stability and Convergence of numerical methods, Runge-Kutta method of second, third and fourth order, General explicit method, Adam-Bashforth, General implicit method, Adam-Moultan, Milne-Simpson method.

Unit V:CurveFitting: Marks10 L:8, T:2
General Least Square Method, Normal equations, Fitting of a polynomial(second and third degree),Fitting of exponential curves, Chebyshev polynomials.</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">1. Kincaid, D., Cheney,W.(2002). Numerical Analysis: Mathematics of Scientific Computing. AMS.
2. Atkinson, K., Han, W. (2003).Elementary Numerical Analysis, John Wiley & Sons.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. Hilderbrand, F.B. (1987). Elementary Numerical Analysis. Dover publications.
2. Conte, S.D. (1980).Elementary Numerical Analysis: Algorithmic approach. Tata Mc Graw Hills
3. Madhumangal, P. (2009).Numerical Analysis for Scientist and Engineers. Narosa Publication House.</td></tr>
<tr><td colspan="2">Website and E-learning Source</td><td colspan="6">http://mathform.org.http://ocw.mit.edu/ocwweb/Mathematics,http://www.opensource.org
.</td></tr>
</table>

<table>
<tr><td colspan="3">Department of Mathematics</td><td colspan="4">Madhabdev University</td></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="2">Classical Mechanics</td><td colspan="2">Paper Number</td><td></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">DSE</td><td>Year</td><td>1</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2">PMTD 101</td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours (Per week)</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td>Lab Practical</td><td>Total</td></tr>
<tr><td colspan="2">3</td><td colspan="2">1</td><td></td><td>4</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">• To introduce Development of Lagrangian approach to solve problems in mechanics.
• To deal with complex problems in phase space based on Hamilton’s principle, basic theorems and procedures.
• To use Advanced techniques and procedures for problems in phase space.</td></tr>
<tr><td colspan="2">Learning Outcome</td><td colspan="6">After going through this course the students will be able to
(i) Explain mechanical problems in phase space
(ii) Describe the approaches of mechanics due to Lagrangian, Hamiltonian.</td></tr>
<tr><td colspan="2">Course outline</td><td colspan="6">Unit1: Mark 15 L:12, T:4
Motion in two dimensions under finite forces and its various applications, Kinetic Energy, Moment of Momentum, Motion of sphere in a rough inclined plane.
UnitII: Mark15 L:11,T:4
Conservation of linear and angular momentum under finite and impulsive forces, Conservative energy.
UnitIII: Mark15 L:11,T:4
Eulerian angles, Euler’s dynamical equations of motion, motion under no external forces, Kinetic Energy, Instantaneous axis of rotation.
Unit IV: Mark15 L:11,T:3
Generalized coordinates: Lagrange’s equations of motion for finite and impulsive forces, conservative forces, Small oscillation. Hamilton’s canonical equations, Hamilton’s principle and principle of least action.</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">1. Goldstein, H., Poole, C., Safko, J. (2002). Classical mechanics. Addision Wesley Publishing Company, INC. USA.
2. Iro, H.(2002).A Modern Approach to Classical Mechanics, World Scientific</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. Calkin, M.G.(1996). Lagrangian and Hamiltonian mechanics.World Scientific, Singapore.</td></tr>
<tr><td colspan="2">Website and E-learning Source</td><td colspan="6">http://mathforum.org,http://ocw.mit.edu/ocwweb/Mathematics,http://www.opensource.org</td></tr>
</table>

<table>
<tr><td colspan="3">Department of Mathematics</td><td colspan="5">Madhabdev University</td></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="3">Combinatorics and Probability</td><td colspan="2">Paper Number</td><td></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">DSE</td><td>Year</td><td>1</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td>Course Code</td><td>PMTD 102</td></tr>
<tr><td>Semester</td><td>I</td><td></td><td></td></tr>
<tr><td colspan="2">Instructional Hours(Per week)</td><td colspan="2">Lecture</td><td>Tutorial</td><td colspan="2">Lab Practical</td><td>Total</td></tr>
<tr><td colspan="2"></td><td colspan="2">3</td><td>1</td><td colspan="2"></td><td>4</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">This course will introduce the theory of enumeration and probability.</td></tr>
<tr><td colspan="2">Learning Outcome</td><td colspan="6">After going through this course, learners will be able to
(i) Use techniques of enumeration in real life problems
(ii) Model the real life situations using probability theory.</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT I:Combinatorics: Marks:25,L:20, T:5

Counting principles, principle of mathematical induction, partitions and allocations, principle of inclusion and exclusion, arrangements, derangements. Pigeon Hole Principle, multinomial theorem, set partitions and Stirling numbers of the second kind, permutations and Stirling numbers of the first kind, infinite matrices, inversion of sequences, probability generating functions, generating functions, evaluating sums, the exponential formula

UNITII: Probability: Marks:20,L:15, T:5

Axiomatic definition of probability, probability spaces, probability measures on countable and uncountable spaces, conditional probability, independence; Random variables, distribution functions, probability mass and density functions, functions of random variables, standard univariate discrete and continuous distributions and their properties;

Unit III: Moments and Joint Distribution Marks15, L:10,T:5

Mathematical expectations, moments, moment generating functions, characteristic functions, inequalities; Random vectors, joint, marginal and conditional distributions, conditional expectations, independence, covariance, correlation, standard multivariate distributions</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">1. Stanley, R. P.(2011).Enumerative Combinatorics. Cambridge Univ Press.
2. Ross, S. M.(2002).A first course in probability. Pearson Education India.
3. Rohatgi,V. K., Saleh, A.K. Md. E. (2001). An Introduction to Probability and Statistics.Wiley.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. Berge, C.(1971).Principles of combinatorics. New York, 176.
2. Aigner, M. (2007).A course in Enumeration .Springer Science & Business Media.
3. Ross, S.M.(2007). Introduction to Probability Models. Elsevier.</td></tr>
<tr><td colspan="2">Website and E-learning Source</td><td colspan="6">http://mathforum.org,
http://ocw.mit.edu/ocwweb/Mathematics,http://www.opensource.org</td></tr>
</table>

<table>
<tr><td colspan="2">Department of Mathematics</td><td colspan="5">Madhabdev University</td></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="3">Fluid Dynamics</td><td colspan="2">Paper Number</td><td></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">DSE</td><td>Year</td><td>1</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td>Course Code</td><td>PMTD 201</td></tr>
<tr><td>Semester</td><td>II</td><td></td><td></td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours(Per week)</td><td colspan="2">Lecture</td><td>Tutorial</td><td colspan="2">Lab Practical</td><td>Total</td></tr>
<tr><td colspan="2">3</td><td>1</td><td colspan="2"></td><td>4</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">The objective of this course is to introduce
• Fundamental aspects of fluid flow behaviours.
• Dynamics of viscous fluid flows and governing equations of motion.</td></tr>
<tr><td colspan="2">Learning Outcome</td><td colspan="6">After going through this course, students will be able to
• Describe stress-strain relationship of Newtonian fluids.
• Derive some exact solutions of Navier-Stokes equations under different geometries.</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UnitI: Kinematics of Fluids in motion & Stress and Strain Analysis: Marks:20, L:15, T:5
Methods of describing fluid motion, material, local and convective derivatives, path lines, stream lines, vortex lines, strain and its types, small deformation theory, stress vector and stress tensor, various stresses, constitutive equations, Reynolds transport formula, conservation laws and mathematical forms in various fluid motions (steady and unsteady, compressible and incompressible, rotational and irrotational etc.), Bernoulli’s equation.

Unit II: Two and Three Dimensional Inviscid Fluid Flows: Marks: 14, L: 10, T:4
Complex potential, Sources, sinks, doublets, images with respect to plane and circle, Milne-Thomson circle theorem, Blasius theorem, motion pasta circular cylinder, axi-symmetric flows, Stokes’s stream function, motion pasta sphere, D-Alembert’s paradox.

Unit III: Navier-Stokes Equations and its Exact Solutions: Marks:14, L:11, T:3
Navier-Stokes equations, rate of change of circulation, diffusion of vorticity, vorticity equation and energy dissipation due to viscosity, exact solutions of Navier-Stokes equations: Couette flow, Poiseuille flow, Hagen-Poiesuille flow through a pipe, flow through annular region, Stokes first problem.

UnitIV: Boundary Layer Theory: Marks:12, L:9,T:3
Laminar boundary layer, two-dimensional boundary layer equations, Blasius equation, boundary layer parameters, separation of boundary layer, momentum and energy integral equation.</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">1. Chatterjee, R. (2015). Mathematical Theory of Continuum Mechanics. Narosa Publishing House.
2. Schlichting, H., Gersten, K. (2016).Boundary-layer theory. Springer.
3. Chorlton, F. (2004).Text book of fluid dynamics. CBS Publisher.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. Spencer, A.J.M.(2004). Continuum Mechanics. Dover Publications.
2. Raisinghania, M.D.(2003). Fluid Dynamics. S.Chand Publications.
3. Lamb, S.R.(1945). Hydrodynamics. Dover Publications.
4. Ramsay, A.S.(1913).Hydrodynamics(ATreatise on Hydromechanics).G.Belland Sons,ltd.
5. Kundu, P.K.Cohen,I.M., Dowling, D.R.(2011).Fluid Mechanics. Academic Press.
6. Thomson, L.M.M. (2011). Theoretical Hydrodynamics. Dover Publications</td></tr>
<tr><td colspan="2">Website and E-learning Source</td><td colspan="6">https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-01-unified-engineering-i-ii-iii-iv-fall-2005-spring-2006/fluid-mechanics/</td></tr>
</table>

<table>
<tr><td colspan="8">Department of Mathematics Madhabdev University</td></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="3">Graph Theory</td><td colspan="2">Paper Number</td><td></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">DSE</td><td>Year</td><td>1</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td>Course Code</td><td>PMTD 202</td></tr>
<tr><td>Semester</td><td>II</td><td></td><td></td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours(Per week)</td><td colspan="2">Lecture</td><td>Tutorial</td><td colspan="2">Lab Practical</td><td>Total</td></tr>
<tr><td colspan="2">3</td><td>1</td><td colspan="2"></td><td>4</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">To build up a foundation of Graph Theory.</td></tr>
<tr><td colspan="2">Learning Outcome</td><td colspan="6">After going through this course, students will be able to
• Define and explain basic concepts in graph theory, including graphs, subgraphs, paths, cycles, and connectivity.
• Analyze various types of graphs such as trees, bipartite graphs, and planar graphs, and understand their properties and applications.
• Explore advanced topics in graph theory, including graph coloring, Eulerian and Hamiltonian paths and cycles, and graph isomorphism.</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">Unit-I Marks: 5, L: 3, T:2
Preliminaries: Graphs, subgraphs, Isomorphism, degree, degree sequence, operations on graphs.
Unit-II Marks: 6, L: 3, T:2
Walk, Trail, Path, Cycle, circuit, Connected graphs, component, distance between vertices, Bipartite graph, eccentricity, radius, diameter.
Unit-III Marks: 6, L: 3, T:5
Tree, Bridge, Center of a tree, Forest, Spanning tree.
Unit-IV Marks: 15, L:10 , T:5
Cut-vertices, Block, vertex-connectivity, edge-connectivity, Eulerian graph and its properties, Hamiltonian graph and its Properties.
Unit-V Marks: 13, L: 7, T:5
Planarity: Basic Concepts, Plane Graphs, Interior face, exterior face, Euler Identity, Maximal Planar graph.
Unit-VI Marks: 15, L: 10, T:5
Coloring: vertex coloring, chromatic number, The Four Color Theorem, independence number, Brook's theorem, edge Coloring, edge chromatic number, The Five color Theorem.</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">1. Chartrand , G. and Zhang , P.(2012). A First Course in Graph Theory, Dover Publication, NewYork.
2. Bondy,J. A. and Murthy,U.S. R.(1976). Graph Theory with Applications, London: Macmillan Press.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. Liu, C.L. Elements of Discrete Mathematics, Tata Mc Graw Hill.
2. Grimaldi, R.P. Discrete and Combinatorial Mathematics, Pearson</td></tr>
</table>

Department of Mathematics							*Madhabdev University*
Title of the Course		**Measure Theory**			**Paper Number**		
Category	**CORE**	**Year**	**2**	**Credits**	**4**	**Course Code**	**PMTC 301**
		Semester	**III**				
Instructional Hours (Per week)		**Lecture**		**Tutorial**	**Lab Practical**		**Total**
		3		**1**			**4**
Objectives of the Course		The learners will be exposed to the Lebesgue Theory of Integration as an extension of the standard Riemann Theory.					
Learning outcome		After going through this course, the students will be able to (i) Describe the properties of Measurable sets and functions. (ii) Integrate functions using Lebesgue Integration tools.					
Course Outline		**Unit-1** Algebra of sets, Borel sets, Extended real numbers. **Unit-2** Lebesgue measure on the Real Line: Lebesgue outer measure, Lebesgue Measurable sets and Lebesgue measure, Non-measurable sets. **Unit-3** Lebesgue Measurable functions, Simple functions, Littlewood's principles. **Unit-4** Lebesgue integral of simple functions, Lebesgue integral of bounded functions, Bounded convergence theorem, Comparison of Riemann and Lebesgue integral. **Unit-5** Lebesgue integral of non-negative functions, Fatou's Lemma, Monotone convergence theorem, Lebesgue general integral, Lebesgue dominated convergence theorem. **Unit-6** Convex function and Jensen's inequality, *Lp* spaces, Young, Holder and Minkowski inequalities, Completeness of *Lp* spaces, Bounded linear functionals on *Lp* spaces.					
Recommended Text		1. Berra, G. D. (2014). Measure Theory and Integration. Wiley Eastern LTD. 2. Royden, H. L. (2002). Real Analysis. Mc-Millan 3. Feller, W. (1966). An Introduction to Probability Theory and its Applications.					
Reference Books		1. Rudin, W. (1998). Principles of Mathematical Analysis. McGraw Hill. 2. Jain, P K., Gupta, V. P., Jain, P. (2010). Lebesgue Measure and Integration. New Age International Publisher.					
Website and E-learning Source		http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics					

<table>
<tr><td colspan="3">Department of Mathematics</td><td colspan="5">Madhabdev University</td></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="3">Topology</td><td colspan="2">Paper Number</td><td></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>2</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td>Course Code</td><td>PMTC 302</td></tr>
<tr><td>Semester</td><td>III</td><td></td><td></td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours (Per week)</td><td colspan="2">Lecture</td><td>Tutorial</td><td colspan="2">Lab Practical</td><td>Total</td></tr>
<tr><td colspan="2">3</td><td>1</td><td colspan="2"></td><td>4</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">To introduce the most general mathematical structure for discussing notions of analysis like convergence, continuity, compactness and connectedness. Notions like separation axioms, nets and filters will be introduced to emphasize that topological structures are more general than metric structures.</td></tr>
<tr><td colspan="2">Learning Outcome</td><td colspan="6">After going through this course, students will be able to
(i) Prove results of classical analysis in a more general setting
(ii) Obtain relationship of continuity with connectedness, compactness and separation axioms</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">Unit I: Basics Topology: Marks: 20, L :15, T: 5

Open Sets, Closed Sets, Neighbourhood, Limit Point, Interior, Closure, Basis, Sub-basis, finer and coarser topology, Subspace.
Continuous Functions, Open Functions, Closed Functions, Homoemorphism, Composition of Continuous Functions, Pasting Lemma, Product Topology, Quotient Topology.

Unit II: Compactness and Connectedness: Marks: 20, L :15, T: 5
Compact Space, Countable Compact Spaces, Linderloff Space, Local Compactness, Idea of Comapacttification, One point compactification, Stone Cech compactification, Connectedness, Path Connectedness, Local Connectedness.

Unit III: Countability, Separation Axioms, Metrisation: Marks: 20, L :15 , T: 5
The countability axioms, the separation axioms, Normal spaces, The Urysohn Lemma, The Tietze Extension theorem. Uniformities and basic definitions, Metrisation, Urysohn Metrization Theorem</td></tr>
<tr><td colspan="2">Recommended Texts</td><td colspan="6">1. Munkres, J. (2015). Topology, Pearson.
2. Joshi, K. D. (1983). Introduction to general topology. New Age International.
3. Simmons, G. F., Hammitt, J. K. (2017). Introduction to topology and modern analysis. New York: McGraw-Hill.
4. Murdeshwar, M.G. (1990). General topology. New Age.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. Lipschutz .S. Schaum's Outlines. New York: McGraw-Hill.
2. Kelley, J. L. (1975). General Topology. Springer.</td></tr>
<tr><td colspan="2">Website and E-learning Source</td><td colspan="6">http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, httip://www.opensource.org</td></tr>
</table>

<table>
<tr><td colspan="3">Department of Mathematics</td><td colspan="5">Madhabdev University</td></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="3">Numerical Partial Differential Equation</td><td colspan="2">Paper Number</td><td></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">CORE</td><td>Year</td><td>2</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td>Course Code</td><td>PMTC 303</td></tr>
<tr><td>Semester</td><td>III</td><td></td><td></td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours (Per week)</td><td colspan="2">Lecture</td><td>Tutorial</td><td colspan="2">Lab Practical</td><td>Total</td></tr>
<tr><td colspan="2">3</td><td>1</td><td colspan="2">0</td><td>4</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">The objective of numerical methods for partial differential equations (PDEs) is to approximate the solutions of these equations using computational techniques.</td></tr>
<tr><td colspan="2">Learning Outcome</td><td colspan="6">After going through this course the students will be able to
(iii) Understand the concepts of accuracy and stability in numerical methods and how they relate to the convergence and reliability of the solutions obtained
(iv) Learn how to handle different types of boundary conditions (e.g., Dirichlet, Neumann, Robin) in numerical PDE solvers
(v) Apply numerical methods to model and simulate complex physical phenomena such as fluid dynamics, heat transfer, electro
(vi) magnetics, structural mechanics, etc.</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">Unit-1 Marks 15, L:12,T:4
Finite difference equation, Solution of Elliptic equation, Numerical solution of one-dimensional Heat equation, Numerical solution of Wave equation, Explicit and implicit schemes, Neumann and mixed problems.

Unit-2 Marks 15, L:11,T:3
Consistency, Stability and convergence, Lax’s equivalence theoram, Upward and Backward scheme, Backward Euler’s scheme.

Unit-3 Marks 15,L:10,T:5
Finite difference scheme for initial and boundary value problem, BTCS, FTCS scheme, Schmidt Method, Crank Nicolson Scheme, Dufort Frankel scheme, Pictorial representation.

Unit-4 Marks 15, L:12,T:4
Systeam of differential equation, initial and boundary conditions, Adaptive Numerical Methods, Predictor-Corrector Method, Euler’s Method, Runge Kutta Method, well posed problem.</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">1. Hoffman , J.D. (2001). Numerical Methods for Engineers and Scientists , McGrew Hill
2. Pundir , S. K. (2019). Applied Numerical Analysis , CBS Publishers & Distribuitors
3. Smith, G. D.(1986). Numerical solution to Partial Differential Equation, Oxford University Press, 3rd Edn.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. Johnson, C.(2009). Numerical solution of Partial differential Equation by the Finite element Method, Dover Publications
2. Langtangen,H. P.(1999) Computational Partial differential Equations Springer Verlag</td></tr>
<tr><td colspan="2">Website and E-learning Source</td><td colspan="6">www.numerical solution of pde.com</td></tr>
</table>

<table>
<tr><td colspan="3">Department of Mathematics</td><td colspan="4">Madhabdev University</td></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="2">Number Theory</td><td colspan="2">Paper Number</td><td></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">DSE</td><td>Year</td><td>2</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2">PMTD 301</td></tr>
<tr><td>Semester</td><td>III</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours (Per week)</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td>Lab Practical</td><td>Total</td></tr>
<tr><td colspan="2">3</td><td colspan="2">1</td><td></td><td>4</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">• To Understand quadratic residues and their importance in modular arithmetic
• To understand the properties and applications of continued fractions.
• To study the Fibonacci numbers and their recursive properties.
• To provide a comprehensive understanding of partitions, including their graphical representation, theoretical properties</td></tr>
<tr><td colspan="2">Learning Outcome</td><td colspan="6">Familiar with Basics of number theory and its application</td></tr>
<tr><td colspan="2">Course outline</td><td colspan="6">Unit1: Marks 15 L:11 , T: 3
Primitive roots, order of an integer mod m, primitive roots for primes, composite numbers having primitive roots, theory of indices
Unit II: Marks 15 L:12 , T:4
Quadratic residues, Euler’s criterion, Legendre’s symbol and its properties, Quadratic Reciprocity Law, Quadratic congruence with composite moduli.
Unit III: Marks 15 L:11 , T: 4
Linear Diophantine equation, Diophantine equation of second degree, Fibonacci numbers and their properties, Continued fractions, Pell’s equation.
Unit IV Marks 15 L: 11, T: 4
Partitions, graphical representation of partitions. Euler’s theorem, generating functions, search for partition identities.</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">1. Burton,D. M.(2017). Elementary Number Theory, McGraw Hill Education (Unit 1,2,3)
2. Andrews,G. E.(2012).Number Theory , Dover Publications (Unit 4)
3. Dickson, L. E.(1971) .History of the Theory of Numbers (Vol. II, Diophantine Analysis). New York: Chelsea Publishing Company.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. Molin, R. A.(2011) . Algebraic number theory, Chapman and Hall/CRC
2. Hardy, G. H. (1938).An Introduction to the Theory of Numbers. Oxford: Clarendon Press,
3. Niven, I., Zuckerman, H.S. and Montgomery, H.L.(2003). An Introduction to the Theory of Numbers (6th edition). New York: John Wiley and Sons</td></tr>
<tr><td colspan="2">Website and E-learning Source</td><td colspan="6"></td></tr>
</table>

Department of Mathematics *Madhabdev University*

Title of the Course		**Magneto-hydrodynamics**			**Paper Number**		
Category	**DSE**	**Year**	**2**	**Credits**	**4**	**Course Code**	**PMTD 302**
		Semester	**III**				
Instructional Hours (Per week)		**Lecture**		**Tutorial**	**Lab Practical**		**Total**
		3		**1**	**0**		**4**

Objectives of the Course

- To understand the solid foundation in calculus and vector calculus.
- To study fundamental concepts of electromagnetism in hydrodynamics through a variety of mathematical modelling techniques.

Learning Outcome

1. Students will be able to demonstrate an understanding of fundamental concepts in electromagnetism, including the definition of charged particles, magnetic fields, electromagnetic potentials, and the non-uniqueness of electromagnetic potentials. They will also be able to calculate electric and magnetic fields produced by uniformly moving and accelerated point charges.
2. Students will develop proficiency in analyzing the behavior of charged particles in electromagnetic fields, particularly in understanding and applying the Lorentz force equation. They will be able to describe the relationship between electric and magnetic fields in Lorentz force, analyze trajectories of charged particles in both uniform and non-uniform magnetic fields, and relate these analyses to real-world phenomena.

Course Outline

Unit-1 Introduction to Electromagnetism: **Marks 15, L:12,T:3**

Definition of charged particles. Meaning of Magnetic field. Electromagnetic Vector and Scalar Potential, Wave equation. Lorentz condition. Non – Uniqueness of electromagnetic potentials. Electric and Magnetic fields due to uniformly moving point charge and accelerated charge.

Unit-2 Introduction to Lorentz Force: **Marks 15, L: 11, T: 4**

Definition and formulation of Lorentz force. Expression of Lorentz force on a moving charged particle in an electromagnetic field. Relationship between electric and magnetic fields in Lorentz force. Analysis of the trajectory of charged particles in uniform and non-uniform magnetic fields.

Unit-3 Maxwell's Equations: **Marks 15, L: 11,T: 4**

Derivation and formulation of Maxwell's equations in integral and differential forms. Interpretation of each equation: Gauss's law for electricity, Gauss's law for magnetism, Faraday's law of electromagnetic induction, and Ampère's law with Maxwell's addition. Wave equation derivation from Maxwell's equations. Application of Maxwell's equations to determine boundary conditions for electric and magnetic fields at interfaces between different media

Unit-4 Introduction to Magneto-hydrodynamics (MHD): **Marks 15, L:11,T: 4**

Overview of magneto-hydrodynamics as the study of the behavior of electrically conducting fluids in the presence of magnetic fields. Basic principles of MHD equations and their derivation from the Navier-Stokes equations and Maxwell's equations. Meaning of Conducting fluid. Induction of electric currents by magnetic fields in conducting fluids, described by the magnetic induction equation. Analysis of Lorentz force exerted by magnetic fields on fluid motion. Influence of magnetic fields on fluid dynamics.

Recommended Text

1. Sengupta, P. Classical Electrodynamics. New Age International Publ.
2. Davidson, P. A. Introduction to Magneto-hydrodynamics
3. Cowling, T. G.(1957) Magneto-hydrodynamics, Inter-science Publishers, New York
4. Shercliff, J. A. A Text Book of Magneto-hydrodynamics, Pergamon Press, Oxford, 1965

Reference Books

1. Cramer, K. R. and Pai, S. I.(1973) Magneto fluid Dynamics for Engineers and Applied Physicists, McGraw Hill, New York

<table>
<tr><td colspan="8">Department of Mathematics Madhabdev University</td></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="3">Mathematical Methods</td><td colspan="2">Paper Number</td><td></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">CORE</td><td>Year</td><td>2</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td>Course Code</td><td>PMTC 401</td></tr>
<tr><td>Semester</td><td>IV</td><td></td><td></td></tr>
<tr><td colspan="2">Instructional Hours (Per week)</td><td colspan="2">Lecture</td><td>Tutorial</td><td colspan="2">Lab Practical</td><td>Total</td></tr>
<tr><td colspan="2"></td><td colspan="2">3</td><td>1</td><td colspan="2">0</td><td>4</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">• To acquaint individuals with essential procedures and tools commonly utilized in analyzing problems within physical science.
• To introduce the calculus of variations technique for addressing intricate optimization challenges across physical science, geometry, and other contemporary fields of interest.</td></tr>
<tr><td colspan="2">Learning Outcome</td><td colspan="6">After going through this course the students will be able to
• Demonstrate proficiency in solving mathematical problems, both analytically and computationally, using appropriate mathematical tools.
• Learn more advanced mathematical techniques such as complex analysis, Fourier analysis, optimization, and numerical methods.</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">Unit-1 Marks 15, L:12,T:4
Linear Functional, Euler Lagrange equation, Euler Poisson equation, Variational problems with functional dependent on function of several independent variable having first order derivative, Isoperimetric problem, Necessary and Sufficient condition for extremum variational problem with fixed bounderies.
Unit-2 Marks 18, L:12,T:3
Fourier series, Generalized Fourier series, Fourier sine and cosine series, Laplace transform and its properties, Convulation and it’s properties, Inverse Laplace transform, Application of Laplace transform.
Unit-3 Marks 15, L:10,T:5
Integral equation, Generalized form of integral equation, Fredhlom and Voltera integral equation and it’s kind, Solution of Fredhlom and Voltera by method of approximation, Method of Resolvant kernel, Iterative scheme for Fredhlom and Voltera integral equation of second kind.
Unit-4 Marks 12, L:11, T:3
Nonlinear programming: formulation of NLPP, General NLPP, Kuhn-Tucker condition. Saddle point and NLPP. Graphical solutions of NLPP, quadratic programming. Wolfe’s modified simplex method.</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">1. Gupta, A,S.(2003) Calculus of Variation with Applications ,Prentice Hall of India, New Delhi
2. Brown J.W . and Churchill , R.(1993) Fourier Series and Boundary Value Problems McGrew Hill
3. Mikhlin , S.G.(2001) Integral equations, The Mac Millam Company, New York
4. Swarup, K., Gupta, P.K., and Mohan, M.,(2007) . Operations Research, Sultan Chand & Sons</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. Poulariks, A. D.(1996). The transform and Application – Handbook , CRC Press
2. Courant, R. and Hilbert , D. (2008) . Methods of Mathematical Physics, Partial Differential Equations. John Wiley & Sons.</td></tr>
<tr><td colspan="2">Website and E-learning Source</td><td colspan="6">http://mathforum.org.
http://ocw.mit.edu/ocwweb/Mathematics.org.</td></tr>
</table>

Department of Mathematics							*Madhabdev University*
Title of the Course		**Computer Programming**			**Paper Number**		
Category	**CORE**	**Year**	**2**	**Credits**	**4**	**Course Code**	**PMTC 402**
		Semester	**IV**				
Instructional Hours (Per week)		**Lecture**		**Tutorial**		**Lab Practical**	**Total**
		3		**1**		**0**	**4**

Objectives of the Course

- To equip students with fundamental principles and practical skills in computer programming using the C language, enabling them to develop efficient and reliable software solutions.
- To foster a deep understanding of programming concepts, problem-solving techniques, and best practices within the context of C programming, empowering students to tackle real-world challenges in various domains.

Learning outcome

After going through this course the students will be able to

- Demonstrate proficiency in writing, debugging, and maintaining C programs to solve a wide range of computational problems.
- Apply fundamental programming concepts learned in the context of C to design and implement efficient algorithms and data structures for solving complex problems.

Course outline

Unit I **Marks 15 L: 12, T:3**

Revision of fundamentals of C: Data types in C, variables in C, input output statements, constant declaration, arithmetic operators in C, arithmetic expressions, assignment statements, arithmetic assignment operators, increment and decrement operators, type conversions, operator precedence. for loop, while loop, do…while loop, if statement, if…else statement, switch statement, conditional operators. The break statement, the continue statement, the go-to statement.

Unit II **Marks 15 L: 08, T: 4**

Arrays: Arrays, declaration of one dimensional arrays, two dimensional arrays. Structures and Unions: User defined data types, structures, array of structures, unions, enumerated data type.

Unit III **Marks 10 L: 10, T: 2**

Function in C: Simple functions, passing arguments to functions with return value, call by value, call by reference, overloaded functions, inline functions, default arguments.

Unit IV **Marks 15 L: 10, T: 3**

Pointers: Introduction; accessing address of a variable; pointer declaration, initialization, accessing variable through pointer, chain of pointers; pointer expressions, increment and scale factor. Pointers and Arrays. Array of pointers. Pointers as function arguments.

Unit V **Marks 05 L: 05, T: 3**

Files in C: Defining and opening a file, closing a file. Input/Output operations on files.

Recommended Text

1. Rajaraman, V.(2002). *Fundamentals of Computers*, Prentice Hall of India, New Delhi
2. Balaguruswamy, E.(2004). *Programming in ANSI C*, Tata McGraw-Hill

Reference Books

1. Kanetkar, Y. P. (2001). *Let us C*, BPB Publication
2. Venkateshmurthy, M. G.(2002). *Programming Techniques through C* , Pearson Education

Website and E-learning Source

<table>
<tr><td colspan="2">Department of Mathematics</td><td colspan="6">Madhabdev University</td></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="3">Functional Analysis</td><td colspan="2">Paper Number</td><td></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">CORE</td><td>Year</td><td>2</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2">PMTC 403</td></tr>
<tr><td>Semester</td><td>IV</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours (Per week)</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td>Lab Practical</td><td>Total</td></tr>
<tr><td colspan="2">3</td><td colspan="2">1</td><td>0</td><td>4</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">• To develop a thorough understanding of normed spaces, including Banach spaces and Hilbert spaces, and their fundamental properties.
• To study the theory of linear operators on normed and inner product spaces, understanding bounded and unbounded operators, and their applications.</td></tr>
<tr><td colspan="2">Learning outcome</td><td colspan="6">After going through this course the students will be able to
• Demonstrate proficiency in writing, debugging, and maintaining C programs to solve a wide range of computational problems.
• Apply fundamental programming concepts learned in the context of C to design and implement efficient algorithms and data structures for solving complex problems.</td></tr>
<tr><td colspan="2">Course outline</td><td colspan="6">Unit-1 Recap pre-requisite topics: Marks 15 L :13, T: 4

Linear spaces and linear maps, Metric spaces and continuous functions, Banach fixed point theorem and its applications to Linear Equations, Differential Equations and Integral Equations

Unit II: Normed and Banach Spaces: Marks 15 L : 12, T: 3
Definitions, examples and basic properties of Normed spaces and Banach spaces. Subspace, Quotient Space, Compactness and finite dimension, Definitions, examples and basic properties of Bounded linear operators and functionals, Dual space.

Unit III: Fundamental theorems for Normed and Banach Spaces: Marks 15 L :10, T: 4
Open mapping theorem and its consequences, Closed graph theorem and its consequences, Uniform boundedness principle. Hahn-Banach Theorem and its consequences. Adjoint of bounded linear operator, Canonical Embedding, Reflexivity

Unit IV: Hilbert Spaces: Marks 15 L :10, T: 4
Definitions, example and basic properties of inner-product spaces and Hilbert spaces, Orthogonal Complements and direct sums, Orthogonal sets and sequences, Series related to Orthonormal sequences and sets, Total orthonormal sets. Legendre, Hermite and Laguerre polynomials, Riesz's representation theorem. Hilbert -Adjoint operator, Self Adjoint operator.</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">1. Kreyszig, E. (1978). Introductory functional analysis with applications. New York: Wiley.
2. Limaye, B. V._Functional Analysis, New Age International Private Limited, 3rd Edition</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. Jain, P. K., Ahuja, O. P., Ahmed, K. (1995). Functional Analysis. New Age International (P) Limited</td></tr>
<tr><td colspan="2">Website and E-learning Source</td><td colspan="6">http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org</td></tr>
</table>

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="3">Foundation in Mathematics</td><td colspan="2">Paper Number</td><td></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">GE</td><td>Year</td><td>1</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td>Course Code</td><td></td></tr>
<tr><td>Semester</td><td>II</td><td></td><td></td></tr>
<tr><td rowspan="2">Instructional Hours(Per week)</td><td colspan="2">Lecture</td><td>Tutorial</td><td colspan="2">Lab Practical</td><td>Total</td></tr>
<tr><td colspan="2">3</td><td>1</td><td colspan="2"></td><td>4</td></tr>
<tr><td>Objectives of the Course</td><td colspan="7">To build up a strong foundation of the basic Mathematical tools</td></tr>
<tr><td>Learning Objectives</td><td colspan="7">After going through this course the students will be able to
(i) Identify the Mathematical objects to describe social and physical systems.
(ii) Use the Mathematical tools to address context based problems</td></tr>
<tr><td>Course Outline</td><td colspan="7">UnitI: Sets and Logic: Marks15 L:12, T:3
Statements, Statements with quantifiers, compound statements, implications; Sets, Power sets, Cartesian product, countability of sets, functions and relations, graphs of functions.

Unit II: Counting Principles: Marks15 L:11,T:4
Sum and Product rule of counting, permutation and combination, multinomial theorem, Pigeon hole principle, inclusion-exclusion principle, set partitions, Catalan numbers.

Unit III: Linear Algebra: Marks15 L:11, T:4
Systems of Linear equations, Vector space, Linear Transformations, matrix and determinants.

Unit IV:Finite Differences and Interpolation: Marks 15 L:11, T:4
Introduction, forward difference operator, Operators E & D, backward differences, central differences, Newton’s forward and backward interpolation formulae, Lagrange’s interpolation formula.</td></tr>
<tr><td>Recommended Text</td><td colspan="7">1. Kumar, A., Kumaresan, S., Sarma, B.K. (2018). A Foundation Course in Mathematics, Narosa.
2. Kumaresan, S. (2006). Linear Algebra- A Geometric Approach, Prentice Hall India.
3. Rao, G. S. (2003). Numerical Analysis. New Age International Publishers.
4. Berge, C. (1971). Principles of combinatorics. Academic New York.</td></tr>
<tr><td>Reference Books</td><td colspan="7">1. Stewart, I., Tall, D. (2015). The Foundations of Mathematics. Oxford University Press.
2. Shastry, S. S. (2012). Introductory Methods of Numerical Analysis, Prentice Hall India Learning Private Limited.</td></tr>
<tr><td>Website and E-learning Source</td><td colspan="7">http://www.mathforum.org, http://opensource.org</td></tr>
</table>

<table>
<tr><td>Title of the Course</td><td colspan="4">Mathematical Reasoning and Aptitude</td><td colspan="2">Paper Number</td><td></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">AEC</td><td>Year</td><td>1</td><td rowspan="2">Credits</td><td rowspan="2">2</td><td>Course Code</td><td>PMTA101</td></tr>
<tr><td>Semester</td><td>I</td><td></td><td></td></tr>
<tr><td rowspan="2">Instructional Hours (Per week)</td><td colspan="3">Lecture</td><td>Tutorial</td><td colspan="2">Lab Practical</td><td>Total</td></tr>
<tr><td colspan="3">2</td><td>0</td><td colspan="2"></td><td>2</td></tr>
<tr><td>Objectives of the Course</td><td colspan="7">• Develop critical thinking skills through mathematical and logical reasoning.
• Enhance problem solving abilities in verbal and non-verbal reasoning task.
• Encourage students to interpret and critically evaluate data, mathematical results, and logical arguments.</td></tr>
<tr><td>Learning Outcome</td><td colspan="7">The course will enable the students to:
• Apply mathematical concepts to solve numerical and geometric problems effectively.
• Analyze and construct logical arguments using deductive and inductive reasoning.
• Interpret and solve verbal reasoning problems.
• Analyze non-verbal information to solve visual reasoning tasks.</td></tr>
<tr><td>Course Outline</td><td colspan="7">Unit-I: Mathematical Reasoning and aptitude:
Fraction, LCM and HCF, Ratio-proportions, percentage, profit and loss, interest and discount, problem on ages, time and distance, time and work, calendar problem, Venn diagram, data interpretations, graphical representation (bar chart, histograms, pie charts, table charts, line charts)

Unit II: Verbal and non-verbal reasoning:
Types of reasoning, Analogy, number series, letter series, figure series, coding and decoding, blood relations, ranking and order, syllogism, direction sense,</td></tr>
<tr><td>Recommended Text</td><td colspan="7">1. Aggarwal, R. S., (2021-Reprint). Quantitative Aptitude, S.Chand and Company Limited.
2. Aggarwal, R. S., (2021-Reprint). A Modern Approach to Verbal and non-Verbal Reasoning., S.Chand and Company Limited.</td></tr>
<tr><td>Reference Books</td><td colspan="7">1. Sijwali,B.S and Sijwali,I (2022-Reprint). A New Approach to Reasoning-Verbal, Non-Verbal & Analytical. Arihant Publication
2. Verma, R. (2022-Reprint). Objective Arithmetic. Arihant Publication.</td></tr>
</table>

<table>
<tr><td colspan="2">Department of Mathematics</td><td colspan="6">Madhabdev University</td></tr>
<tr><td colspan="2">Title of the Course</td><td colspan="3">Mathematical Modelling</td><td colspan="2">Paper Number</td><td></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">GE</td><td>Year</td><td>2</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>III</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours (Per week)</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td>Lab Practical</td><td>Total</td></tr>
<tr><td colspan="2">3</td><td colspan="2">1</td><td>0</td><td>4</td></tr>
<tr><td colspan="2">Prerequisites for the Course</td><td colspan="6">Basic knowledge of calculus and set theory.</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">• To introduce the reader to solve ordinary differential equations of first and second order, also to introduce the preliminary of graph theory.
• To introduce the readers with some Mathematical modeling problems using differential equations and Graphs.</td></tr>
<tr><td colspan="2">Learning outcome</td><td colspan="6">After going through this course the students will be able to
(i) Solve first and second order Differential equations.
(ii) Build and solve Mathematical models using Differential Equations
(iii) Build and solve Mathematical models using Graph Theory</td></tr>
<tr><td colspan="2">Course outline</td><td colspan="6">Unit I: First and Second Order Differential Equations Marks 15 L: 12, T: 3
General and particular solutions, separation of variables, Homogeneous equations, Linear Differential Equations of first order, General and particular solutions of homogeneous and non-homogeneous linear differential equations of second order with constant coefficients, First order systems, solution of two-dimensional systems (Simple cases)

Unit II: Mathematical Modelling Through Differential Equations Marks 15 L: 11, T: 4
Techniques of mathematical modeling, Mathematical modeling through first and second order ordinary differential equations: Linear growth and Decay models, non-linear growth and decay models, Compartment models, mathematical modeling in dynamics, Rectilinear motion, Miscellaneous models..

Unit III: Graph Theory Marks 15 L: 11, T: 4
Introduction, Graphs and their representations, Graph terminology, Types of graphs, Fundamental and some additional theorems of graph theory, Operation on graphs, Matrix representation of a graph, Adjacency and incidence matrices.

Unit IV: Mathematical Modelling Through Graphs Marks 15 L: 11, T: 4
Situations that can be modeled through graphs, Mathematical modeling in terms of directed graphs, Signed graphs, Weighted diagraphs, Non-oriented graphs.</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">1. Edwards H. C., Penny D. E. (1995). Differential Equations and Boundary Value Problems: Computing and Modeling. Prentice Hall.
2. Kapur, J. N. (1988) Mathematical Modelling, New Age International Publishers.
3. Deo, N. (2017). Graph theory with applications to engineering and computer science. Courier Dover Publications.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. Barnes, B., Fulford, G. R. (2008). Mathematical Modelling with Case Studies, CRC Press.
2. Bender, E. A. (2012). An introduction to mathematical modeling. Courier Corporation.
3. Meerschaert, M. M. (2013). Mathematical Modelling, Academic Press.</td></tr>
<tr><td colspan="2">Website and E-learning Source</td><td colspan="6">http:/www.mathforum.org, http:/opensource.org</td></tr>
</table>

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="3">Research Methodology</td><td>Paper Number</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">AEC</td><td>Year</td><td>2</td><td rowspan="2">Credits</td><td rowspan="2">2</td><td>Course Code</td><td>PMTA-301</td></tr>
<tr><td>Semester</td><td>III</td><td></td><td></td></tr>
<tr><td colspan="2">Instructional Hours (Per week)</td><td colspan="2">Lecture</td><td>Tutorial</td><td colspan="2">Lab Practical</td><td>Total</td></tr>
<tr><td colspan="2"></td><td colspan="2">1</td><td>0</td><td colspan="2">1</td><td>2</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">• To introduce students to the basic issues and concepts in mathematical research.
• To explore the various methodologies adopted in mathematical research.
• To introduce students to the use of LaTeX for manuscript preparation.
• To teach students how to organize and structure a research paper.</td></tr>
<tr><td colspan="2">Learning Outcome</td><td colspan="6">• Students will have a thorough understanding of the research process in mathematics.
• Students will be able to conduct independent mathematical research, from problem identification to publication.
• Students will be skilled in using LaTeX for preparing and presenting their research work.
• Students will be prepared to contribute to academic and professional communities through high-quality research and presentations.</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">Unit-1 Fundamentals of Mathematical Research Marks 15, L:12,T:3
Basic issues of Mathematics, objects and avenues of Mathematical research methodology of Mathematical research, various methods adopted for doing research in Mathematics.
Unit-2 Objectives and types of research Marks 15, L: 11, T: 4
Motivation and objectives, Research methods vs. methodology, Type of research- Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical.
Unit-3 Mathematics Research Preparation Marks 15, L: 11,T: 4
How to organize a paper, How to write a mathematical statement viz. theorem, remark, proof etc. how to write Abstract and Bibliography, Review of Literature, Preparation of a talk and seminar paper, Preparation of a project.
Unit-4 : Manuscript Preparation using Latex Marks 15, L:11,T: 4
Use of Latex, Preparation of a manuscript using Latex (Research Paper and Seminar presentation)</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">1. Krantz, S.G., A Primer of Mathematical Writings, University Press.
2. Kumar, R. (2005). Research Methodology-A step by step guide for beginners, 2nd Ed. Pearson Education.
3. A primer to Latex Tutorials, Ed. E. Krishnan, Indian Tex users group, Trivandrum, India, 2003 September, E-source:http://www.tug.org.in/tutorials.html</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. Anthony, M., Graziano, A. M. and Raulin, M.L. (2009). Research Methods: A Process of Inquiry, Allyn and Bacon,
2. John, W. B., Kahn, V. (1998). Research in Education, 8th Ed. PHI Publication,
3. Krishna Swami, K.N. and others. (2009). Management Research Methodology-Integration of principles, methods and Techniques, 1st Ed. Pearson Education,
4. Kothari, C. R. (1985). Research Methodology, 2nd Ed. Wiley Eastern, New Delhi.</td></tr>
</table>