St. Xavier's College (Autonomous)
Ahmedabad-09
M. Sc. Mathematics

Courses of M. Sc. Mathematics

St. Xavier's College (Autonomous)
Ahmedabad-09
M. Sc. Mathematics

Semester: I
Metric Space (Theory) **Course Code: PMT 1801**
No. of Credits: 04 **Learning Hours: 60 Hours**

Course Outcomes:

CO1 Student will be able to identify and exemplify metrics and topologies.

CO2 Student will be able to test the convergence of sequence in different metric spaces.

CO3 Student will be able to obtain closure, interior and boundary of a subset of different metric spaces.

CO4 Student will be able to identify and exemplify continuous functions in different means.

CO5 Student will be able to identify and exemplify compact and connected subsets of different metric spaces.

Unit 1: Metric and Metric Spaces, Metric from an inner product and a norm, Open balls and Open sets, Equivalent metrics, Interior of a set, Subspace topology. (Omit proofs of Cauchy-Schwarz, Young's, Hlder's and Minkowski's inequalities).

Unit 2: Convergence of a sequence, Limit and Cluster points, Bolzano-Weierstrass Theorem, Cauchy sequences and Completeness, Bounded sets, Dense sets, Basis, Boundary of a set.

Unit 3: Continuous functions, Equivalent definition of continuity, Distance between two sets, Urysohn's Lemma for metric space, Gluing Lemma, Topological property, Uniform continuity, Limit of a function, Open and closed maps.

Unit 4: Compact spaces and their properties, Continuous functions on Compact spaces, Characterization of compact metric spaces, connected spaces, Product of two connected spaces, Path connected spaces.

Text books:

1. Chapter 1 to 5 from Topology of Metric Spaces, S. Kumaresan, Narosa Publishing House, 2005.

Reference books:

1. Introduction to Real Analysis, R. G. Bartle and D. R. Sherbert, (3rd edition), John Wiley & Sons (ASIA), 2000.
2. Principles of Mathematical Analysis, Walter Rudin, (3rd edition), International Student Edition, McGraw-Hill,1985.
3. Various Articles on Topology, S. Kumaresan available at http://math.mu.ac.in/mtts/downloads.html/.

St. Xavier's College (Autonomous)
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Semester: I
Number Theory (Theory) — **Course Code: PMT 1802**
No. of Credits: 04 — **Learning Hours: 60 Hours**

Course Outcomes:

CO1 Student will gain working knowledge of fundamentals of theory of numbers.

CO2 Student will be able to solve different mathematical problems using the nature of numbers.

CO3 Student will be able to apply number theory in different area of mathematics.

CO4 Student will be able to use some number theoretic functions in solving some mathematical problems.

Unit 1: (Divisibility): Foundations, Division algorithm, greatest common divisor, Euclid's algorithm, Fundamental Theorem, Properties of primes.

Unit 2: (Arithmetical Functions): The function $[x]$, multiplicative functions, Euler's (totient) function $\phi(n)$, The Mobius function $\mu(n)$, The functions $\tau(n)$ and $\sigma(n)$. Brief introduction of convolution of arithmetical functions, perfect numbers.

Unit 3: (Congruences): Definitions, Chinese-Remainder theorem,Theorems of Fermat and Euler, Wilson's theorem, Lagrange's theorem.

Unit 4: (Miscellaneous Topics): Finite, infinite continued Fractions, linear Diophantine equations, Pell's equations, Pythagorean triples, brief introduction of Fermat's last theorem. The order of an integer modulo, Primitive roots, indices. Legendre Symbol and its properties, Quadratic Reciprocity Law.

Text books:

1. A Concise introduction to the Theory of Numbers, Alan Baker (Cambridge Uni. Press,Cambridge).

Reference books:

1. An introduction to the Theory of Numbers (5th edition) by Ivan Nivan, H. S. Zuckerman, H.L. Montgomery (John Wiley & Sons Inc.)
2. Elementary Number theory (Sixth edition) by David M. Burton, Tata McGraw-Hill Publishing Co. Ltd., New Delhi
3. Number Theory, S. G. Telang, Tata Mc Graw Hill,1996.
4. Elementary Theory of Numbers, C. Y. Hsiung, Allied Publishers Ltd.-India.
5. Number Theoryz, George E. Andrews, Hindustan Publishing Corporation-Delhi.
6. Elementary Number Theory, Gareth A. Jones & J. Mary Jones, Springer Verlag.
7. Number Theory, J. Hunter, Oliver and Boyd-London.
8. Beginning Number Theory, Neville Robbins, Narosa Pub. House New Delhi.

9. Introduction to the theory of Numbers, G. H. Hardy & E. M. Wright, Oxford Uni. Press
10. Higher Algebra, S. Barnard & J. M. Child, Macmillan India Ltd
11. Elements of Number Theory, I. M. Vinogradov, Dover Pub. Inc.
12. Elementary Number Theory in Nine chapters, James J. Tattersall, Cambridge Uni Press
13. A first course in Theory of Numbers, K. C. Chowdhary, Asian Books Pvt Ltd New Delhi.
14. 1001 problems in Classical Number Theory, Jean Marie De Konick Armed Mercier, AMS.
15. An Excursion in Mathematics, M. R. Modak, S. A. Katre, V. V. Acharyaand, V. M. Sholapurkar, Bhaskaracharya Pratishthana, Pune.

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Semester: I
Complex Analysis-I (Theory) **Course Code: PMT 1803**
No. of Credits: 04 **Learning Hours: 60 Hours**

Course Outcomes:

CO1 Students will be able to perform operations on complex numbers.

CO2 Students will be able to express complex numbers in polar form and obtain roots of complex numbers.

CO3 Students will be able to identify and exemplify continuous functions, differentiable functions and analytic functions.

CO4 Students will be able to evaluate logarithms of nonzero complex numbers and exponentials and integral powers of complex numbers.

CO5 Students will be able to evaluate integrals of complex functions.

Unit 1: Basic definitions and notations, Algebraic properties, Polar coordinates, Euler's formula, Products and Quotients in exponential form, Roots of complex Numbers, Continuous complex functions, Limits involving point at infinity.

Unit 2: Differentiable complex functions, Cauchy-Riemann equations, Harmonic functions of two variables, Reflection principle.

Unit 3: Elementary functions, Contours, Contour integrals, Anti-derivatives.

Unit 4: Cauchy-Goursat theorem, simply connected domain, Multiply connected domains, Cauchy's integral formula and its extension, Liouville's theorem, Fundamental theorem of Algebra, Maximum moduli principle of functions.

Text books:

1. Complex variables and Applications (8th edition). J. W. Brown and R. V. Churchill, McGraw Hill. International Edition 2009. ISBN: 978-007-126328-3. OR MHID: 007-126328-4.

Reference books:

1. Introduction to Functions of Complex Variable, C. J. Hamilton, Marcel Dekker Inc. NewYork.
2. Complex Analysis, I. Stewart and David Tall, Cambridge University Press.
3. Complex Analysis, J. C. Duncan, John Wiley & Sons, London.
4. Complex Analysis, Lars Ahlfors, McGraw Hills. Indian Edition.
5. Functions of One Complex Variable, John B. Conway, Narosa Publishing house,2002.
6. Foundations of Complex Analysis, S. Ponnusamy, Narosa Publishing house,2005.
7. Complex Variables (Theory and applications), H. S. Kasana, Prentice-Hall of India Pvt. Ltd.,2006.

8. Compex Analysis for Mathematics and Engineering, John H. Mathews and Russel Howell, Narosa Publishing house.

9. Theory & problems of Complex Analysis, Murray R. Spiegel, McGraw-Hill Co. (Metric Editions)

10. Complex Analysis, Serge Lang, (Third Edition), Springer

11. Principles of Mathematical Analysis, Walter Rudin, McGraw-Hill, India.

12. The Elements of Complex Analysis,(Second Edition), B. Choudhary, Wiley Eastern Ltd, New Delhi, 1992

13. An introduction to complex analysis, A. R. Shastri, Macmillan.

14. Theory of complex functions, R. Remmert, Springer.

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Semester: I

Ordinary Differential Equation (Theory) **Course Code: PMT 1804**

No. of Credits: 04 **Learning Hours: 60 Hours**

Course Outcomes:

CO1 Students will be able to formulate ordinary differential equations.

CO2 Students will be able to solve ordinary differential equations.

CO3 Students will be able to solve ordinary differential equations using power series.

CO4 Students will be able to solve some real-life problems using ordinary differential equations.

Unit 1: Review of second order linear equations. Series solutions of first order equations, Second order linear equations, ordinary points.

Unit 2: Second order linear equations: regular singular points, Gauss's hypergeometric equation, the point at infinity.

Unit 3: Hermite polynomials, Chebyshev polynomials and the minimax property. Legendre polynomials, properties of Legendre polynomials.

Unit 4: Bessel functions, properties of Bessel functions; Bessel's integral formula. Existence and uniqueness of solutions: the method of successive approximations, Picard's theorem, systems of equations.

Text books:

1. Differential Equations with Applications and Historical Notes, 2nd Edition, G. F. Simmons, Tata McGraw-Hill Publishing Co. Ltd., 2008.
2. Chapter 5 (Omit Appendices C and E), Chapter 8 (Omit Appendices A and B), Chapter 13.

Reference books:

1. Introduction to Ordinary Differential Equations, A. L. Rabenstein, Academic Press.
2. Advanced Engineering Mathematics (8thEdition) Erwin Kreyszig, Wiley-India,2008.
3. An Introduction to Ordinary Differential Equations, E. A. Coddington,Prentice Hall of India, 2001.
4. Textbook of Ordinary Differential Equations, S. G. Deo, V. Lakshmikantham and V. Raghavendra, Tata McGraw Hill Book Co., 1997.
5. Differential Equations, S. L. Ross, John Wiley & Sons,2004.
6. Ordinary differential equations, Birkhoff G and Rota G.C., Boston,1962
7. AnintroductiontoDifferentialEquations, SaberN.Elaydi,Springerverlag, Second edition, 1995.
8. Ordinary Differential Equations, V.I. Arnold, Prentice-Hall of India, New Delhi,1998

9. Ordinary Differential Equation, Walter.
10. Theory of ordinary differential equations, E.A. Codington, N. Levinson, Tata McGraw-Hill, India.
11. Lectures on ordinary differential equations, Hurewicz W., M.I.T. Press
12. I. N., Elements of Partial Differential Equations, Sneddon, McGraw-Hill Publ. Co., 1957.
13. Introduction to Ordinary Differential Equations, Rabenstein, A. L., Academic Press.
14. Ordinary Differential Equations: A First Course, Somasundaram, D. Narosa Publ. House, New Delhi, 2002.

Semester: I
Practicals based on PMT-1801 and PMT-1802 (Practical) **Course Code: PMT 1805L**
No. of Credits: 06 **Learning Hours: 90 Hours**

Course Outcomes:

CO1 Student will be able to obtain closure, interior and boundary of a subset of different metric spaces.

CO2 Student will be able to identify and exemplify continuous functions in different means.

CO3 Student will be able to identify and exemplify compact and connected subsets of different metric spaces.

CO4 Student will be able to solve different mathematical problems using the nature of numbers.

CO5 Student will be able to use some number theoretic functions in solving some mathematical problems.

List of practicals (problems on):

(1) Problems based on metric space including inner product and norm.

(2) Problems based on open and closed sets, Interior of a set, closure of set, cluster points, Boundary of set.

(3) Problems based on complete, bounded and dense set.

(4) Problems based on convergence, divergent and Cauchy Sequence.

(5) Problems based on continuous functions and uniform continuity.

(6) Problems based on compact space and their properties.

(7) Problems based on connected space and their Properties.

(8) Problems based on open, closed map and fixed-point theorem on continuous function.

(9) Problems based on division algorithm, greatest common divisor and Euclid's algorithm.

(10) Problems based on fundamental theorem and properties of primes.

(11) Problems based on $[x]$ function, $\phi(n)$, $\tau(n)$ and $\sigma(n)$./

(12) Problems based on the Mobius function $\mu(n)$, convolution of arithmetical functions, perfect numbers.

(13) Problems based on congruence, Chinese-Remainder theorem, Fermat theorem and Euler theorem.

(14) Problems based on Wilson's theorem and Lagrange's theorem.

(15) Problem based on continued fractions, linear Diophantine equations $ax + by = c$, Pell's equations, Pythagorean triples.

(16) Problem based on the order of an integer modulo, primitive roots, indices. Legendre symbol and its properties and quadratic reciprocity law.

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Semester: I

Practicals based on PMT-1803 and PMT-1804 (Practical)	**Course Code:**	**PMT 1806L**
No. of Credits: 06	**Learning Hours:**	**90 Hours**

Course Outcomes:

CO1 Students will be able to perform operations on complex numbers.

CO2 Students will be able to express complex numbers in polar form and obtain roots of complex numbers.

CO3 Students will be able to identify and exemplify continuous functions, differentiable functions and analytic functions.

CO4 Students will be able to evaluate integrals of complex functions.

CO5 Students will be able to formulate ordinary differential equations.

CO6 Students will be able to solve ordinary differential equations.

CO7 Students will be able to solve ordinary differential equations using power series.

CO8 Students will be able to solve some real-life problems using ordinary differential equations.

List of practicals (problems on):

(1) Problems based on finding argument, sketching the sets, finding roots and sketching them and also problems on finding limit involving infinity.

(2) Problems based on C-R equations and the sufficient condition for differentiability and in polar form.

(3) Problems based on rough sketches of images of horizontal and vertical lines under the exponential map. Examples on finding harmonic conjugate. Examples on Reflection Principle.

(4) Problems based on $e^z, Logz, z^c$.

(5) Problems based on trigonometric, hyperbolic functions and their inverses.

(6) Problems based on contour integrals and their upper bound and problems based on deformation of paths.

(7) Problems based on Cauchy integral formula and its extension.

(8) Problems based on maximum modulus principle and Miscellaneous problems.

(9) Problems based on first order linear equation, second order linear homogeneous equation with constant coefficient and the use of a known solution to find another solution.

(10) Problems based on second order linear non-homogeneous equation (Method of undetermined coefficients and method of variation of parameters).

(11) Problems based on second order linear equation by power series method and Frobenius method-I.

(12) Problems based on second order linear equation by power series method and Frobenius method-II.

(13) Problems based on Hermite polynomials, Chebyshev polynomials and Legendre polynomials.

(14) Problems based on Bessel functions-I.

(15) Problems based on Bessel functions-II.

(16) Problems based on the Picard's method of successive approximations.

Semester: III

Abstract Algebra-I (Theory)	**Course Code:**	**PMT 2801**
No. of Credits: 04	**Learning Hours:**	**60 Hours**

Course Outcomes:

CO1 Students will be to identify and exemplify different types of concepts of group theory like subgroup, normalizer, centralizer, order of an element, order of a group, cyclic subgroup and use them in other fields of mathematics.

CO2 Students will be apply many mathematical concepts studied in abstract mathematics such as permutation groups, symmetric groups and alternating groups, normal subgroup and quotient group in allied fields of mathematics.

CO3 Student will be able to solve different mathematical problems using the transition between groups by some mathematical tools such as homomorphism & isomorphism.

CO4 Student will be able to demonstrate and describe advanced topics such as Sylow theorems and finite simple groups.

Unit 1: Introduction to groups, symmetries of a square, the dihedral groups, elementary properties of groups, finite groups, subgroups, subgroup tests, cyclic groups, classification of subgroups of cyclic groups.

Unit 2: Permutation groups, cycle notation, properties of permutations, isomorphism, Cayley's theorem, properties of isomorphism, automorphism, properties of coset, Lagrange's theorem and consequences and further applications. External direct products and their properties. The group of units modulo n as an external direct product and further applications.

Unit 3: Normal subgroups, factor groups, applications of factor groups. Internal direct product, group homomorphism and their properties, the first isomorphism theorem. Fundamental theorem of finite Abelian groups, isomorphism classes of abelian groups.

Unit 4: The conjugacy classes, the class equation, Sylow theorems and their applications. Finite simple groups, non-simplicity tests, the simplicity of the group A_5.

Text books:

1. Contemporary Abstract Algebra, 8th Edition, Joseph A Gallian, Cengage Learning, 2013. Chapters: 1 to 11, 24,25.

Reference books:

1. BasicAbstractAlgebra(2ndEdition)-PBBhattacharya,SKJain,SRNagpaul,Cambridge Uni Press, 1995.

2. Algebra, Michael Artin, PHI Learning Pvt Ltd, New Delhi.

3. A Course in Algebra, E B Vinberg, American Mathematical Society, 2003.

4. Algebra, Thomas W Hungerford, Springer, 2004.

5. Topics in Algebra, I.N. Herstein, Second Edition, John Wiley.
6. Topics in Algebra,I. H. Sheth, PHI.
7. Abstract Algebra, Davis S. Dummit and Richard M. Foole, John Wiley.
8. A First course in Abstract Algebra, John Fraleigh (3rdEdition), Narosa Publishing House, New Delhi.

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Semester: II
Measure and Integration (Theory) — **Course Code: PMT 2802**
No. of Credits: 04 — **Learning Hours: 60 Hours**

Course Outcomes:

CO1 Student will be able to recognize measurable sets.

CO2 Student will be able to obtain measure of measurable sets.

CO3 Student will be able to recognize Lebesgue integrable functions.

CO4 Student will be able to obtain Lebesgue integral of Lebesgue integrable functions.

CO5 Student will be able to obtain Fourier series of Lebesgue integrable functions.

Unit 1: The structure of open sets in R, length of open sets and closed sets, inner and outer measure of bounded sets, measurable sets and some of its properties. Further properties of measurable sets, non-measurable sets, definition and the properties of measurable functions.

Unit 2: A quick review of the definition of Riemann integral, Lebesgue integral for bounded functions and its comparison with Riemann integral, properties of Lebesgue integral for bounded functions.

Unit 3: The Lebesgue integral of non-negative and unbounded functions, its properties, Lebesgue dominated convergence theorem, Fatou's Lemma and its consequences like Monotone convergence theorem and the countable additivity of the Lebesgue integral, A very brief introduction to Lebesgue integral on R and in plane.

Unit 4: Square integrable functions, the Schwarz and Minkowski's inequality, Completeness, Dense sets, definition and introduction to Fourier series of integrable functions.

Text books:

1. The course is based on the book Methods of Real Analysis by Richard Goldberg, Oxford & IBH Publishing Company, 1964.
2. Unit-I Chapter - V (Theorem 5.4 F) Chapter XI (Section - 11.1 & 11.2) Chapter XI (Section - 11.3 & 11.4)
3. Unit-II Chapter VII (Section - 7.1 & 7.2) Chapter XI (Section - 11.5 & 11.6) Unit-III Chapter XI (Section - 11.7 & 11.8, 11.10A, 11.10B, 11.10C)
4. Unit-IV Chapter XI (Section - 11.9) Chapter XII (Section - 12.1)

Reference books:

1. Theory of Functions of a real variable Volume-I by I. P. Natanson, Frederic Ungar Publishing Co., New York1964.
2. Real Analysis by H. L. Royden (3 edition), Pearson Prentice Hall (2007).

3. Measure and Integration by I. K. Rana, Narosa Publishing House (1997).
4. Measure and Integration, D. De Barra, Wiely Eastern Limited,1981.
5. Measure Theory, P. R. Halmos, Van Nostrand Publishers,1979.
6. Real and complex Analysis, Walter Rudin, Tata-Mc Graw-Hill Publishing Co. Ltd.,1987.
7. Lebesgue Integration, J. H. Williamson, Holt, Rienhart and Winston Inc.,1962.
8. Measure and Integration, Stein and Shakarchi, Princeton Lectures in Analysis, Princeton University-Press.
9. Mathematical Analysis an Introduction, Andrew Browder, Springer Undergraduate Texts in Mathematics, 1999.
10. Introduction to measure theory, De Barra G. Van Nostrand Reinhold Co.,1974

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Semester: II
Complex Analysis-II (Theory) **Course Code: PMT 2803**
No. of Credits: 04 **Learning Hours: 60 Hours**

Course Outcomes:

CO1 Students will be able to represent complex functions as Taylor series and Laurent series.

CO2 Students will be able to determine residues of complex functions.

CO3 Students will be able to analyze functions using series representation of complex functions.

CO4 Students will be able evaluate integrals of complex functions using residues.

CO5 Students will be able evaluate integrals of real functions using residues.

Unit 1: Convergence of Taylor series, Laurent series and Uniqueness, Convergence of sequences and series, Uniform and absolute convergence of power series, Multiplication and division of power series.

Unit 2: Residue, Cauchy's residue theorem, Residue at infinity, Types of isolated singular points, Residues at poles, Zeros and poles of order m, Behavior of function near removable and essential singular points.

Unit 3: Evaluation of improper integrals from Fourier Analysis using residues, Jordan's lemma. Indented paths, Indentation around a branch cut, Integration along a branch Cut, Definite integrals involving sines and cosines using residues.

Unit 4: Argument principle, Rouch's theorem and Möbius transformations (Bi-linear transformation).

Text books:

1. Complex variables and Applications (8th edition) J. W. Brown and R. V. Churchill, McGraw Hills. International Edition 2009. ISBN: 978-007-126328-3. OR MHID: 007-126328-4.

Reference books:

1. Introduction to Functions of Complex Variable, C. J. Hamilton, Marcel Dekker Inc. New York.
2. Complex Analysis, I. Stewart and David Tall, Cambridge University Press.
3. Complex Analysis, J. C. Duncan, John Wiley & Sons,London.
4. Complex Analysis, Lars Ahlfors, McGraw Hills. IndianEdition.
5. Functions of One Complex Variable, John B. Conway, Narosa Publishing house, 2002.
6. Foundations of Complex Analysis, S. Ponnusamy, Narosa Publishing house, 2005.
7. Complex Variables (Theory and applications), H. S. Kasana, Prentice-Hall of India Pvt. Ltd.,2006.
8. Complex Analysis, S. Lang, Springer Paperback,2005.
9. Complex Analysis, Stein and Shakarchi, Princeton Lectures in Analysis, Princeton University Press, 2003.

Semester: II

Partial Differential Equation (Theory)	**Course Code:**	**PMT 2804**
No. of Credits: 04	**Learning Hours:**	**60 Hours**

Course Outcomes:

CO1 Students will be able to formulate partial differential equations.

CO2 Students will be able to classify partial differential equations.

CO3 Students will able to solve partial differential equations using different techniques. Students will be able to solve one dimensional wave equation, Heat equation and Laplace equation with different boundary conditions using partial differential equations.

CO4 Students will able to solve Dirichlet problem and Neumann problem using partial differential equations.

Unit 1: Review of curves and surfaces; genesis of first order PDE; classification of integrals; linear equations of the first order; Pfaffian differential equations; compatible systems of first order PDE, Charpit's method.

Unit 2: Jacobi's method; integral surfaces through a given curve; quasi-linear equations (characteristic curves and the initial value problem), Non-linear first order PDE (characteristic curves and the initial value problem).

Unit 3: Genesis of second order PDE; classification of second order PDE. Introduction to the initial and boundary value problems, One dimensional wave equation: vibrations of an infinite string, vibrations of a semi-infinite string, Vibration of a string of finite-length, Heat conduction problem, infinite rod, finite rod.

Unit 4: Riemann's method, Laplace's equation: boundary value problems; maximum and minimum principles; the Dirichlet problem for a circle, for the upper half plane, for a rectangle, Neumann's problem for the upper half plane and for a circle, Harnack's theorem; Green's function, Families of equipotential surfaces.

Text books:

1. Differential Equations with Applications and Historical Notes, 2nd Edition, G. F. Simmons, Tata McGraw-Hill Publishing Co. Ltd., 2008.
2. Chapter 5 (Omit Appendices C and E), Chapter 8 (Omit Appendices A and B), Chapter 13.

Reference books:

1. Elements of Partial Differential Equations, - I. Sneddon, McGraw-Hill Kogakusha Ltd.
2. Methods of Mathematical Physics Vol.2, - R. Courant and D. Hilbert, Wiley Eastern Pvt. Ltd., 1975.
3. Fourier Series and Boundary Value Problems, R. V. Churchill, McGraw Hill Book Co., 1963.
4. Partial differential equations An Introduction, Strauss W. A, Wiley, John and sons 1992.

5. An introduction to PDE’s, Renardy and Rogers, Springer-Verlag, 1999.
6. Waves and reaction-diffusion equations, second edition, Smoller: Shock,1994.
7. Partial Differential equations, Kevorkian, Wadsworth and Brooks/ cole
8. Partial differential equations, F.John, Springer.
9. Partial differential equations, Evans L.C., AMS, 1998.
10. Lectures on partial differential equations, B. Folland, Tata institute of Fundamental
11. Research, Bombay, 1983. Introduction to partial differential equations, B.Folland.
12. Analytical and Numerical Methods for Partial differential equations, M.Junk.
13. Elliptic Partial differential equations of second order, D.Gilbarg and N.S. Trudinger.
14. Partial Differential Equations, Phoolan Prasad and Ravindran, R., Wiley Eastern.
15. Partial Differential equations, R. C. McOwen, Pearson Education, 2004.

Semester: II
Practicals based on PMT-2801 and PMT-2802 (Practical) **Course Code:** **PMT 2805L**
No. of Credits: 06 **Learning Hours:** **90 Hours**

Course Outcomes:

CO1 Students will be to identify and exemplify different types of concepts of group theory like subgroup, normalizer, centralizer, order of an element, order of a group, cyclic subgroup and use them in other fields of mathematics.

CO2 Student will be able to solve different mathematical problems using the transition between groups by some mathematical tools such as homomorphism & isomorphism.

CO3 Student will be able to obtain measure of measurable sets.

CO4 Student will be able to recognize Lebesgue integrable functions.

CO5 Student will be able to obtain Lebesgue integral of Lebesgue integrable functions.

CO6 Student will be able to obtain Fourier series of Lebesgue integrable functions.

List of practicals (problems on):

(1) Problems based on group, subgroups and finite groups.

(2) Problems based on subgroup structure of finite subgroups and element's order.

(3) Problems based on permutation groups and isomorphism.

(4) Problems based on Lagrange's theorem, external direct products.

(5) Problems based on normal subgroups, factor groups and internal direct products.

(6) Problems based on group homomorphism and their properties.

(7) Problem based on fundamental theorem of finite abelian groups, conjugacy classes and class equation.

(8) Problem based on Sylow theorems and their applications.

(9) Problems based on inner and outer measure of bounded sets.

(10) Problems based on measurable sets and some of its properties.

(11) Problems based on properties of measurable sets, non-measurable sets.

(12) Problems based on measurable functions.

(13) Problems based on Riemann integral and Lebesgue integral for bounded functions.

(14) Problems based on properties of Lebesgue integral for bounded functions.

(15) Problems based on the Lebesgue integral of non-negative and unbounded functions, its properties, Lebesgue dominated convergence theorem.

(16) Problems based on Fatou's lemma and its consequences like monotone convergence theorem and the countable additivity of the Lebesgue integral.

Semester: II
Practicals based on PMT-2803 and PMT-2804 (Practical) **Course Code: PMT 2806L**
No. of Credits: 06 **Learning Hours: 90 Hours**

Course Outcomes:

CO1 Students will be able to represent complex functions as Taylor series and Laurent series.

CO2 Students will be able to determine residues of complex functions.

CO3 Students will be able evaluate integrals of complex functions using residues.

CO4 Students will be able to formulate partial differential equations.

CO5 Students will able to solve partial differential equations using different techniques.

CO6 Students will be able to solve one dimensional wave equation, Heat equation and Laplace equation with different boundary conditions using partial differential equations.

List of practicals (problems on):

(1) Problems based on finding Laurent series, Taylor series and division of power series.

(2) Problems based on finding residues; three types of isolated singular points and problems based on Cauchy's residue theorem.

(3) Problems based on residues at infinity and its application (i.e. Theorem on Page 238 of the textbook).

(4) Problems based on finding residues at poles i.e. based on ϕ method, problems based on zeroes, poles and special method for finding residues at a simple pole (i.e. based on Theorem 2 on page 253 of the textbook).

(5) Problems based on finding improper integrals using residue theory.

(6) Problems based on finding integrals from Fourier analysis and based on indented path technique.

(7) Problems based on finding definite integrals involving SINES and COSINES using residue theory.

(8) Problems based on Rouche's theorem and Möbius transformations (Bi-linear transformation) and Miscellaneous problems.

(9) Problems based on Langrage's equation and Pfaffian differential equations.

(10) Problems based on Charpit's method and Jacobi's method.

(11) Problems based on integral surfaces through a given circle.

(12) Problems based on Cauchy problem for Quasi linear equation and non-Linear first order PDE.

(13) Problems based on method of separation of variables.

(14) Problems based on various initial and boundary value problems for the Wave equation.

(15) Problems based on various initial and boundary value problems for the Heat equation.

(16) Problems based on various initial and boundary value problems for the Laplace equation.

Semester: III

Abstract Algebra-II (Theory)	**Course Code:**	**PMT 3801**
No. of Credits: 04	**Learning Hours:**	**60 Hours**

Course Outcomes:

CO1 Student will be able to demonstrate and analyze rings, subrings, integral domains and ideals factor rings.

CO2 Student will be able to use ring homomorphism, factorization of polynomials and divisibility in integral domains to solve various problems.

CO3 Student will be able to classify fields, extension fields and structure of finite fields. Apply field theory for geometric constructions.

CO4 Student will be able to demonstrate and describe advanced topics such as Galois theory and cyclotomic extensions.

Unit 1: Introduction to rings, properties of rings, subrings, ideals and factor rings; integral domains, fields, prime ideals and maximal ideals (12, 13, 14).

Unit 2: Ring homomorphism, properties of ring homomorphism, the field of quotients, polynomial rings; irreducibility tests, unique factorization in Z[x]; divisibility in integral domains. (15, 16, 17, 18)

Unit 3: Splitting field, finite extensions of field; properties of algebra extensions, finite fields, geometric constructions. (20, 21, 22, 23).

Unit 4: Fundamental theorem of Galois Theory; solvability of polynomials by radicals, solvability of a quantic, Cyclotomic polynomials. (32, 33).

Text books:

1. Contemporary Abstract Algebra, 8th Edition, Joseph A Gallian, Cengage Learning, 2013. Chapters: 12-23, 32,33.

Reference books:

1. Basic Abstract Algebra (2nd Edition)-P B Bhattacharya, S K Jain, S R Nagpaul, Cambridge Uni Press, 1995.
2. Algebra, Michael Artin, PHI Learning Pvt Ltd, New Delhi.
3. A Course in Algebra, E B Vinberg, American Mathematical Society, 2003.
4. Algebra, Thomas W Hungerford, Springer, 2004.
5. Topics in Algebra, I.N. Herstein, Second Edition, John Wiley.
6. Topics in Algebra,I. H. Sheth, PHI.
7. Abstract Algebra, Davis S. Dummit and Richard M. Foote, John Wiley.
8. A First course in Abstract Algebra, John Fraleigh (3rd Edition), Narosa Publishing House, New Delhi.
9. Basic Algebra, N. Jacobson, Hind Publishing Corporation.

Semester: III
Real Analysis(Theory) **Course Code: PMT 3802**
No. of Credits: 04 **Learning Hours: 60 Hours**

Course Outcomes:

CO1 Student will be able to identify and exemplify measurable functions.

CO2 Student will be able to identify and exemplify functions of bounded variation.

CO3 Student will be able to identify and exemplify absolutely continuous function.

CO4 Student will be able to test the convergence of Fourier series.

Unit 1: Convergence in measure and the related important results, Approximations of measurable functions by bounded measurable functions and continuous functions, Weierstrass approximation theorems.

Unit 2: Square-summable functions, Schwarz and Minkowski's inequality, Completeness of $L^2([a,b])$, Dense subsets of $L^p([a,b])$ as a generalization of $L^2([a,b])$, a quick introduction of sequence spaces l_2 and l_p.

Unit 3: Monotonic function and its differentiability (assuming Vitali's covering theorem), functions of finite (bounded) variation on and its properties, Absolutely continuous functions on , differential properties of absolutely continuous function.

Unit 4: The indefinite Lebesgue integral and the fundamental theorem of calculus, Definition of Fourier series and convergence problem, $(C, 1)$ summability of Fourier series, the theory of Fourier series, Convergence of Fourier series.

Text books:

1. Theory of Functions of a real variable Volume-I by I. P. Natanson, Frederic Ungar Publishing Co., New York1964.
2. Methods of Real Analysis by Richard Goldberg, Oxford & IBH Publishing Company, 1964.

Reference books:

1. Real Analysis by H. L. Royden (3rd edition), Pearson Prentice Hall(2007).
2. Measure and Integration by I. K. Rana, Narosa Publishing House (1997).
3. Trignomatric Series, - A. Zygmund, Cambridge University Press(1968).
4. Fourier Series, a modern introduction Vol.1, - R. E. Edwards(Springer)
5. Measure and Integration, G. D. De Barra, Wiely Eastern Limited, 1981.
6. Measure Theory, P. R. Halmos, Van NostrandPublishers,1979.
7. Real and complex Analysis, Walter Rudin, Tata-Mc Graw-Hill Publishing Co. Ltd.,1987.
8. Lebesgue Integration, J. H. Williamson, Holt, Rienhart and Winston Inc.,1962.

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Semester: III
Numerical Analysis (Theory) — **Course Code: PMT 3803A**
No. of Credits: 04 — **Learning Hours: 60 Hours**

Course Outcomes:

CO1 Students will be able to obtain estimated solution of equations.

CO2 Students will be able to obtain estimated values from the given data.

CO3 Students will be able to estimate curves and surfaces.

CO4 Students will be able to obtain estimated value of derivative from the given data.

CO5 Students will be able to obtain estimated value of integral from the given data.

Unit 1: Solution of Algebraic and Transcendental Equations: Method of False Position, Iteration method, Newton Raphson Method, Ramanujan's Method, Secant Methods, Mulller's Method, Graeffe's root-squaring method, Lin-Bairstow's Method, Solution of System of non-linear Equations.

Unit 2: Interpolation : Error in Polynomial Interpolation, Finite Differences, Detection of Error by use of Difference table, Differences of a Polynomial, Newton's Formulae for interpolation, Central Difference Interpolation Formulae, Practical Interpolation, Interpolation with uneven space points, Divided Differences and Their Properties, Inverse Interpolation, Double Interpolations, Kriging.

Unit 3: Spline functions: Introduction, Cubic Splines, Surface fitting by Cubic Splines, Cubic B-splines.

Unit 4: Numerical Differentiation and Integration: Introduction, Numerical Differentiation, Maximum and minimum values of a tabulated function, Numerical Integration, Euler-Maclaurin formula, Numerical Integration with different step sizes, Gaussian integration, Generalized quadrature, Numerical double integration.

Text books:

1. Introductory Methods of Numerical Analysis, S. S. Sastry, PHI, NewDelhi, 1997.

Reference books:

1. Numerical Methods with C++ programming & Matlab, Nita H. Shah, 2nd Edition, PHI.
2. An Introduction to Finite Element Method, J.N. Reddy, McGraw Hill Publication (2003) (For unit IV).
3. Introduction to Numerical Analysis, C.E. Froberg, Addision Wesley publishing Company, 6th edition, 1981.
4. Computer based numerical Algorithms, E. V. Krishnamurthy and S. K. Sen, East-West press Pvt. Ltd. 1976.
5. Elementary Numerical Analysis Algorithmic approach, Conte S. D. and Carldeboor, McGraw Hill company, 3rd edition, 1981.

6. Numerical analysis for scientists and Engineers, M. K. Jain, New Age International Ltd.
7. Numerical methods, J. D. Faires and R. Burden, 2nd edition, Brooks/cole publishing Co., 1998.
8. Solving ordinary differential equations, I and II, E. Hairer, E. P. Norsett and G. Warner, Springer series in computational mathematics 8, Springer, Berlin,1993.
9. Numerical Mathematical Analysis, James Blaine Scarborough.
10. Numerical Analysis and Computational Procedures, S. A. Mollah.
11. Computer-Oriented Numerical Methods, Third Edition, V. Rajaraman.
12. Computational Mathematics, B. P. Demidovich, I.A. Maron.

Semester: III
Advanced Linear Algebra (Theory) **Course Code: PMT 3803B**
No. of Credits: 04 **Learning Hours: 60 Hours**

Course Outcomes:

CO1 Student will be able to identify vector space and subspace.

CO2 Student will be able to obtain basis and determine dimension of vector spaces and subspaces.

CO3 Student will be able to solve different mathematical problems using the transition between vector spaces by some mathematical tools such as linear transformations.

CO4 Students will be able to employ advanced concepts of linear algebra to solve some scientific problems.

Unit 1: Quick review of vector spaces, examples of sequence and function spaces. Linear spans; linear dependence/independence and basis, examples of finite dimensional and infinite dimensional vector spaces, quotient space and its dimension, dual space, dual basis, dimension of the annihilator. Solution of the system of simultaneous linear homogeneous equations.

Unit 2: Definitions and examples of algebra, algebra analog of Cayley theorem, minimal polynomial of a linear transformation, rank of a linear transformation, characteristic roots, characteristic vectors and results related to characteristic vectors, matrix associated with a linear transformation on finite dimensional vector space, isomorphism between the space of linear transformations and the space of matrices, similarity of matrices and similarity of linear transformations.

Unit 3: Relation of the minimal polynomials of a linear transformation and its induced linear transformation on a quotient space, triangular matrix associated to a linear transformation, nilpotent linear transformation, canonical matrix associated to a nilpotent linear transformation, existence and uniqueness of invariants of a nilpotent linear transformation. Jordan form of a linear transformation.

Unit 4: Trace and its applications, Jacobson's lemma, transpose of a matrix. Definition of the determinant of a matrix, determinant of a triangular matrix, a matrix with equal rows, a product of matrices, application of determinant: regularity of a matrix, Cramer's rule to solve system of simultaneous non-homogeneous linear equations, quadratic forms: diagonalization of a symmetric matrix, symmetric matrix associated to a quadratic form, classification of quadratics.

Text books:

1. Topics in Algebra, Herstein I. N., Wiley Eastern Ltd., New Delhi, 1975. Sections: 4.1, 4.2, 4.3, 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.8,6.9.
2. Linear Algebra, Kwak J. H., Hong S., (Second Edition), Birkhauser, 2004. Sections: 8.1,8.2

Reference books:

1. Linear Algebra: A Geometric Approach, Kumaresan S., PHI,2000.
2. Introduction to Topology and Modern Analysis, Simmons G. F., McGraw-HillCo., Tokyo, 1963.
3. Linear Algebra, Helson H., Second Edition, Hindustan Book Agency, TRIM-4,1994.
4. Linear Algebra, Ramachandra Rao A. and Bhimasankaram P., Second Edition,Hindustan Book Agency, TRIM-19,2000.

Semester: III
Mathematical Programming (Theory) **Course Code: PMT 3804A**
No. of Credits: 04 **Learning Hours: 60 Hours**

Course Outcomes:

CO1 Student will be able to formulate linear programming problems, solve linear programming problems and interpret solution of linear programming problems.

CO2 Student will be able to formulate nonlinear programming problems, solve nonlinear programming problems and interpret solution of nonlinear programming problems.

CO3 Students will be able to make decision about replacement of items using Replacement models.

CO4 Students will be able to make decision for completion of jobs with different processing levels using sequencing in optimized manner.

CO5 Students will be able to set up best utilization of service facilities using simulation.

Unit 1: Quick review of Simplex method, Revised Simplex Method, Non-linear programming: Introduction, Maxima and Minima of Functions and their solutions, Quadratic forms, Convex and Concave functions, Unconstrained optimization - Functions with single variables, Multi variable functions. Constrained optimization - Equality constraints, Inequality constraints, Quadratic programming, Wolfe's method.

Unit 2: Dynamic programming: Introduction, Components of dynamic programming, computational algorithm, shortest route problem, single additive constraint, multiplicative separable return function, single additive constraint, additive separable return function, single multiplicative constraint, additive separable return function, solution of linear programming problem. Some applications.

Unit 3: Replacement models: Introduction, Failure of Items, Replacement of items that deteriorate, replacement of items with increasing running cost, replacement of items that fail completely, group replacement policy, recruitment and promotional problems, equipment renewal problem.

Unit 4: Sequencing: Introduction, Notations and Terminologies, Principal Assumptions, Sequencing Rules, Sequencing jobs through one process, sequencing jobs through two serial process, Johnson's algorithm, processing n jobs through three machines, processing n jobs through m machines, Scope of Sequencing.
Simulation: Introduction, Steps involved in Simulation, Advantages and disadvantages of simulation, Monte Carlo simulation, applications of simulation.

Text books:

1. Operations Research, Nita H. Shah, Ravi M. Gor and Hardik Soni, PHI Publications, New Delhi, 2007.

Reference books:

1. Operations Research: An Introduction, Eighth edition, H. A. Taha, PHI Publications, New Delhi, 2006.

2. Introduction to Operations Research, F. S. Hiller and G. J. Lieberman, Sixth Edition, McGraw Hill.
3. Simulation, Gordan, Printice Hall.
4. Operations Research, J.P. Singh and N. P. Singh.
5. Operations Research, J. K. Sharma.

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Semester: III
Financial Mathematics (Theory) — **Course Code: PMT 3804B**
No. of Credits: 04 — **Learning Hours: 60 Hours**

Course Outcomes:

CO1 Students will be able to demonstrate Arbitrage, Return and Interest, Time Value of Money, Bonds, Shares and Indices, Models and Assumptions.

CO2 Students will be able to exhibit Net Present Value (NPV), Internal Rate of Return (IRR), Comparison of IRR and NPV, Bonds price and yield, Clean and Dirty Price, Price-Yield Curves, Duration, Term structure of Interest rates, Immunization, Convexity.

CO3 Students will be able to exemplify random returns, Portfolio Diagrams and Efficiency, Feasible Set. He can also demonstrate Markowitz Model and Capital Asset Pricing Model, CAPM as a pricing formula.

CO4 Students will be able to exhibit different numerical techniques-to identify the hedging with futures, Currency futures, Stock Index Futures of the market.

CO5 Students will be able to construct Stock Price Models such as Lognormal, Geometric Brownian Motion, Binomial Tree Mode Options.

CO6 Students will be able to demonstrate Implied Volatility and Dynamic Hedging, Risk-Neutral Valuation.

CO7 Students will be able to demonstrate the Black-Scholes PDE. He further can illustrates Speculating with options and Value at Risk and various models like Linear Model, Quadratic Model and the classical Monte Carlo Simulation.

Unit 1: Basic Concepts: Arbitrage, Return & Investment, Time Value of Money, Bonds, Shares and Indices, Models & Assumptions. Deterministic Cash Flows: Net Present Value, Internal Rate of Return, Comparison of IRR & NPV, Bonds: Price & Yield, Clean & Dirty Price, Price-Yield curves, Duration, Term Structure of Interest rates, Immunization, Convexity, Callable Bonds.

Unit 2: Random Cash Flows: Random Returns, Portfolio Diagrams and Efficiency, Feasible Set, Markowitz Model, Capital Asset Pricing Model, Diversification, CAPM as a pricing formula, Numerical Techniques. Forwards and Futures: Forwards and Futures, Price and Contract, Method of Replicating Portfolios, Hedging with futures, Currency futures, Stock Index Futures.

Unit 3: Stock Price Models: Lognormal, Geometric Brownian Motion, Binomial Tree Mode Options: Call and Put, Call-Put Parity, Binomial Options Pricing Model, Pricing American Options, Factors Influencing Option Premiums, Options on Assets with Dividends, Dynamic Hedging, Risk-Neutral Valuation, The Black-Scholes Model: Risk-Neutral Valuation, The Black- Scholes Formula, Options on Futures, Options on Assets with Dividends.

Unit 4: The Black-Scholes Model: Black-Scholes and BOPM, Implied Volatility, Dynamic Hedging, The Greeks, The Black-Scholes PDE, Speculating with options. Value at Risk: Definition of VAR, Linear Model, Quadratic Model, Monte Carlo Simulation, The Martingale.

Text books:

1. The Calculus of Finance, by Amber Habib, Universities Press. (Chapters1-8).

Reference books:

1. Futures and Other Financial Derivatives, Hull, J. C. Options, Prentice Hall, 8thedition.
2. PDE and Martingale Methods in Option Pricing, Pascucci, A. Bocconi, Springer, 2011.
3. Tools for Computational Finance, R. U. Seydel, University text, 3rd Edition Springer,2000.
4. Financial Derivatives in Theory and Practice, J.B. Hunt and J.E. Kennedy, Wiley, 2005.
5. Financial Calculus: An introduction to Derivative Pricing, M. Baxter and A. Rennie, Cambridge, UK, 1996.
6. Introduction to the Mathematics of Finance, R. J. Williams, AMS,2011.
7. The Mathematics of Finance: Modelling and Hedging, Victor Goodman & Joseph Stampfli, AMS.
8. A course in Financial Calculus, Alison Etheridge, Cambridge University Press, 2002.
9. Introduction to Stochastic Calculus Applied to Finance, Chapman and Hall, 1996.
10. Martingale Methods in Financial Modeling, Marek Musiela and Marek Rutkowski, Springer Verlag, New York,1998.
11. Mathematics of Financial Markets, Robert J Elliot and P.Ekkehard Kopp, Springer Verlag, New York 2001.

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Semester: III
Combinatorics (Theory) **Course Code: PMT 3804C**
No. of Credits: 04 **Learning Hours: 60 Hours**

Course Outcomes:

CO1 Student will be able to apply various elementary counting techniques for counting problems.

CO2 Student will be able to apply binomial theorem and Pascal's triangle.

CO3 Student will be able to apply pigeonhole principle and Ramsey theory for various problems.

CO4 Student will be able to apply Principle of Inclusion and Exclusion in various counting problems.

CO5 Student will be able to apply the techniques of Ordinary Generating functions and Exponential Generating function in various counting problems in various graph theoretical algorithms

Unit 1: Permutations, Combinations, Binomial Coefficients: Two basic Counting Principles, Permutations, Circular Permutations, Combinations, The Injection and Bijection Principles, Arrangements and Selections with Repetitions, Distribution Problems. The Binomial Theorem, Combinatorial Identities, The Pascal's Triangle, Chu Sinh-Chieh's Identity, Shortest Routes in a Rectangular Grid, Some Properties of Binomial Coefficients.

Unit 2: The Pigeonhole principle and Ramsey Numbers: Introduction, The Pigeonhole Principle, More Examples, Ramsey type of Problems and Ramsey Numbers, Bounds on Ramsey Numbers.

Unit 3: The Principle of Inclusion and Exclusion: Introduction, The Principle, A Generalization, Integer Solutions and Shortest routes, Surjective Mappings and Stirling Numbers of the Second Kind, Derangements and a Generalization, The Sieve of Eratosthenes and Euler phi function, TheProblem of Des Mnages.

Unit 4: Generating Functions: Ordinary Generating Functions, Some Modeling Problems, Partition of Integers, Exponential Generating Functions.

Text books:

1. Principles and Techniques in Combinatorics, Chen Chuan Chong and Koh Khee Meng, World Scientific.

Reference books:

1. Combinatorics: Theory and applications, V. Krishnamurthy, Affiliated East-West Press.

2. Introductory Combinatorics, Richard A. Brualdi, Pearson.

3. Applied Combinatorics, A. Tucker, John Wiley & Sons.

4. Discrete Mathematics, Norman L. Biggs, Oxford University Press.

5. Discrete Mathematics and its applications, Kenneth Rosen, Tata McGraw Hills.

6. Combinatorial Techniques, Sharad S. Sane Hindustan Book Agency, 2013.
7. Combinatorics including concepts of Graph Theory, V. K. Balakrishnan, Schaum's Outline Series, McGraw-Hill, INC.
8. A Path to Combinatorics for Undergraduates Counting Strategies, Titu Andreescu and Zuming Feng, Birkhauser.
9. Introduction to Combinatorial Mathematics, C. L. Liu, McGraw Hill Book Company.
10. Introduction to Combinatorics, 4th Edition, Richard A. Brualdi, Pearson Education.
11. A First Course in Graph Theory and Combinatorics, Sebastian M Cioaba and M Ram Murty, Hindustan Book Agency.
12. Combinatorial Theory, Marshall Hall Jr., 2nd Edition, Wiley-Inter Science Publications.
13. An Introduction to Combinatorial Analysis, John Riordan, Wiley Publications.
14. Introduction to Combinatorics, Gerald Berman and K. D. Fryer, Academic Press.
15. Combinatorics and Graph Theory, John M. Harries, Jeffry L. Hirst, Michael J. Mossinghoff, 2nd Edition, Springer
16. Foundations of Discrete Mathematics, K. D. Joshi.

Semester: III
Practicals based on PMT-3801 and PMT-3802 (Practical) **Course Code: PMT 3805L**
No. of Credits: 06 **Learning Hours: 90 Hours**

Course Outcomes:

CO1 Student will be able to identify rings, subrings, integral domains and ideals factor rings.

CO2 Student will be able to use ring homomorphism, factorization of polynomials and divisibility in integral domains to solve various problems.

CO3 Student will be able to identify and exemplify functions of bounded variation.

CO4 Student will be able to identify and exemplify absolutely continuous function.

CO5 Student will be able to test the convergence of Fourier series.

List of practicals (problems on):

(1) Problems based on rings, subrings, ideals and Factor rings.

(2) Problems based on integral domains, Fields, Prime ideals and Maximal ideals.

(3) Problems based on ring homomorphisms.

(4) Problems based on unique factorization in Z[X]; divisibility in integral domains.

(5) Problems based on splitting fields; finite extensions of fields.

(6) Problems based on algebras extensions; finite fields.

(7) Problems based on geometric constructions.

(8) Problems based on solvability of polynomials by radicals.

(9) Problem based on outer and inner measure, measurable sets and measurable functions.

(10) Problem based on sequences of measurable functions.

(11) Problem based on square-summable and p-summable functions.

(12) Problem based on Holder's and Minkowski's inequality for functions and numbers.

(13) Problem based on derived numbers and derivatives.

(14) Problem based on increasing functions and functions of finite variation.

(15) Problem based on Cantor set and Cantor function.

(16) Problem based on Fourier series.

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Semester: III
Practicals based on PMT-3803A and PMT-3804A (Practical) **Course Code: PMT 3806L**
No. of Credits: 06 **Learning Hours: 90 Hours**

Course Outcomes:

CO1 Students will be able to obtain estimated solution of equations.

CO2 Students will be able to obtain estimated values, curves and surfaces from the given data.

CO3 Students will be able to obtain estimated value of derivative and integral from the given data.

CO4 Student will be able to formulate linear programming problems, solve linear programming problems and interpret solution of linear programming problems.

CO5 Student will be able to formulate nonlinear programming problems, solve nonlinear programming problems and interpret solution of nonlinear programming problems.

CO6 Students will be able to make decision about replacement of items using replacement models.

CO7 Students will be able to make decision for completion of jobs with different processing levels using sequencing in optimized manner.

CO8 Students will be able to set up best utilization of service facilities using simulation.

List of practicals (problems on):

(1) Problems based on iteration method for solving $x = g(x)$ and Bracketing method for locating a root.

(2) Problems based on Newton Raphson, Secant method and Graeffe's root-squaring method.

(3) Problems based on the solution of linear systems by Gaussian elimination, Gauss- Jordan method.

(4) Problems based on 1) Triangularization method: Crout's method, Cholesky method, 2) Iteration methods: Gauss-Jacobi, Gauss-Seidel.

(5) Problems based on eigen value problem for matrices: Power method, inverse power method, Jacobi or Given's method for real symmetric matrices and singular value decomposition.

(6) Problems based on different interpolation formulae.

(7) Problems based on numerical differentiation, maxima and minima of function.

(8) Problems based on different numerical integration formulae and numerical double integrals.

(9) Problems based non-linear programming with constrained and unconstrained optimization.

(10) Problems based on quadratic programming and Wolfe's method.

(11) Problems based on dynamic programming I.

(12) Problems based on dynamic programming II.

(13) Problems based on replacement-I.

(14) Problems based on replacement-II.

(15) Problems based on sequencing jobs.

(16) Problems based on simulation.

Semester: III
Practicals based on PMT-3803A and PMT-3804B (Practical) **Course Code:** **PMT 3806L**
No. of Credits: 06 **Learning Hours:** **90 Hours**

Course Outcomes:

CO1 Students will be able to obtain estimated solution of equations.

CO2 Students will be able to obtain estimated values, curves and surfaces from the given data.

CO3 Students will be able to obtain estimated value of derivative and integral from the given data.

CO4 Students will be able to demonstrate Arbitrage, Return and Interest, Time Value of Money, Bonds, Shares and Indices, Models and Assumptions.

CO5 Students will be able to exhibit Net Present Value (NPV), Internal Rate of Return (IRR), Comparison of IRR and NPV, Bonds price and yield, Clean and Dirty Price, Price-Yield Curves, Duration, Term structure of Interest rates, Immunization, Convexity.

Pricing Model, CAPM as a pricing formula.

CO6 Students will be able to exhibit different numerical techniques-to identify the hedging with futures, Currency futures, Stock Index Futures of the market.

CO7 Students will be able to construct Stock Price Models such as Lognormal, Geometric Brownian Motion, Binomial Tree Mode Options.

CO8 Students will be able to demonstrate Implied Volatility and Dynamic Hedging, Risk-Neutral Valuation, the Black-Scholes PDE. He further can illustrates Speculating with options and Value at Risk and various models like Linear Model, Quadratic Model and the classical Monte Carlo Simulation.

List of practicals (problems on):

(1) Problems based on iteration method for solving $x = g(x)$ and Bracketing method for locating a root.

(2) Problems based on Newton Raphson, Secant method and Graeffe's root-squaring method.

(3) Problems based on the solution of linear systems by Gaussian elimination, Gauss- Jordan method.

(4) Problems based on 1) Triangularization method: Crout's method, Cholesky method, 2) Iteration methods: Gauss-Jacobi, Gauss-Seidel.

(5) Problems based on eigen value problem for matrices: Power method, inverse power method, Jacobi or Given's method for real symmetric matrices and singular value decomposition.

(6) Problems based on different interpolation formulae.

(7) Problems based on numerical differentiation, maxima and minima of function.

(8) Problems based on different numerical integration formulae and numerical double integrals.

(9) Problems based on basic concepts: Arbitrage, Return and Investment, Time Value of Money, Bonds, Shares and Indices, Models and Assumptions.

(10) Problems based on deterministic cash flows: Net present Value, Internal rate of return, Comparison of IRR and NPV, Bonds: Price and Yield, Clean and Dirty Price, Price-Yield curves, Duration, Term structure of interest rates, Immunisation, Convexity, Callable Bonds.

(11) Problems based on random cash flows: Random returns, Portfolio diagrams and efficiency, Feasible set, Markowitz model, Capital asset pricing model, Diversification, CAPM as a pricing formula, Numerical techniques.

(12) Problems based on Forwards and Futures, Price and Contract, Method of Replicating Portfolios, Hedging with futures, Currency futures, Stock Index Futures.

(13) Problems based on Stock price models: Lognormal, Geometric Brownian Motion, Binomial Tree Model.

(14) Problems based on options: Call and Put, Call-Put Parity, Binomial Options Pricing Model, Pricing American Options, Factors Influencing Option Premiums, Options on Assets with Dividends, Dynamic Hedging, Risk-Neutral Valuation, The Black-Scholes Model: Risk-Neutral Valuation, The Black-Scholes Formula, Options on Futures, Options on Assets with Dividends.

(15) Problems based on the Black-Scholes Model: Black-Scholes and BOPM, Implied Volatility, Dynamic Hedging, The Greeks, The Black-Scholes PDE, Speculating with options.

(16) Problems based on definition of VAR, Linear Model, Quadratic Model, Monte Carlo Simulation, The Martingale.

Semester: III
Practicals based on PMT-3803A and PMT-3804C (Practical) **Course Code:** **PMT 3806L**
No. of Credits: 06 **Learning Hours:** **90 Hours**

Course Outcomes:

CO1 Students will be able to obtain estimated solution of equations.

CO2 Students will be able to obtain estimated values, curves and surfaces from the given data.

CO3 Students will be able to obtain estimated value of derivative and integral from the given data.

CO4 Student will be able to apply various elementary counting techniques for counting problems.

CO5 Student will be able to apply binomial theorem and Pascal's triangle.

CO6 Student will be able to apply pigeonhole principle and Ramsey theory for various problems.

CO7 Student will be able to apply Principle of Inclusion and Exclusion in various counting problems.

CO8 Student will be able to apply the techniques of Ordinary Generating functions and Exponential Generating function in various counting problems in various graph theoretical algorithms.

List of practicals (problems on):

(1) Problems based on iteration method for solving $x = g(x)$ and Bracketing method for locating a root.

(2) Problems based on Newton Raphson, Secant method and Graeffe's root-squaring method.

(3) Problems based on the solution of linear systems by Gaussian elimination, Gauss- Jordan method.

(4) Problems based on 1) Triangularization method: Crout's method, Cholesky method, 2) Iteration methods: Gauss-Jacobi, Gauss-Seidel.

(5) Problems based on eigen value problem for matrices: Power method, inverse power method, Jacobi or Given's method for real symmetric matrices and singular value decomposition.

(6) Problems based on different interpolation formulae.

(7) Problems based on numerical differentiation, maxima and minima of function.

(8) Problems based on different numerical integration formulae and numerical double integrals.

(9) Problems based on permutations and combinations.

(10) Problems based on binomial coefficients.

(11) Problems based on Pigeonhole principle.

(12) Problems based on Ramsey numbers.

(13) Problems based on integer solutions, shortest routes, surjective mapping and Sterling numbers of the second kind.

(14) Problems based on derangements, Euler Phi function and Des Mnages.

(15) Problems based on generating functions and modelling.

(16) Problems based on partition of integers and exponential functions.

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Semester: III
Practicals based on PMT-3803B and PMT-3804A (Practical) **Course Code: PMT 3806L**
No. of Credits: 06 **Learning Hours: 90 Hours**

Course Outcomes:

CO1 Student will be able to identify vector space and subspace.

CO2 Student will be able to obtain basis and determine dimension of vector spaces and subspaces.

CO3 Student will be able to solve different mathematical problems using the transition between vector spaces by some mathematical tools such as linear transformations.

CO4 Student will be able to formulate linear programming problems, solve linear programming problems and interpret solution of linear programming problems.

CO5 Student will be able to formulate nonlinear programming problems, solve nonlinear programming problems and interpret solution of nonlinear programming problems.

CO6 Students will be able to make decision about replacement of items using replacement models.

CO7 Students will be able to make decision for completion of jobs with different processing levels using sequencing in optimized manner.

CO8 Students will be able to set up best utilization of service facilities using simulation.

List of practicals (problems on):

(1) Problems based on functional spaces and basis of it.

(2) Problems based on dual of normed linear spaces, quotient spaces and solution of system of linear equations, Cramer's rule.

(3) Problems based on isomorphism of space of linear functions and matrices.

(4) Problems based on characteristic polynomials, minimal polynomial, rank and null spaces.

(5) Problems based on triangularization of matrices of linear transformation, nilpotent matrix.

(6) Problems based on Jordan form of linear transformation and its applications.

(7) Problems based on trace, determinant and its applications.

(8) Problems based on diagonalization of a symmetric matrix and symmetric matrix associated to a quadratic form.

(9) Problems based non-linear programming with constrained and unconstrained optimization.

(10) Problems based on quadratic programming and Wolfe's method.

(11) Problems based on dynamic programming I.

(12) Problems based on dynamic programming II.

(13) Problems based on replacement-I.

(14) Problems based on replacement-II.

(15) Problems based on sequencing jobs.

(16) Problems based on simulation.

Semester: III
Practicals based on PMT-3803B and PMT-3804B (Practical) **Course Code: PMT 3806L**
No. of Credits: 06 **Learning Hours: 90 Hours**

Course Outcomes:

CO1 Student will be able to identify vector space and subspace.

CO2 Student will be able to obtain basis and determine dimension of vector spaces and subspaces.

CO3 Student will be able to solve different mathematical problems using the transition between vector spaces by some mathematical tools such as linear transformations.

CO4 Students will be able to demonstrate Arbitrage, Return and Interest, Time Value of Money, Bonds, Shares and Indices, Models and Assumptions.

CO5 Students will be able to exhibit Net Present Value (NPV), Internal Rate of Return (IRR), Comparison of IRR and NPV, Bonds price and yield, Clean and Dirty Price, Price-Yield Curves, Duration, Term structure of Interest rates, Immunization, Convexity.

Pricing Model, CAPM as a pricing formula.

CO6 Students will be able to exhibit different numerical techniques-to identify the hedging with futures, Currency futures, Stock Index Futures of the market.

CO7 Students will be able to construct Stock Price Models such as Lognormal, Geometric Brownian Motion, Binomial Tree Mode Options.

CO8 Students will be able to demonstrate Implied Volatility and Dynamic Hedging, Risk-Neutral Valuation, the Black-Scholes PDE. He further can illustrates Speculating with options and Value at Risk and various models like Linear Model, Quadratic Model and the classical Monte Carlo Simulation.

List of practicals (problems on):

(1) Problems based on functional spaces and basis of it.

(2) Problems based on dual of normed linear spaces, quotient spaces and solution of system of linear equations, Cramer's rule.

(3) Problems based on isomorphism of space of linear functions and matrices.

(4) Problems based on characteristic polynomials, minimal polynomial, rank and null spaces.

(5) Problems based on triangularization of matrices of linear transformation, nilpotent matrix.

(6) Problems based on Jordan form of linear transformation and its applications.

(7) Problems based on trace, determinant and its applications.

(8) Problems based on diagonalization of a symmetric matrix and symmetric matrix associated to a quadratic form.

(9) Problems based on basic concepts: Arbitrage, Return and Investment, Time Value of Money, Bonds, Shares and Indices, Models and Assumptions.

(10) Problems based on deterministic cash flows: Net present Value, Internal rate of return, Comparison of IRR and NPV, Bonds: Price and Yield, Clean and Dirty Price, Price-Yield curves, Duration, Term structure of interest rates, Immunisation, Convexity, Callable Bonds.

(11) Problems based on random cash flows: Random returns, Portfolio diagrams and efficiency, Feasible set, Markowitz model, Capital asset pricing model, Diversification, CAPM as a pricing formula, Numerical techniques.

(12) Problems based on Forwards and Futures, Price and Contract, Method of Replicating Portfolios, Hedging with futures, Currency futures, Stock Index Futures.

(13) Problems based on Stock price models: Lognormal, Geometric Brownian Motion, Binomial Tree Model.

(14) Problems based on options: Call and Put, Call-Put Parity, Binomial Options Pricing Model, Pricing American Options, Factors Influencing Option Premiums, Options on Assets with Dividends, Dynamic Hedging, Risk-Neutral Valuation, The Black-Scholes Model: Risk-Neutral Valuation, The Black-Scholes Formula, Options on Futures, Options on Assets with Dividends.

(15) Problems based on the Black-Scholes Model: Black-Scholes and BOPM, Implied Volatility, Dynamic Hedging, The Greeks, The Black-Scholes PDE, Speculating with options.

(16) Problems based on definition of VAR, Linear Model, Quadratic Model, Monte Carlo Simulation, The Martingale.

Semester: III
Practicals based on PMT-3803B and PMT-3804C (Practical) **Course Code: PMT 3806L**
No. of Credits: 06 **Learning Hours: 90 Hours**

Course Outcomes:

CO1 Student will be able to identify vector space and subspace.

CO2 Student will be able to obtain basis and determine dimension of vector spaces and subspaces.

CO3 Student will be able to solve different mathematical problems using the transition between vector spaces by some mathematical tools such as linear transformations.

CO4 Student will be able to apply various elementary counting techniques for counting problems.

CO5 Student will be able to apply binomial theorem and Pascal's triangle.

CO6 Student will be able to apply pigeonhole principle and Ramsey theory for various problems.

CO7 Student will be able to apply Principle of Inclusion and Exclusion in various counting problems.

CO8 Student will be able to apply the techniques of Ordinary Generating functions and Exponential Generating function in various counting problems in various graph theoretical algorithms.

List of practicals (problems on):

(1) Problems based on functional spaces and basis of it.

(2) Problems based on dual of normed linear spaces, quotient spaces and solution of system of linear equations, Cramer's rule.

(3) Problems based on isomorphism of space of linear functions and matrices.

(4) Problems based on characteristic polynomials, minimal polynomial, rank and null spaces.

(5) Problems based on triangularization of matrices of linear transformation, nilpotent matrix.

(6) Problems based on Jordan form of linear transformation and its applications.

(7) Problems based on trace, determinant and its applications.

(8) Problems based on diagonalization of a symmetric matrix and symmetric matrix associated to a quadratic form.

(9) Problems based on permutations and combinations.

(10) Problems based on binomial coefficients.

(11) Problems based on Pigeonhole principle.

(12) Problems based on Ramsey numbers.

(13) Problems based on integer solutions, shortest routes, surjective mapping and Sterling numbers of the second kind.

(14) Problems based on derangements, Euler Phi function and Des Mnages.

(15) Problems based on generating functions and modelling.

(16) Problems based on partition of integers and exponential functions.

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Semester: IV
Advanced Calculus (Theory) **Course Code: PMT 4801**
No. of Credits: 04 **Learning Hours: 60 Hours**

Course Outcomes:

CO1 Student will be able to employ concepts of multivariate calculus.

CO2 Student will be able to obtain series expansion of several real valued functions of more than one variable and use it in real-life estimation problems.

CO3 Students will be able to employ multivariate differential calculus to solve extreme value problems.

CO4 Students will be able to solve some real-life problems using multiple integral.

CO5 Students will be able to employ vector calculus to solve some scientific problems.

Unit 1: Continuity of functions of several variables, Differential and differentiability of functions of several variables, Partial derivatives, Composition of differentiable mappings, Chain rule, Higher order partial derivatives, Higher order differentials.

Unit 2: Taylor's theorem, Critical points, Extreme value problems, Regular mappings, inverse of mapping, The Implicit function theorem; Curves and surfaces, Length of curves and area of surface.

Unit 3: Integration in higher dimensions; multiple integrals and iterated integrals; change of variables for multiple integrals; functions defined by integrals.

Unit 4: Arc length and line integrals; Green's theorem; surface area and surface integrals; vector derivatives; the divergence theorem; some applications to physics; Stoke's theorem.

Text books:

1. Calculus of several variables, Casper Goffman, Harper & Row, New York, Evanston & London and John Weather hill, Inc., Tokyo.

Reference books:

1. Advanced Calculus, Gerald B. Folland, Pearson India Education Services Pvt. Ltd.,2012, Chapters2-5. ginco
2. Advanced Calculus, David V. Widder, Prentice - Hall of India Pvt. Ltd., New Delhi,1968. ginco
3. Advanced Calculus, Patrick M. Fitzpatrick, The Sally Series. Indian Edition, AMS, ISBN 978-0-8218-5209. ginco
4. Mathematical Analysis, T. M. Apostol, 2nd Edition. ginco
5. Advanced Calculus, Volume II- T. M. Apostol.

Semester: IV
Functional Analysis (Theory) **Course Code: PMT 4802**
No. of Credits: 04 **Learning Hours: 60 Hours**

Course Outcomes:

CO1 Student will be able to identify and exemplify normed linear space.

CO2 Student will be able to obtain basis and determine dimension of vector spaces and subspaces.

CO3 Student will be able to identify and exemplify Banach spaces, quotient space.

CO4 Student will be able to identify and exemplify conjugate space of a vector space.

Unit 1: Review of linear spaces, quotient linear spaces, direct sums of linear subspaces, basis of a linear space - existence using Zorn's lemma, linear transformations from a linear space to another, projections on a linear space.

Unit 2: Normed linear spaces, Banach spaces, quotient of a normed linear space by a closed linear subspace, continuous linear transformations from a normed linear space to a normed linear space, finite dimensional normed linear spaces.

Unit 3: Conjugate space of a normed linear space, Hahn-Banach theorem with consequences, the natural imbedding of a normed linear space in its second conjugate space, Reflexive spaces, open mapping theorem, projections on a Banach space, closed graph theorem.

Unit 4: The uniform boundedness theorem, conjugate of an operator on a Banach space, Hilbert spaces, orthogonal complements, complete orthonormal sets in a Hilbert space. Conjugate space of a Hilbert space.

Text books:

1. Introduction to topology and modern analysis, G. F. Simmons, McGraw - Hill Book Co. 1963; Chapter 8 (42 onwards) to Ch.10 (upto 54).

Reference books:

1. Functional analysis, B. V. Limaye, New Age International Limited publishers.
2. An introduction to Hilbert Spaces, S. K. Berberian, Oxford Uni. Press, 1959. D.Van Nostrand Co. Inc. Princeton, N.J., 1967, also available in paperback, edition by Springer.
3. A Hilbert space problem book, P. R.Halmos.
4. An introductory functional analysis with application, E. Kreyszig, WSE edition,1989, paperback.
5. Linear Analysis An Introductory course, Bela Bollobas, Foundation Books, Delhi (Cheap edition), 1994.

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Semester: IV
Advanced Numerical Analysis (Theory) — **Course Code: PMT 4803A**
No. of Credits: 04 — **Learning Hours: 60 Hours**

Course Outcomes:

CO1 Students will be able to obtain estimated solution of system of linear equations.

CO2 Students will be able to obtain estimated solution of system of ordinary differential equations.

CO3 Students will be able to obtain estimated solution of system of partial differential equations.

CO4 Students will be able to obtain eigenvalues and eigenvectors of matrix.

Unit 1: Numerical Linear Algebra: Introduction, Triangular matrices, LU decomposition of a matrix, Vector and matrix norms, Solutions of linear systems-Direct methods, Solutions of linear systems-Iterative methods, Matrix eigenvalues problem, Singular value decomposition.

Unit 2: Numerical solutions of ordinary differential equations: Introduction, Solutions by Taylor's method, Picard's method of successive approximations, Euler's method, Runge-Kutta methods, Predictor-corrector Methods, Cubic Spline method, Simultaneous and higher order equations, Some general remarks, Boundary value problems.

Unit 3: Numerical solutions of partial differential Equations: Introduction, Laplace's equation, Finite difference approximations to derivatives, Solution of Laplace's equation, Heat equation in one dimension, Iterative methods for the solution of equations, Application of Cubic Spline, Wave equation.

Unit 4: Finite Element Method: Introduction, Methods of approximation, Application to two-dimensional problems, Finite Element Method, Concluding remarks.

Text books:

1. Introductory Methods of Numerical Analysis, S. S. Sastry, Prentice Hall of India, New Delhi, 1997.

Reference books:

1. Numerical Methods with C++ programming & Matlab, Nita H. Shah, 2ndEdition, PHI.
2. An Introduction to Finite Element Method, J.N. Reddy, McGraw HillPublication,2003.
3. Introduction to Numerical Analysis, C. E. Froberg, Addision Wesley publishing Company, 6th edition,1981.
4. Computer based numerical Algorithms, E. V. Krishnamurthy and S. K. Sen, East- West press Pvt. Ltd. 1976.
5. Elementary Numerical Analysis Algorithmic approach, Conte S. D. and Carldeboor, McGraw Hill company, 3rd edition,1981.
6. Numerical analysis for scientists and Engineers, M. K. Jain, New Age International Ltd.

7. Numerical methods, J. D. Faires and R. Burden, 2nd edition, Brooks/cole publishing Co., 1998.
8. Solving ordinary differential equations, I and II, E. Hairer, E. P. Norsett and G. Warner, Springer series in computational mathematics 8, Springer, Berlin,1993.
9. Numerical Mathematical Analysis, James Blaine Scarborough.
10. Numerical Analysis and Computational Procedures, S. A. Mollah.
11. Computer-Oriented Numerical Methods, Third Edition, V. Rajaraman.
12. Computational Mathematics, B.P. Demidovich, I.A. Maron.

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Semester: IV
Mathematical Methods (Theory) **Course Code: PMT 4803B**
No. of Credits: 04 **Learning Hours: 60 Hours**

Course Outcomes:

CO1 Students will be able to solve IVP and BVP by using calculus of several variables.

CO2 Students will be able to solve integral equations.

CO3 Students will be able to identify and exemplify compact operators.

CO4 Students will be able to solve ordinary differential equations using Laplace transform.

CO5 Students will be able to solve integral equations using Laplace transform.

Unit 1: Calculus of Variation: Functional, Euler's equation, Other forms of Euler's equation, some special forms of Euler's equation, Geodesics. Isoperimetric problems, several dependent variables, Functional involving higher order derivatives.

Unit 2: Integral Equations: Integral equations, types of integral equations, conversion of differential equation into an integral equation and vice versa, solution of integral equation, Integral equations of convolution type, Abel's integral equations, integro differential equation.

Unit 3: Fredholm integral equations: Compact operators, some properties of compact operators, compact operators on $C([a, b])$ and $L^2([a, b])$, Fredholm integral equations, Fredholm alternative theorem, solutions of Fredholm integral equations for separable kernels.

Unit 4: Laplace Transform: Laplace transform, Laplace transforms of some functions, Properties of Laplace transform, Inverse Laplace transform, Convolution theorem, Applications to solutions of ordinary differential equations, Applications to the solutions of diffusion equation and wave equation.

Reference books:

1. Higher Engineering Mathematics, B. S. Grewal, Khanna Publs, 3rd Edition, Delhi.
2. An elementary course on variational problems in calculus, N. Kumar, Narosa publishing House, New Delhi, 2005.
3. Functional analysis, B. V. Limaye, 2nd Edition, New Delhi, 1996.
4. Calculus of variations with applications, S. Gupta, PHI, New Delhi, 1999.
5. Integral Equations and Applications, S. G. Mikhlin.
6. Introduction to Partial Differential Equations, Shankar Rao.
7. Mathematical Methods, Courant and Hilbert.
8. Special Functions of Mathematical Physics and Chemistry, N. Sneddon.
9. Applied Mathematics for Engineers and Physicists, L. A. Pipes.
10. Advanced Differential Equations, M. D. Raisinghania.

Semester: IV
Graph Theory (Theory) **Course Code: PMT 4804A**
No. of Credits: 04 **Learning Hours: 60 Hours**

Course Outcomes:

CO1 Student will be able to demonstrate basic properties of graphs.

CO2 Student will be able to describe and apply the relationship between the properties of a matrix representation of a graph and the structure of the underlying graph.

CO3 Student will be able to apply various graph theoretical algorithms.

CO4 Student will be able to apply Matching Theory to real life problems.

CO5 Student will be able to apply Coloring problems to solve some real-life problems.

Unit 1: Revision of Elementary concepts of Graphs: Graph, Vertex Degrees, Subgraphs, Paths & Cycles, Matrix Representation of Graphs, Trees, Spanning Trees.

Unit 2: Matchings: Matching and Augmenting Paths, The Marriage Problem, The Personal Assignment Problem, The Optimal Assignment Problem.

Unit 3: Planar Graphs: Plane and Planar Graphs, Euler's Formula, The Platonic Bodies, Kuratowski's Theorem, The Dual of a plane Graph.

Unit 4: Coloring: Vertex Coloring, Critical Graphs, Cliques, Edge Coloring

Text books:

1. A First Look at Graph Theory, John Clark, Derek Allan Holton- World Scientific, ISBN 81-7023-463-8;
   Chapters 1 (omit 1.8), 2 (omit 2.4 to 2.6), 4 (omit 4.5), 5 (omit 5.5), 6 (omit 6.2, 6.4, 6.6)

Reference books:

1. Introduction to Graph Theory, R. J. Wilson, Longman.

2. Introduction to Graph Theory, Douglas B. West, Prentice-Hall of India, Second Edition, 2006, ISBN-81-203-2142-1.

3. Invitation to Graph Theory, S. Arumugam, S. Ramachandran, Scitech Publication (India) Pvt. Ltd, Chennai.

4. A First Course in Graph Theory, S. A. Choudum, Macmillan India Ltd, SBN 033392 040 6.

5. A First Course in Graph Theory and Combinatorics, Sebastian M Cioaba and M Ram Murty, Hindustan Book Agency.

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Semester: IV
Quantitative Techniques (Theory) | **Course Code:** **PMT 4804B**
No. of Credits: 04 | **Learning Hours:** **60 Hours**

Course Outcomes:

CO1 Students will be able to manage inventory using different inventory models.

CO2 Students will be able to manage queue arising in different types of service facilities.

CO3 Student will be able to exhibit the notion of PERT & CPM and its applications.

CO4 Students will be able to schedule projects and construct networks using PERT & CPM. Student will be able to set up different game strategies and solve some real-life problems.

Unit 1: Inventory theory: Introduction, Types of Inventory, Costs Involved in Inventory Problems, EOQ Model with Constant Rate of Demand, Limitations of the EOQ Formula, EOQ Model with Finite Replenishment Rate, EOQ Model with Shortages, Order-Level, Lot-Size System, Order-Level Lot-Size System with Finite Replenishment Rate, Several Items Inventory Model with Constraints, EOQ Model with Quantity Discounts, Probabilistic Order-Level System, Probabilistic Order-Level System with Instantaneous Demand.

Unit 2: Queuing theory: Introduction, Queuing System, Classification of Queuing Models, Distribution of Arrivals (The Poisson Process), Pure Birth Process, Distribution of Inter-arrival Time, Distribution of Departures (Pure Death Process), Distribution of Service Time, Solution of Queuing Models, (M/M/1): (∞/FCFS) Model, (M/M/1): (N/FCFS) Model, (M/M/C): (∞/FCFS) Model, (M/M/C): (N/FCFS) Model, (M/M/1): (R/GD) Model, (M/M/C): (R/GD) Model, (M/Ek/1): (∞/FCFS) Model.

Unit 3: Game theory: Introduction, Two Person Zero-Sum Games, Maximin and Minimax Principles, Mixed Strategies, Expected Pay-Off, Solution of 2×2 Mixed Strategy Game, Solution of 2×2 Mixed Strategy Game by the Method of Oddments, Dominance Principle, Solution of Game by Matrix Method, Solution of a Two Person Zero-Sum $2 \times n$ Game, Graphical Method for Solving a $2 \times n$ or $m \times 2$ Game, Linear Programming Method for the Solutions of Game, Algebraic Method for Solving a Game, Solution of 3×23 Games with Mixed Strategy by the Method of Oddments, Iterative Method for Approximate Solution.

Unit 4: Network analysis: Introduction, Origin and Use of PERT & CPM, Applications of PERT & CPM, framework of PERT & CPM, Constructing the Project and Network, Dummy activities and Events, Rules for Network Construction, Finding the critical Path, PERT, PERT Cost Analysis, Cost and Networks, Least Cost Scheduling rules.

Text books:

1. Operations Research, Nita H. Shah, Ravi M. Gor and Hardik Soni, PHI Publications, New Delhi, 2007.

Reference books:

1. Operations Research: An Introduction, Eighth edition, H. A. Taha, PHI Publications, New Delhi,2006.

2. Introduction to Operations Research, F. S. Hiller and G. J. Liberman, McGraw Hills Publication.
3. Simulation, Gordan, Printice Hall.
4. Operations Research, J.P. Singh and N.P. Singh.
5. Operations Research, J.K.Sharma.

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Semester: IV
Differential Geometry (Theory) **Course Code: PMT 4804C**
No. of Credits: 04 **Learning Hours: 60 Hours**

Course Outcomes:

CO1 Students will be able to parameterize curve and explore different properties of curve.

CO2 Students will be able to parameterize surface and explore different properties of surface.

CO3 Students will be able to analyze different properties of curve using second fundamental form.

CO4 Students will be able to explore and exhibit different notions related to surfaces.

Unit 1: Space curves, planar curves, parameterization, curvature, torsion, signed curvature, Frenet-Serret equations, fundamental theorem of curve theory, isoperimetric inequality.

Unit 2: Surfaces: smooth surfaces, tangents, normals, first fundamental form, isometries of surfaces, conformal mappings of surfaces, surface area.

Unit 3: Second fundamental form, Gauss map, normal and principal curvature, geodesic curvature and normal curvature of a curve, Meunier's theorem, Euler's theorem, Gaussian and mean curvature.

Unit 4: Tangent vector field and its covariant derivative, Gauss equations, Christoffel symbols, geodesics, geodesic equations, characterization of geodesics on surfaces like sphere, cylinder, plane and surface of revolution, Codazzi-Mainardi equations, Theorem a Egregium, local Gauss Bonnet theorem (statement only) and its applications.

Text books:

1. Elementary Differential Geometry, Pressley Andrew, SUM Series, (Second Edition), 2010. Chapter 1: (Except sections 1.4 and 1.5), Chapter 2, Chapter 3: 3.1 (Except 3.1.4), 3.2, Chapter 4: 4.1, Definition 4.2.1 and examples, definition of a smooth map, 4.4, definition of a normal,Chapter6:6.1,6.2(except6.2.4,6.2.5), (except7.4.6,7.4.7,7.4.8,7.4.9,7.4.10), Chapter 8:8.1,8.2, Chapter9:9.1,9.2,9.3.1, Chapter 10: 10.1, 10.2.1, Chapter 13: 13.1.2 (statement and applications)

Reference books:

1. Introduction to Differential Geometry, Goetz A., Addison Wesley, Publ. Co., 1970.
2. Differential Geometry in Three Dimensions, Weatherburn C.E., Cambridge University Press, 1964.

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Semester: IV
Practicals based on PMT-4801 and PMT-4802 (Practical) **Course Code:** **PMT 4805L**
No. of Credits: 06 **Learning Hours:** **90 Hours**

Course Outcomes:

CO1 Students will be able to employ multivariate differential calculus to solve extreme value problems.

CO2 Students will be able to solve some real-life problems using multiple integral.

CO3 Students will be able to employ vector calculus to solve some scientific problems.

CO4 Student will be able to identify and exemplify normed linear space.

CO5 Student will be able to obtain basis and determine dimension of vector spaces and subspaces.

CO6 Student will be able to identify and exemplify Banach spaces, quotient space.

CO7 Student will be able to identify and exemplify conjugate space of a vector space.

CO8 Student will be able to identify and exemplify Hibert spaces.

List of practicals (problems on):

(1) Problem based on continuity of function of several variables.

(2) Problem based on differentiability of function of several variables.

(3) Problem based on Taylor's theorem, extreme value problems.

(4) Problem based on the implicit function theorem and its applications.

(5) Problem based on integration in higher dimensions.

(6) Problem based on change of order of integration and change of variables for multiple integrals

(7) Problem based on arc length and line integrals.

(8) Problem based on surface area and surface integrals.

(9) Problems based on vector space and related concepts.

(10) Problems based on linear transformations.

(11) Problems based on normed linear spaces and Banach spaces.

(12) Problems based on continuous linear transformations.

(13) Problems based on the conjugate and the second conjugate spaces of normed linear spaces.

(14) Problems based on the open mapping, closed graph theorems and the uniform boundedness principle.

(15) Problems based on Hilbert space and related concepts-I.

(16) Problems based on Hilbert space and related concepts-II.

Semester: IV
Practicals based on PMT-4803A and PMT-4804A (Practical) | **Course Code: PMT 4806L**
No. of Credits: 06 | **Learning Hours: 90 Hours**

Course Outcomes:

CO1 Students will be able to obtain estimated solution of system of linear equations.

CO2 Students will be able to obtain estimated solution of system of ordinary differential equations.

CO3 Students will be able to obtain estimated solution of system of partial differential equations.

CO4 Students will be able to obtain eigenvalues and eigenvectors of matrix.

CO5 Student will be able to apply various graph theoretical algorithms.

CO6 Student will be able to apply Matching Theory to real life problems.

CO7 Student will be able to apply Coloring problems to solve some real life problems.

List of practicals (problems on):

(1) Problems based on Linear Spline, Quadratic Spline.

(2) Problems based on Cubic Spline, Cubic B-spline.

(3) Problems based on numerical solutions of differential equations: Euler's modified method, Runge-Kutta method.

(4) Problems based on numerical solutions of differential equations: Predictor corrector method, Cubic Spline method.

(5) Problems based on numerical solutions of partial differential equations: Numerical methods of solving elliptic equations, Finite difference approximations to derivatives.

(6) Problems based on numerical solutions of partial differential equations: Numerical methods of solving parabolic and hyperbolic equations.

(7) Problems based on finite element method I.

(8) Problems based on finite element method II.

(9) Problems based on the Chinese Postman Problem (3.2).

(10) Problems based on the Two-Optimal Algorithm (3.4).

(11) Problems based on the Closest Insertion Algorithm (3.4).

(12) Problems based on a matching Algorithm for bipartite graphs (4.3).

(13) Problems based on the Hungarian Algorithm (4.3).

(14) Problems based on the Kuhn-Munkers Algorithm (4.4).

(15) Problems based on the simple sequential coloring Algorithms (6.2).

(16) Problems based on the Largest- First Sequential Algorithm (Welsh and Powell) (6.2).

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Semester: IV
Practicals based on PMT-4803A and PMT-4804B (Practical) **Course Code:** **PMT 4806L**
No. of Credits: 06 **Learning Hours:** **90 Hours**

Course Outcomes:

CO1 Students will be able to obtain estimated solution of system of linear equations.

CO2 Students will be able to obtain estimated solution of system of ordinary differential equations.

CO3 Students will be able to obtain estimated solution of system of partial differential equations.

CO4 Students will be able to obtain eigenvalues and eigenvectors of matrix.

CO5 Students will be able to manage inventory using different inventory models.

CO6 Students will be able to manage queue arising in different types of service facilities.

CO7 Student will be able to exhibit the notion of PERT & CPM and its applications.

CO8 Students will be able to schedule projects and construct networks using PERT & CPM.

List of practicals (problems on):

(1) Problems based on Linear Spline, Quadratic Spline.

(2) Problems based on Cubic Spline, Cubic B-spline.

(3) Problems based on numerical solutions of differential equations: Euler's modified method, Runge-Kutta method.

(4) Problems based on numerical solutions of differential equations: Predictor corrector method, Cubic Spline method.

(5) Problems based on numerical solutions of partial differential equations: Numerical methods of solving elliptic equations, Finite difference approximations to derivatives.

(6) Problems based on numerical solutions of partial differential equations: Numerical methods of solving parabolic and hyperbolic equations.

(7) Problems based on finite element method I.

(8) Problems based on finite element method II.

(9) Problems based on Inventory models-I.

(10) Problems based on Inventory models-II.

(11) Problems based on (M/M/1): (∞/FCFS), (M/M/1): (N/FCFS), (M/M/C): (∞/FCFS), (M/M/C): (N/FCFS) Models.

(12) Problems based on (M/M/1): (R/GD) Model, (M/M/C): (R/GD) Model, (M/Ek/1): (∞/FCFS) Models.

(13) Problems based on Game theory-I.

(14) Problems based on Game theory -II.

(15) Problems based on Project Management- I.

(16) Problems based on Project Management- II.

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Semester: IV

Practicals based on PMT-4803A and PMT-4804C (Practical) **Course Code: PMT 4806L**

No. of Credits: 06 **Learning Hours: 90 Hours**

Course Outcomes:

CO1 Students will be able to obtain estimated solution of system of linear equations.

CO2 Students will be able to obtain estimated solution of system of ordinary differential equations.

CO3 Students will be able to obtain estimated solution of system of partial differential equations.

CO4 Students will be able to obtain eigenvalues and eigenvectors of matrix.

CO5 Students will be able to parameterize curve and explore different properties of curve.

CO6 Students will be able to parameterize surface and explore different properties of surface.

CO7 Students will be able to analyze different properties of curve using second fundamental form.

CO8 Students will be able to explore and exhibit different notions related to surfaces.

List of practicals (problems on):

(1) Problems based on Linear Spline, Quadratic Spline.

(2) Problems based on Cubic Spline, Cubic B-spline.

(3) Problems based on numerical solutions of differential equations: Euler's modified method, Runge-Kutta method.

(4) Problems based on numerical solutions of differential equations: Predictor corrector method, Cubic Spline method.

(5) Problems based on numerical solutions of partial differential equations: Numerical methods of solving elliptic equations, Finite difference approximations to derivatives.

(6) Problems based on numerical solutions of partial differential equations: Numerical methods of solving parabolic and hyperbolic equations.

(7) Problems based on finite element method I.

(8) Problems based on finite element method II.

(9) Problems based on curves, its parameterization and curvature.

(10) Problems based on torsion, signed curvature and Frenet-Serret equations.

(11) Problems based on surfaces and its first fundamental forms.

(12) Problems based on tangents, normal and surface area.

(13) Problems based on second fundamental forms of surfaces and principal curvature.

(14) Problems based on curves on surface and geodesic curvature.

(15) Problems based on Christoffel symbols and characterization of geodesics on surfaces like sphere.

(16) Problems based on geodesics on surface like cylinder, plane and surface of revolution.

Semester: IV
Practicals based on PMT-4803B and PMT-4804A (Practical) **Course Code: PMT 4806L**
No. of Credits: 06 **Learning Hours: 90 Hours**

Course Outcomes:

CO1 Students will be able to solve the system of differential equations and determine its stability.

CO2 Students will be able to solve integral equations.

CO3 Students will be able to solve ordinary differential equations and integral equations using Laplace transform.

CO4 Student will be able to apply various graph theoretical algorithms.

CO5 Student will be able to apply Matching Theory to real life problems.

CO6 Student will be able to apply Coloring problems to solve some real life problems.

List of practicals (problems on):

(1) Problems based on the eigenvalue-eigenvector method of finding solutions of system of differential equations $x = Ax$.

(2) Problems based on fundamental matrix solutions of system of differential equation $x = Ax$, Stability of linear systems.

(3) Problems based on Euler-Lagrange equations-I.

(4) Problems based on Euler-Lagrange equations-II.

(5) Problems based on Fredholm and Volterra integral equation of the first kind and second kind.

(6) Problems based on integral equations with symmetrical kernels and separable kernels.

(7) Problems based on Laplace transform and inverse Laplace transform using elementary functions, differentiation, integration and convolution theorems of Laplace transform.

(8) Problems based on finding solution of ordinary differential equations using Laplace transform.

(9) Problems based on the Chinese Postman Problem (3.2).

(10) Problems based on the Two-Optimal Algorithm (3.4).

(11) Problems based on the Closest Insertion Algorithm (3.4).

(12) Problems based on a matching Algorithm for bipartite graphs (4.3).

(13) Problems based on the Hungarian Algorithm (4.3).

(14) Problems based on the Kuhn-Munkers Algorithm (4.4).

(15) Problems based on the simple sequential colouring Algorithms (6.2).

(16) Problems based on the Largest- First Sequential Algorithm (Welsh and Powell) (6.2).

St. Xavier's College (Autonomous)
Ahmedabad-09
M. Sc. Mathematics

Semester: IV
Practicals based on PMT-4803B and PMT-4804B (Practical) **Course Code: PMT 4806L**
No. of Credits: 06 **Learning Hours: 90 Hours**

Course Outcomes:

CO1 Students will be able to solve the system of differential equations and determine its stability.

CO2 Students will be able to solve integral equations.

CO3 Students will be able to solve ordinary differential equations and integral equations using Laplace transform.

CO4 Students will be able to manage inventory using different inventory models.

CO5 Students will be able to manage queue arising in different types of service facilities.

CO6 Student will be able to exhibit the notion of PERT & CPM and its applications.

CO7 Students will be able to schedule projects and construct networks using PERT & CPM.

CO8 Student will be able to set up different game strategies and solve some real life problems.

List of practicals (problems on):

(1) Problems based on the eigenvalue-eigenvector method of finding solutions of system of differential equations $x = Ax$.

(2) Problems based on fundamental matrix solutions of system of differential equation $x = Ax$, Stability of linear systems.

(3) Problems based on Euler-Lagrange equations-I.

(4) Problems based on Euler-Lagrange equations-II.

(5) Problems based on Fredholm and Volterra integral equation of the first kind and second kind.

(6) Problems based on integral equations with symmetrical kernels and separable kernels.

(7) Problems based on Laplace transform and inverse Laplace transform using elementary functions, differentiation, integration and convolution theorems of Laplace transform.

(8) Problems based on finding solution of ordinary differential equations using Laplace transform.

(9) Problems based on Inventory models-I.

(10) Problems based on Inventory models-II.

(11) Problems based on (M/M/1): (∞/FCFS), (M/M/1): (N/FCFS), (M/M/C): (∞/FCFS), (M/M/C): (N/FCFS) Models.

(12) Problems based on (M/M/1): (R/GD) Model, (M/M/C): (R/GD) Model, (M/Ek/1): (∞/FCFS) Models.

(13) Problems based on Game theory-I.

(14) Problems based on Game theory -II.

(15) Problems based on Project Management- I.

(16) Problems based on Project Management- II.

Semester: IV
Practicals based on PMT-4803B and PMT-4804C (Practical) **Course Code: PMT 4806L**
No. of Credits: 06 **Learning Hours: 90 Hours**

Course Outcomes:

CO1 Students will be able to solve the system of differential equations and determine its stability.

CO2 Students will be able to solve integral equations.

CO3 Students will be able to solve ordinary differential equations and integral equations using Laplace transform.

CO4 Students will be able to parameterize curve and explore different properties of curve.

CO5 Students will be able to parameterize surface and explore different properties of surface.

CO6 Students will be able to analyze different properties of curve using second fundamental form.

CO7 Students will be able to explore and exhibit different notions related to surfaces.

List of practicals (problems on):

(1) Problems based on the eigenvalue-eigenvector method of finding solutions of system of differential equations $x = Ax$.

(2) Problems based on fundamental matrix solutions of system of differential equation $x = Ax$, Stability of linear systems.

(3) Problems based on Euler-Lagrange equations-I.

(4) Problems based on Euler-Lagrange equations-II.

(5) Problems based on Fredholm and Volterra integral equation of the first kind and second kind.

(6) Problems based on integral equations with symmetrical kernels and separable kernels.

(7) Problems based on Laplace transform and inverse Laplace transform using elementary functions, differentiation, integration and convolution theorems of Laplace transform.

(8) Problems based on finding solution of ordinary differential equations using Laplace transform.

(9) Problems based on curves, its parameterization and curvature.

(10) Problems based on torsion, signed curvature and Frenet-Serret equations.

(11) Problems based on surfaces and its first fundamental forms.

(12) Problems based on tangents, normal and surface area.

(13) Problems based on second fundamental forms of surfaces and principal curvature.

(14) Problems based on curves on surface and geodesic curvature.

(15) Problems based on Christoffel symbols and characterization of geodesics on surfaces like sphere.

(16) Problems based on geodesics on surface like cylinder, plane and surface of revolution.