MIC-01: Algebra (03 credits) (Lecture: 30)

Course Objectives: The primary objective of this course is to introduce the basic tools of theory of equations, complex numbers, number theory and matrices to understand their linkage to the real-world problems.

Course Learning Outcomes: This course will enable the students to:
i) Employ De Moivre's theorem in a number of applications to solve numerical problems.
ii) Apply Euclid's algorithm and backwards substitution to find greatest common divisor.
iii) Recognize consistent and inconsistent systems of linear equations by the row echelon form of the augmented matrix, using rank.

Course Contents:

Unit 1 **(Lecture: 08)**
Polar representation of complex numbers, De Moivre's theorem and its applications, Logarithms of complex quantities'Hyperbolic functions,Gregory series , Summation of series,.

Unit 2 **(Lecture: 07)**
Cartesian product of sets, Equivalence relations, Functions, Composition of functions, Invertible functions, Partial and Total order relation,Countable and Uncountable sets,

Unit 3 **(Lecture: 08)**
Matrices, Operation on Matrices, Kinds of matrices, Transpose, symmetric & skew symmetric matrices, Hermitian and skew Hermitian matrices , Adjoint and Inverse of a matrix, Solution of a system of linear equations by matrix methods.

Unit 4 **(Lecture: 07)**
Fundamental theorem of algebra, Relation between roots and coefficients of a polynomial equation, Evaluation of symmetric functions of roots , Transformation of equation, Solution of Cubic equation (Cardon's method).

References:

1. Dickson, Leonard Eugene (1922). *First Course in The Theory of Equations*. John Wiley & Sons, Inc. New York.
2. Lay, David C., Lay, Steven R., & McDonald, Judi J. (2016). *Linear Algebra and its Applications* (5th ed.). Pearson Education

Additional Readings:

1. Andrilli, Stephen, & Hecker, David (2016). *Elementary Linear Algebra* (5th ed.). Academic Press, Elsevier India Private Limited.

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2. Burton, David M. (2007). *Elementary Number Theory* (7th ed.). Tata Mc-Graw Hill Edition, Indian Reprint.
3. K.K.Jha , Advanced Set Theory, Nav Bharat Publication, Patna
4. M.L.Khanna, Theory of Equations, Jai Prakash Nath& Co. Merrut (U.P.)
5. Lalji Prasad, Matrices, Paramount Publications Patna
6. Dasgupta , Trigonometry, Bharti Bhawan Patna

MIC-02: Calculus & Geometry (03 credits) (Lecture: 30)

Course Objectives: The primary objective of this course is to introduce the basic tools of calculus and geometric properties of different conic sections which are helpful in understanding their applications in planetary motion, design of telescope and to the real-world problems.

Course Learning Outcomes: This course will enable the students to:
i) Apply derivatives in Optimization, Social sciences, Physics and Life sciences etc.
ii) Compute area of surfaces of revolution and the volume of solids by integrating over cross-sectional areas.

Course Contents:

Unit 1 **(Lectures: 08)**
Successive differentiation and Leibnitz's theorem, Maclaurin's and Taylor's series of Expansion, Partial differentiation and Euler's theorem, Total Differential, L'Hospital's rule, Tangent and Normal, Asymptotes, Curvature.

Unit 2 **(Lectures: 08)**
Evaluation of definite integrals, Reduction formulae, Length of plane curve and area bounded by plane curves, Volumes and Surface area of solid revolution.

Unit 3 **(Lectures: 07)**
Transformation of rectangular axes, General equations of Conic and its Reduction to the normal form, Equation of the tangent and normal at a point of the Conic.

Unit 4 **(Lectures: 07)**
Sphere, Cone, Cylinder, Central conicoid, Paraboloids, Plane section of conicoid, Generating lines, Tangent plane and normal to a conicoid.

References:

1. Anton, Howard, Bivens, Irl, & Davis, Stephen (2013). *Calculus* (10th ed.). John Wiley & Sons Singapore Pte. Ltd. Indian Reprint (2016) by Wiley India Pvt. Ltd. Delhi.
2. Osborne, George. A. (1906). *Differential and Integral Calculus with Examples and Applications*. Revised Edition. D. C. Health & Co. Publishers. Boston, U.S.A.
3. Strauss, Monty J., Bradley, Gerald L., & Smith, Karl J. (2007). *Calculus* (3rd ed.). Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). Delhi. Indian Reprint 2011.
4. SL.Loney , Coordinate Geometry
5. Thomas, Jr. George B., Weir, Maurice D., & Hass, Joel (2014). *Thomas' Calculus* (13th ed.). Pearson Education, Delhi. Indian Reprint 2017.

Additional Readings:

1. Lalji Prasad , Integral Calculus, Paramount Publications Patna
2. Shanti Narayan , P.K.Mittal , Integral Calculus, S. Chand, New Delhi
3. B.C. Das and B.N. Mukherjee, Differential calculus, Dhur& Sons Pvt.Ltd. Kolkatta

4. A skwith, The Analytical Geometry of the conic sections.
5. S L Loney ,Coordinate Geometry
6. Dasgupta, Differential calculus, Bharti Bhawan Patna

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SEMESTER- III

MIC-03: Real Analysis

Course Outcomes

After the completion of the course, the student will be able to:

CO1: Understand many properties of the real line and learn to define sequence in terms of functions.
CO2: Recognize bounded, convergent, divergent, Cauchy and monotonic sequences.
CO3: Apply tests for convergence and absolute convergence of an infinite series of real numbers.

MIC-03: Real Analysis (3 credits) Full Marks- 100		
Unit	**Topics to be covered**	**No. of Lectures**
1	Dedekind theory of real numbers, Algebraic and order properties of R, Archimedean Property, Density Theorem, Completeness property of R, Bounded sets, Theorems on Suprema and Infima.	10
2	Sequence and its convergence, Bounded sequence, Monotone sequences, Subsequences, Limit of a sequence, Limit Theorem, Bolzano-Weierstrass theorem for sequences, Cauchy sequence, Cauchy's general principle of convergence.	10
3	Infinite series and their convergence, Cauchy Criterion, Tests for convergence: Comparison test, D'Alembert Ratio Test, Cauchy's root test, Rabbe's test, Logarithmic test, Cauchy integral test, Gauss's test, Alternating series, Leibnitz test, Absolute and Conditional convergence.	10
	TOTAL	30

Book References:

1. Bartle, Robert G., & Sherbert, Donald R. (2015). Introduction to Real Analysis (4th ed.). Wiley India Edition. New Delhi.
2. Ross, Kenneth A. (2013). Elementary Analysis: The theory of calculus (2nd ed.). Undergraduate Texts in Mathematics, Springer. Indian Reprint.
3. Malik, S. C. & Arora, Savita. (2021). Mathematical Analysis (6th ed.). New Age International Publishers, New Delhi.
4. Jha,K.K. Advanced Course in Real Analysis and Higher Analysis. New Bharat Publishing House.

SEMESTER-IV

MIC-04: Ordinary Differential Equations

Course Outcomes

After the completion of the course, the student will be able to:

CO1: Understand the concept of ordinary differential equation.
CO2: Solve first order linear and non-linear differential equation and linear differential equations of higher order using various techniques.
CO3: Apply these techniques to solve and analyze various mathematical models.

MIC-04: Ordinary Differential Equations (3 credits) Full Marks-100		
Unit	**Topics to be covered**	**No. of Lectures**
1	Formulation of Differential equations and its order and degree, General, Particular and Singular solutions of differential equations, variables separable, Equations reducible to variables separable, Homogeneous differential equations, Equations reducible to homogeneous form, Exact differential equations and equations reducible to the exact form, Linear differential equations and equations reducible to linear form, Bernoulli equation.	10
2	Differential equations of first order but not of first degree, Singular solutions, Clairaut's form, Linear differential equation of order greater than one with constant coefficients, Cauchy- Euler Equation, Legendre's Linear Equation.	10
3	Second order linear differential equations with variable coefficients: Use of a known solution to find another, normal form, method of undetermined coefficient, variation of parameters, Total differential equation in three variables, Simultaneous differential equations.	10
	TOTAL	30

Book References:

1. Simmons, George F. (2016). Differential Equations with Applications and Historical Notes. Tata–McGraw Hill Publishing Company Limited, New Delhi.
2. Raisinghania, M.D. (2020). Ordinary and Partial Differential Equations (20th ed.). S. Chand Publication.
3. Bronson, R. &Coasta, Gabriel B. (2021). Schaum's Outline of Differential Equations (5th ed.). McGraw Hill.
4. Prasad, Lalji. (2019). Differential Equations. Paramount Publication.

SEMESTER – V

MIC-05: Theory of Real Functions

Course Outcomes

After the completion of the course, the student will be able to understand:

CO1: The concept of limit of a function.
CO2: The geometrical properties of continuous functions on closed intervals.
CO3: The applications of mean value theorem.

MIC-05: Theory of Real Functions (3 credits) Full Marks-100		
Unit	**Topics to be covered**	**No. of Lectures**
1	Limit of functions, Sequential criterion for limits, Divergence criteria, Limit theorems, One-sided limits, Infinite limits and limits at infinity.	08
2	Continuous functions, Sequential criterion for continuity and discontinuity, Algebra of continuous functions, Properties of continuous functions on closed intervals.	10
3	Differentiability of a function, Algebra of differentiable functions, Increasing and Decreasing functions, Sign of derivatives,Darboux's theorem, Intermediate value theorem for derivatives, Rolle's theorem, Lagrange's and Cauchy's Mean value theorem and their applications.	12
	TOTAL	30

Book References:

1. Bartle, Robert G., & Sherbert, Donald R. (2015). Introduction to Real Analysis (4th ed.). Wiley India Edition. New Delhi.
2. Ross, Kenneth A. (2013). Elementary Analysis: The theory of calculus (2nd ed.). Undergraduate Texts in Mathematics, Springer. Indian Reprint.
3. Malik, S. C. & Arora, S. (2021). Mathematical Analysis (6th ed.), New Age International Publishers, New Delhi.
4. Jha,K.K. Advanced Course in Real Analysis and Higher Analysis. New Bharat Publishing House.

SEMESTER- V

MIC-06: Group Theory

Course Outcomes

After the completion of the course, the student will be able to:

CO1: Recognize the mathematical objects that are groups, and classify them as abelian, cyclic and permutation groups, etc.

CO2: Explain the significance of the notion of cosets, normal subgroups, and factor groups.

CO3: Understand the concept of group homomorphism and isomorphism.

MIC-06: Group Theory (3 credits) Full Marks: 100		
Unit	**Topics to be covered**	**No. of Lectures**
1	Definition and examples of groups, Elementary properties of groups, Subgroups and examples of subgroups, Generator of a group, Cyclic group, Properties of cyclic groups.	10
2	Permutations Group, Even and odd permutations, Alternating Group, Cosets and its properties, Lagrange's theorem, Fermat's Little theorem, Normal subgroups, Quotient groups, Center of a group, Normalizer of an element, Normalizer of a subgroup.	10
3	Group homomorphisms, Kernel of a group homomorphism, Fundamental theorem of group homomorphism, Isomorphisms, Properties of Isomorphisms, First, Second and Third isomorphism theorems for groups, Cayley's theorem.	10
	TOTAL	30

Book References:

1. Gallian, Joseph. A. (2013). Contemporary Abstract Algebra (8th ed.). Cengage Learning India Private Limited, Delhi. Fourth impression, 2015.
2. Herstein I. N. (2003). Topics in Algebra (2nd ed.). John Wiley & Sons.
3. Khanna, Vijay K. & Bhambri, S. K. A Course in Abstract Algebra (5th ed.). Vikash Publishing House Private Limited, New Delhi.
4. Fraleigh, John B. (2002). A Course in Abstract Algebra (7th ed.). Pearson Education.

SEMESTER- VI

MIC-07: Partial Differential equation

Course Outcomes

After the completion of the course, the student will be able to:

CO1: Formulate, classify and transform partial differential equations into canonical form.

CO2: Solve linear and non-linear partial differential equations using various methods; and apply these methods in solving some physical problems.

CO3: Apply Laplace transformation for solving PDEs.

MIC-07: Partial Differential Equation (3 credits) Full Marks-100		
Unit	**Topics to be covered**	**No. of Lectures**
1	Introduction to PDEs, Order and Degree of a PDE, Classification of partial differential equations (PDEs), formation and solution of PDEs, derivation of PDEs by elimination of arbitrary functions.	10
2	Linear partial differential equation of first order, Lagrange's solution of linear equation, Solution of partial differential equations using Charpit's method, solution of equations of the form f(p,q)=0, f(z,p,q)=0, f(x,p)=f(y,q) and z=px+qy+f(p,q) using Charpit's method.	10
3	Laplace transforms and its application to partial differential equations. Inverse Laplace transformations and its properties, convolutions.	10
	TOTAL	30

Book References:

1. Myint-U, Tyn& Debnath, Lokenath. (2007). Linear Partial Differential Equation for Scientists and Engineers (4th ed.). Springer, Third Indian Reprint, 2013.
2. Sneddon, I. N. (2006). Elements of Partial Differential Equations, Dover Publications. Indian Reprint.
3. M. D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand Publication.
4. Peter J. Olver, Introduction to partial differential equations, Speringer
5. S.K. Pundir and R. Pundir, Advanced Partial Differential Equations (with boundary value problems), Pragati Prakashan.

SEMESTER- VI

MIC-08: Ring Theory and Linear Algebra

Course Outcomes

After the completion of the course, the student will be able to understand:

CO1: The fundamental concept of Rings, subrings, ideals and the corresponding homomorphisms.

CO2: The concept of linear independence of vectors over a field, the idea of a finite dimensional vector space, basis of a vector space and the dimension of a vector space.

MIC-08: Ring Theory and Linear Algebra (3 credits) Full Marks-100		
Unit	**Topics to be covered**	**No. of Lectures**
1	Definition and examples of rings, properties of rings, subrings, characteristics of a subring, Ideal, Ideal generated by a subset of a ring, quotient ring, operation on ideals, prime and maximal ideals.	10
2	Ring homomorphisms, properties of ring homomorphism, isomorphism theorems.	10
3	Definition of linear space, general properties of linear space, vector subspaces, linear combination of vectors, linear span. Linear dependence and independence of vectors, basis of a vector space, finite dimensional vector spaces.	10
	TOTAL	30

Book References:

1. Gallian, Joseph. A. (2013). Contemporary Abstract Algebra (8th ed.). Cengage Learning India Private Limited. Delhi. Fourth impression, 2015.
2. Friedberg, Stephen H., Insel, Arnold J., & Spence, Lawrence E. (2003). Linear Algebra (4th ed.). Prentice-Hall of India Pvt. Ltd. New Delhi.
3. I.N. Herstein, Abstract Algebra, Prentice Hall, New Jersey.
4. Hoffman and Kunze, Linear Algebra.
5. Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.
6. Lalji Prasad, Linear Algebra, Paramount Publications.
7. S.K. Mapa, Higher Algebra (Abstract and Linear), Levant Books, Kolkata.

SEMESTER- VII

MIC-09: Multivariate Calculus

Course Outcomes

After the completion of the course, the student will be able to understand:

CO1: The conceptual variations when advancing in calculus from one variable to multivariable discussions.
CO2: Inter-relationship amongst the line integral, double and triple integral formulations.
CO3: Applications of multi variable calculus tools in different disciplines.

MIC-09 : Multivariate Calculus (4 credits) Full Marks-100		
Unit	**Topics to be covered**	**No. of Lectures**
1	Functions of several variables, Limits and continuity, Partial derivatives, Higher order partial derivatives, Euler's theorem on Homogeneous function	10
2	Double integrals in Cartesian and polar co-ordinates, Triple integrals, Change of variables in double and triple integrals.	10
3	Line integrals, Applications of line integrals: Mass and Work, Fundamental theorem for line integrals, Definition of vector field, Conservative vector fields, Divergence and curl.	10
4	Green's theorem- Tangential and Normal form, Evaluate line integrals using Green's theorem, Surface integrals, Stokes' theorem.	10
	TOTAL	40

Book References:

1. Malik, S.C. & Arora, Savita (2017). Mathematical Analysis, New Age International Private Limited.
2. Marsden, J. E., Tromba, A., & Weinstein, A. (2004). Basic Multivariable Calculus. Springer (SIE). First Indian Reprint.
3. Thomas' Calculus, 14e Paperback, George B. Thomas, Joel Hass, Christopher Heil, Maurice D. Weir, Pearson Education.
4. Prasad Lalji, Advanced Calculus, Paramount Publications, Revised Edition (2015).

SEMESTER- VIII

MIC-10: Complex Analysis

Course Outcomes

After the completion of the course, the student will be able to:

CO1: Understand the significance of differentiability of complex functions leading to the understanding of Cauchy-Riemann equations.

CO2: Evaluate the contour integrals and understand the role of Cauchy-Goursat theorem and the Cauchy integral formula.Expand some simple functions as their Taylor and Laurent series.

MIC-10: Complex Analysis (4 credits) Full Marks-100		
Unit	**Topics to be covered**	**No. of Lectures**
1	Introduction to complex number and geometrical interpretation, algebra of complex numbers, functions of complex variables, limit of a complex function, continuity and uniform continuity, differentiability, Analytic and regular function, Cauchy-Riemann equation and it's applications.	10
2	Exponential function, logarithmic function, Branches, trigonometric and hyperbolic functions, derivatives of functions, Definite integrals of functions, Contours, Contour integrals and its examples.	10
3	Complex integration, Cauchy's theorem, Cauchy's Goursat theorem (Statement only), primitives, Cauchy's integral formula, Cauchy's integral formula for the derivative of an analytic function, Morera's theorem.	10
4	Convergence of sequences and series, Taylor series and its examples; Laurent series and its examples, Absolute and uniform convergence of power series.	10
	TOTAL	40

Book References:

1. Brown, James Ward, & Churchill, Ruel V. (2014). Complex Variables and Applications (9th ed.). McGraw-Hill Education. New York.
2. S. Ponnusamy, (2011) Foundation of complex Analysis, Alpha Science International Ltd. UK.
3. Bak, Joseph & Newman, Donald J. (2010). Complex analysis (3rd ed.). Undergraduate Texts in Mathematics, Springer. New York.
4. Zills, Dennis G., & Shanahan, Patrick D. (2003). A First Course in Complex Analysis with Applications. Jones & Bartlett Publishers, Inc.
5. Mathews, John H., & Howell, Rusell W. (2012). Complex Analysis for Mathematics and Engineering (6th ed.). Jones & Bartlett Learning. Narosa, Delhi. Indian Edition.