**MATH 304: COMPLEX ANALYSIS I [CF 3.0, 45 HOURS]**

**COURSE PURPOSE**

Solve problems of heat flow, potential theory, fluid mechanics and many other problems in Science and Engineering.

The purpose of Complex Analysis I is to introduce students to the fundamental concepts and techniques of complex analysis. This course aims to provide a solid foundation in the theory of functions of a complex variable, focusing on essential topics such as complex differentiation and integration, Cauchy's theorem, and residue calculus. This course is essential for students pursuing advanced studies in mathematics, physics, and engineering, as complex analysis has numerous applications in these fields.

**EXPECTED LEARNING OUTCOMES**

By the end of this course, the learner should be able to:

1. Understand and apply the concept of complex numbers and their properties.
2. Define and analyze functions of a complex variables, including limits, continuity, and differentiability.
3. Apply Cauchy's theorem and its consequences, such as Cauchy's integral formula.
4. Utilize series representations of analytic functions, including Taylor and Laurent series.
5. Solve problems involving residues and poles, and use residue calculus to evaluate complex integrals.
6. Application of Cauchy integral formula and residue theorem to evaluate integrals

**Course Content**

Complex numbers, Functions of complex variables and their properties. The complex plane,

Singularities, residues and poles Complex differentiation, Analytic functions and harmonic functions

Complex integration; Cauchy theorem and Cauchy formula, residue theorem power series-Taylors

and Laurent Series;

**Teaching and Learning Methods**

Lectures, presentations, group discussions, syndicate work/tutorials and Question/ Answer approach.

**Instructional Materials and Equipment**

Overhead projector, Power point, Flip charts, Hand-outs, Charts and Felt Pens.

**Course Assessment**

CATs and Assignments 40%, Final examinations 60%, Total marks 100%

**REFERENCES**

Joseph Bak, Donald J. Newmann(2010 ) Complex Analysis, 3rd edition, Springer

Gameline T. W (2001): Complex Analysis, Springer,

Murray Spiegel et al (2009): Schaums Outline of Complex Variables, 2nd edition, McGraw-Hill,

Edward B. Saff,( 2003): Fundamentals of Complex Analysis with Applications to Engineering and Science, 3rd edition, Prentice Hall

Eberhard Freitag and Rolf Busam (2009): Complex Analysis: Fundamentals of the Classical Theory of Functions 2nd Edition,

James Ward Brown and Ruel V. Churchill (2013): Complex Variables and Applications, 9th Edition,

**MATH 322: ORDINARY DIFFERENTIAL EQUATIONS (L/P 45/0; CF 3.0)**

**Course Purpose**

The purpose of Ordinary Differential Equations I is to introduce students to the fundamental concepts and methods used to solve ordinary differential equations (ODEs). This course aims to provide students with a solid foundation in understanding and solving first-order and higher-order differential equations, as well as their applications in various fields. This course is essential for students in mathematics, engineering, physics, and other sciences where ODEs are commonly used to model real-world phenomena.

**Expected Learning Outcomes**

At the end of the course unit the student should be able to:

Classify differential equations and derive ODEs

Solve first-order differential equations

Solve higher-order linear differential equations with constant coefficients.

Apply the method of undetermined coefficients, variation of parameters and inverse D-Operator for non-homogeneous differential equations.

Apply differential equations to model and solve real-world problems in physics, chemistry, biology and economics.

**Course Content**

Introduction, classification and derivation of ODEs

First order equations solving and applications. Second order equations. Higher-order linear

Differential equations with constant coefficients, methods for solving homogeneous .Solving non-

Homogeneous differential equations using undetermined coefficients, Variation of parameters.

Inverse differential Operators. Application of second order to real life situations

**Teaching and Learning Methods**

Lectures, presentations, group discussions, syndicate work/tutorials, Question/ Answer approach

**Course Assessment**

CATs and Assignments 40%, Final examinations 60%, Total marks 100%

**References**

William E. Boyce and Richard C. DiPrima (2017): Elementary Differential Equations and Boundary Value Problems, 11th Edition

James Stewart (2003): Calculus, Early Transcendentals, International Student Edition,5th Edition,

George F. Simmons (2016): Differential Equations with Applications and Historical Notes, 3rd Edition,

Vladimir I. Arnold (1992): Ordinary Differential Equations, 10th Edition,

Dennis G. Zill (2017): A First Course in Differential Equations with Modeling Applications, 11th Edition,

James R. Brannan and William E. Boyce (2015): Differential Equations: An Introduction to Modern Methods and Applications 3rd Edition

**MATH 323: NUMERICAL ANALYSIS I (L/P 45/0; CF 3.0)**

**Course Purpose**

The purpose of Numerical Analysis I is to introduce students to the fundamental methods and techniques used to approximate solutions to mathematical problems that cannot be solved analytically. This course aims to develop students' understanding of numerical algorithms, error analysis, and the practical implementation of these methods using computational tools. It is essential for students in mathematics, engineering, physics, and computer science, as numerical methods are widely used in these disciplines.

**Expected Learning Outcomes**

At the end of the course the student should be able to:

1. Understand and implement basic numerical methods for solving mathematical problems.

2. Analyze the accuracy and stability of numerical algorithms.

3. Solve linear and nonlinear equations using numerical techniques

4. Interpolate functions using numerical technics/polynomials

5. Perform numerical integration and differentiation.

6. Implement numerical algorithms using appropriate software tools.

**Course Content**

Introduction to errors. Solution of nonlinear equation f(x) = 0. Lagrange and divided differences interpolation. Interpolation based on finite differences. Inverse interpolation. Numerical differentiation. Numerical integration. Newton-Cotes, Romberg formulae. Systems of linear equation. Implementation of these methods using computational tools and understand their practical applications.

**Teaching and Learning Methods**

Lectures, presentations, group discussions, syndicate work/tutorials and Question/ Answer approach

**Instructional Materials And Equipment**

Overhead projector, Power point, Flip charts, Hand-outs, Charts and Felt Pens.

**Course Assessment**

CATs and Assignments 40%, Final examinations 60%, Total marks 100%

**References**

1. Richard L. Burden and J. Douglas Faires (2015) : Numerical Analysis, 10th Edition,

2. Endre Süli and David F. Mayers (2003) : An Introduction to Numerical Analysis’

3. Steven C. Chapra and Raymond P. Canale (2019) : Numerical Methods for Engineers, 8th Edition,

4. Heinbockel J. H.: (2020 ) : Numerical Methods for Scientific Computing

5. Steven C. Chapra (2018): Applied Numerical Methods with MATLAB for Engineers and Scientists,

4th Edition

6. Butcher J.C. (2016) : Numerical Methods for Ordinary Differential Equations, 3rd Edition,

**MATH 404: COMPLEX ANALYSIS II (L/P 45/0; CF 3.0)**

**Course Purpose**

The purpose of this course is to Building on the foundation laid in Complex Analysis I, Complex Analysis II delves deeper into advanced topics and applications of complex analysis. The course covers more sophisticated concepts such as conformal mappings, Riemann surfaces, and analytic continuation. Students will explore advanced integration techniques, the theory of entire and meromorphic functions, and applications in various scientific and engineering disciplines.

**Expected Learning Outcomes**

By the end of this course, the learner should be able to:

Evaluate the residues using residue theorem.

Analyze and apply conformal mappings and their properties.

Understand the concept and applications of Riemann surfaces.

Perform analytic continuation and understand its significance.

Explore advanced integration techniques and their applications in various fields.

**Course Content**

Calculus of residues and applications; more advanced treatment of power series; Laurent series and the residue theorem, improper integral, definite integral of trigonometric functions, integration around branch point; Analytic continuation; conformal mapping; conjugate harmonic functions, transformations of harmonic functions, transformation of boundary conditions and application. theory of entire and meromorphic functions,

The Schwartz-Christoffel transformation and its application

**Teaching and Learning Methods**

Lectures, presentations, group discussions, syndicate work/tutorials and Question/ Answer approach

**Instructional Materials And Equipment**

Overhead projector, Power point, Flip charts, Hand-outs, Charts and Felt Pens.

**Course Assessment**

CATs and Assignments 30%, Final examinations 70%, Total marks 100%

**References**

Joseph Bak, Donald J. Newmann(2010 ) Complex Analysis, 3rd edition, Springer

Gameline T. W (2001): Complex Analysis, Springer,

Murray Spiegel et al (2009): Schaums Outline of Complex Variables, 2nd edition, McGraw-Hill,

Edward B. Saff,( 2003): Fundamentals of Complex Analysis with Applications to Engineering and Science, 3rd edition, Prentice Hall

Eberhard Freitag and Rolf Busam (2009): Complex Analysis: Fundamentals of the Classical Theory of Functions 2nd Edition,

James Ward Brown and Ruel V. Churchill (2013): Complex Variables and Applications, 9th Edition,

**MATH 421: PARTIAL DIFFERENTIAL EQUATIONS I (L/P 45/0; CF 3.0)**

. The purpose of Partial Differential Equations I is to introduce students to the fundamental concepts, techniques, and applications of partial differential equations (PDEs). This course aims to develop students' understanding of how PDEs arise in various scientific and engineering contexts, and how to solve them using analytically .The course is essential for students in mathematics, physics, engineering, and related fields, as PDEs are crucial for modeling a wide range of phenomena. Students will learn to apply these techniques to solve problems arising in various scientific and engineering fields, with an emphasis on both theoretical understanding and practical application

**Expected Learning Outcomes**

By the end of this course, the learner should be able to:

Derive PDEs from given primitives

Classify PDEs and understand the characteristics of different types of linear first order PDE

Solve first-order linear PDEs

Classify and solve different types of non-linear first order PDE

Apply PDEs to model and solve problems involving Orthogonal trajectories of systems of curves on a surface

Apply PDEs to model and solve problems involving Integral surfaces passing through a given curve.

**Course Content**

Introduction to partial differential equations, focusing on their derivation, classification, and methods of solution. Linear first-order PDEs and the method of characteristics, Simultaneous differential equations of the first order. Methods of solution of first order PDEs, Surface and curves in the three dimensions. Integral surfaces passing through a given curve**.** Orthogonal trajectories of systems of curves on a surface. Classifying and solving non-linear partial differential equations of the first order. Set of general methods of Cauchy, Charpit and Jacobi in solving non-linear partial differential equations of the first order. Compatible systems of linear first order PDEs.Pfaffian differential equations and their solutions.

**Teaching and Learning Methods**

Lectures, presentations, group discussions, syndicate work/tutorials, Question/ Answer approach

**Course Assessment**

CATs and Assignments 40%, Final examinations 60%, Total marks 100%

**References**

Walter A. Strauss (2007): Partial Differential Equations: An Introduction 2nd Edition, John Wiley & Sons

Stanley Farlow J (1993): Partial Differential Equations for Scientists and Engineers, Dover

Michael Shearer and Rachel Levy (2015): Partial Differential Equations An Introduction to Theory and Applications 1st Edition

Richard Haberman (2012): Applied Partial Differential Equations with Fourier Series and Boundary Value Problems 5th Edition,Prentice-Hall

David Borthwick (2017): Introduction to Partial Differential Equations 1st Edition

Robert C. McOwen (2003):Partial Differential Equations: Methods and Applications, 2nd Edition,

**MATH 422: ORDINARY DIFFERENTIAL EQUATIONS II**

**Course Purpose**

This course builds on the foundational knowledge from Ordinary Differential Equations I. Ordinary Differential Equations II delves into more advanced techniques for solving and analyzing differential equations. The Students will learn to apply these methods to complex problems and understand their implications in various scientific and engineering contexts

**Expected Learning Outcomes**

By the end of this course, the learner should be able to:

1. Analyze and solve systems of linear and nonlinear differential equations.
2. Find the power series solutions of differential equations
3. Solve differential equations for power series solutions
4. Obtain matrix solutions Solve differential equations
5. Analyze special differential equations
6. Apply advanced solution techniques to complex real-world problems in science and engineering.

**Course Content**

Higher order differential equation solutions by reduction of order. Total differential equations. The wronskian and solutions of differential equations. Systems of differential equations, power series solutions of ODEs, differential equations and matrices: matrix solution. Special functions: Legendre and Bessels.

**Teaching and Learning Methods**

Lectures, presentations, group discussions, syndicate work/tutorials, Question/ Answer approach

**Course Assessment**

CATs and Assignments 40%, Final examinations 60%, Total marks 100%

**References**

William E. Boyce and Richard C. DiPrima (2017): Elementary Differential Equations and Boundary Value Problems, 11th Edition

James Stewart (2003): Calculus, Early Transcendentals, International Student Edition,5th Edition,

George F. Simmons (2016): Differential Equations with Applications and Historical Notes, 3rd Edition,

Vladimir I. Arnold (1992): Ordinary Differential Equations, 10th Edition,

Dennis G. Zill (2017): A First Course in Differential Equations with Modeling Applications, 11th Edition,

James R. Brannan and William E. Boyce (2015): Differential Equations: An Introduction to Modern Methods and Applications 3rd Edition

**MATH 423: NUMERICAL ANALYSIS II (L/P 45/0; CF 3.0)**

**Course Purpose**

The purpose of this course is to build on the concepts introduced in Numerical Analysis I. Numerical Analysis II delves into more advanced numerical techniques and their applications. Iteratively solving linear systems, estimating eigenvalue problem using appropriate mathematical syntax and terminology. Moreover, the learners will apply these principles to design algorithms for solving mathematical problem

**Expected Learning Outcomes**

At the end of this course the student should be able to:

Solve systems of linear algebraic equations using LU decomposition

Interpolate functions inversely and using Hermite interpolation

Apply iterative methods to solve systems of linear equations

State and apply least squares and Chebychev’s approximations of functions

Conduct advanced matrix computations, including eigenvalue problems.

Develop and analyze complex numerical algorithms for practical applications.

Write application algorithms for application using the above numerical methods

**Course Content**

Hermite interpolation. Newton's fundamental formula. Iterated interpolation. Inverse

interpolations. LU decomposition methods, Jacob’s and Gauss-Seidal iterative methods.

Approximation of functions: Least squares approximation, Chebyshev and Pade rational

approximation ,Eigenvalues and eigenvectors of matrices by iterative methods

**Teaching and Learning Methods**

Lectures, presentations, group discussions, syndicate work/tutorials and Question/ Answer approach

**Instructional Materials and Equipment**

Overhead projector, Power point, Flip charts, Hand-outs, Charts and Felt Pens.

**Course Assessment**

CATs and Assignments 40%, Final examinations 60%, Total marks 100%

**References**

1. Richard L. Burden and J. Douglas Faires (2015) : Numerical Analysis, 10th Edition,

2. Endre Süli and David F. Mayers (2003) : An Introduction to Numerical Analysis’

3. Steven C. Chapra and Raymond P. Canale (2019) : Numerical Methods for Engineers, 8th Edition,

4. Heinbockel J. H.: (2020 ) : Numerical Methods for Scientific Computing

5. Steven C. Chapra (2018): Applied Numerical Methods with MATLAB for Engineers and Scientists,

4th Edition

6. Butcher J.C. (2016) : Numerical Methods for Ordinary Differential Equations, 3rd Edition,