Learning Outcomes based Curriculum Framework (LOCF)

For

B.Sc. Mathematics

(Four Year Degree Programme)

w.e.f. Session 2021-22

<u>University School for Graduate Studies</u>

Chaudhary Devi Lal University

Sirsa-125055

Semester-III (w.e.f. 2022-23)

Course Code	Course Title	Credit			
		Lecture	Tutorial	Practical	Total
BSC/Maths/3/CC 5	Advanced Calculus	5	1	-	6
BSC/Maths/3/CC 6	Vector Calculus	5	1	-	6
BSC/Maths/3/CC 7	Mathematical Statistics	5	1	-	6
BSC/Maths/3/SEC2	Special Functions-I	2	-	-	2
………/3/GEC3	To be opted by students from Pool of Generic elective Courses	-	-	-	6
Generic Elective Course offered by Department of Mathematics					
BSC/Maths/3/GEC3	Number Theory and Trigonometry	5	1	-	6
Total					**26**

26/4/2022

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BSC/Maths/3/CC5
Advanced Calculus

Marks(Total) : 100
Time : 3 Hrs

Marks (Theory): 70
Marks (Internal Assessment) : 30
Credits: Th(5)+T(1) = 06

Note for the Paper Setter: *The question paper will consists of NINE questions in all. The first question will be compulsory and will consist of FIVE short questions of 2 marks each covering the whole syllabus. In addition, EIGHT more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions selecting at least one question from each unit.*

Course Outcomes: This course will enable the students to:

1. Understand the concept of continuous function and derivative and apply the knowledge to prove mean value theorems.
2. Understand the limit and continuity of the function in two variables. Know the concept of partial differentiation.
3. Know the differentiability of function in two variables and how to calculate maximum & minimum of function in two variables.
4. Know about curves in spaces, Involutes, evolutes and concept of Surface and Envelopes.

Unit – I

Continuity, Sequential Continuity, properties of continuous functions, Uniform continuity, chain rule of differentiability. Mean value theorems; Rolle's Theorem and Lagrange's mean value theorem and their geometrical interpretations. Taylor's Theorem with various forms of remainders, Darboux intermediate value theorem for derivatives, Indeterminate forms.

Unit – II

Limit and continuity of real valued functions of two variables. Partial differentiation. Total Differentials; Composite functions & implicit functions. Change of variables. Homogenous functions & Euler's theorem on homogeneous functions. Taylor's theorem for functions of two variables.

Unit – III

Differentiability of real valued functions of two variables. Schwarz and Young's theorems. Implicit function theorem. Maxima, Minima and saddle points of two variables. Lagrange's method of multipliers.

Unit – IV

Curves: Tangents, Principal normals, Binormals, Serret-Frenet formulae. Locus of the centre of curvature, Spherical curvature, Locus of centre of Spherical curvature, Involutes, evolutes, Bertrand Curves. Surfaces: Tangent planes, one parameter family of surfaces, Envelopes.

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Books Recommended:

1. C.E. Weatherburn , Differential Geometry of three dimensions, Radhe Publishing House, Calcutta
2. Gabriel Klaumber, Mathematical analysis, Marcel Dekkar, Inc., New York, 1975
3. R.R. Goldberg , Real Analysis, Oxford & I.B.H. Publishing Co., New Delhi, 1970
4. Gorakh Prasad, Differential Calculus, Pothishala Pvt. Ltd., Allahabad
5. S.C. Malik , Mathematical Analysis, Wiley Eastern Ltd., Allahabad.
6. Shanti Narayan, A Course in Mathemtical Analysis, S.Chand and company, New Delhi
7. Murray, R. Spiegel, Theory and Problems of Advanced Calculus, Schaum Publishing co., New York

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BSC/Maths/3/CC6
Vector Calculus

Marks(Total) : 100
Time : 3 Hrs

Marks (Theory) : 70
Marks (Internal Assessment) : 30
Credits: Th(5)+T(1) = 06

Note for the Paper Setter: *The question paper will consists of NINE questions in all. The first question will be compulsory and will consist of FIVE short questions of 2 marks each covering the whole syllabus. In addition, EIGHT more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions selecting at least one question from each unit.*

Course Outcomes: This course will enable the students to:

1. Understand the concept of scalar and vector product of three vectors and four vectors product and differentiation of vectors.
2. Know the concept of Gradient, Divergence and Curl.
3. Understand the concept of orthogonal curvilinear coordinates, cylindrical coordinates and spherical coordinates.
4. Understand vector integration. Theorems of Gauss Green & Stokes and problems based on these theorems.

Unit – I

Scalar and vector product of three vectors, product of four vectors. Reciprocal vectors. Vector differentiation. Scalar Valued point functions, vector valued point functions, derivative along a curve, directional derivatives

Unit– II

Gradient of a scalar point function, physical interpretation of grad Φ, characteristics of gradient. Divergence and curl of vector point function, physical interpretations of div and curls of vector point functions, characteristics of Div $\vec{f}$ and Curl $\vec{f}$. Gradient, divergence and curl of sums and product and their related vector identities. Laplacian operator.

Unit – III

Vector integration; Line integral, Surface integral, Volume integral. Theorems of Gauss, Green & Stokes and problems based on these theorems.

Unit – IV

Orthogonal curvilinear coordinates, Conditions for orthogonality, fundamental triad of mutually orthogonal unit vectors. Gradient, Divergence, Curl and Laplacian operators in terms of orthogonal curvilinear coordinates, Cylindrical co-ordinates and Spherical co-ordinates.

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Books Recommended:

1. Murrary R. Spiegal, Theory and Problems of Advanced Calculus, Schaum Publishing Company, New York.
2. Murrary R. Spiegal, Vector Analysis, Schaum Publishing Company, New York.
3. N. Saran and S.N. Nigam, Introduction to Vector Analysis, Pothishala Pvt. Ltd., Allahabad.
4. Shanti Narayna, A Text Book of Vector Calculus. S. Chand & Co., New Delhi.

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BSC/Maths/3/CC7
Mathematical Statistics

Marks (Total) : 100
Time : 3 Hrs

Marks (Theory):.70
Marks (Internal Assessment) : 30
Credits: Th(5)+T(1) = 06

Note for the Paper Setter: *The question paper will consists of NINE questions in all. The first question will be compulsory and will consist of FIVE short questions of 2 marks each covering the whole syllabus. In addition, EIGHT more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions selecting at least one question from each unit.*

Course Outcomes: This course will enable the students to:

1. Understand the concept of Mean, Median, Mode Geometric mean, Harmonic mean and Measure of dispersion.
2. Learn about moment of Skewness and Kurtosis.
3. Understand basic concept of Probability, Bayes' theorem and its application, learn about Random variable and Probability function.
4. Know about concept of Correlation for Bivariate Data and Learn about concept of Linear Regression.

Unit – I

Measures of Central Tendency and Location: Mean, median, mode, geometric mean, harmonic mean, partition values.
Measures of Dispersion: Absolute and relative measures of range, quartile deviation, mean deviation, standard deviation (σ), coefficient of variation.

Unit – II

Moments, Skewness and Kurtosis: Moments about mean and about any point and derivation of their relationships, effect of change of origin and scale on moments, Sheppard's correction for moments (without derivation), Charlier's checks, Concepts of Skewness and Kurtosis.

Unit –III

Basic concepts in Probability, Bayes' theorem and its applications.
Random Variable and Probability Functions: Definition and properties of random variables, discrete and continuous random variable, probability mass and density functions, distribution function.

Unit– IV

Correlation for Bivariate Data: Concept and types of correlation, Scatter diagram, Karl Pearson Coefficient (r) of correlation and rank correlation coefficient.

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Linear Regression: Concept of regression, principle of least squares and fitting of straight line, derivation of two lines of regression, properties of regression coefficients, standard error of estimate obtained from regression line, correlation coefficient between observed and estimated values. Angle between two lines of regression. Difference between correlation and regression.

Books Suggested:

1. A.M. Mood, F.A. Graybill and D.C. Boes, Introduction to the theory of Statistics, McGraw Hill, 1974.
2. Baisnab and M. Jas, Element of Probability and Statistics, Tata McGraw Hill.
3. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons, 2002.
4. P.L.Meyer, Introductory Probability and Statistical Applications, Addison-Wesley Publishing Company, 1970.

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BSC/Maths/3/SEC2
Special Functions-I

Marks(Total) : 50
Time : 2 Hrs

Marks (Theory) : 30
Marks (Internal Assessment) : 20
Credits: Th(5)+T(1) = 06

Note for the Paper Setter: *The question paper will consists of NINE questions in all. The first question will be compulsory and will consist of FIVE short questions of 2 marks each covering the whole syllabus. In addition, EIGHT more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions selecting at least one question from each unit.*

Course Outcomes: This course will enable the students to:

1. Know about Power series method to solve differential equations, Beta and gamma functions, Bessel equation and its solution, recurrence relations and generating functions, Orthogonality of Bessel functions.
2. Learn about Legendre and Hermite differential equations and their solutions, Rodrigues' Formula for Legendre & Hermite Polynomials, Orhogonality of Legendre and Hermite polynomials.

Unit – I

Series solution of differential equations – Power series method, Definitions of Beta and Gamma functions. Bessel equation and its solution: Bessel functions and their properties-Convergence, recurrence, Relations and generating functions, Orthogonality of Bessel functions.

Unit– II

Legendre and Hermite differentials equations and their solutions: Legendre and Hermite functions and their properties-Recurrence Relations and generating functions. Orhogonality of Legendre and Hermite polynomials. Rodrigues' Formula for Legendre & Hermite Polynomials, Laplace Integral Representation of Legendre polynomial.

Books Recommended:

1. Erwin Kreyszing, Advanced Engineering Mathematics, John Wiley & Sons, Inc., New York, 1999
2. A.R. Forsyth, A Treatise on Differential Equations, Macmillan and Co. Ltd.
3. I.N. Sneddon, Special Functions of Mathematical Physics & Chemistry. Oliver and Boyd: Interscience Publishers.
4. W.W. Bell, Special Functions for Scientists and Engineers, Dover Publications Inc, 2004.

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Generic Elective Course

BSC/Maths/3/GEC3

Number Theory and Trigonometry

Marks (Theory): 70 | **Marks (Total): 100**
Marks (Internal Assessment): 30 | **Time: 03 Hours**
Credits: Th(5)+T(1) = 06

<u>Note for the Paper Setter:</u> *The question paper will consists of NINE questions in all. The first question will be compulsory and will consist of FIVE short questions of 2 marks each covering the whole syllabus. In addition, EIGHT more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions selecting at least one question from each unit.*

Course Outcomes: This course will enable the students to:

1. Understand the basic concepts of number theory and their applications in problem solving. Prove Fermat and Wilson's theorems and their applications.
2. Know residue system, Euler's ϕ function, Quadratic residues. Legendre symbols, Moebius function and Moebius inversion formula.
3. Understand De Moivre's Theorem and its Applications. Trigonometrical and hyperbolic functions along with their properties.
4. Know inverse circular and hyperbolic functions and their properties along with their related problems.

Unit-I

Divisibility, G.C.D. (greatest common divisors), L.C.M.(least common multiple) Primes, Fundamental Theorem of Arithemetic. Linear Congruences, Fermat's theorem. Wilson's theorem and its converse. Linear Diophanatine equations in two variables

Unit-II

Complete residue system and reduced residue system modulo m. Euler's ϕ function Euler's generalization of Fermat's theorem. Chinese Remainder Theorem. Quadratic residues. Legendre symbols. Lemma of Gauss; Gauss reciprocity law. Greatest integer function [x]. The number of divisors and the sum of divisors of a natural number n (The functions d(n) and σ(n)). Moebius function and Moebius inversion formula.

Unit-III

De Moivre's Theorem and its Applications. Expansion of trigonometrical functions. Direct circular and hyperbolic functions and their properties.

Unit-IV

Inverse circular and hyperbolic functions and their properties. Logarithm of a complex quantity. Gregory's series. Summation of Trigonometry series.

Recommended Books:

1. S.L. Loney, Plane Trigonometry Part – II, Macmillan and Company, London.
2. R.S. Verma and K.S. Sukla, Text Book on Trigonometry, Pothishala Pvt. Ltd.

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Allahabad.
3. Gareth A. Jones & J. Mary Jones (2005). *Elementary Number Theory*. Springer.
4. Neville Robbins (2007). *Beginning Number Theory* (2nd edition). Narosa.
5. I. Niven (2012). *An Introduction to the Theory of Numbers* (5th edition). John Wiley & Sons.
6. Ivan Ninen and H.S. Zuckerman, An Introduction to the Theory of Numbers, Wiley Publications, 1991.

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Semester-IV (w.e.f. 2022-23)

Course Code	Course Title	Credit			
		Lecture	Tutorial	Practical	Total
BSC/Maths/4/CC8	Solid Geometry	5	1	-	6
BSC/Maths/4/CC9	Transform Techniques	5	1	-	6
BSC/Maths/4/CC10	Elementary Partial Differential Equations	5	1	-	6
BSC/Maths/4/SEC3	Special Functions-II	2	-	-	2
………/4/GEC4	To be opted by students from Pool of Generic elective Courses	-	-	-	6
Generic Elective Course offered by Department of Mathematics					
BSC/Maths/4/GEC4	Ordinary Differential Equations	5	1	-	6
Total					**26**

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BSC/Maths/4/CC8
Solid Geometry

Marks (Theory) : 70
Marks (Internal Assessment) : 30
Credits: Th(5)+T(1) = 06

Marks(Total) : 100
Time : 3 Hrs

Note for the Paper Setter: *The question paper will consists of NINE questions in all. The first question will be compulsory and will consist of FIVE short questions of 2 marks each covering the whole syllabus. In addition, EIGHT more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions selecting at least one question from each unit.*

Course Outcomes: This course will enable the students to:

1. Know about the General Equation of second degree, detailed concepts of Conic Section.
2. Learn about concept of sphere and its properties, co-axial system. Understand about cone, and cylinder.
3. Understand about central conicoids.
4. Know about Paraboloids.

Unit– I

General equation of second degree. Tracing of conics. Tangent at any point to the conic, chord of contact, pole of line to the conic, director circle of conic. System of conics. Confocal conics. Polar equation of a conic, tangent and normal to the conic.

Unit – II

Sphere: Plane section of a sphere. Sphere through a given circle. Intersection of two spheres, radical plane of two spheres. Co-axial system of spheres
Cones. Right circular cone, enveloping cone and reciprocal cone.
Cylinder: Right circular cylinder and enveloping cylinder.

Unit – III

Central Conicoids: Equation of tangent plane. Director sphere. Normal to the conicoids. Polar plane of a point. Enveloping cone of a coincoid. Enveloping cylinder of a coincoid.

Unit– IV

Paraboloids: Circular section, Plane sections of conicoids.
Generating lines. Confocal conicoid. Reduction of second degree equations.

Books Recommended:

1. R.J.T. Bill, Elementary Treatise on Coordinary Geometry of Three Dimensions, MacMillan India Ltd. 1994.
2. P.K. Jain and Khalil Ahmad: A Textbook of Analytical Geometry of Three Dimensions, Wiley Eastern Ltd. 1999.

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BSC/Maths/4/CC9
Transform Techniques

Marks (Theory) : 70
Marks (Internal Assessment) : 30
Credits: Th(5)+T(1) = 06

Marks(Total) : 100
Time : 3 Hrs

Note for the Paper Setter: *The question paper will consists of NINE questions in all. The first question will be compulsory and will consist of FIVE short questions of 2 marks each covering the whole syllabus. In addition, EIGHT more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions selecting at least one question from each unit.*

Course Outcomes: This course will enable the students to:

1. Understand the concept of Laplace Transforms and some theorems Differentiation & Integral of Laplace transformation and solution of Differential equation using Laplace transform.
2. Know about finite Laplace Transformation and its properties and applications, Fourier Transform and solution of Ordinary differential equations using Fourier Transformation.
3. Learn about the concept of Mellin transform and Z-Transform.
4. Understand the Hankel Transformation its properties and application to boundary value problems and PDE.

Unit – I

Laplace Transform: – Existence theorem for Laplace transforms, Linearity of the Laplace transforms, Shifting theorems, Laplace transforms of derivatives and integrals, Differentiation and integration of Laplace transforms, Convolution theorem, Inverse Laplace transforms, convolution theorem, Inverse Laplace transforms of derivatives and integrals, solution of ordinary differential equations using Laplace transform.

Unit – II

Finite Laplace transformation: Definition and Properties, shifting and scaling theorem. **Fourier transforms:** Linearity property, Shifting, Modulation, Convolution Theorem, Fourier Transform of Derivatives, Relations between Fourier transform and Laplace transform, Parseval's identity for Fourier transforms, solution of differential Equations using Fourier Transforms.

Unit – III

Mellin Transform: Definition and Properties of Mellin transform, shifting and scaling properties, Mellin transform of derivatives and integral.

Z-Tranform:- Z-Tranform and inverse Z-Tranform of elementary function, shifting theorem, Convolution theorem, initial and final value theorem.

Unit – IV

Hankel Tranform: Basic properties of Hankel transform, Basic Operational properties, Hankel transform of derivatives and some elementary functions, Relation between Fourier and Hankel transform with application to boundary value problem and PDE.

Books Recommended:

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1. Erwin Kreyszing, Advanced Engineering Mathematics, John Wiley & Sons, Inc., New York, 1999.
2. A.R. Forsyth, A Treatise on Differential Equations, Macmillan and Co. Ltd.
3. I.N. Sneddon, The use of integral transform, McGraw Hill, 1972
4. Murray R. Spiegel, Laplace transform, Schaum's Series.

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BSC/Maths/4/CC10

Elementary Partial Differential Equations

Marks (Theory) : 70
Marks (Internal Assessment) : 30
Credits: Th(5)+T(1) = 06

Marks(Total) : 100
Time : 3 Hrs

Note for the Paper Setter: *The question paper will consists of NINE questions in all. The first question will be compulsory and will consist of FIVE short questions of 2 marks each covering the whole syllabus. In addition, EIGHT more questions will be set unit-wise comprising of two questions from each of the four units. The candidates are required to attempt four more questions selecting at least one question from each unit.*

Course Outcomes: This course will enable the students to:

1. Know about Linear and non-linear PDE of first order, their solution and Various methods of solution.
2. Learn about higher order PDE with constant and variable coefficients.
3. Understand classification of PDE of second order and Monge's methods to solve second order PDE.
4. Cauchy's problems for second order PDE, concept of characteristic curves, & equation method of separation of variables, solution of Laplace's equation, Wave equation and Heat equation.

Unit – I

Partial differential equations: Formation, order and degree, Linear and Non-Linear Partial differential equations of the first order: Complete solution, singular solution, General solution, Solution of Lagrange's linear equations, Charpit's general method of solution. Compatible systems of first order equations, Jacobi's method.

Unit– II

Linear partial differential equations of second and higher orders, Linear and non-linear homogeneous and non-homogeneous equations with constant coefficients, Partial differential equation with variable coefficients reducible to equations with constant coefficients, their complimentary functions and particular integrals, Equations reducible to linear equations with constant coefficients.

Unit – III

Classification of linear partial differential equations of second order, hyperbolic, parabolic and elliptic types, Reduction of second order linear partial differential equations to Canonical (Normal) forms and their solutions, Solution of linear hyperbolic equations, Monge's method for partial differential equations of second order.

Unit– IV

Cauchy's problem for second order partial differential equations, Characteristic equations and characteristic curves of second order partial differential equation, Method of separation of variables: Solution of Laplace's equation, Wave equation (one and two dimensions), Diffusion (Heat) equation (one and two dimension) in Cartesian Co-ordinate system.

Books Recommended:

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1. D.A.Murray, Introductory Course on Differential Equations, Orient Longman, (India), 1967
2. Erwin Kreyszing, Advanced Engineering Mathematics, John Wiley & Sons, Inc., New York, 1999
3. A.R. Forsyth, A Treatise on Differential Equations, Macmillan and Co. Ltd.
4. Ian N.Sneddon, Elements of Partial Differential Equations, McGraw Hill Book Company, 1988
5. Frank Ayres, Theory and Problems of Differential Equations, McGraw Hill Book Company, 1972
6. J.N. Sharma and Kehar Singh, Partial Differential Equations, Alpha Sciences, 2008.

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BSC/Maths/4/SEC 3
Special Functions-II

Marks (Theory) : 30
Marks (Internal Assessment) : 20
Credits: Th(5)+T(1) = 06

Marks(Total) : 50
Time : 2 Hrs

Note for the paper setter: The question paper will consist of five questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, four more questions will beset unit-wise comprising of two questions from each of the units. The candidates are required to attempt two more questions selecting at least one question from each unit.

Course Outcomes: This course will enable the students to:

1. Understand about Laguerre's polynomials their equation, generating function, associated Laguerre's polynomials and its properties.
2. Know about the concept of hypergeometric functions, their series, integral formula confluent hypergeometric function and generalized hypergeometric series.

Unit-I

Laguerre Polynomials: Laguerre's equation and its solution, generating function, alternative expression for the Laguerre polynomials, explicit expressions and special values of the Laguerre polynomials, orthogonality properties of Laguerre polynomials, relation between Laguerre polynomials and their derivatives, recurrence relations, associated Laguerre polynomials, properties of the associated Laguerre polynomials.

Unit-II

Hypergeometric functions: The hypergeometric series, an integral formula for the hypergeometric series, the hypergeometric equation, linear relation between the solutions of the hypergeometric equation, relation of contiguity, the confluent hypergeometric function, generalized hypergeometric series.

Books Recommended:

1. W.W. Bell, Special Functions for Scientists and Engineers, D. Van Nostrand Company Ltd., London 1968
2. I.N. Sneddon, Special Functions of Mathematical Physics and Chemistry, Interscience Publishers, Inc., New York, 161.

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Generic Elective Course

BSC/Maths/4/GEC 4

Ordinary Differential Equations

Marks (Theory): 70 | **Marks (Total): 100**
Marks (Internal Assessment): 30 | **Time: 03 Hours**
Credits: Th(5)+T(1) = 06

<u>Note for the paper setter:</u> *The question paper will consist of five questions in all. First question will be compulsory and will consist of five short questions of 2 marks each covering the whole syllabus. In addition, four more questions will beset unit-wise comprising of two questions from each of the units. The candidates are required to attempt two more questions selecting at least one question from each unit.*

Course Outcomes: The course will enable the students to:

1. Understand the basic concepts of ordinary differential equations and to learn various techniques of finding exact solutions of certain solvable first order differential equations.
2. Develop the skills of solving homogeneous and non-homogeneous second order linear ordinary differential equations with constant coefficients.
3. Know the skills of solving non-homogeneous second order linear ordinary differential equations with variable coefficients.
4. Develop the skills and methods of solving ordinary simultaneous differential equations with constant coefficients.

Unit-I

Geometrical meaning of a differential equation. Exact differential equations, integrating factors. First order higher degree equations solvable for *x,y,p* Lagrange's equations, Clairaut's equations. Equation reducible to Clairaut's form. Singular solutions.

Unit-II

Orthogonal trajectories: in Cartesian coordinates and polar coordinates. Self orthogonal family of curves. Linear differential equations with constant coefficients. Homogeneous linear ordinary differential equations. Equations reducible to homogeneous.

Unit-III

Linear differential equations of second order: Reduction to normal form. Transformation of the equation by changing the dependent variable/ the independent variable. Solution by operators of non-homogeneous linear differential equations. Reduction of order of a differential equation. Method of variations of parameters. Method of undetermined coefficients.

Unit-IV

Ordinary simultaneous differential equations. Solution of simultaneous differential equations involving operators (d/dx) or (d/dt) etc. Simultaneous equation of the form $dx/P = dy/Q = dz/R$. Total differential equations. Condition for $Pdx + Qdy + Rdz = 0$ to be exact. General method of solving $Pdx + Qdy + Rdz = 0$ by taking one variable constant. Method of auxiliary equations.

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Recommended Books:

1. Erwin Kreyszig (2011). *Advanced Engineering Mathematics* (10th edition). J. Wiley & Sons
2. Shepley L. Ross (2007). *Differential Equations* (3rd edition). Wiley.
3. George F. Simmons (2017). *Differential Equations with Applications and Historical Notes* (3rd edition). CRC Press. Taylor & Francis.
4. D.A. Murray, Introductory Course in Differential Equations. Orient Longaman(India). 1967
5. A.R.Forsyth, A Treatise on Differential Equations, Macmillan and Co. Ltd.,London
6. E.A. Codington, Introduction to Differential Equations. B.Rai & D.P. Chaudhary, Ordinary Differential Equations, Narosa PublishingHouse Pvt. Ltd.

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