B.Sc. (Mathematics) (Part II) (Semester – III)
Choice Based Credit System with Multiple Entry and Multiple Exit Option (NEP-2020)

1. Title : Mathematics
2. Year of implementation : Academic Year 2023–24
3. Duration : The duration of the course shall be one year and two semester
4. Pattern : Semester
5. Structure of Course :

Paper-No.	**Course Code**	**Title of the Paper**	**Total Marks**	**Theory/ Practical perweek**
Semester-III				
V	DSC-C5	Elements of Differential Equations	50	03
VI	DSC-C6	Numerical Methods	50	03
		Semester-IV		
VII	DSC-D5	Vector Calculus	50	03
VIII	DSC-D6	Integral Calculus	50	03
(Semester III & IV)				
CCPM-II		Differential equations, Numerical methods, Vector and Integral Calculus	50	04*
CCPM-III		Numerical Recipes in Scilab	50	04*

*** Note: 8 hours per week per batch(CCPM – II & CCPM – III) (Semester IIIand Semester IV)(Batch as a whole class).**

Subject Equivalence of theory and practical papers as follows

Old Syllabus	New Syllabus
Semester - III	
Analysis-I	Elements of Differential Equations
Algebra-I	Numerical Methods
Semester - IV	
Analysis-II	Vector Calculus
Algebra-II	Integral Calculus

Scheme of examination

The Theory examination shall be conducted semester-wise.

The Theory paper shall carry 100 Marks for each semester.

The Practical examination shall be conducted at the end of each academic year.

The Practical paper shall carry 100 marks.

The evaluation of the performance of the students in theory shall be on the basis of Semester Examination.

Nature of Theory Question Paper (Each Semester)
Common Nature of Question Paper as per Science Faculty.

Nature of Practical Question Paper (For CCPM – II & CCPM – III)

(Practical Question Paper will be of 40 marks)

Q.1	**(A)**	(10 Marks)
	(B)	(05 Marks)
	OR	
Q.1	**(A)**	(10 Marks)
	(B)	(05 Marks)
Q.2	**(A)**	(10 Marks)
	(B)	(05 Marks)
	OR	
Q.2	**(A)**	(10 Marks)
	(B)	(05 Marks)
Q.3	Attempt any TWO of the following	
	(A)	(05 Marks)
	(B)	(05 Marks)
	(C)	(05 Marks)
	(D)	(05 Marks)

*** Certified Journal carries 05 marks.**
*** For viva- voce Max. 05 Marks.**

Course code	**:**	DSC – C5
Title of course	**:**	Elements of Differential Equations
Theory	**:**	32 Hrs. (40 lecturers of 48 min.)
Marks	**:**	50 (Credit: 02)

Course Learning Outcomes: This course will enable the students to:

CO1: identify types of higher order ordinary differential equations.
CO2: solve different types of higher order ordinary differential equations.
CO3: understand geometrical interpretation of simultaneous and total differential equations.

Unit 1: **(20 Hrs.)**

1.1. **Homogeneous linear differential equations**
  1.1.1. Definition: Homogeneous linear differential equation (Cauchy - Euler differential equation).
  1.1.2. Method of solution and examples.
  1.1.3. Definition: Legendre's linear differential equation.
  1.1.4. Method of solution of Legendre's linear differential equation and examples.

1.2. **Second order linear differential equations**
  1.2.1. Definition (general form): Second order linear differential equation.
  1.2.2. Methods of solution of Second order linear differential equation.
    1.2.2.1. Complete solution when one integral is known: method and examples.
    1.2.2.2. Transformation of the equation by changing the dependent variable (removal of first order derivative) and examples.
    1.2.2.3. Transformation of the equation by changing the independent variable and examples.
    1.2.2.4. Method of variation of parameters and examples.

Unit 2: **(12 Hrs.)**

2.1. Ordinary Simultaneous linear differential equations
  2.1.1. Definition: Ordinary Simultaneous linear differential equations.
  2.1.2. Geometrical interpretation of ordinary simultaneous differential equations.
  2.1.3. Methods of Solving Simultaneous Linear Differential Equations and examples.

2.2. Total differential equations.
  2.2.1. Definition: Total differential equation.
  2.2.2. Necessary condition for integrability of total differential equation
  2.2.3. Geometrical interpretation of total differential equation. Geometrical relation between total differential equations and simultaneous Linear differential equations
  2.2.4. Methods of solving total differential equations:
    a) Method of Inspection.
    b) Solution of homogeneous equations.

c) Use of Auxiliary equation.
d) Treating one variable as a constant.

Recommended book:

1. Ordinary and Partial Differential Equations, M. D. Raisinghania, Eighteenth revised edition 2016; S. Chand and Company Pvt. Ltd. New Delhi.

Scope:

[**Part I – Chapter 6:** 6.1, 6.2, 6.3, 6.4, 6.9, 6.10, 6.11;

Part I – Chapter 10: 10.1, 10.2, .10.3, 10.4 (excluding 10.4A and 10.4B), 10.5, 10.6, 10.7, 10.8, 10.9, 10.10, 10.11, 10.13, 10.14;

Part II – Chapter 2: 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 2.10, 2.11;

Part II – Chapter 3: 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 3.10, 3.11, 3.12, 3.13]

Reference books:

1. Differential Equations, Shepley L. Ross, Third Edition 1984; John Wiley and Sons, New York.
2. Elements of Partial Differential Equations, Ian Sneddon, Seventeenth Edition, 1982; Mc-Graw-Hill International Book Company, Auckland
3. Introductory course in Differential Equations, D. A. Murray, Khosala Publishing House, Delhi.

Course code	**:**	DSE – C6
Title of course	**:**	Numerical Methods
Theory	**:**	32 Hrs. (40 lecturers of 48 min.)
Marks	**:**	50 (Credit: 02)

Course Learning Outcomes: This course will enable the students to:

CO1: find numerical solutions of algebraic, transcendental and system of linear equations.

CO2: learn about various interpolating methods to find numerical solutions.

CO3: find numerical solutions of integration and ODE by using various methods.

CO4: apply various numerical methods in real life problems.

Unit- 1 **(16Hrs.)**

1.1 Solutions of Algebraic and Transcendental Equations:

1.1.1 Introduction
1.1.2.Mathematical Preliminaries
1.1.3 Bisection Method
1.1.4 Method of False position
1.1.5 Newton- Raphson method
1.1.6 Examples based on art.1.1.3 to 1.1.5

1.2 Interpolation

1.2.1 Introduction
1.2.2 Finite differences
1.2.3 Forward differences
1.2.4 Backward differences
1.2.5 Symbolic relations and Separation of symbols
1.2.6 Newton’s formulae for Interpolation
  1.2.6.1 Newton’s forward difference interpolation formula
  1.2.6.2 Newton’s backward difference interpolation formula
1.2.7 Interpolation with Unevenly Spaced Points
  1.2.7.1 Lagrange’s Interpolation Formula
1.2.8 Examples based on art.1.2.2 to 1.2.7

Unit- 2 **(16Hrs.)**

2.1 Numerical Integration

2.1.1 General formula
2.1.2 Trapezoidal rule
2.1.3 Simpson's 1/3- rule
2.1.4 Simpson's 3/8- rule
2.1.5 Examples based on art. 2.1.2 to 2.1.4.

2.2 Solutions of Linear system of equations

2.2.1 Solutions of linear system - Direct method
  2.2.1.1 Gauss Elimination Method
2.2.2 Solutions of linear system - Iterative method
  2.2.2.1 Gauss-Seidel Method
2.2.3 Examples based on art. 2.2.1 to 2.2.2.

2.3 Numerical Solutions of ODE:

- 2.3.1 Introduction
- 2.3.2 Solution by Taylor's series method
- 2.3.3 Picard's method of successive approximation
- 2.3.4 Euler's method
- 2.3.5 Modified Euler's method
- 2.3.6 Runge-Kutta methods
  - 2.3.6.1 second order Runge-Kutta (without proof)
  - 2.3.6.2 fourth order Runge-Kutta (without proof)
- 2.3.7 Examples based on art. 2.3.2 to 2.3.6.

Recommended Book -

1. S. S. Sastry - Introductory Methods of Numerical Analysis: Fifth Edition, Prentice Hall India Learning Private Limited, New Delhi (2012).

Scope: [**Chapter-1:** 1.1(a,b,d,c,f), 1.2**; Chapter-2:** 2.1, 2.2, .2.3, 2.5; **Chapter-3:** 3.1, 3.3, 3.6, 3.9; **Chapter-6:** 6.4; **Chapter-7:** 7.5, 7.6; **Chapter-8:** 8.1, 8.2, 8.3, 8.4, 8.5]

Reference Books -

1. M.K.Jain, S.R.K.Iyengar & R.K.Jain - Numerical Methods (Problems and Solutions): Revised Second Edition, New Age International Pvt Ltd Publishers, Mumbai.
2. H.C. Saxena - Finite Differences and Numerical Analysis, S. Chand & Company Ltd.(2005).
3. Dr. B. S. Grewal, Numerical Methods in Engineering & Science, Khanna Publishers.

B.Sc. (Mathematics) (Part II) (Semester – IV)
Choice Based Credit System with Multiple Entry and Multiple Exit Option (NEP-2020)

Course code	**:**	DSE – D5
Title of course	**:**	Vector Calculus
Theory	**:**	32 Hrs. (40 lecturers of 48 min.)
Marks	**:**	50 (Credit: 02)

Course Learning Outcomes: This course will enable the students to:

CO1**:** understand and evaluate the concepts of gradient, divergence and curl of point functions in terms of cartesian co-ordinate system.

CO2**:** understand and evaluate different types of line, surface & volume integrals and the two integral transformation theorems of Gauss and Stokes.

Unit 1 Differential Operators **(16 Hrs.)**

1.1 Scalar and Vector valued Point functions
1.2 Limit and continuity of a scalar and vector point functions
1.3 Directional Derivatives of scalar and vector Point Functions & examples
1.4 The Operator ∇
1.5 Gradient of a Scalar Point Function & examples
1.6 Geometrical Interpretation of grad $\emptyset$, where $\emptyset$ is a scalar point function
1.7 Divergence and Curl of vector point function
- 1.7.1 Definition of $div\ f$ and $curl\ f$, where f is a vector point function
- 1.7.2 Expressions of $div\ f$ and $curl\ f$ in terms of components of f
- 1.7.3 Characters of div f and curl f as point functions
- 1.7.4 Problems based on 1.7

1.8 Gradient, Divergence and Curl of Sums
- 1.8.1 $grad\ (\emptyset \pm \varphi) = grad\ \emptyset \pm grad\ \varphi$
- 1.8.2 $div\ (f \pm g) = div\ f \pm div\ g$
- 1.8.3 $curl\ (f \pm g) = curl\ f \pm curl\ g$

1.9 Gradient, Divergence and Curl of Products
- 1.9.1 $grad\ (\emptyset\varphi),\ grad\ (f \cdot g)$
- 1.9.2 $div\ (\emptyset f),\ div\ (f \times g)$
- 1.9.3 $curl\ (\emptyset f),\ curl\ (f \times g)$

1.10 Second Order Differential Operators
- 1.10.1 $div\ grad\ \emptyset = \nabla \cdot \nabla\emptyset = \frac{\partial^2\emptyset}{\partial x^2} + \frac{\partial^2\emptyset}{\partial y^2} + \frac{\partial^2\emptyset}{\partial z^2}$
- 1.10.2 $curl\ grad\ \emptyset = \nabla \times \nabla\emptyset = 0$
- 1.10.3 $div\ curl\ f = \nabla \cdot \nabla \times f = 0$
- 1.10.4 $grad\ div\ f = curl\ curl\ f + \sum \frac{\partial^2 f}{\partial x^2}$

1.11 The Laplacian Operator, ∇^2 and examples

Unit 2 Integral Transformations **(16 Hrs.)**

2.1 Some preliminary concepts: Oriented curve, Smooth curve, Smooth surface, classification of regions

2.2 Line integrals

2.3 Circulation, work done by a force

2.4 Surface integrals, flux

2.5 Volume integrals

2.6 Problems based on 2.2 to 2.5

2.7 Green's theorem in the plane

2.8 Green's theorem in the plane in vector notation

2.9 Problems based on 2.7 and 2.8

2.10 The Divergence theorem of Gauss (statement only)

2.11 Stoke's theorem (statement only)

2.12 Line integrals independent of path

2.13 Physical interpretation of div. and curl

Recommended Book:

1. Shanti Narayan & P. K. Mittal: Vector Calculus, S. CHAND & CO (Pvt) LTD, RAM NAGAR, NEW DELHI-110055.

Scope: [**Chapter -6:** 6.1 to 6.17]

2. J. N. Sharma & A. R. Vasishtha: Vector Calculus, KRISHNA Prakashan Media (P) Ltd., Meerut.

Scope: [Chapter- 3]

Reference Books:

1. M. L. Khanna: Vector Calculus, Jai Prakash Nath & Co. Meerut
2. P. N. Wartikar and J. N. Wartikar: A text book of Applied Mathematics (Vol-II), Vidhyarthi Griha Prakashan, Pune.
3. B. S. Grewal: Higher Engineering Mathematics, Khanna Publishers, New Delhi-110002.
4. R. K. Jain & S. R. K. Iyengar: Advanced Engineering Mathematics, fourth edition, Narosa Publishing House New Delhi.

Course code	**:**	DSE – D6
Title of course	**:**	Integral Calculus
Theory	**:**	32 Hrs. (40 lecturers of 48 min.)
Marks	**:**	50 (Credit: 02)

Course Learning Outcomes: This course will enable the students to:

CO1: understand special functions.
CO 2: understand types of multiple integrals.
CO 3: apply special functions in applications.
CO 4: apply multiple integrals in real life problems.

Unit 1. Gamma and Beta Function. **(16Hrs.)**

1.1 Gamma function.

1.1.1 Definition of Gamma function and examples.

1.1.2 Properties of Gamma function.

1.1.2.1 $\Gamma(1) = 1$

1.1.2.2 $\Gamma(n+1) = n\,\Gamma(n)$ in general.

1.1.2.3 $\Gamma(n+1) = n!$ if n is positive integer.

1.1.2.4 $\Gamma(0) = \infty$, $\Gamma(\infty) = \infty$

1.1.2.5 $\Gamma(n) = 2\int_0^\infty e^{-x^2} x^{2n-1} dx$, $n > 0$

1.1.2.6 $\Gamma(n) = k^n \int_0^\infty e^{-kx} x^{n-1} dx$, $n, k > 0$

1.1.2.7 Examples based on article 1.1.2

1.2 Beta function.

1.2.1 Definition of Beta function and examples.

1.2.2 Properties of Beta function.

1.2.2.1 $\beta(m,n) = \beta(n,m)$; $m,n \geq 0$

1.2.2.2 $\beta(m,n) = 2\int_0^{\frac{\pi}{2}} sin^{2m-1}\theta cos^{2n-1}\theta \, d\theta$; $m,n \geq 0$

1.2.2.3 $\int_0^{\frac{\pi}{2}} sin^p\theta \, cos^q\theta \, d\theta = \frac{1}{2}\beta\left(\frac{p+1}{2}, \frac{q+1}{2}\right)$ p, q > -1

1.2.2.4 $\beta(m,n) = \frac{\Gamma(m)\Gamma(n)}{\Gamma(m+n)}$, m, n > 0

1.2.2.5 $\Gamma\left(\frac{1}{2}\right) = \sqrt{\pi}$

1.2.2.6 $\beta(m,n) = \int_0^\infty \frac{x^{m-1}}{(1+x)^{m+n}}\,dx$

1.2.2.7 $\beta(m,n) = a^n b^m \int_0^\infty \frac{x^{m-1}}{(a+bx)^{m+n}}\,dx$

1.2.2.8 Duplication formula of Gamma function.

1.2.2.9 Examples based on article 1.2.2

Unit 2. Differentiation under integral sign, Error functions and Multiple integrals (16Hrs.)

2.1 Differentiation under integral sign

2.1.1 Leibnitz first rule of differentiation under integral sign**.**

2.1.2 Leibnitz second rule of differentiation under integral sign**.**

2.1.3 Examples based on articles 2.1.1 and 2.1.2

2.2 Error functions

2.2.1 Definition of $\mathrm{erf}(x)$, $\mathrm{erf_c}(x)$ and examples.

2.2.2 Properties of error functions.

2.2.2.1 $\mathrm{erf}(0) = 0,\ \mathrm{erf}(\infty) = 1$

2.2.2.2 $\mathrm{erf}(x) + \mathrm{erf_c}(x) = 1$

2.2.2.3 $\mathrm{erf}(-x) = -\mathrm{erf}(x)$

2.2.2.4 $\mathrm{erf_c}(-x) = 1 + \mathrm{erf}(x)$

2.2.2.5 $\mathrm{erf_c}(x) + \mathrm{erf_c}(-x) = 2$

2.2.2.6 Examples based on article 2.2.2

2.3 Multiple Integrals

2.3.1 Evaluation of double integrals in Cartesian form.

2.3.2 Evaluation of double integrals in Polar form.

2.3.3 Evaluation of double integrals in Cartesian form over the given region.

2.3.4 Evaluation of double integrals in Cartesian form by changing order of integration.

2.3.5 Evaluation of double integrals from Cartesian form to Polar form.

2.3.6 Proof of 1.2.2.4

Recommended Book:

1. P. N. Wartikar and J. N. Wartikar, A text book of Applied Mathematics,
Pune Vidhyarthi Griha Prakashan, Pune. Vol. I, 2011.

Scope: Section III: Integral Calculus: Chapter XIV: 14.9,
Chapter XVI: 16.1 to 16.4, Chapter XIX: 19.1 to 19.3, Chapter XXI: 21.1 to 21.5

Reference Books:

1. Shantinarayan and Dr. P. K. Mittal, Integral Calculus, S. Chand and Company, New Delhi, 2020.
2. B. S. Grewal, Higher Engineering Mathematics, Khanna Publishers, Delhi, 2012.

Core Course Practical in Mathematics (CCPM – II) (NEP-2020)
Marks 50 (Credit 04)
(Differential equations, Numerical methods, Vector and Integral Calculus)

Course Learning Outcomes: This course will enable the students to:
CO1: solve different types of differential equations.
CO2: apply various numerical methods to find approximate solutions of problems.
CO3: understand different types of line, surface and volume integrals.
CO4: understand special functions.

Sr. No.	Title of Experiment	No. of Practical
1	Cauchy – Euler Differential Equation.	1
2	Second order differential equation when one integral is known.	1
3	Second order differential equation by removal of first order derivative.	1
4	Simultaneous linear differential equation.	1
5	Method of false position.	1
6	Lagrange's interpolation method.	1
7	Gauss-Seidel method.	1
8	Picard's and Taylor series method.	1
9	Gamma function.	1
10	Beta function.	1
11	Evaluation of Double integral by change of order.	1
12	Evaluation of Double integral in Cartesian form over a given region.	1
13	Examples on Curl, Divergence and Gradient.	1
14	Solenoidal and Irrotational vector field.	1
15	Evaluation of Line Integral and work done	1
16	Examples on Green's theorem.	1

Recommended books:

1. Ordinary and Partial Differential Equations, M. D. Raisinghania, Eighteenth revised edition 2016; S. Chand and Company Pvt. Ltd. New Delhi.
2. Introductory Methods of Numerical Analysis, S. S. Sastry, Fifth Edition, Prentice Hall India Learning Private Limited, New Delhi (2012).

3. A text book of Applied Mathematics, J. N. Wartikar and P. N. Wartikar, Vidhyarthi Griha Prakashan, Pune.
4. Higher Engineering Mathematics, B. S. Grewal, Khanna Publishers, Delhi.

Reference books:

1. Differential Equations, Shepley L. Ross, Third Edition 1984; John Wiley and Sons, New York.
2. Numerical Methods (Problems and Solutions), M. K. Jain, S. R. K. Iyengar & R. K. Jain, Revised Second Edition, New Age International Pvt Ltd Publishers, Mumbai.
3. Integral Calculus, Shanti Narayan and P. K. Mitta, 11th revised edition (reprint 2016), S. Chand and company Pvt. Ltd., New Delhi.
4. A text book of Vector Calculus, Shanti Narayan & P. K. Mittal, S. Chand & Company
5. M. L. Khanna: Vector Calculus, Jai Prakash Nath & Co. Meerut [Unit-1]
6. J. N. Sharma & A. R. Vasishtha: Vector Calculus, KRISHNA Prakashan Media (P) Ltd., Meerut. [Unit-2]

Core Course Practical in Mathematics (CCPM – III)(NEP-2020)
Marks 50 (Credit 04)
(Numerical Recipes in Scilab)

Course Learning Outcomes: This course will enable the students to:

CO1: understand and implement basic numerical algorithms using Scilab, including root-finding, interpolation, differentiation, and integration.

CO2: learn how to use Scilab built-in functions and programming tools to solve mathematical problems, and how to create custom functions and scripts for more complex tasks.

CO3: gain practical experience with real-world applications of numerical methods, such as data analysis, optimization, and simulation.

CO4: develop critical thinking skills and the ability to analyze and interpret numerical results.

Sr. No	Title of Experiment	No. of Practicals
1	Introduction: Application, feature, Scilab environment, workspace,working directory, Scilab as a calculator, Scilab operators, mathematical predefined functions, constants, variables and their types.	1
2	Matrix: Row matrix, column matrix, general matrix, operation like matrix addition, matrix subtraction, matrix product.	1
3	Accessing element of matrix: Size of Matrix, Length of matrix, accessing element using one index, two indices	1
4	Sub Matrix: Accessing sub matrix of given matrix using ':' operator &'$' operator	1
5	Advanced matrix operations: Matrix functions: eye(), zero (), ones(), spec(), empty matrix, element-wise operation, determinant, inverse, trace of matrix& diagonal element of matrix.	1
6	Polynomial: Creating a polynomial 1) using roots 2) using coefficients, Find roots of polynomial, derivative companion matrix, numerator & denominator of rational, simplifying rational.	1
7	Plotting graph: Creating graphs of simple functions.	1
8	Introduction Scilab programming: disp(), Boolean operators, conditional statement (if select), find() and() or(), looping statement.	1
9	Advanced Scilab programming using function: Creating Scilab function and its execution.	1
10	Numerical Methods to find roots of a given algebraic or transcendental equation: a) Bisection Method b) Newton-Raphson Method.	1
11	Interpolation(Unequally Spaced Data) Lagrange's interpolation formula	1
12	Interpolation(Equally Spaced Data) a) Newton Gregory forward interpolation formula. b) Newton Gregory backward interpolation formula.	1

Sr. No	Title of Experiment	No. of Practicals
13	Numerical Integration: a) Trapezoidal Rule. b) Simpson's 1/3rd Rule. c) Simpson's 3/8th Rule.	1
14	Numerical Methods for solution of Ordinary Differential Equations: a) Euler Method. b) Euler's Modified Method.	1
15	Numerical Methods for solution of Ordinary Differential Equations: a) Runge-Kutta Second Order Method b) Runge-Kutta Fourth Order Method.	1
16	Numerical Methods for solution of a system of Linear Equations: (Unique solution case only) Gauss-Elimination Method.	1

Recommended Books:

Introduction to Scilab: For Engineers and Scientists **Book by Sandeep Nagar**

Reference Books:

1. Scilab: A Practical Introduction to Programming and Problem Solving Kindle Edition by Tejas Sheth (Author).
2. Scilab A Hands on Introduction by Satish Annigeri .
3. Engineering and Scientific Computing with Scilab 1999th Edition by Claude Gomez (Editor), C. Bunks (Contributor), J.-P. Chancelier (Contributor), F. Delebecque (Contributor), M. Goursat (Contributor), R. Nikoukhah (Contributor), S.Steer (Contributor).
4. Scilab: from Theory to Practice - I. Fundamentals Book by Philippe Roux.
5. Advanced Programming in SciLab: Chetana Jain , Alpha Science International Ltd (2020).