Deccan Education Society's

Fergusson College (Autonomous), Pune

Learning Outcomes-Based Curriculum

for 3/4 years B. Sc. Programme as per guidelines

of

NEP-2020

For

S. Y. B. Sc. (Mathematics)

With effect from Academic Year

2024-2025

B. Sc. Major Mathematics

Program Outcomes (POs)

PO1	**Disciplinary Knowledge** Demonstrate comprehensive knowledge of the discipline that forms a part of a postgraduate programme. Execute strong theoretical and practical understanding generated from the specific programme in the area of work.
PO2	**Critical Thinking and Problem solving** Exhibit the skill of critical thinking and understand scientific texts and place scientific statements and themes in contexts and also evaluate them in terms of generic conventions. Identify the problem by observing the situation closely, take actions and apply lateral thinking and analytical skills to design the solutions.
PO3	**Social competence** Exhibit thoughts and ideas effectively in writing and orally; communicate with others using appropriate media, build effective interactive and presenting skills to meet global competencies. Elicit views of others, present complex information in a clear and concise way and help reach conclusions in group settings.
PO4	**Research-related skills and Scientific temper** Infer scientific literature, build a sense of enquiry and able to formulate, test, analyze, interpret and establish hypothesis and research questions; and to identify and consult relevant sources to find answers. Plan and write a research paper/project while Emphasizing on academics and research ethics, scientific conduct and creating awareness about intellectual property rights and issues of plagiarism.
PO5	**Trans-disciplinary knowledge** Create new conceptual, theoretical and methodological understanding that integrates and transcends beyond discipline-specific approaches to address a common problem.
PO6	**Personal and professional competence** Perform independently and also collaboratively as a part of a team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PO7	**Effective Citizenship and Ethics** Demonstrate empathetic social concern and equity centred national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
PO8	**Environment and Sustainability** Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.
PO9	**Self-directed and Life-long learning** Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.

Program Specific Outcomes (PSOs) of Department of Mathematics

PSO1	Bachelor’s degree in mathematics is the culmination of in-depth knowledge of algebra, calculus, geometry, differential equations and several other branches of mathematics. This also leads to study of related areas like computer science and statistics. Thus, this programme helps learners in building a solid foundation for higher studies in mathematics.
PSO2	The skills and knowledge gained has intrinsic beauty, which also leads to proficiency in analytical reasoning. This can be utilized in modelling and solving real life problems.
PSO3	Students undergoing this programme learn to logically question assertions, to recognize patterns and to distinguish between essential and irrelevant aspects of problems. They also share ideas and insights while seeking and benefitting from knowledge and insight of others. This helps them to learn behave responsibly in a rapidly changing interdependent society.
PSO4	Students completing this programme will be able to present mathematics clearly and precisely, make vague ideas precise by formulating them in the language of mathematics, describe mathematical ideas from multiple perspectives and explain fundamental concepts of mathematics to non-mathematicians.
PSO5	Completion of this programme will also enable the learners to join teaching profession in primary and secondary schools.
PSO6	This programme will also help students to enhance their employability for government jobs, jobs in banking, insurance and investment sectors, data analyst jobs and jobs in various other public and private enterprises.

Fergusson College (Autonomous), Pune
Second Year Curriculum as per NEP 2020

Department of Mathematics

Course Structure

Semester	Paper	Paper Code	Paper Title	Type	Credits
III	Major	MTS-201	Multivariable Differential Calculus and Ordinary Differential Equations	Theory	4
		MTS-200	Mathematics Practical - 3	Practical	2
	Major(BA)	MTS-202	Basic Linear Algebra	Theory	4
	Minor	MTS-211	Linear Algebra	Theory	2
		MTS-212	Mathematics Practical - 5	Practical	2
		MTS-213	Multivariable Calculus	Theory	2
		MTS-214	Mathematics Practical - 6	Practical	2
	Minor(CS)	MTS-215	Applied LinearAlgebra	Theory	2
	Minor(CS)	MTS-216	Mathematics Practical – 3	Practical	2
	Minor(BA)	MTS-219	Operations Research	Theory	4
	OE -III	MTS-220	MS Excel	Theory	2
	VSC	MTS-230	Python -I	Theory	2
	VSC (BA)	MTS-231	Python -II	Theory	2
	SEC	MTS-240	Linear Algebra for Data Science-I	Theory	2
	CEP	MTS-245	Community Engagement Programme (CEP)	-	2
IV	Major	MTS-251	Multivariable Integral Calculus and Group Theory	Theory	4
		MTS-250	Mathematics Practical - 4	Practical	2
	Major(BA)	MTS-252	Advance Linear Algebra	Theory	4
	Minor	MTS-261	Calculus of Several Variables	Theory	2
		MTS-262	Mathematics Practical - 7	Practical	2
		MTS-263	Differential Equations and Applications	Theory	2
		MTS-264	Mathematics Practical - 8	Practical	2
	Minor(CS)	MTS-265	Computational Geometry	Theory	2
	Minor(CS)	MTS-266	Mathematics Practical – 4	Practical	2
	Minor(BA)	MTS-269	Optimization Techniques	Theory	4
	OE-IV	MTS-270	Mathematics for Economics and Finance	Theory	2
	VSC	MTS-280	Python - II	Theory	2
	SEC	MTS-290	Linear Algebra for Data Science-II	Theory	2
	SEC(BA)	MTS-291	MS Excel	Theory	2
	FP	MTS-295	Field Project (FP)	-	2

** OE – Open Elective, SEC- Skill Enhancement Course, VSC- Vocational Skill Course*

Teaching and Evaluation (Only for FORMAL education courses)

Course Credits	No. of Hours per Semester Theory/Practical	No. of Hours per Week Theory/Practical	Maximum Marks	CE 40 %	ESE 60%
1	15 / 30	1 /2	25	10	15
2	30 / 60	2 /4	50	20	30
3	45 / 90	3 /6	75	30	45
4	60 / 120	4 /8	100	40	60

Eligibility: As per the rules and regulations of Savitribai Phule Pune University (SPPU)

S. Y. B. Sc. (Major) Semester III		
Title of the Course and Course Code	**Multivariable Differential Calculus and Ordinary Differential Equations (MTS-201)**	**Number of Credits: 04**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		Bloom's cognitive level
CO1	Recall and identify the definitions of multivariable functions, partial derivatives, gradients, and directional derivatives. Recall the definitions of different types of ordinary differential equations, such as linear, nonlinear, first-order, second order, etc.	1
CO2	Understand the implications of higher-order partial derivatives in determining concavity and inflection points. Understand the behavior of solutions through graphical and analytical methods.	2
CO3	Apply multivariable calculus to solve problems in physics, economics, engineering, and other fields that involve functions of multiple variables. Apply different solution methods to solve a variety of ordinary differential equations. Apply ODEs to model real-world phenomena in fields such as physics, engineering, biology, and economics.	3
CO4	Analyze the behavior of multivariable functions using partial derivatives, including identifying and classifying critical points. Analyze the stability of equilibrium solutions using phase plane analysis.	4
CO5	Assess the applicability of multivariable calculus concepts and techniques in modeling real-world problems. Critically evaluate the appropriateness of different solution methods for specific types of ODEs.	5
CO6	Formulate and solve new optimization problems based on real-world scenarios using multivariable calculus techniques. Create mathematical models based on ODEs to describe complex systems.	6

Suggested Pedagogical Processes

- Lecture method: Concepts and operations of sets, Matrix Algebra, Graphs, Trees on Blackboard with examples, problems on sets using Venn diagrams
- ICT-supplemented teaching
- Experiential learning
- Case studies
- Problem-based learning
- Student seminars
- Group discussions

MTS-201: Multivariable Differential Calculus and Ordinary Differential Equations (Major)

Course Contents

Semester III

Unit No.	Title of Unit and Contents	No. of hours
I	**Differential Calculus of scalar and vector fields:** 1.1 Functions from R^n to R^m, Scalar and vector fields 1.2 Open balls and open sets 1.3 Limits and continuity 1.4 The derivative of a scalar field with respect to a vector 1.5 Directional derivatives and partial derivatives 1.6 Partial derivatives of higher order 1.7 Directional derivatives and continuity 1.8 The total derivative 1.9 The gradient of a scalar field 1.10 A sufficient condition for differentiability 1.11 A chain rule for derivatives of scalar fields 1.12 Applications to geometry. Level sets. Tangent planes 1.13 Derivatives of vector fields 1.14 Differentiability implies continuity 1.15 The chain rule for derivatives of vector fields 1.16 Matrix form of the chain rule 1.17 Sufficient conditions for the equality of mixed partial derivatives	**15**
II	**Applications of the Differential Calculus:** 2.1 Partial differential equations 2.2 A first-order partial differential equation with constant coefficients 2.3 The one-dimensional wave equation 2.4 Derivatives of functions defined implicitly 2.5 Maxima, minima, and saddle points 2.6 Second-order Taylor formula for scalar fields 2.7 The nature of a stationary point determined by the eigenvalues of the Hessian matrix 2.8 Second-derivative test for extrema of functions of two variables 2.9 Extrema with constraints. Lagrange's multipliers 2.10 The extreme-value theorem for continuous scalar fields	**15**
III	**First order differential Equations** 3.1 Introduction 3.2 Solution of differential equations, Statement of Picard's theorem, formation of differential equation 3.3 Solving first order differential equations: Variable separable, homogeneous equations 3.4 Exact equation, Integrating factors, Reduction of order 3.5 Orthogonal trajectories	**10**
IV	**Second Order Equations** 4.1 General solution of homogeneous equation, Wronskian, homogeneous equation with constant coefficients 4.2 Use of a known solution to find another 4.3 Method of undetermined coefficients 4.4 Method of variation of parameter 4.5 Solving higher order linear equations	**10**

V	**Systems of first order equations** 5.1 Existence and uniqueness of solution (statement only), Conversion of equation to a system of equations 5.2 Solution of linear systems, homogeneous linear systems with constant coefficients 5.3 Types of critical points and phase portrait for linear systems	**10**

Learning Resources:

Reference Books	1. Tom M. Apostol, Calculus Vol II, Second Edition, John Wiley & Sons, Inc. New York, 1991. 2. George B. Thomas, *Thomas' Calculus*, Pearson (Fourteenth Edition) 3. G. F. Simmons, Differential Equations with Applications and Historical Notes, CRC Press (Third Edition). 4. Morris Hirsch, Stephen Smale and Robert Devaney, *Differential Equations, Dynamical Systems and An introduction to Chaos*, Elsevier

S. Y. B.Sc. Semester III		
Title of the Course and Course Code	**Mathematics Practical - 3 MTS-200 (Major- Practical)**	**Number of Credits: 02**
1	Domain, range, graphs, limit and continuity of functions of several variables	
2	Partial derivatives and differentiability of functions of several variables	
3	Chain rule and applications	
4	Applications to partial differential equations	
5	Extreme values of functions and Taylor's theorem	
6	Method of Lagrange's multiplier	
7	Solving First order equations	
8	Applications of first order ordinary differential equations	
9	Methods of solving second order equations	
10	Applications of second order equations	
11	Solving linear systems of equations	
12	Phase portraits and applications	

S. Y. B. A. Semester III (Major)		
Title of the Course and Course Code	**Basic Linear Algebra (MTS- 202)**	**Number of Credits: 04**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		Bloom's cognitive level
CO1	Define basic linear algebra terms, such as vectors, matrices, and scalars.	1
CO2	Explain the concept of linear independence and dependence in vectors.	2
CO3	Define vector spaces and subspaces. Apply concepts of vector spaces to model data and understand the structure of data sets. Implement vector operations to manipulate and analyze data.	3
CO4	Analyze the geometric transformations induced by linear mappings.	4
CO5	Evaluate the appropriateness of using linear algebra techniques for a given data science problem.	5
CO6	Design and implement a linear algebra-based solution to a complex data manipulation problem. Propose and implement improvements to existing linear algebra algorithms for data processing	6

MTS-202: Basic Linear Algebra (Major)

Course Contents

Semester III

Unit No.	Title of Unit and Contents	No. of hours
I	**Vector Algebra:** Definition of Vectors Scalar Multiplication Vector Summation Linear Combination Inner Products Cauchy Schwarz Inequality Norm of Vector and Orthogonality Projecting One Vector on Another	**12**
II	**Linear Independence and Linear Subspaces:** Introduction Linear Independence Linear Subspaces Linear Equations Basis and Dimension Projection on Subspaces Sample Linear Regression	**10**

III	**Orthonormal Basis and the Gram-Schmidt Process:** Orthonormal Basis The Gram-Schmidt Process general case The Gram-Schmidt Process linear independent case	**5**
IV	**Linear Functions:** 4.1 Definitions 4.2 Linear Function and its Linear Subspaces	**4**
V	**Matrices:** 5.1 Basic Concepts 5.2 Rank of Matrix 5.3 Scalar Multiplication 5.4 Matrix Summation 5.4 Matrix by vector Multiplication 5.5 Rank of Matrix 5.6 Linear Equations and Homogeneous Equations 5.7 Matrix by Matrix Multiplication 5.8 The QR Factorization 5.9 Row and Column Operations 5.10 Echelon Matrices and The Rank of a Matrix	**16**
VI	**Invertible Matrices and The Inverse of a Matrix:** 6.1 Left Inverses 6.2 Right Inverses 6.3 Invertible Matrices 6.4 Solving Set of Linear Equations 6.5 Invertible Matrices 6.6 Inverse of a Matrix by Row Operations 6.7 Change of Basis and similar Matrices	**13**

Learning Resources:

Textbook	Moshe Haviv, Linear Algebra for Data Science, World Scientific Publishing Co Pte. Ltd., Singapore. Chapter 1, Chapter 2, Chapter 3, Chapter 4, Chapter 5, Chapter 6.
Reference Books	Howard Anton, Chris Rorres., Elementary Linear Algebra, John Wiley & Sons, Inc K. Hoffmann and R. Kunze, Linear Algebra, Second Ed. Prentice Hall of India, New Delhi, (1998). G. Strang, Linear Algebra and its Applications, Fourth Ed., Cengage Learning. S. Kumaresan, Linear Algebra a Geometric Approach, Prentice-Hall of India, New Delhi. 5. V. Sahai and V. Bist, Linear Algebra, Narosa. S. Lang, Introduction to Linear Algebra, Second Ed. Springer.

S. Y. B.Sc. Semester III		
Title of the Course and Course Code	**Linear Algebra (MTS-211) (Minor- Theory)**	**Number of Credits: 02**
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Recall the definition of a vector space. Identify the properties that define a set as a vector space. Recognize examples of vector spaces. Recall the definition of a basis for a vector space.	1
CO2	Explain the concept of vector addition and scalar multiplication in a vector space. Interpret geometrically the operations of vector addition and scalar multiplication. Describe the notion of linear independence and spanning sets in vector spaces. Explain the concept of dimension of a vector space.	2
CO3	Apply the properties of vector spaces to determine whether a given set with defined operations forms a vector space. Solve systems of linear equations using vector space methods. Apply the concepts of linear independence and spanning sets to solve problems involving vector spaces. Apply the concept of dimension to determine the number of independent vectors needed to span a subspace.	3
CO4	Analyse the structure of vector spaces and their subspaces. Evaluate whether a given set of vectors forms a basis for a vector space. Compare and contrast different bases for the same vector space. Analyse the relationship between linear transformations and vector spaces.	4
CO5	Assess whether a given set of vectors is linearly independent. Critique proofs related to properties of vector spaces. Evaluate the validity of statements regarding subspaces of a vector space. Judge the applicability of vector space concepts to solve real-world problems.	5
CO6	Design examples of vector spaces with specified properties. Construct proofs of properties of vector spaces. Develop algorithms for finding bases of vector spaces. Create applications of vector space concepts in other areas of mathematics or science.	6

Suggested Pedagogical Processes

- Lecture method: Concepts and operations of sets, Matrix Algebra, Graphs, Trees on Blackboard with examples, problems on sets using Venn diagrams
- ICT supplemented teaching
- Experiential learning
- Case studies
- Problem based learning
- Student seminars
- Group discussions

MTS-211: Linear Algebra (Minor)

Course Contents

Semester III

Unit No.	Title of Unit and Contents	No. of hours
I	**Vector Spaces** 1.1 Vector spaces and subspaces, 1.2 Null spaces, column spaces and linear transformations 1.3 Linearly independent sets, bases 1.4 Coordinate system 1.5 The dimension of a vector space 1.6 Rank 1.7 Change of basis 1.8 Applications to Markov Chains	**15**
II	**Orthogonality and least squares** 2.1 Inner product, length and orthogonality 2.2 Orthogonal sets 2.3 Orthogonal projections 2.4 The Gram-Schmidt process 2.5 Least squares problems 2.6 Applications to Linear Models 2.7 Inner product spaces and its applications	**15**

Learning Resources:

Reference Books	1. Lay, D. C. Lay, S. R. and Mc Donald, J. J. (2016). Linear Algebra and Its Applications, Fifth Edition, Pearson, Boston. 2. Bapat, R.B. (2011). Linear Algebra and Linear Models. Springer and Hindustan Book Agency. 3. Beezer, R. A. (2004). A First Course in Linear Algebra, Congruent Press, Washington 4. Gilbert, S. (2014). Linear Algebra and Its Applications, 4th Ed., Cengage Learning India Pvt. Ltd. 5. Hohn, F. E. (1973). Elements of Matrix Algebra, Macmillan 6. Kollo, T. and Rosen, D. von (2005). Advanced Multivariate Statistics with Matrices, Springer, New York. 7. Kumaresan, S. (2000). Linear Algebra: A Geometric Approach, Prentice Hall 8. Ramachandra Rao, A. and Bhimasankaram, P. (2000). Linear Algebra. Hindustan Book Agency 9. Rao, C. R. (1995). Linear Statistical Inference and Its Applications, Wiley 10. Searle, S. R. and Khuri, A. I. (2017). Matrix Algebra Useful for Statistics, 2nd Ed., John Wiley, New York. 11. Moshe Haviv, Linear Algebra for Data Science, World Scientific Publishing Co Pte. Ltd., Singapore.

S. Y. B.Sc. Semester III		
Title of the Course and Course Code	**Mathematics Practical - 5 (MTS-212) (Minor- Practical)**	**Number of Credits: 02**
1	Practical on vector spaces.	
2	Practical on subspaces.	
3	Practical on linear independence.	
4	Practical on spanning set,	
5	Practical on the basis.	
6	Practical on linear transformations.	
7	Practical on change of basis.	
8	Practical on inner product.	
9	Practical on Gram-Schmidt.	
10	Practical on least square problems.	
11	Practical on linear models.	
12	Practical on applications.	

S. Y. B. Sc. (Minor) Semester III		
Title of the Course and Course Code	**Multivariable Calculus (MTS-213)**	**Number of Credits: 02**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		Bloom's cognitive level
CO1	Recall and recognise the definitions of multivariable calculus concepts, such as partial derivatives, gradients, and multiple integrals.	1
CO2	Explain the geometric interpretation of partial derivatives and gradients in three dimensions. Demonstrate an understanding of the concept of multiple integration and its applications. Interpret the meaning of line integrals and surface integrals.	2
CO3	Solve problems involving partial derivatives and gradients, including optimisation problems. Apply multiple integration techniques to find volumes, surface areas, and centre of mass. Utilize vector calculus concepts to solve problems related to curves and surfaces in space.	3
CO4	Analyze and interpret the significance of critical points and saddle points in multivariable functions. Break down a complex region into simpler parts for the purpose of integration. Examine the properties and applications of vector fields.	4
CO5	Evaluate the appropriateness of different methods for solving multivariable calculus problems. Assess the validity of mathematical proofs related to multivariable calculus theorems. Critically evaluate the importance of multivariable calculus in various fields (physics, economics, and engineering).	5
CO6	Formulate and solve real-world problems using multivariable calculus concepts. Design applications that involve the use of partial derivatives and multiple integrals in modelling physical phenomena. Develop algorithms or procedures that leverage vector calculus for specific tasks.	6

Suggested Pedagogical Processes

- Lecture method: Concepts and operations of sets, Matrix Algebra, Graphs, Trees on Blackboard with examples, problems on sets using Venn diagrams
- ICT supplemented teaching
- Experiential learning
- Case studies
- Problem based learning
- Student seminars
- Group discussions

MTS-213: Multivariable Calculus (Minor)
Semester III
Course Contents

Unit No.	Title of Unit and Contents	No. of hours
I	**Vector Functions** 1.1 Vector Functions and Space Curves 1.2 Derivatives and Integrals of Vector Functions 1.3 Arc Length and Curvature 1.4 Velocity and Acceleration	**5**
II	**Partial Derivatives** 2.1 Functions of Several Variables, Limits and Continuity 2.2 Partial Derivatives 2.3 Tangent Planes 2.4 The Chain Rule 2.5 Directional Derivatives and the Gradient Vector 2.6 Maximum and Minimum Values, Lagrange's multiplier	**8**
III	**Multiple Integrals** 3.1 Double Integrals over Rectangles 3.2 Iterated Integrals 3.3 Double Integrals over General Regions, Surface Area 3.4 Triple integrals 3.5 Change of Variables, Cylindrical and Spherical Coordinates	**10**
IV	**Vector Integrals** 4.1 Line Integrals 4.2 Green's Theorem, Curl and Divergence 4.3 Surface Integrals, Stokes' Theorem, The Divergence Theorem	**7**

Learning Resources:

Reference Books	1. Stewart James, Daniel K. Clegg, and Saleem Watson. *Multivariable calculus*. Cengage Learning, 2020. 2. G B Thomas, M. D. Weir, J. Hass, *Thomas' Calculus: Multivariable*, Pearson 3. Robert Wrede, Murrey R. Speigel, *Theory And Problems of Advanced Calculus*, Schaum's Outline Series, Mc GRAW Hill 4. J E Marsden, A. J. Tromba, A. Weinstein, *Basic Multivariable Calculus*, Springer Verlag

S. Y. B.Sc. Semester III		
Title of the Course and Course Code	**Mathematics Practical - 6 (MTS-214)** **(Minor - Practical)**	**Number of Credits: 02**
1	Vector functions, derivative and integral, Space curves	
2	Arc length, curvature, Torsion, velocity and acceleration	
3	Functions of several variables, limit and continuity	
4	Partial derivatives and tangent palne	
5	Chain rule and applications	
6	Applications of directional derivatives, gradient	
7	Extreme values of functions	
8	Evaluation of double integral, iterated integrals, sketch of regions, General region and Surface area	
9	Triple integral, change of variables	
10	Line integrals, Green's theorem and applications	
11	Stokes' theorem and applications	
12	Gauss's divergence theorem and applications	

Semester III		
MTS-215 – Applied Linear Algebra **Credits - 2**		
Course Outcomes (COs)		
Course Outcome number	**Description** **On completion of the course, the students will be able to:**	**Bloom's Cognitive level**
CO1	Recall all Matrix operations and properties	1
CO2	Discuss concepts of linear independence, spanning set, basis, orthogonality	2
CO3	Compute inner product, norm, angle, distance between vectors, Eigen values, Eigenvectors of matrices.	3
CO4	Explain Linear transformations and its basic properties	4
CO5	Determine whether the matrix is diagonalizable.	5
CO6	Develop ability to apply linear algebra concepts to solve problems in various fields.	6

Unit No.	Title of Unit and Contents	No. of hours
I	**Matrices and Linear Equations** 1.1 Introduction 1.2 Matrices 1.3 Elementary Row operations, Row Echelon form. 1.4 Solution to System of Linear Equations	**4**
II	**Vector Spaces** 2.1 Introduction 2.2 Euclidean Spaces 2.3 Subspaces 2.4 Linear Span 2.5 Linear Independence 2.6 Basis 2.7 Coordinates	**9**
III	**Inner Product** 3.1 Introduction 3.2 Length, Distance, Angle 3.3 Orthogonality **3.4 Gram-Scmidt Orthogonalization Process**	**4**
IV	**Linear Transformations** 4.1 Introduction 4.2 Linear transformation	**7**

	4.3 Kernel and Range of a Linear Transformation 4.4 Standard Matrix	
V	**Eigenvalues and Eigenvectors** 5.1 Introduction 5.2 Eigenvalues and Eigenvectors 5.3 Diagonalization	**6**

Learning Resources:

1) Elementary Linear Algebra with supplemental Applications, by Howard Anton, Chirs Rorres, Wiley Student Edition, Eleventh Edition.

2) Linear Algebra and it’s Applications, David C. Lay, Steven R. Lay, Judi J. MacDonald Pearson Publication, 2016, Fifth Edition.

3) Linear Algebra with Applications, W. Keith Nicholson, Lyryx Learning Team.

Semester III		
MTS216– Mathematics Practical- 3 **Credits - 2**		
Course Outcomes (COs)		
Course Outcome number	**Description** **On completion of the course, the students will be able to:**	**Bloom's Cognitive level**
CO1	Show different matrix operations in python.	1
CO2	Explain different Numerical Interpolation techniques.	2
CO3	Illustrate Basic programming skills in python.	3
CO4	Explain different concepts related to vectors.	4
CO5	Evaluate Eigenvalues and Eigenvectors of matrices.	5
CO6	Development of problem-solving skills by applying mathematical concepts to practical situations.	6

Unit No.	Title of Unit and Contents
1	Introduction to python - I (Data Types, List, tuples, array)
2	Introduction to python - II (basic operations on matrices)
3	Basic Python Programming - I
4	Basic Python Programming - II
5	Newton's Forward Interpolation Technique using Python
6	Newton's Backward Interpolation Technique using Python
7	Divided Difference Interpolation Technique using Python
8	Lagrange Interpolation Technique using Python
9	Vector Spaces
10	Inner product spaces
11	Eigenvalues and Eigenvectors - I
12	Eigenvalues and Eigenvectors - II
13	Student Activity –I
14	Students Activity – II
15	Students Activity – III

S. Y. B. Sc. (Minor) Semester III		
Title of the Course and Course Code	**Operations Research (MTS- 219)**	**Number of Credits: 04**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		Bloom's cognitive level
CO1	Recognize and recall the basic definition of Linear Programming. Memorize key terms such as objective function, decision variables, constraints, and feasible region. Define the basic terms used in linear programming such as decision variables, objective function, constraints, and feasible solution. Define the term "transportation problem."	1
CO2	Describe the role of the objective function in LP. Explain the significance of decision variables and constraints. Differentiate between feasible and infeasible solutions. Explain the purpose of the simplex method in solving linear programming problems. Differentiate between balanced and unbalanced transportation problems.	2
CO3	Apply the graphical method to solve LP problems with two decision variables. Calculate and interpret the coordinates of corner points. Solve a given linear programming problem using the simplex method step by step. Solve a basic transportation problem using the method of the Northwest Corner Rule, Minimum Cost Method.	3
CO4	Compare and contrast the simplex method with other optimization techniques. Compare and contrast different methods for solving transportation problems.	4
CO5	Critically assess multiple optimal solutions in LP. Evaluate the implications of unbounded solutions or infeasible solutions in the context of the simplex method.	5
CO6	Develop LP models based on real-world problems. Formulate a new linear programming problem and apply the simplex method to find the optimal solution. Design a transportation model for a specific supply chain scenario.	6

MTS-219: Operations Research
Course Contents
Semester III

Unit No.	Title of Unit and Contents	No. of hours
I	**Linear Programming-The Graphical Method:** 1.1 Introduction 1.2 General structure of linear programming problem 1.3 Important Definitions 1.4 General Solutions methods to linear programming problem 1.5 Special Cases in linear programming problem 1.6 Two variable LP Model	**10**
II	**Linear Programming- The Simplex Method:** 2.1 Introduction 2.2 Standard form of a linear programming problem 2.3 Simplex algorithm (Maximization case) 2.4 Simplex algorithm (Minimization case)	**16**
III	**Duality** Definition of the dual problem, primal dual relationship	**8**
III	**Transportation Problem:** 3.1 Introduction 3.2 Mathematical model of transportation problems 3.3 The transportation algorithm 3.4 Methods for finding initial solution 3.5 Test for optimality 3.6 Maximization transportation problems	**16**
IV	**The Assignment Model** The Hungarian method, Simplex explanation of the Hungarian method	**10**

Learning Resources:

Textbook	1. J. K. Sharma, Operations Research (Theory and Applications, second edition, 2006), Macmillan India Ltd. Chapter 2: 2.2, 2.8 Chapter3: 3.1 to 3.4, Chapter 4: 4.1 to 4.4, Chapter 5 5.1,5.2,5.3, Chapter 9: 9.1 to 9.7, Chapter 10: 10.1 to 10.4.
Reference Books	1. Hamdy A. Taha, Operation Research (Eighth Edition, 2009), Prentice Hall of India Pvt. Ltd, New Delhi. 2. Frederick S. Hillier, Gerald J. Lieberman, Introduction to Operations Research (Eighth Edition), Tata McGraw-Hill. 3. Hira and Gupta, Operation Research

S. Y. B. Sc. Semester III		
Title of the Course and Course Code	**MS Excel MTS-220 (OE-III)**	**Number of Credits: 2**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Recognize and recall basic Excel functions and formulas.	
CO2	Interpret data presented in Excel spreadsheets.	
CO3	Create charts and graphs to represent data effectively.	
CO4	Analyse data trends and patterns using Excel features like PivotTables and Pivot Charts.	
CO5	Critique the effectiveness of different Excel functions and tools for specific tasks.	
CO6	Develop complex Excel spreadsheets for various purposes, such as budgeting, forecasting, or data tracking.	

MTS-220 MS Excel

Course Contents

Semester III

Unit No.	Title of Unit and Contents	No. of hours
I	**Entering and editing data** 1.1 Entering and editing text and values 1.2 Entering and editing formulas 1.3 Saving and updating workbooks	2
II	**Modifying a worksheet** 2.1 Moving and copying data 2.2 Moving and copying formulas 2.3 Inserting and deleting ranges, rows, and columns 2.4 Cell comments	2
III	**Using functions** 3.1 Entering functions 3.2 AutoSum 3.3 Other common functions	4
IV	**Formatting Text formatting** 4.1 Row and column formatting 4.2 Number formatting 4.3 Conditional formatting 4.4 Additional formatting options	2
V	**Charts** 5.1 Bar Chart 5.2 Line Chart 5.3 Pie Chart	4

	5.4 Tree Map 5.5 Histogram 5.6 Scatter Plot	
VI	**Subtotal Functions** 6.1 Create an outline and consolidate data 6.2 Create subtotals in a list 6.3 Use multiple subtotal functions- SUBTOTAL, SUMIF 6.4 Create custom views to save different sets of worksheets display and print settings	4
VII	**Range names and Filter date** 7.1 Define and apply cell and range names 7.2 Use names in Formulas 7.3 Filter data based on complex criteria 7.4 Use conditional filters 7.5 Copy filtered results to another range	5
VIII	**Pivot Tables** 8.1 Prepare data in a table format and name the table 8.2 Create a PivotTable for analyzing 8.3 Use the Download Actuals page in Account 8.4 Reconciliation as example 8.5 Modify or re-arrange fields	5
IX	**Selected Functions** 9.1 Using IF and SUMIF functions to calculate a value based on specified criteria 9.2 Use ROUND function to round off numbers 9.3 Use VLOOKUP to find values in worksheet data 9.4 Use HLOOK UP	2

Learning Resources:

Reference Books	**Learning resources:** **Reference Book:** Beginning Excel 2019 by Noreen Brown; Barbara Lave; Hallie Puncochar; Julie Romey; Mary Schatz; Art Schneider; and Diane Shingledecker Open Oregon Educational Resources

S. Y. B. Sc. Semester III		
Title of the Course and Course Code	**Python-I (MTS-230) (VSC)**	**Number of Credits: 2 Hours: 30**
Students will acquire the following skills on completion of the course:		
1.	Explain features and future of Python.	
2.	Use variables, identifiers and keywords, etc.	
3.	Examine and execute operators, expressions and various operations on input data.	
4.	Implement conditional statement.	
5.	Differentiate between break and continue keywords.	
6.	Formulate strings and identify concepts related with it.	
7.	Describe different data structures and their syntax.	
8.	Construct and evaluate user define functions.	
9.	Use Python packages.	
10.	Use and explain built-in functions.	

MTS-230: Python-I (VSC)

<u>Course Contents</u>

<u>Semester III</u>

Unit No.	Title of Unit and Contents	No. of hours
I	**Basics of Python Programming** 1.1 Feature, History and Future of Python 1.2 Writing and executing first Python program 1.3 Literal Constants 1.4 Variable and Identifiers 1.5 Data types 1.6 Input Operations 1.7 Comment, Reserve Words and Indentation 1.8 Operators and Expressions 1.9 Operations on Strings	**4**
II	**Decision Control Statements** 2.1 Introduction to Decision Control statements 2.2 Selection/Conditional Branching Statements 2.3 Basic Loop Structure/Iterative Statements 2.4 Nested Loops 2.5 The Break and Continue Statements 2.6 The Pass Statement 2.7 The Else Statement Used with Loops	**10**
III	**Python String Revised** 3.1 Concatenating, appending and Multiplying Strings 3.2 Strings Are Immutable 3.3 String Formatting Operators 3.4 Built-in String Method and Functions	**4**

	3.5 Slice Operations 3.6 Ord () and Char () Functions 3.7 In and Not in Operators 3.8 Comparing and Iterating String	
IV	**Data Structure** 4.1 Sequences 4.2 List 4.3 Tuple 4.4 Sets 4.5 Dictionaries	**4**
V	**Function and Modules** 5.1 Need for a Function 5.2 Function Definition 5.3 Function Call 5.4 Variable Scope and Lifetime 5.5 The Return Statement 5.6 More on Defining Function 5.7 Lambda Functions 5.8 Recursive Functions 5.9 Module 5.10 Introduction to Object Oriented Programming using Python	**8**

Learning Resources:

Text Book	Reema Thareja, Python Programming Using Problem Solving Approach, Oxford University Press, 2015 Chapter 3, Chapter 4, Chapter 5, Chapter 6, Chapter 7, Chapter 8.
Reference Books	1. Allen Downey,Think Python, How to Think Like a Computer Scientist, Green Tea Press Needham, Massachusetts, 2015. 2. Robert Johansson, Introduction to Scientific Computing in Python, SMTEBOOKS, Apress, 2016. 3. Hans-PetterHalvorsen,Python for Scientific engineering, 2020.
E-resources	https://tinyurl.com/yu4bdsnn Programming, Data Structures And Algorithms Using Python - Course (nptel.ac.in)-Swayam Course on Python by Madhavan Mukund

Proposed Evaluation Methods:

1. **Home assignment and attendance**
2. **Program writing and evaluating in lab**
3. **Viva to determine Python language knowledge**

S. Y. B.Sc. Semester III		
Title of the Course and Course Code	**Python - II (MTS-231)** **(VSC- Theory)**	**Number of Credits: 02**
Unit No.	**Title of Unit and Contents**	**No. of hours**
I	**Decision Control Statements Revised** **1.1 Conditional and alternative statements** **1.2 Chained and Nested if, if-else, if-elif-else, nested if, nested if-else**	**6**
II	**Numerical Methods in Python** 2.8 **Roots of Equations** 2.9 **Newton-Rapson Method** 2.10 **False Position Method** 2.11 **Numerical Integration** 2.12 **Trapezoidal Rule** 2.13 **Simpson's 1/3rd Rule** 2.14 **Simpson's 3/8th Rule**	**10**
III	**Linear Algebra** 3.9 **Matrix Construction** 3.10 **Addition, Subtraction, Multiplication of Matrices** 3.11 **Power and Inverse of Matrix** 3.12 **Accessing rows and columns** 3.13 **Deleting and Inserting Rows of Matrix** 3.14 **Determinant, Row Echelon Form** 3.15 **Null Space, Column Space, Rank** 3.16 **Solving Systems of Linear Equations** 3.17 **Gauss-Jordan Method** 3.18 **Gauss-Eliminations Method** 3.19 **LU-Decomposition Method** 3.20 **Eigenvalues, Eigenvector's and Diagonalization**	**12**
IV	**Recursive Functions** 4.6 **Factorial of a number** 4.7 **Greatest Common Divisor** 4.8 **Finding Exponents** 4.9 **The Fibonacci Series**	**2**

Learning Resources:

Reference Books	1. Reema Thareja, Python Programming Using Problem Solving Approach, Oxford University Press 2. Allen Downey,Think Python, How to Think Like a Computer Scientist, Green Tea Press Needham, Massachusetts, 2015 3. Robert Johansson, Introduction to Scientific Computing in Python, 2016 4. Hans-PetterHalvorsen,Python for Scientific engineering, 2020 Unit-5: Chapter-31

S. Y. B. Sc. Semester III (SEC-II)		
Title of the Course and Course Code	**Linear Algebra for Data Science-I (MTS- 240)**	**Number of Credits: 02**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		Bloom's cognitive level
CO1	Define basic linear algebra terms, such as vectors, matrices, and scalars.	1
CO2	Explain the concept of linear independence and dependence in vectors.	2
CO3	Define vector spaces and subspaces. Apply concepts of vector spaces to model data and understand the structure of data sets. Implement vector operations to manipulate and analyze data.	3
CO4	Analyze the geometric transformations induced by linear mappings.	4
CO5	Evaluate the appropriateness of using linear algebra techniques for a given data science problem.	5
CO6	Design and implement a linear algebra-based solution to a complex data manipulation problem. Propose and implement improvements to existing linear algebra algorithms for data processing	6

MTS-240: Linear Algebra for Data Science-I (SEC-2)
Course Contents
Semester III

Unit No.	Title of Unit and Contents	No. of hours
I	**Vector Algebra:** 1.1 Definition of Vectors 1.2 Vector Operations 1.3 Norm of Vector and Orthogonality 1.4 Projecting One Vector on Another	**4**
II	**Linear Independence and Linear Subspaces:** 2.1 Linear Independence 2.2 Linear Subspaces 2.3 Basis and Dimension 2.4 Projection on Subspaces 2.5 Sample Linear Regression	**4**
III	**Orthonormal Basis and the Gram-Schmidt Process:** 3.1 Orthonormal Basis 3.2 The Gram-Schmidt Process	**2**

IV	**Linear Functions:** 4.1 Definitions 4.2 Linear Function and its Linear Subspaces	**4**
V	**Matrices:** 5.1 Rank of Matrix 5.2 Linear Equations and Homogeneous Equations 5.3 Matrix by Matrix Multiplication 5.4 The QR Factorization 5.5 Row and Column Operations 5.6 Echelon Matrices and The Rank of a Matrix	**8**
VI	**Invertible Matrices and The Inverse of a Matrix:** 6.1 Left Inverses 6.2 Right Inverses 6.3 Invertible Matrices 6.4 Solving Set of Linear Equations 6.5 Invertible Matrices 6.6 Inverse of a Matrix by Row Operations 6.7 Change of Basis and similar Matrices	**8**

Learning Resources:

Text Book	Moshe Haviv, Linear Algebra for Data Science, World Scientific Publishing Co Pte. Ltd., Singapore. Chapter 1, Chapter 2, Chapter 3, Chapter 4, Chapter 5, Chapter 6.
Reference Books	Howard Anton, Chris Rorres., Elementary Linear Algebra, John Wiley & Sons, Inc K. Hoffmann and R. Kunze, Linear Algebra, Second Ed. Prentice Hall of India , New Delhi, (1998). G. Strang, Linear Algebra and its Applications, Fourth Ed., Cengage Learning. S. Kumaresan, Linear Algebra A Geometric Approach, Prentice-Hall of India, New Delhi. 5. V. Sahai and V. Bist, Linear Algebra, Narosa. S. Lang, Introduction to Linear Algebra, Second Ed. Springer.

<table>
<tr><th colspan="3">S. Y. B. Sc. (Major) Semester IV</th></tr>
<tr><td>Title of the Course and Course Code</td><td>Multivariable Integral Calculus and Group Theory (MTS-251)</td><td>Number of Credits: 04</td></tr>
<tr><td colspan="2">Course Outcomes (COs)
On completion of the course, the students will be able to:</td><td>Bloom’s cognitive level</td></tr>
<tr><td>CO1</td><td>Define a group and its basic properties.
Recall the definition of group axioms.
Remember the definitions of important terms such as subgroup, coset, and normal subgroup.
Identify examples and counterexamples of groups.</td><td>1</td></tr>
<tr><td>CO2</td><td>Explain the significance of group axioms and how they define group structures.
Describe the concept of subgroup and its relationship with the parent group.
Interpret the meaning and importance of group homomorphisms.
Differentiate between various types of groups (e.g., abelian, cyclic, dihedral) and understand their properties.</td><td>2</td></tr>
<tr><td>CO3</td><td>Apply the group axioms to determine if a given set with an operation forms a group.
Solve problems involving cosets, normal subgroups, and factor groups.
Apply group homomorphisms to prove properties of groups.
Use the concepts of group actions to solve permutation puzzles or symmetry problems.</td><td>3</td></tr>
<tr><td>CO4</td><td>Analyze the structure of groups and subgroups using Lagrange's theorem.
Compare and contrast different types of groups based on their properties.
Evaluate the validity of proofs related to group theory.
Analyze the relationship between group theory and other branches of mathematics, such as geometry and number theory.</td><td>4</td></tr>
<tr><td>CO5</td><td>Critique proofs and arguments related to group theory.
Evaluate the applications of group theory in various fields such as physics, chemistry, and cryptography.
Assess the significance of group theory in understanding symmetry and pattern recognition.
Evaluate the effectiveness of different problem-solving strategies in group theory.</td><td>5</td></tr>
<tr><td>CO6</td><td>Design new problems or exercises related to group theory to test understanding.
Devise group theoretic algorithms for specific applications.
Create visual representations or demonstrations illustrating group concepts.
Develop new theorems or conjectures in group theory and provide proofs or counterexamples.</td><td>6</td></tr>
</table>

Suggested Pedagogical Processes

- Lecture method: Concepts and operations of sets, Matrix Algebra, Graphs, Trees on Blackboard with examples, problems on sets using Venn diagrams
- ICT-supplemented teaching
- Experiential learning
- Case studies
- Problem-based learning
- Student seminars
- Group discussions

MTS-251: Multivariable Integral Calculus and Group Theory (Major)

Course Contents

Semester IV

Unit No.	Title of Unit and Contents	No. of hours
I	**Line Integrals:** 1.1 Introduction, Paths and line integrals 1.2 Other notations for line integrals 1.3 Basic properties of line integrals 1.4 The concept of work as a line integral 1.5 Line integrals with respect to arc length 1.6 Applications of line integrals 1.7 Open connected sets. 1.8 Independence of the path 1.9 The second fundamental theorem of calculus for line integrals 1.10 Applications to mechanics 1.11 The first fundamental theorem of calculus for line integrals 1.12 Necessary and sufficient conditions for a vector field to be a gradient 1.13 Necessary conditions for a vector field to be a gradient 1.14 Special methods for constructing potential functions 1.15 Applications to exact differential equations of first order 1.16 Potential functions on convex set	**10**
II	**Multiple Integral:** 2.1 Introduction 2.2 Partitions of rectangles. 2.3 Step functions the double integral of a step function 2.4 The definition of the double integral of a function defined and bounded on a rectangle 2.5 Upper and lower double integrals 2.6 Evaluation of a double integral by repeated one-dimensional integration, 2.7 Geometric interpretation of the double integral as a volume Integrability of continuous functions, 2.8 Integrability of bounded functions with discontinuities 2.9 Double integrals extended over more general regions 2.10 Applications to area and volume 2.11 Further applications of double integrals 2.12 Green’s theorem in the plane, 2.13 Some applications of Green’s theorem 2.14 A necessary and sufficient condition for a two-dimensional vector field to be a gradient 2.15 Change of variables in a double integral 2.16 Special cases of the transformation formula	**10**
III	**Surface Integral:** 3.1 Parametric representation of a surface 3.2 The fundamental vector product 3.3 The fundamental vector product as a normal to the surface 3.4 Area of a parametric surface 3.5 Surface integrals	**10**

	3.6 Change of parametric representation 3.7 Other notations for surface integrals 3.8 The theorem of Stokes 3.9 The curl and divergence of a vector field 3.10 Further properties of the curl and divergence 3.11 Extensions of Stokes' theorem 3.12The divergence theorem (Gauss theorem :) 3.13Applications of the divergence theorem	
IV	Groups: 4.1 Definition and Examples of Groups, 4.2Elementary Properties of Groups, 4.3 Historical Notes 4.4 Finite Groups and Subgroups: Terminology and Notation, Subgroup Tests, Examples of Subgroups 4.5 Cyclic groups: Properties of Cyclic Groups, Classification of Subgroups of Cyclic Groups	**15**
V	**Permutation Group:** 5.1 Definition and Notation, 5.2 Cycle Notation, 5.3 Properties of Permutations, 5.4 A Check Digit Scheme Based on D_5 5.5 Isomorphism's: Motivation, Definition and Examples, Cayley's Theorem, Properties of Isomorphism's, Automorphisms 5.6 Cosets and Lagrange's Theorem: Properties of Cosets, Lagrange's Theorem and Consequences, An Application of Cosets to Permutation Groups, The Rotation Group of a Cube and a Soccer Ball	**15**

Learning Resources:

Reference Books	1. Tom M. Apostol, Calculus Vol II, Second Edition, John Wiley & Sons, Inc. New York, 1991. 2. Gallian J. A. (2010) Contemporary Abstract Algebra, 7th Edition. 3. M. Artin, Algebra, Prentice Hall of India, New Delhi, 1994. 4. N. Herstein, Topics in Algebra, Wiley, 1990. § 2.1 to § 2.10 5. P. B. Bhattacharya, S. K. Jain and S. R. Nagpal, Basic Abstract Algebra, Second Ed., Foundation Books, New Delhi, 1995. 6. J. B. Fraleigh, A First Course in Abstract Algebra, Third Ed., Narosa, New Delhi, 7. N. S. Gopalakrishnan, University Algebra, Second Ed., New Age International, New Delhi, 1986. 8. D. A. R. Wallace, Groups, Rings and Fields, Springer-Verlag, London, 1998. 9. I. N. Herstein, Abstract Algebra 10. Stewart James, Daniel K. Clegg, and Saleem Watson. *Multivariable calculus*. Cengage Learning, 2020. 11. G B Thomas, M. D. Weir, J. Hass, *Thomas' Calculus: Multivariable*, Pearson 12. Robert Wrede, Murrey R. Speigel, *Theory and Problems of Advanced Calculus,* Schaum's Outline Series, Mc GRAW Hill 13. J E Marsden, A. J. Tromba, A. Weinstein, *Basic Multivariable Calculus*, Springer Verlag

S. Y. B.Sc. Semester IV		
Title of the Course and Course Code	**Mathematics Practical - 4 (MTS-250) (Major- Practical)**	**Number of Credits: 02**
1	Practical on line integral-I	
2	Practical on line integral-II	
3	Practical on line integral-III	
4	Practical on multiple integral-I	
5	Practical on multiple integral-II	
6	Practical on surface integral-I	
7	Practical on surface integral-II	
8	Practical on surface integral-III	
9	Practical on groups and subgroups	
10	Practical on cyclic groups	
11	Practical on permutaion groups	
12	Practical on Lagrange’s theorem	

S. Y. B. A. Semester IV (Major)		
Title of the Course and Course Code	**Advance Linear Algebra (MTS-252)**	**Number of Credits: 04**
Course Outcomes (COs) On completion of the course, the students will be able to:		Bloom's cognitive level
CO1	Recall key properties of matrix addition, subtraction, and scalar multiplication.	1
CO2	Interpret geometrically the solutions to systems of linear equations. Demonstrate an understanding of eigenvectors and eigenvalues in the context of linear transformations.	2
CO3	Apply matrix operations to solve systems of linear equations.	3
CO4	Evaluate the efficiency of different matrix algorithms for solving linear algebra problems. Analyze the impact of singular value decomposition in data compression.	4
CO5	Evaluate the appropriateness of using linear algebra techniques for a given data science problem.	5
CO6	Design and implement a linear algebra-based solution to a complex data manipulation problem. Propose and implement improvements to existing linear algebra algorithms for data processing	6

MTS-252 Advance Linear Algebra (Major)

Course Contents

Semester IV

Unit No.	Title of Unit and Contents	No. of hours
I	**The Pseudo-Inverse Matrix, Projections and Regresion:** Introduction Least Square Solutions The casting out algorothm Simple Linear Regression Multiple Linear Regression	**10**
II	**Determinants:** 2.1 Introduction 2.2 Permutations 2.3 The Determinant 2.4 The Vandermonde Determinant 2.5 Determinant and Row Operations 2.6 Minor Matrices and the Determinant 2.7 The Adjoint Matrix 2.8 Fitting a Polynomial 2.9 Cramer's Method for Solving Linear Equations	**16**

III	**Eigensystem and Diagonalizability:** 3.1 Introduction 3.2 The Characteristic Polynomial 3.2 Left and Right Eigensystem 3.3 Algebraic and Geometric Multiplicities of Eigenvalues 3.4 Similar Matrices and Their Eigensystem 3.5 Bases with Eigenvectors and Diagonalizable Matrices 3.6 The spectral Representation	**14**
IV	**Symmetric Matrices:** 4.1 Introduction 4.2 Eigensystem and Symmetric Matrices 4.3 Positive Matrices 4.4 Two criteria for positiveness of matrices 4.5 Covariance Matrices 4.6 Computing Eigensystem 4.7 The Power Method and Deflation	**14**
V	**Singular Value Decomposition:** 5.1 Introduction and some preliminaries 5.2 Singular Value Decomposition	**6**

Learning Resources:

Text Book	1. Moshe Haviv, Linear Algebra for Data Science, World Scientific Publishing Co Pte. Ltd., Singapore. Chapter 1, Chapter 2, Chapter 3, Chapter 4, Chapter 5, Chapter 6.
Reference Books	1. Howard Anton, Chris Rorres., Elementary Linear Algebra, John Wiley & Sons, Inc 2. K. Hoffmann and R. Kunze, Linear Algebra, Second Ed. Prentice Hall of India , New Delhi, (1998). 3. G. Strang, Linear Algebra and its Applications, Fourth Ed., Cengage Learning. 4. S. Kumaresan, Linear Algebra A Geometric Approach, Prentice-Hall of India, New Delhi. 5. V. Sahai and V. Bist, Linear Algebra, Narosa. 5. S. Lang, Introduction to Linear Algebra, Second Ed. Springer.

S. Y. B.Sc. Semester IV		
Title of the Course and Course Code	**Calculus of Several Variables MTS-261 (Minor- Theory)**	**Number of Credits: 02**
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Recall the definition of partial derivatives for functions of several variables. Recognize the chain rule for functions of several variables. Remember the definitions of gradient, divergence, and curl. Recall the concept of directional derivatives and their relationship to gradients. Recall the definition of double and triple integrals.	1
CO2	Explain the geometric interpretation of partial derivatives. Describe how the chain rule extends to functions of several variables. Understand the geometric interpretation of the gradient, divergence, and curl. Interpret the meaning of directional derivatives in terms of slopes along specified directions. Understand the concept of iterated integrals and their relationship to double and triple integrals.	2
CO3	Apply the chain rule to find derivatives of composite functions of several variables. Compute gradients, divergences, and curls of vector fields. Apply directional derivatives to optimize functions of several variables. Compute double and triple integrals over various regions. Apply change of variables in multiple integrals.	3
CO4	Analyse the behaviour of functions of several variables using partial derivatives. Analyse vector fields and their properties using gradient, divergence, and curl. Investigate the geometric significance of critical points in functions of several variables. Analyse the effects of changing the order of integration in iterated integrals.	4
CO5	Evaluate the correctness of solutions to optimization problems using directional derivatives. Critique the application of calculus of several variables in modelling real-world problems. Assess the validity of conclusions drawn from theorems such as the divergence theorem or Stokes' theorem. Judge the appropriateness of different methods for computing multiple integrals in various contexts.	5
CO6	Design examples of functions of several variables to illustrate specific concepts such as critical points or optimization. Develop proofs of theorems related to calculus of several variables, such as the implicit function theorem. Create applications of gradient, divergence, and curl in physics or	6

	engineering contexts. Design problems that require students to apply multiple integration techniques to solve real-world problems.	

Suggested Pedagogical Processes

- Lecture method: Concepts and operations of sets, Matrix Algebra, Graphs, Trees on Blackboard with examples, problems on sets using Venn diagrams
- ICT supplemented teaching
- Experiential learning
- Case studies
- Problem based learning
- Student seminars
- Group discussions

MTS-261: Calculus of Several Variables

(Minor) Course Contents

Semester IV

Unit No.	Title of Unit and Contents	No. of hours
I	**Limits, Continuity and Differentiability**: 1.1 Functions of two and three variables 1.2 Notions of limits and continuity 1.3 Limit along a path 1.4 Examples. 1.5 Definition and examples of Partial Derivatives 1.6 Differential and differentiability, necessary and sufficient conditions for differentiability 1.7 Higher order partial derivatives 1.8 Schwartz's theorem without proof 1.9 Young's theorem without proof	**10**
II	**Chain Rules and Extreme Values:** 2.1 Chain Rules of f(g(x,y)) and f(g(u,v),h(u,v)) 2.2 Euler's theorem for homogeneous functions.Mean Value theorem 2.3 Taylor's theorem for functions of two variables 2.4 Extreme values of functions of two variables 2.5 Necessary conditions for extreme values.Sufficient conditions for extreme values 2.6 Lagrange's method of undetermined coefficients	**10**
III	**Multiple Integrals:** 3.1 Double integrals, evaluation of double integrals. 3.2 Change of order of integration for two variables. 3.3 Double integration in Polar co-ordinates. 3.4 Triple integrals.Evaluation of triple integrals.Jacobians, 3.5 Change of variables (Results without proofs) Applications to Area and Volumes.	**10**

Learning Resources:

Reference Books	1. James Stewart (2012). Multivariable Calculus (7th edition). Brooks/Cole. Cengage. 2. Shanti Narayan and P.K. Mittal, A Course in Mathematical Analysis, S. Chand and Co. 12th Edition, 1979. 3. Jerrold Marsden, Anthony J. Tromba & Alan Weinstein (2009). Basic Multivariable Calculus, Springer India Pvt. Limited 4. John M. H. Olmsted, Advanced Calculus, Eurasia Publishing House, New Delhi,1970. 5. D.V. Widder, Advanced Calculus (IInd Edition), Prentice Hall of India, New Delhi, 1944. 6. M.R. Spiegel, Advanced Calculus: Schaum Series 7. T.M. Apostol, Calculus Vol. II (IInd Edition), John Willey, New York, (1967) 8. Monty J. Strauss, Gerald L. Bradley & Karl J. Smith (2011). Calculus (3rd edition), Pearson Education. Dorling Kindersley (India) Pvt. Ltd. 9. George B. Thomas Jr., Joel Hass, Christopher Heil & Maurice D. Weir (2018). Thomas' Calculus (14th edition). Pearson Education.

S. Y. B.Sc. Semester IV		
Title of the Course and Course Code	**Mathematics Practical - 7 (MTS-262) (Minor- Practical)**	**Number of Credits: 02**
1	Practical on limits I	
2	Practical on limits-II	
3	Practical on continuity I	
4	Practical on continuity-II	
5	Practical on derivatives I	
6	Practical on derivatives-II	
7	Practical on chain rule	
8	Practical on extreme values I	
9	Practical on extreme values-II	
10	Practical on multiple integral-I	
11	Practical on multiple integral-II	
12	Practical on multiple integral-III	

<table>
<tr><th colspan="3">S. Y. B. Sc. (Minor) Semester IV</th></tr>
<tr><td>Title of the Course and Course Code</td><td>Differential Equations and Applications (MTS-263)</td><td>Number of Credits: 02</td></tr>
<tr><td colspan="2">Course Outcomes (COs)
On completion of the course, the students will be able to:</td><td>Bloom's cognitive level</td></tr>
<tr><td>CO1</td><td>Recall and recognize the definitions of basic terms and concepts in ODEs such as order, linearity, homogeneity, etc.
Remember and reproduce various techniques for solving different types of ODEs (e.g., separable, exact, homogeneous, etc.).
Memorize and apply standard ODE solving methods like variation of parameters, integrating factors, etc.</td><td>1</td></tr>
<tr><td>CO2</td><td>Interpret and explain the significance of solutions to differential equations in real-world contexts.
Comprehend the theoretical underpinnings of existence and uniqueness theorems for ODEs.
Understand the geometrical interpretations of solutions to first-order ODEs and interpret phase portraits.</td><td>2</td></tr>
<tr><td>CO3</td><td>Apply different techniques of solving ODEs to various practical problems in physics, engineering, economics, and other fields.
Utilize appropriate software tools (like MATLAB, Mathematica, or Python libraries) to solve ODEs numerically and visualize solutions.
Apply mathematical concepts to model real-world phenomena as differential equations and solve them.</td><td>3</td></tr>
<tr><td>CO4</td><td>Analyze the behavior of solutions to ODEs under different initial conditions and parameter values.
Evaluate the stability of equilibrium solutions and critical points of dynamical systems.
Critically assess the appropriateness of different solution methods for specific types of ODEs and problem scenarios.</td><td>4</td></tr>
<tr><td>CO5</td><td>Judge the validity and accuracy of solutions obtained using different methods by comparing them with theoretical expectations or numerical results.
Critique the limitations and assumptions underlying various solution techniques for ODEs.
Assess the applicability of mathematical models based on differential equations in describing real-world phenomena.</td><td>5</td></tr>
<tr><td>CO6</td><td>Formulate and construct new models for physical, biological, or social systems based on ODEs.

Design and implement algorithms or computational methods for solving ODEs efficiently and accurately.

Develop novel approaches for analyzing and interpreting solutions to ODEs in specific contexts or applications</td><td>6</td></tr>
</table>

Suggested Pedagogical Processes

- Lecture method: Concepts and operations of sets, Matrix Algebra, Graphs, Trees on Blackboard with examples, problems on sets using Venn diagrams
- ICT supplemented teaching
- Experiential learning
- Case studies
- Problem based learning
- Student seminars
- Group discussions

MTS-263: Differential Equations and Applications (Minor)

Course Contents

Semester IV

Unit No.	Title of Unit and Contents	No. of hours
I	**First order differential equations:** 1.1 Modelling with differential equations 1.2 Direction field and Euler's method 1.3 Separable equations 1.4 Orthogonal trajectories 1.5 Mixing problems 1.6 Models for population growth 1.7 Linear equations and applications to electric circuits 1.8 Predator-Prey systems	10
II	**Second Order Differential Equations:** 2.1 Second Order Linear equations, Initial value problems, linearly independent solutions 2.2 Second order nonhomogeneous equations 2.3 Method of undetermined coefficients 2.4 Method of variation of parameter 2.5 Applications: Vibrating spring, Damped vibrations, Forced vibrations, Electric Circuits 2.6 Series solutions	10
III	**Systems of first order equations:** 3.1 Existence and uniqueness of solution (statement only), Conversion of equation to a system of equations 3.2 Solution of linear systems, homogeneous linear systems with constant coefficients 3.3 Types of critical points and phase portrait for linear and nonlinear systems	10

Learning Resources:

Reference Books	1. James Stewart, Single Variable Calculus, Early Transcendentals (Chapter 9) 2. James Stewart, Multivariable Calculus (Chapter 17) 3. G. F. Simmons, *Differential Equations with Applications and Historical Notes*, CRC Press (Third Edition). 4. James C. Robinson, *In Introduction to Ordinary Differential Equations*, Cambridge University Press. 5. George B. Thomas, *Thomas' Calculus*, Pearson (Fourteenth Edition) 6. Morris Hirsch, Stephen Smale and Robert Devaney, *Differential Equations, Dynamical Systems and An introduction to Chaos*, Elsevier

S. Y. B.Sc. Semester IV		
Title of the Course and Course Code	**Mathematics Practical - 8 (MTS-264) (Minor- Practical)**	**Number of Credits: 02**
1	Modeling with differential equations and direction field	
2	Separable equations and orthogonal trajectories	
3	Mixing problems, Population growth	
4	Linear equations and predator pray system	
5	Solving second order equations, linearly independent solutions	
6	Solving nonhomogeneous equations	
7	Method of undetermined coefficients, variation of parameter	
8	Applications of second order equations	
9	Series solution of differential equations	
10	Solving planar linear system	
11	Critical points and phase portraits	
12	Applications of system of equations	

Semester IV		
MTS-265 – Computational Geometry **Credits - 2**		
Course Outcomes (COs)		
Course Outcome number	**Description** **On completion of the course, the students will be able to:**	**Bloom's Cognitive level**
CO1	Identify basic 2-D and 3-D transformation matrices like Shearing, Scaling reflections, rotations.	1
CO2	Understand the effect of transformations on the points, intersecting lines, parallel lines	2
CO3	Apply different types of projections.	3
CO4	Explain rotation about arbitrary point in 2D and about arbitrary axis in 3D.	4
CO5	Determine reflections through arbitrary lines in 2D and arbitrary planes in 3D.	5
CO6	Develop ability to design and analyze algorithms for solving geometric tasks.	6

MTS- 265: Computational Geometry Course Contents

Semester IV

Unit No.	Title of Unit and Contents	No. of hours
I	**Two Dimensional Transformations** 1.1 Basic 2-D transformations (Scaling, Shearing, Rotation about origin, Reflections) 1.2 Transformation of points, Straight lines 1.3 Solid body transformations 1.4 Concatenation of transformations 1.5 Rotation about arbitrary point 1.6 Reflection through an arbitrary line	**12**
II	**Three Dimensional Transformations** 2.1 Basic 3-D transformations 2.2 Concatenation 2.3 Rotation about an axis parallel to any one of the coordinate axes 2.4 Reflection through a plane parallel to anyone of the coordinate planes 2.5 Rotation about an arbitrary axis 2.6 Reflection through an arbitrary plane	**10**
III	**Projection** 3.1 Introduction 3.2 Orthographic Projections 3.3 Axonometric Projections 3.4 Oblique Projections 3.5 Single point Perspective Projections	**8**

Learning Resources:

1) D.F.Rogers, J.A.Adams,Mathematical elements for Computer Graphics,McGraw Hill Edition.
2) Duncan Marsh, Applied Geometry for Computer Graphics and CAD, Springer Publication, Second Edition.
3) M.E.Mortenson,Computer Graphics Handbook, Industrial Pres Inc.

Semester IV		
MTS-266 – Mathematics Practical- 4 **Credits - 2**		
Course Outcomes (COs)		
Course Outcome number	**Description** **On completion of the course, the students will be able to:**	**Bloom's Cognitive level**
CO1	Show different geometric effects using Python.	1
CO2	Understand 2-D and 3-D transformations.	2
CO3	Apply different types of projections.	3
CO4	Classify the position of a point with respect to line/convex polygon.	4
CO5	Evaluate equispaced points on different plane curves.	5
CO6	Develop ability to design and analyze algorithms for solving geometrictasks.	6

Unit No.	Title of Unit and Contents
1	Generate n- equidistant points on a circle.
2	Generate n- equidistant points on a Ellipse.
3	Generate n- equidistant points on a parabola y = 4 a x^2
4	Generate n- equidistant points on a hyperbola.
5	2 Dimensional transformations
6	3 Dimensional transformations
7	Projections
8	Implementation of 2D and 3D transformations using python-I
9	Implementation of 2D and 3D transformations using python-II
10	Sorting of points with respect to line (using python programming) Sorting of points with respect to convex polygon(using python programming)
11	Finding the pairs of points having shortest mutual distance and maximummutual distance.
12	Find the nearest neighborhood of each point in the given set.
13	Student Activity –I
14	Students Activity – II
15	Students Activity – III

S. Y. B. A. Semester IV		
Title of the Course and Course Code	**Optimization Techniques (MTS-269)**	**Number of Credits : 04**
		Bloom's cognitive level
CO1	Recall and define key decision analysis terms and concepts. Memorize relevant formulas and methods used in decision analysis. Define the basic principles of game theory. Define key terms related to sequencing. Recall the basic steps involved in sequencing.	1
CO2	Explain the principles of decision analysis and their application. Explain the fundamental concepts of game theory, including the different types of games. Explain the concept of sequencing and its importance.	2
CO3	Apply decision analysis techniques to solve practical problems. Demonstrate the application of game theory in real-world scenarios, such as business negotiations, sports strategy, and political decision-making. Solve basic sequencing problems using appropriate techniques.	3
CO4	Critically assess the outcomes of various strategies in different types of games. Break down complex sequencing problems into smaller components.	4
CO5	Assess the effectiveness of different strategies in achieving optimal outcomes in various game situations. Assess the validity and reliability of sequencing solutions.	5
CO6	Construct payoff matrices for strategic decision-making.	6

MTS-269: Optimization Techniques

Course Contents

Semester IV

Unit No.	Title of Unit and Contents	No. of hours
I	**Decision Analysis:** 1.1 Introduction 1.2 Steps of decision making process 1.3 Types of decision making environment 1.4 Decision making under uncertainty	**8**
II	**Game Theory:** 2.1 Introduction 2.2 Two persons zero sum game 2.3 Pure strategies: Games with saddle point 2.4 Mixed strategies: Games without saddle point 2.5 The rules of dominance 2.6 Algebraic solution method games without saddle point 2.7 Graphical solution method games without saddle point	**14**

III	**Sequencing Problem:** 3.1 Introduction 3.2 Notations, Terminology and Assumptions 3.3 Processing n jobs through two machines 3.4 Processing n jobs through three machines	**8**
IV	**Network Models** CPM and PERT, Network representation, Critical Path Computations, Construction of the time schedule, Linear programming formulation of CPM, PERT calculations	**14**
V	**Replacement and Maintenance Models** Introduction, Types of failure, Replacement of items whose efficiency deteriorates with time through three machines	**8**
VI	**Classical Optimization Theory** Unconstrained problems, Necessary and sufficient conditions, Newton Raphson method, Constrained problems, Equality constraints(Lagrangian)	**8**

Learning Resources:

Text Book	1 J. K. Sharma, Operations Research (Theory and Applications, second edition, 2006), Macmillan India Ltd. Chapter 11: 11.1 to 11.4, Chapter 12: 12.1 to 12.6, Chapter 13: 13.1 to 13.6, Chapter 17 17.1, 17.2,17.3 Chapter 20: 20.1 to 20.4, Chapter 23: 23.1,23.2.
Reference Books	1 Hamdy A. Taha, Operation Research (Eighth Edition, 2009), Prentice Hall of India Pvt. Ltd, New Delhi. 2 Frederick S. Hillier, Gerald J. Lieberman, Introduction to Operations Research (Eighth Edition), Tata McGraw-Hill. 3 Hira and Gupta, Operation Research

S. Y. B. Sc. Semester IV		
Title of the Course and Course Code	**Mathematics for Economics and Finance MTS-270 (OE-IV)**	**Number of Credits: 2**
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Recognize and remember terminology specific to mathematical methods in economics.	
CO2	Demonstrate an understanding of the relationship between mathematical models and real-world economic phenomena.	
CO3	Apply mathematical models to analyze economic and financial data.	
CO4	Evaluate the appropriateness of various mathematical models for different economic situations.	
CO5	Evaluate the effectiveness of different mathematical approaches in solving economic and financial problems.	
CO6	Develop and construct mathematical models to represent economic and financial systems.	

MTS-270 Mathematics for Economics and Finance

Course Contents

Semester IV

Unit No.	Title of Unit and Contents	No. of hours
I	**Mathematical models in economics** 1.1 Introduction 1.2 A model of the market 1.3 Market equilibrium 1.4 Excise tax	3
II	**The elements of finance** 2.1 Interest and capital growth 2.2 Income generation 2.3 The interval of compounding	4
III	**The cobweb models** 3.1 How stable is market equilibrium?	4

	3.2 An example 3.3 The general linear case 3.4 Economic interpretation	
IV	**Introduction to optimization** 4.1 Profit maximization 4.2 Critical points 4.3 Optimization in an interval 4.4 Infinite intervals	5
V	**The derivative in economics I** 5.1 Elasticity of demand 5.2 Profit maximization again 5.3 Competition versus monopoly	6
VI	**Linear equations I** 6.1 A two-industry 'economy' 6.2 Linear equations in matrix form 6.3 Solutions of linear equations by row operations 6.4 Arbitrage portfolios and state prices	8

Learning Resources:

Reference Books	**Learning resources:** 1. Martin Anthony and Norman Biggs, Mathematics for economics and finance Methods and modelling, Cambridge University Press (Ch.1,Ch.4, Ch.5, Ch.8, Ch.9, Ch.16, 16.1,16.2,16.3 Ch.17 , 17.4) **References:** 1. Edward Dowling, Introduction to Mathematical Economics, Schaum's Outline Series. 2. Frank Ayres, Mathematics of Finance, Schaum's Outline Series.

S. Y. B.Sc. Semester IV		
Title of the Course and Course Code	**Python - II (MTS-280)** **(VSC- Theory)**	**Number of Credits: 02**
Unit No.	**Title of Unit and Contents**	**No. of hours**
I	**Decision Control Statements Revised** **1.3 Conditional and alternative statements** **1.4 Chained and Nested if, if-else, if-elif-else, nested if, nested if-else**	**6**
II	**Numerical Methods in Python** 2.15 **Roots of Equations** 2.16 **Newton-Rapson Method** 2.17 **False Position Method** 2.18 **Numerical Integration** 2.19 **Trapezoidal Rule** 2.20 **Simpson's 1/3rd Rule** 2.21 **Simpson's 3/8th Rule**	**10**
III	**Linear Algebra** 3.21 **Matrix Construction** 3.22 **Addition, Subtraction, Multiplication of Matrices** 3.23 **Power and Inverse of Matrix** 3.24 **Accessing rows and columns** 3.25 **Deleting and Inserting Rows of Matrix**	**12**

	3.26 **Determinant, Row Echelon Form** 3.27 **Null Space, Column Space, Rank** 3.28 **Solving Systems of Linear Equations** 3.29 **Gauss-Jordan Method** 3.30 **Gauss-Eliminations Method** 3.31 **LU-Decomposition Method** 3.32 **Eigenvalues, Eigenvector's and Diagonalization**	
IV	**Recursive Functions** 4.10 **Factorial of a number** 4.11 **Greatest Common Divisor** 4.12 **Finding Exponents** 4.13 **The Fibonacci Series**	**2**

Learning Resources:

Reference Books	5. Reema Thareja, Python Programming Using Problem Solving Approach, Oxford University Press 6. Allen Downey,Think Python, How to Think Like a Computer Scientist, Green Tea Press Needham, Massachusetts, 2015 7. Robert Johansson, Introduction to Scientific Computing in Python, 2016 8. Hans-PetterHalvorsen,Python for Scientific engineering, 2020 Unit-5: Chapter-31

S. Y. B. Sc. Semester IV (SEC-IV)		
Title of the Course and Course Code	**Linear Algebra for Data Science-II (MTS-290)**	**Number of Credits : 02**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		Bloom's cognitive level
CO1	Recall key properties of matrix addition, subtraction, and scalar multiplication.	1
CO2	Interpret geometrically the solutions to systems of linear equations. Demonstrate an understanding of eigenvectors and eigenvalues in the context of linear transformations.	2
CO3	Apply matrix operations to solve systems of linear equations.	3
CO4	Evaluate the efficiency of different matrix algorithms for solving linear algebra problems. Analyze the impact of singular value decomposition in data compression.	4
CO5	Evaluate the appropriateness of using linear algebra techniques for a given data science problem.	5
CO6	Design and implement a linear algebra-based solution to a complex data manipulation problem. Propose and implement improvements to existing linear algebra algorithms for data processing.	6

MTS-290 Linear Algebra for Data Science-II (SEC-3)

Course Contents

Semester IV

Unit No.	Title of Unit and Contents	No. of hours
I	**The Pseudo-Inverse Matrix, Projections and Regresion:** Least Square Solutions Simple Linear Regression Multiple Linear Regression	4
II	**Determinants:** 2.1 Permutations 2.2 The Determinant 2.3 Determinant and Row Operations 2.4 Minor Matrices and the Determinant 2.5 The Adjoint Matrix 2.6 Cramer's Method for Solving Linear Equations	6
III	**Eigensystem and Diagonalizability:** 3.1 The Characteristic Polynomial 3.2 Left and Right Eigensystem 3.3 Algebraic and Geometric Multiplicities of Eigenvalues 3.4 Similar Matrices and Their Eigensystem 3.5 Bases with Eigenvectors and Diagonalizable Matrices 3.6 The spectral Representation	8
IV	**Symmetric Matrices:** 4.1 Eigensystem and Symmetric Matrices 4.2 Positive Matrices 4.3 Covariance Matrices 4.4 Computing Eigensystem	8
V	**Singular Value Decomposition:** 5.1 Introduction and some preliminaries 5.2 Singular Value Decomposition	4

Learning Resources:

Text Book	1. Moshe Haviv, Linear Algebra for Data Science, World Scientific Publishing Co Pte. Ltd., Singapore. Chapter 7, Chapter 8, Chapter 9, Chapter 10, Chapter 11.
Reference Books	1. Howard Anton, Chris Rorres., Elementary Linear Algebra, John Wiley & Sons, Inc 2. K. Hoffmann and R. Kunze, Linear Algebra, Second Ed. Prentice Hall of India , New Delhi, (1998). 3. G. Strang, Linear Algebra and its Applications, Fourth Ed., Cengage Learning. 4. S. Kumaresan, Linear Algebra A Geometric Approach, Prentice-Hall of India, New Delhi. 5. V. Sahai and V. Bist, Linear Algebra, Narosa. 5. S. Lang, Introduction to Linear Algebra, Second Ed. Springer.

S. Y. B. Sc. Semester IV		
Title of the Course and Course Code	**MS Excel MTS-291 (SEC)**	**Number of Credits: 2**
Course Outcomes (COs) On completion of the course, the students will be able to:		**Bloom's cognitive level**
CO1	Recognize and recall basic Excel functions and formulas.	
CO2	Interpret data presented in Excel spreadsheets.	
CO3	Create charts and graphs to represent data effectively.	
CO4	Analyse data trends and patterns using Excel features like PivotTables and Pivot Charts.	
CO5	Critique the effectiveness of different Excel functions and tools for specific tasks.	
CO6	Develop complex Excel spreadsheets for various purposes, such as budgeting, forecasting, or data tracking.	

MTS-291 MS Excel

Course Contents

Semester IV

Unit No.	Title of Unit and Contents	No. of hours
I	**Entering and editing data** 1.1 Entering and editing text and values 1.2 Entering and editing formulas 1.3 Saving and updating workbooks	2
II	**Modifying a worksheet** 2.1 Moving and copying data 2.2 Moving and copying formulas 2.3 Inserting and deleting ranges, rows, and columns 2.4 Cell comments	2
III	**Using functions** 3.1 Entering functions 3.2 AutoSum 3.3 Other common functions	4
IV	**Formatting Text formatting** 4.1 Row and column formatting 4.2 Number formatting 4.3 Conditional formatting 4.4 Additional formatting options	2
V	**Charts** 5.1 Bar Chart 5.2 Line Chart 5.3 Pie Chart 5.4 Tree Map	4

	5.5 Histogram 5.6 Scatter Plot	
VI	**Subtotal Functions** 6.1 Create an outline and consolidate data 6.2 Create subtotals in a list 6.3 Use multiple subtotal functions- SUBTOTAL, SUMIF 6.4 Create custom views to save different sets of worksheets display and print settings	4
VII	**Range names and Filter date** 7.1 Define and apply cell and range names 7.2 Use names in Formulas 7.3 Filter data based on complex criteria 7.4 Use conditional filters 7.5 Copy filtered results to another range	5
VIII	**Pivot Tables** 8.1 Prepare data in a table format and name the table 8.2 Create a PivotTable for analyzing 8.3 Use the Download Actuals page in Account 8.4 Reconciliation as example 8.5 Modify or re-arrange fields	5
IX	**Selected Functions** 9.1 Using IF and SUMIF functions to calculate a value based on specified criteria 9.2 Use ROUND function to round off numbers 9.3 Use VLOOKUP to find values in worksheet data 9.4 Use HLOOK UP	2

Learning Resources:

Reference Books	**Learning resources:** **Reference Book:** Beginning Excel 2019 by Noreen Brown; Barbara Lave; Hallie Puncochar; Julie Romey; Mary Schatz; Art Schneider; and Diane Shingledecker Open Oregon Educational Resources

Fergusson College
(Autonomous) Pune

Guidelines for

Community Engagement and Social Responsibility
(CESR)

for S.Y.B.A./B.Sc./B.Voc. (NEP)

Introduction:

Higher Educational Institutions (HEIs) can play an important role to achieve the objectives of socio-economic development of New India through their active community engagement. This approach will also contribute to improve the quality of both teaching and research in HEIs as they will develop a better understanding of issues in the society. There is a need to focus on improving societal linkages and enabling students to become socially productive [1].

The goals of 'fostering social responsibility and community engagement' comprise of:

1. Improving the quality of teaching/learning, by bridging the gap between theory and practice through community engagement;
2. Promoting deeper interactions between higher educational institutions and local communities for identification and solution of real-life problems faced by the communities in a spirit of mutual benefit;
3. Facilitating partnerships between local communities and institutions of higher education so that students and teachers can learn from local knowledge and wisdom;
4. Engaging higher education institutions with local communities in order to make curriculum, courses and pedagogies more appropriate to achieve the goals of national development;
5. Catalysing acquisition of values of public service and active citizenship amongst students and youth, which would also encourage, nurture and harness the natural idealism of youth;
6. Undertaking research projects in partnership with local community through community-based research methods.

Forms of Community Engagement

a) **Linking learning with community service**
In this approach, students and teachers apply their knowledge and skills in a chosen community to improve the lives of people in that community. This can be achieved through the model of 'service-learning' (a globally accepted best practice), providing engagement opportunities to students from various disciplines and courses to apply their knowledge to address the challenges of a specific community. For example, students of chemistry can conduct water and soil testing in local areas and share the results with the local community.

b) Linking research with community knowledge
In this approach, various faculties and programmes of HEIs devise joint research projects in partnership with the communities and local agencies. The community's own knowledge is integrated into the design and conduct of the research. New research by students helps them to complete their academic requirements, and at the same time the community's knowledge is systematized. Community-based Participatory Research (CBPR) approaches are gaining recognition in this regard.

Students of engineering, for example, can undertake research in partnership with the community on solid and liquid waste disposal.

c) Knowledge sharing and knowledge mobilization

The knowledge available with students and teachers in various disciplines is made available to the local community to realize its developmental aspirations, secure its entitlements and access its benefits from various agencies and schemes. These can take the forms of enumerations, surveys, awareness camps and campaigns, training, learning manuals/films, maps, study reports, public hearings, policy briefs, cleanliness andhygiene teachings, legal aid clinics, etc. For example, students can undertake a 'swachhtasurvekshana' and/or nutrition survey for mothers and children, and educate them about hygiene and nutrition.

d) Devising new curriculum and courses

Many institutions of higher education develop new curricula in existing courses as well as design new courses to engage with the community. This enriches the curriculum of existing courses through locally-appropriate subject matter. It also creates new, locally appropriate educational programmes that interest a new generation of students. For example, new courses on financial inclusion, entrepreneurship development and nutritional value of local produce can improve knowledge and business opportunities forstudents.

e) Including practitioners as teachers

Local community elders, women leaders, tribals, entrepreneurs and civil society practitioners have enormous practical knowledge of a wide variety of issues—from agriculture and forestry to child-rearing, micro-planning, water-harvesting and project management. This expertise can be tapped by inviting such practitioners to co-teach courses both in the classrooms and in the field. Such instructors should be duly recognized, compensated and respected for their practical experience and knowledge.

f) Social innovations by students

The students can be encouraged to initiate learning projects with a social impact and supported by HEIs. Incubation of such social innovation projects by students can also have meaningful links to existing curriculum and courses. Some competitions for socialinnovation are being organized by some HEIs; they should be integrated into the curriculum.

Community Engagement and Social Responsibility (CESR) Course

The Community Engagement and Social Responsibility course is an immersive and transformative learning experience designed for second-year undergraduate students. In an era where the intersections of diverse disciplines are more critical than ever, this course stands at the forefront of transdisciplinary and multidisciplinary education. As the heartbeat of societal progress, this compulsory course seeks to connect students with their communities, fostering a deep sense of social responsibility. Rooted in the belief that academic knowledge should transcend classroom walls, the aim is to equip students with the tools to analyse, comprehend, and address pressing social issues. Through dynamic and interactive learning methods, students will not only explore the complexities of community dynamics but also actively contribute to the development of sustainable solutions.

General guidelines -

1. The implementation mechanism of CESR Course is to be decided by respective departments.
2. Each department should ensure collaborations/Tie-ups (in terms of MoU/LoI) with relevant industries/organizations/NGOs as per project requirements.
3. Expertise of Local community elders, women leaders, tribals, entrepreneurs and civil society practitioners can be tapped by inviting them to co-teach courses both in the classrooms and in the field. Such instructors should be duly recognized, compensated and respected for their practical experience and knowledge.
4. The CESR course has to implemented ONLY through the department. Students cannot approach to NGOs /Organisations individually for the same. All the communication to the NGOs/Organizations should be done through the department.
5. Departments should maintain the relevant documents (such as attendance records, proposals, CESR diary, MoUs/LoI etc) and correspondence regarding CESR course.

Objectives:

1. CESR Theory

a) To develop an understanding of community needs and challenges.
b) To equip students with skills to identify problem areas within the community.
c) To guide students in creating effective project proposals.
d) To apply classroom knowledge of courses to field realities and thereby improve the quality of learning.

2. CESR Field Work:

a) To provide practical experience in implementing community projects.
b) To assess students' ability to apply theoretical knowledge in real-world situations.
c) To develop skills in project management, teamwork, and communication.

*Course outcomes should be designed at departmental level in alignment with above course objectives

Course structure

MTS-245	Community Engagement Programme	[Credits-2]

- As per the NEP guidelines, the UG students are expected to complete this program in their **third semester** from the academic year 2024-25.
- The academic schedule must be planned by the departments, 1 credit to be allotted to classroom and tutorials (15 hours) and 1 credit to field engagement – students learning hours (30 hours)
- **<u>Classroom Engagement and Field Engagement</u>**:

  2 credits of classroom engagement and field Engagement comprises of followingcomponents:

  - Understanding Community Needs
  - Identifying Project Opportunities
  - Crafting and Finalising Effective Project Proposals
  - Lectures on community sociology and challenges.
  - Case studies and discussions on successful community engagement projects.

MTS-245 Community Engagement Programme (CEP) [Credits-2]	
Community engagement –Basics (1 Credit)	
Topics Covered	**Activities**
Introduction to Community Engagement	- Overview of theories and models - Importance of interdisciplinary approaches
Social Issues Analysis	- Guest lecture by a social scientist or experts from diverse sectors - Group discussion and analysis of contemporary social issues
Community Needs Assessment	- Theory on needs assessment methodologies - Field visit for practical application
Stakeholder Engagement	- Guest lecture from a community organizer - Simulated stakeholder engagement role-play
Community engagement – Field Work (1 Credit)	
Topics Covered	**Activities**
Cultural Competence in Community Work	- Cultural sensitivity training - Case studies on community engagement
Writing Project Proposal and finance resource management	- Develop a community project proposal and finance resource management - Timeline for implementation
Field Work Skills Training	- Training in data collection, interviewing, and observation - Practical exercises in the community
Ethical Considerations in Community Engagement	- Guest lecture on ethical dilemmas in community work - Case studies and group discussions

	Credit	Contact/ learning Hours	Course component
Sem III	1 1	15 hrs. 30 (student learning hrs.)	Classroom engagement and tutorials Field Engagement (Requirement Gathering)

Note: Class engagement: 1 Credit = 1 Hour

For field engagement/ Field Project: 1 Credit = 2 Hours

Evaluation of Classroom Engagement and Field Engagement (Sem. III)

Evaluate each student for 50 marks per semester at department level –

- 20 marks for Continuous evaluation (CE)

- Participation in class activities and discussions.
- Submission of reflective essays.

30 marks for End Semester Examination (ESE)

- Based on evaluation of Project Proposal.

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MTS-295	Field Project (FP)	[Credits-2]

- As per the NEP guidelines, the UG students are expected to complete this program in their **fourth semester** from the academic year 2024-25.
- 2 credits of **Field Project** comprises of the ways of implementing actual field engagement which needs to be determined by respective departments.

	Credit	Student learning Hours	Course component
Sem IV	2	60 hrs.	Exclusively Field Project

Note: For field engagement/ Field Project: 1 Credit = 2 Hours

Please note that the Following table is to be considered as general guideline and can be customised as per department specific needs.

MTS-295 Field Project (FP) [Credits-2]	
Foundations of Field Work (1 credit)	
Topics Covered	**Activities**
Field visits, Field work Reflection and Analysis	- Reflective journals on field experiences - Group presentations
Community Impact Assessment	- Methods for assessing project impact - Group project: Conduct impact assessment in a chosen community
Advanced Field Work (1 credit)	
Topics Covered	**Activities**
Field Work, Project Presentation Review and Integration	- Review of key concepts from previous credits - Integration of community engagement and fieldwork principles - Analysis - Submission of CEP/FP project report

<u>Evaluation consists of two parts:</u>

Evaluate each student for 50 marks per semester at department level –

- 20 marks for Continuous evaluation (CE)
  - Progress report on project implementation. (Field diary)

- 30 marks for End Semester Examination (ESE)
  - Project Report
  - Final presentation of field project findings assessing project outcomes and reflections.

UGC Recommended field-based activities:

1. Interaction with Self Help Groups (SHGs) women members, and study their functions and challenges; planning for their skill-building and livelihood activities;
2. Visit Mahatma Gandhi National. Rural Employment Guarantee Act 2005 (MGNREGS) project sites, interact with beneficiaries and interview functionaries at the work site;
3. Field visit to Swachh Bharat project sites, conduct analysis and initiate problem solving measures;
4. Conduct Mission Antyodaya surveys to support under Gram Panchayat Development Plan (GPDP);

5. Interactive community exercise with local leaders, panchayat functionaries, grass-root officials and local institutions regarding village development plan preparation and resource mobilization;
6. Visit Rural Schools/mid-day meal centers, study academic and infrastructural resources, digital divide and gaps;
7. Participate in Gram Sabha meetings, and study community participation;
8. Associate with Social audit exercises at the Gram Panchayat level, and interact with programme beneficiaries;
9. Visit to local Nagarpalika office and review schemes for urban informal workers and migrants;
10. Attend Parent Teacher Association meetings, and interview school drop outs;
11. Visit local Anganwadi Centre and observe the services being provided;
12. Visit local NGOs, civil society organisations and interact with their staff and beneficiaries;
13. Organize awareness programmes, health camps, Disability camps and cleanliness camps;
14. Conduct soil health test, drinking water analysis, energy use and fuel efficiency surveys and building solar powered village;
15. Raise understanding of people's impacts of climate change, building up community's disaster preparedness;
16. Organize orientation programmes for farmers regarding organic cultivation, rational use of irrigation and fertilizers, promotion of traditional species of crops and plants and awareness against stubble burning;
17. Formation of committees for common property resource management, village pond maintenance and fishing;
18. Identifying the small business ideas (handloom, handicraft, khadi, food products, etc.) for rural areas to make the people self-reliant.
19. Any other Community engagement activity with approval of BOS and Academic Council. (Note that every department can also find CEP allied with their subject.)

Reference

1. **Guidelines on "Fostering Social Responsibility & Community Engagement in HigherEducation Institutions in India 2.0 (https://www.ugc.gov.in/publication/ebook)**