Department of Mathematics

Jaypee Institute of Information Technology, Noida

Semester II

Linear Algebra (19M21MA116)

Vector space, linear combination, linear dependence and independence, basis and dimension, linear transformation, null space and range space, rank-nullity theorem, change of basis, linear functional, eigenvalues and eigenvectors, diagonalisation, invariant subspaces, Jordan canonical representation, norm of a matrix, inner product space, orthogonal and orthonormal vectors, normed space, Gram-Schmidt process for orthogonalisation, quadratic forms.

Course Description

Course Code	**19M21MA116**	**Semester Even**	**Semester II Session-** 2023- 2024 **Month from** Jan 2024-June 2024	
Course Name	Linear Algebra			
Credits	4		**Contact Hours**	3-1-0
Faculty (Names)	**Coordinator(s)**			
	Teacher(s) (Alphabetically)			

COURSE OUTCOMES		**COGNITIVE LEVELS**
After pursuing the above-mentioned course, the students will be able to:		
C120.1	Explain the vector spaces and their properties.	Understanding Level (C2)
C120.2	apply various concepts of the linear transformation.	Applying Level (C3)
C120.3	solve problems related to matrix diagonalization.	Applying Level (C3)
C120.4	analyse inner product spaces and its properties.	Analysing Level (C4)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	Vector spaces	Vector space, subspace, elementary properties of vector spaces, sum of subspaces, linear combination, linear dependence and independence, basis and dimension, ordered bases and coordinates	10
2.	Linear transformation	Basic definitions, null space and range space, rank-nullity theorem, matrix of linear transformation,	10

		change of basis, linear functional, dual spaces, dual basis.	
3.	Canonical forms	Eigenvalues and eigenvectors, eigen space, minimal polynomial, The Cayley-Hamilton theorem, diagonalisation, invariant subspaces, Jordan canonical representation, norm of a matrix, computation of a matrix exponential.	10
4.	Inner product space	Inner product spaces, orthogonal and orthonormal vectors, normed space, Gram-Schmidt process for orthogonalisation, projection theorem, quadratic forms, positive definite forms, adjoint operator, unitary operators, normal operators.	12
		Total number of lectures	**42**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 (Quiz, Assignments, Tutorials)
Total	**100**

Project based learning: Each student in a group of 2-3 will collect literature on canonical forms and inner product space to solve some practical problems. To make the subject application based, the students analyze to deal with afore mentioned topics.

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	**K. Hoffman and R. Kunze,** Linear Algebra 2nd Ed., Prentice Hall of India, 2015.
2.	**V. Krishnamurty, V. P. Mainra and J. L. Arora,** An introduction to Linear Algebra, Affilated East-West, 1976.
3.	**G. Strang,** Linear Algebra and its applications, 4rd Ed., Thomson, 2007.
4.	**H. Anton and C. Rorres,** Elementary linear algebra, 11th Ed., Wiley, 2016**.**
5.	**G. H. Golub and C. F. V Loan,** Matrix Computations, 3rd Ed., Hindustan Book Agency, 2007.

CO-PO-PSO Mapping

	PO1	**PO2**	**PO3**	**PSO1**
C120.1	**2**	**1**	**-**	**2**
C120.2	**3**	**2**	**-**	**2**
C120.3	**3**	**2**	**-**	**2**

C120.4	**3**	**2**	**-**	**2**

Mathematical Statistics (19M21MA211)

Random variables, probability density and cumulative distribution functions, MGF and CF, joint, marginal and conditional distributions, probability distributions, Binomial, Poisson, Uniform, Normal distributions, Sampling theory, random sampling, distribution of sample mean, proportion and variance, property of a good estimation, point estimation, completeness, Factorization theorem, Rao-Blackwell theorem, Cramer-Rao inequality, Maximum likelihood method of estimation and method of moments, confidence intervals, null and alternative hypothesis, type-I and type II errors, testing of hypothesis for goodness of fit, large samples test, ANOVA, Regression.

Course Description

Course Code	**19M21MA211**	**Semester Even**	**Semester II Session-** 2023- 2024 **Month from** Jan 2024-June 2024
Course Name	Mathematical Statistics		
Credits	4	**Contact Hours**	3-1-0
Faculty (Names)	**Coordinator(s)**		
	Teacher(s) (Alphabetically)		

COURSE OUTCOMES		**COGNITIVE LEVELS**
After pursuing the above-mentioned course, the students will be able to:		
CO1	explain random variables and some standard distributions.	Understanding Level (C2)
CO2	apply the concepts of random sampling, parametric point and interval estimation.	Applying Level (C3)
CO3	apply hypothesis testing for goodness of fit and large sample tests.	Applying Level (C3)
CO4	analyze the sample data using ANOVA and regression analysis.	Analyzing Level (C4)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	Random variables and its properties	Discrete and continuous random variables, univariate and bivariate random variables, joint, marginal and conditional distributions, expectation of a random variable, moment generating function (MGF) and characteristic function of a random variable, correlation.	**9**

2.	Probability distributions	Binomial, Poisson, uniform, normal distributions.	**7**
3.	Theory of sampling	Sampling theory, random sampling, distribution of sample mean, variance.	**4**
4.	Point and interval estimation	General concept of estimation, unbiasedness, consistency, efficiency and sufficiency, factorization theorem, completeness, Rao-Blackwell theorem, Cramer-Rao inequality, method of moments, confidence interval.	**9**
5.	Hypothesis testing	Null and alternative hypothesis, type I and type –II error, analysis of discrete data and Chi-square test of goodness of fit, large sample tests.	**5**
6.	Analysis of variance	One way of analysis with equal and unequal sample size, tests for the homogeneity of variances.	**4**
7.	Regression	Simple and multiple linear regression, elementary regression, regression curve and scedastic curves	**4**
		Total number of lectures	**42**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 (Quiz, Assignments, Tutorials)
Total	**100**

Project based learning: Students in small groups will collect sample data set and make simple/multiple linear regression models. They will validate and analyze the model by hypothesis testing and ANOVA. By this student will be able to make simple/multiple linear regression models.

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	**A. M. Mood, F. A. Graybill and D. C. Boes,** Introduction to the theory of statistics, 3rd Indian Ed., Mc Graw Hill, 2001.
2.	**R. V. Hogg and A. T. Craig,** Introduction to mathematical Statistics, Mc-Millan, 1995.
3.	**V. K. Rohatgi,** An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern, 1984.
4.	**S. M. Ross,** A First Course in Probability, 6th edition, Pearson Education Asia, 2002.
5.	**S. Palaniammal,** Probability and Random Processes, PHI Learning Private Limited, 2012.
6.	**P. L. Mayer,** Introductory Probability and Statistical Applications, Addison-Wesley, Second Edition, 1972.
7.	**R. E. Walpole, R H. Myers, S. L. Myers, and K. Ye,** Probability & Statistics for Engineers & Scientists, 9th edition, Pearson Education Limited, 2016.
8.	**I. Miller and M. Miller, John E. Freund's** Mathematical Statistics with Applications, 8th Edition, Pearson Education Limited 2014.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1
CO1	**3**	**2**	**-**	**2**
CO2	**3**	**2**	**-**	**2**
CO3	**3**	**2**	**-**	**2**
CO4	**3**	**2**	**-**	**2**

Functional Analysis (19M21MA119)

Normed space, Banach space and related results, subspace of Banach space, finite dimensional normed space and subspaces, linear operators, bounded and continuous linear operators, principle of uniform boundedness, boundedness and continuity of linear transformations, Hahn-Banach theorem, open mapping theorem, closed graph theorem, Inner product spaces, Schwartz and Minkowski inequalities, Hilbert spaces, relation between Banach and Hilbert spaces, projections, orthonormal basis, Riesz-representation theorem, convex sets, projection theorem, orthogonal and orthonormal systems in Hilbert spaces, characterization of complete orthonormal systems, Banach fixed point theorem and its simple applications.

Course Description

Course Code	**19M21MA119**	**Semester**	**Even**	**Semester II** **Session-** 2023- 2024 **Month from** Jan 2024-June 2024
Course Name	Functional Analysis			
Credits	4	**Contact Hours**	3-1-0	
Faculty (Names)	**Coordinator(s)**			
	Teacher(s) (Alphabetically)			

COURSE OUTCOMES		**COGNITIVE LEVELS**
After pursuing the above-mentioned course, the students will be able to:		
C123.1	explain the concept of normed spaces, Banach spaces and their properties	Understanding Level (C2)
C123.2	apply concepts of Banach space to prove Hahn-Banach theorem, open mapping theorem and closed graph theorem.	Applying Level (C3)
C123.3	explain inner product space, Hilbert spaces, orthonormal basis and Reisz-representation theorem	Understanding Level (C2)
C123.4	develop the concept of orthonormal systems and solve related problems.	Applying Level (C3)

C123.5	examine contraction mapping, Banach fixed point theorem and its simple applications.		Analyzing Level (C4)
Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	Normed spaces and Banach space I	Review of Holder inequality, Minkowski inequality and vector spaces with examples to l_p and L_p spaces, normed space, Banach space, subspace of Banach space.	5
2.	Normed spaces and Banach space II	Finite dimensional normed space and subspaces. Linear operators, bounded and continuous linear operators, their properties and related results.	7
3.	Some fundamental theorems of normed spaces	Principle of uniform boundedness, boundedness and continuity of linear transformations, Hahn-Banach theorem, open mapping theorem, closed graph theorem.	6
4.	Inner Product Spaces and Hilbert spaces 1	Inner product spaces, Schwarz and Minkowski inequalities, Hilbert spaces, relation between Banach and Hilbert spaces, projections, orthonormal basis, Reisz-representation theorem.	8
5.	Inner Product Spaces and Hilbert spaces II	Convex sets, existence and uniqueness of a vector of minimum length, projection theorem, orthogonal and orthonormal systems in Hilbert spaces with examples.	8
6.	Inner product spaces and Hilbert spaces III	Bessel's inequality, Parseval's identity, characterization of complete orthonormal systems.	4
7.	Banach fixed point theorem	Contraction mapping, Banach fixed point theorem and its applications.	4
		Total number of lectures	**42**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 (Quiz, Assignments, Tutorials)
Total	**100**

Project based learning: Each student in a group of 3-4 will apply the concepts of contraction mapping and Banach fixed point theorem to solve related problems.

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)	
1.	**E. Kreyszig**, Introductory Functional Analysis with Applications, John Wiley and Sons, Inc., 2011.
2.	**W. Rudin,** Functional Analysis, Mc-Graw Hill, 1991.
3.	**G. F. Simmons,** Introduction to Topology and Modern Analysis, Tata Mc-Graw Hill Education, New Delhi, 2016.
4.	**A. H. Siddiqi, K. Ahmad and P. Manchanda**, Introduction to Functional Analysis with Applications, Anamaya Publication, New Delhi, 2006.
5.	**L. Debnath and P. Mikusinski**, Introduction to Hilbert spaces with Applications, 3rd Edition, Elsevier, 2005.
6.	**G. Bachman and L. Narici,** Functional Analysis, Academic Press, 1972
7.	**M. T. Nair,** Functional Analysis: A First Course, PHI India, 2004.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1
C123.1	2	1	-	1
C123.2	3	2	-	2
C123.3	2	1	-	1
C123.4	3	2	-	1
C123.5	3	2	-	2

Partial Differential Equations (19M21MA120)

Linear, semi-linear and quasi-linear equations, Cauchy problem, method of characteristics, nonlinear first order PDE's, complete integrals, envelopes and singular solutions, classification of second order equations, Laplace equation, fundamental solutions, maximum principles and mean value formulas, properties of harmonic functions, Green's function, parabolic equations in one space dimension, fundamental solution, maximum principle, wave equation, Duhamel's principle, methods of separation of variables for Laplace, heat and wave equations.

Course Description

Course Code	19M21MA120	Semester Even	Semester II Session- 2023- 2024 Month from Jan 2024-June 2024
Course Name	Partial Differential Equations		
Credits	4	Contact Hours	3- 1- 0

Faculty (Names)	**Coordinator(s)**	
	Teacher(s) (Alphabetically)	

COURSE OUTCOMES		**COGNITIVE LEVELS**
After pursuing the above-mentioned course, the students will be able to:		
C124.1	classify and solve first order linear and nonlinear partial differential equations (PDE).	Applying Level (C3)
C124.2	explain Fourier series and Fourier transforms.	Understanding Level (C2)
C124.3	classify second order PDE and solve Laplace equation in cylindrical and spherical polar coordinates.	Applying Level (C3)
C124.4	solve heat equation in cylindrical and spherical polar coordinates.	Applying Level (C3)
C124.5	solve wave equation using separation of variables.	Applying Level (C3)
C124.6	apply Fourier transforms to solve PDE.	Applying Level (C3)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1	First-order Partial Differential Equations (PDEs)	Formation and classification of first-order PDEs, linear semi-linear and quasi-linear equations, Cauchy problem, method of characteristics, nonlinear first order PDEs, complete integrals, envelopes and singular solutions, discontinuous solutions (shock waves), compatible systems, Lagrange method for first order PDEs, Charpit's method, Jacobi's method for nonlinear PDEs.	10
2	Fourier Series	Introduction to Fourier series, convergence of Fourier series for continuous and piecewise continuous functions, Fourier cosine and sine series, Fourier transform, Fourier sine and cosine transform.	5
3	Second-Order PDEs	Classification of second-order linear partial differential equations into hyperbolic, parabolic and elliptic PDEs, reduction to canonical forms.	3
4	Laplace's Equation	Basic concepts, types of boundary value problems, the maximum and minimum principle, Green's identity and fundamental solution, Green's function, Poisson integral formula, the method of separation of variables, the Dirichlet problem for the rectangle, the	8

		Dirichlet problem for annuli and disk, the exterior Dirichlet problem, solution of Laplace equation in cylindrical and spherical polar coordinates.	
5	Heat Equation	Derivation of the heat equation, maximum and minimum principles, uniqueness, continuous dependence, method of separation of variables, solution of heat equation in cylindrical and spherical polar coordinates.	6
6	Wave Equation	Derivation of the wave equation, infinite string problem, D'Alembert solution of the wave equation, semi-infinite string problem, finite vibrating string problem, method of separation of variables, inhomogeneous wave equation, Duhamel's principle.	7
7	Fourier transform methods for PDEs	Fourier transform methods for heat flow problem in an infinite and semi-infinite rod, Infinite string problem, Laplace equation in a half-plane.	3
		Total number of lectures	**42**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 (Quiz, Assignments, Tutorials)
Total	**100**

Project based learning: Each student in a group of 3-4 will apply the concepts of Laplace's equation, Heat equation, Wave equation to solve some field problems.

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	**Sneddon, I. N.,** Elements of Partial Differential Equations, McGraw Hill, 2013.
2.	**John, F.,** Partial Differential Equations, Springer Verlag, 1982.
3.	**Strauss, W. A.,** Partial Differential Equations: An Introduction, John Wiley, 1992.
4.	**Willams, W. E.,** Partial Differential Equations, Oxford, 1980.
5.	**Evans, L. C.,** Partial Differential Equations, AMS, 1998.
6.	**McOwen, R.,** Partial Differential Equations, Pearson, 2002.
7.	**Powers, D. L.,** Boundary Value Problems and Partial Differential Equations, 5th Ed., Academic Press, 2006.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1
C124.1	**3**	**2**	**-**	**1**
C124.2	**2**	**1**	**-**	**2**
C124.3	**3**	**2**	**-**	**2**
C124.4	**3**	**2**	**-**	**2**
C124.5	**3**	**2**	**-**	**2**
C124.6	**3**	**2**	**-**	**2**

Computer Programming (19M21MA118)

Number system, integer and floating point arithmetic, expressions and operators, conditions and selection statements, looping and control structures, string processing, addresses and pointers, arrays, pointers into arrays, constants, references, structures, functions, parameters, passing by value, passing by reference, passing arguments by constant reference, recursive functions, function overloading and default arguments, classes, access control, class implementation, constructors, destructor, operators overloading, friend functions.

Course Description

Course Code	**19M21MA118**	**Semester Even**	**Semester II Session-** 2023- 2024 **Month from** Jan 2024-June 2024
Course Name	Computer Programming		
Credits	3	**Contact Hours**	3-0-0
Faculty (Names)	**Coordinator(s)**		
	Teacher(s) (Alphabetically)		

COURSE OUTCOMES		**COGNITIVE LEVELS**
After pursuing the above-mentioned course, the students will be able to:		
C122.1	explain representation of numbers in computer programming.	Understanding Level (C2)
C122.2	explain basic concepts of programming.	Understanding Level (C2)
C122.3	apply the concepts of programming through functional decomposition.	Applying Level (C3)
C122.4	construct the pointers for dynamic memory allocation.	Applying Level (C3)

C122.5	apply the object-oriented programming in solving various problems.	Applying Level (C3)

Module No.	Title of the Module	Topics in the Module	No. of Lectures for the module
1.	Basic Computer Fundamentals	Introduction to computer systems; number system, integer, signed integer, fixed and floating-point representations; integer and floating-point arithmetic, expression and operators.	5
2.	Basics of Programming	Input/output; Constants, variables, expressions and operators; Naming conventions and styles; Conditions and selection statements; Looping and control structures (while, for, do-while, break and continue); Arrays; File I/O, header files, string processing; Pre-processor directives.	10
3.	Programming through functional decomposition	Structures; design of functions, void and value returning functions, parameters, scope and lifetime of variables, passing by value, passing by reference, passing arguments by constant reference, recursive functions; Function overloading and default arguments; Library functions.	10
4.	Pointers	Pointers; Dynamic data and pointers, dynamic arrays.	5
5.	Object Oriented Programming Concepts	Data hiding, abstract data types, classes, access control; Class implementation-default constructor, constructors, copy constructor, destructor, operator overloading, friend functions; Object oriented design (an alternative to functional decomposition) inheritance and composition; Dynamic binding and virtual functions; Polymorphism; Dynamic data in classes.	12
		Total number of lectures	**42**

Evaluation Criteria

Components	Maximum Marks
T1	20
T2	20
End Semester Examination	35
TA	25 (Quiz, Assignments, Tutorials)
Total	**100**

Project based learning: A group of 2 to 3 students will be formed. Each group will have a group leader to develop coordination among the group members. Each group will be assigned a project based on programming skills. The group leader of each group will submit a report of 6-7 pages and then finally each member of the group will be evaluated through a viva voce.

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	**Lafore R.,** Object-Oriented Programming in C++. Sams Publishing, 4th edition, 2001.
2.	**Stroustrup, B.,** The C++ Programming Language. Addison-Wesley, 3rd edition, 1997.
3.	**Deitel, H.M. and Deitel, P.J.,** C++ How to Program. Prentice Hall, 8th edition, 2011.
4.	**Schildt, H.,** C++: The Complete Reference. McGraw-Hill, 4th Ed., 2002.
5.	**Lippman, S. B. and Lajoie, J. and Moo, B.E.,** The C++ Primer. Addison-Wesley Professional, 5th Ed., 2012.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1
C122.1	**2**	**1**	**-**	**1**
C122.2	**2**	**1**	**-**	**1**
C122.3	**3**	**2**	**-**	**1**
C122.4	**3**	**2**	**-**	**2**
C122.5	**3**	**2**	**-**	**1**

Computer Programming Lab (19M25MA111)

Number system, integer and floating-point arithmetic, expressions and operators, conditions statements, looping and control structures, string processing, addresses and pointers, arrays, references, structures, functions, recursive functions, function overloading and default arguments, classes, access control, class implementation, constructors, destructor, operators overloading, friend functions.

Course Description

Course Code	**19M25MA111**	**Semester**	**Even**	**Semester II Session-** 2023- 2024 **Month from** Jan 2024-June 2024
Course Name	Computer Programming Lab			
Credits	1	**Contact Hours**	0-0-2	
Faculty (Names)	**Coordinator(s)**			
	Teacher(s) (Alphabetically)			
COURSE OUTCOMES				**COGNITIVE LEVELS**
After pursuing the above-mentioned course, the students will be able to:				

C170.1	explain data types, variables, and arithmetic operators.	Understanding Level (C2)
C170.2	explain basic concepts of conditional statements, loops, structures and to understand the use of arrays.	Understanding Level (C2)
C170.3	apply the concepts of programming through functional decomposition.	Applying Level (C3)
C170.4	describe the usage of the pointers for dynamic memory allocation.	Applying Level (C3)
C170.5	develop the programs using various concepts of object oriented programming	Applying Level (C3)

Module No.	**Title of the Module**	**List of Experiments**	**CO**
1.	Basic Computer Fundamentals	Write programs in C++ to understand the arithmetic operators, logical and relational operators.	C170.1
2.	Basic Programming and Statements	Write programs in C++ for I/O functions and conditional statements like if … else etc.	C170.2
3.	Basic Programming and loops	Write programs in C++ for controlling execution through loops e.g. for, while and do … while etc.	C170.2
4.	Use of loops and statements	Write C++ programs for n!, e^x, sin$x$, log(1+x).	C170.2
5.	Arrays and strings	Write C++ programs using 1D and 2D arrays like Sorting of arrays, Matrix multiplication. Strings.	C170.2
6.	Structures	Write C++ programs of time and distance structures	C170.2
7.	Functions	Write C++ programs using functions for Matrix multiplication, HCF of two numbers, factorial, etc.	C170.3
8.	Functions	Write programs in C++ using call by value, reference, recursive functions, function overloading.	C170.3
9.	Pointers	Write programs in C++ for handling addressing through pointers.	C170.4
10.	Object oriented programming Concepts	Write programs in C++ using OOPs concepts like Object and classes, Constructor, Destructors.	C170.5
11.	Object oriented programming Concepts	Write program of Complex class. Use of Operator overloading, Friend functions.	C170.5
12.	Object oriented programming Concepts	Write programs in C++ showing the application of Inheritance.	C170.5

Evaluation Criteria	
Components	**Maximum Marks**
Lab Test 1	20
Lab Test 2	20
TA	60 (Quiz, Assignments, Tests, Viva)
Total	**100**

Project based learning: A group of 2 to 3 students will be formed. Each group will have a group leader to develop coordination among the group members. Each group will be assigned a project based on its commercial and general applications illustrating the programming skills. The group leader of each group will submit a report of 5-6 pages and then finally each member of the group will be evaluated through a viva voce.

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	**Lafore R.,** Object-Oriented Programming in C++. Sams Publishing, 4th edition, 2001.
2.	**Stroustrup, B.,** The C++ Programming Language. Addison-Wesley, 3rd edition, 1997.
3.	**Deitel, H.M. and Deitel, P.J.,** C++ How to Program. Prentice Hall, 8th edition, 2011.
4.	**Schildt, H.,** C++: The Complete Reference. McGraw-Hill, 4th Ed., 2002.
5.	**Lippman, S. B. and Lajoie, J. and Moo, B.E.,** The C++ Primer. Addison-Wesley Professional, 5th Ed., 2012.

CO-PO-PSO Mapping:

	PO1	**PO2**	**PO3**	**PSO1**
C170.1	**2**	**2**	**-**	**1**
C170.2	**3**	**3**	**-**	**2**
C170.3	**3**	**2**	**-**	**2**
C170.4	**2**	**2**	**-**	**1**
C170.5	**3**	**2**	**-**	**2**

Advanced Matrix Theory (20M22MA211)

Review of Vector spaces, existence and uniqueness of solution for a system of linear equations, LU- decomposition methods, Crout's and DooLittle's methods, Cholesky method, conjugate gradient method, p-norms of a vector, norms of a matrix, condition number, Orthogonal matrices, expansion in terms of orthonormal basis–Fourier series, orthogonal complement, Pythagoras theorem, Eigen values, eigenvectors and their properties, power method, inverse power methods, Q-R algorithm, eigen system of Hermitian matrix, spectral radius,

Gershgorin's theorem, Singular Values and Singular Value Decomposition, Approximation methods of function of matrices, application to solve discrete dynamical system of the type $x(t+1) = Ax(t)$, $x(0) = \alpha$, reduction of an n^{th} order equation.

Course Description

Course Code	**20M22MA211**	**Semester Odd**	**Semester II Session-** 2023- 2024 **Month from** Jan 2024-June 2024
Course Name	Advanced Matrix Theory		
Credits	3	**Contact Hours**	3-0-0
Faculty (Names)	**Coordinator(s)**		
	Teacher(s) (Alphabetically)		

COURSE OUTCOMES		**COGNITIVE LEVELS**
After pursuing the above-mentioned course, the students will be able to:		
CO1	solve the system of linear equations using direct and iterative methods.	Applying Level (C3)
CO2	explain matrix norms, orthogonal complement and apply the revised Gram-Schmidt process in constructing orthonormal basis and Q-R decomposition.	Applying Level (C3)
CO3	construct Gershgorin's circles, quadratic and canonical forms and solve smallest and largest eigenvalue problems, eigen system of Hermitian matrix and singular value decomposition.	Applying Level (C3)
CO4	analyze systems of differential and difference equations arising in dynamical systems using matrix calculus.	Analyzing Level (C4)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	**Linear System of equations**	Existence and uniqueness of solution for a system of linear equations, LU- decomposition methods, Crout's and DooLittle's methods, Cholesky method, conjugate gradient method.	**7**
2.	**Normed and Inner Product Spaces**	*p*-norms of a vector, norms of a matrix, condition number, Orthogonal matrices, QR factorization, expansion in terms of orthonormal basis–Fourier series, orthogonal complement, Pythagoras theorem.	**10**
3.	**Eigen value Problems**	Eigen values and Eigenvectors, spectral radius, Greshgorin's theorem, Power and Inverse power methods eigen system of a Hermitian matrix, Singular Values and Singular Value Decomposition.	**12**

4.	**Matrix Calculus**	Powers and functions of matrices, approximation methods of function of matrices, application to solve discrete dynamical systems $x(t+1) = Ax(t)$, $x(0) = \alpha$ and a system of differential equations of the form $dx/dt = Ax$, $x(0) = \alpha$.	**13**
		Total number of lectures	**42**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 (Quiz, Assignments)
Total	**100**

Project based learning: Each student in a group of 3-4 will apply the concepts of matrix calculus to solve system of differential equations related to some practical problems.

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	**R. Bronson,** Matrix Methods an Introduction, Academic Press, 1991.
2.	**G. H. Golub,** Matrix Computations, 4th Edition, Johns Hopkins University Press, 2013.
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CO-PO-PSO Mapping

	PO1	**PO2**	**PO3**	**PSO1**
CO1	**3**	**2**	**-**	**2**
CO2	**3**	**2**	**-**	**2**
CO3	**3**	**2**	**-**	**2**
CO4	**3**	**2**	**-**	**2**