COURSE STRUCTURE FOR M.Tech (All)														
			M.Tech (All)											
Sr. No.	Course/Lab Code	Course/Lab Name	Teaching Scheme					Examination Scheme						
			L	T	P	C	Hrs/Wk	Theory			Practical		Total
								MS	ES	IA	LW	LE/Viva	Marks
1.	20MA501T	**Advanced Numerical Techniques and Computer Programming**	3	1	0	4	4	25	50	25	--	--	100
2.	20MA 501P	**Advanced Numerical Techniques and Computer Programming Lab**	0	0	2	1	2				50	50	100
3.	20MA502T	**Mathematical Foundation of Cyber Security**	3	1	0	4	4	25	50	25	--	--	100
4.	20MA503T	**Mathematics for Data Science**	3	0	0	3	3	25	50	25	--	--	100
5.	20MA505T	**Numerical Methods and Geostatistics (SPT)**	3	0	0	0	3	25	50	25	--	--	100
6.	20MA504T	**Probability and Statistics for Data Science**	3	1	0	0	4	25	50	25	--	--	100
		Total	**15**	**3**	**2**	**12**	**20**						**600**

IA- Internal Assessment, MS-Mid Semester; ES – End Semester Exam, LW – Lab Work, LE – Lab Examination.

M.Tech. (All Branches of Engineering except Solar, Cyber Security and SPT)

20MA501T					Advanced Numerical Techniques and Computer Programming					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs. / Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand and acquaint the concept of various numerical methods.
- To develop numerical skills in solving problem of engineering interest.
- To enrich the concept of finite element techniques.
- To extract the roots of a polynomial equation.

UNIT 1 EIGEN VALUES/ VECTORS AND INTERPOLATION **10 Hrs.**

Curve fitting, Least square approximations (discrete and continuous data), Introduction to interpolation, Newton Gregory Forward Interpolation Formula, Newton Gregory Backward Interpolation Formula, Central difference interpolation formula, Lagrange's Interpolation Formula for unevenly spaced Formula, Error in interpolation, Newton's Divided Difference Formula, cubic spline interpolation.

UNIT 2 NUMERICAL SOLUTION OF NON-LINEAR EQUATIONS AND POLYNOMIAL **08 Hrs.**

Introduction, Solution of nonlinear simultaneous equations, Descarte's Sign rule, Horner's method, Lin-Bairstow's method, Graeffe's root squaring method, Muller's method, Comparison of various methods.

UNIT 3 NUMERICAL SOLUTION OF ODEs AND PDEs **14 Hrs.**

Mathematical modeling and engineering problem solving, Taylor's method, Euler's method, Runge-Kutta methods of various order, Modified Euler's method, Predictor corrector method: Adam's method, Milne's method. Solution of Boundary value problems using finite differences. Finite difference approximation of partial derivatives, Classification of 2nd order PDEs, different type of boundary conditions, solutions of Elliptic, parabolic and hyperbolic equations of one and two dimensions, Crank- Nicholson method, ADI method.

UNIT 4 INTRODUCTION TO FINITE ELEMENT METHOD **08 Hrs.**

Introduction, Method of Approximation, The Rayleigh-Ritz Method, The Galerkin Method, Application to One dimensional/ two-dimensional problems.

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Apply a suitable numerical technique to extract approximate solution to the problem whose solution cannot be obtained by routine methods.

CO2 – Analyze the accuracy of numerical methods by estimating error.

CO3 – Analyze / interpret the achieved numerical solution of problems by reproducing it in graphical or tabular form.

CO4 – Evaluate a polynomial on which operations like division, differentiation and integration can be done smoothly from the data generated by performing an experiment or by an empirical formula.

CO5 – Evaluate a sufficiently accurate solution of various physical models of science as well as engineering interest whose governing equations can be approximated by linear/nonlinear ODEs or PDEs or system of ODEs or PDEs.

CO6 – Design /develop an appropriate numerical algorithm for various problems of science and engineering.

TEXT/REFERENCE BOOKS

1. B.S. Grewal, Numerical Methods in Engineering and Science with Programs in C & C++, Khanna Publishers, 2010.
2. S.S. Sastry, Introductory Methods for Numerical Analysis, 4th ed. Prentice Hall of India, 2009.
3. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 5th ed., New Age International, 2007.
4. C F Gerald and P O Wheatley, Applied Numerical analysis, 7th ed., Pearson education, 2003.
5. Erwin Kreyszig, Advanced Engineering Mathematics, 9th ed., Wiley publication, 2005.
6. R.K. Jain & S.R.K. Iyengar, Advanced Engineering Mathematics, 3rd ed. Narosa, 2002.

20MA 501P					ADVANCED NUMERICAL TECHNIQUES AND COMPUTER PROGRAMMING LAB					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs. / Week	Theory			Practical		Total
					MS	ES	IA	LW	LE/Viva	Marks
0	0	2	1	2	---	---	---	50	50	100

Computer program (in MATLAB) of following topics/methods will be discussed and executed in the lab.

1. Curve fitting,
2. Newton Gregory Forward Interpolation Formula,
3. Newton Gregory Backward Interpolation Formula,
4. Lagrange’s Interpolation Formula for unevenly spaced Formula,
5. Newton’s Divided Difference Formula, cubic spline interpolation.
6. Graeffe’s root squaring method,
7. Euler’s method,
8. Runge-Kutta methods,
9. Modified Euler’s method,
10. Predictor corrector method: Adam’s method, Milne’s method.
11. Solution of Boundary value problems using finite differences.
12. Solution of tridiagonal system,
13. Solution of elliptic, parabolic and hyperbolic equations of one and two dimensions

20MA502T					Mathematical Foundation of Cyber Security					
Teaching Scheme										
L	T	P	C	Hrs. / Week	Theory			Practical		Total
					MS	ES	IA	LW	LE/Viva	Marks
3	1	0	4	4	25	50	25	--		100

COURSE OBJECTIVES

- To provide fundamental concept of abstract algebra.
- To study basic concepts of set theory and binary operations.
- To study different operations on algebraic structure.
- To study advanced number theory concepts

UNIT 1 GROUP THEORY **10 Hrs.**

Introduction to Set Theory, Binary Operations on Sets, Equivalence Relations, Introduction to Groups, Subgroups, Cyclic Groups, dihedral groups , Permutation Groups, , cosets, Lagrange's theorem, Normal Subgroups, Quotient Groups, Isomorphisms, Homomorphisms

UNIT 2 RINGS AND FIELDS **10 Hrs.**

Definition and basic concepts in rings, examples and basic properties, zero divisors, integral domains, fields, characteristic of a ring, quotient field of an integral domain, subrings, ideals, maximal ideal, prime ideal, quotient rings. Euclidean domains, Polynomials, prime, irreducible elements and their properties. Eisensteins irreducibility criterion and Gauss's lemma.

UNIT 3 ELEMENTARY NUMBER THEORY **12 Hrs.**

The division algorithm, Divisibility and the Euclidean algorithm, The fundamental theorem of arithmetic, Modular arithmetic and basic properties of congruences; Principles of mathematical induction and well ordering principle. Primality Testing algorithms, Chinese Remainder Theorem, Quadratic Congruence

UNIT 4 ADVANCED NUMBER THEORY **08 Hrs.**

Advanced Number Theory – Primality Testing algorithms, Chinese Remainder Theorem, Quadratic Congruence, Discrete Logarithm, Factorization Methods, Side Channel Attacks, Shannon Theory, Perfect Secrecy, Semantic Security.

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Define the concepts related to the basics of set theory and binary operations.
CO2 - Demonstrate knowledge and understanding of groups, subgroups, and order of an element in finite groups.
CO3 - Develop understanding of algebraic structure ring, and field.
CO4 - Discover different operations on algebraic structure.
CO5 - Choose appropriate algebraic structure for cryptographic operation.
CO6 - Develop understanding of use of algebraic structure in number theory algorithms.

TEXT/REFERENCE BOOKS

1. D.S. Dummit and R.M. Foote, "Abstract Algebra", John Wiley
2. Michael Artin, "Algebra", Pearson Education.
3. J.A. Gallian, "Contemporary Abstract Algebra", Narosa Publishing House.
4. I. N. Herstein, "Topics in Algebra", Wiley.
5. N. Jacobson, "Basic Algebra I", Hindustan Publishing Company.
6. William Stallings, "Cryptography and Network Security Principles and Practice", Pearson Education.

20MA503T					Mathematics for Data Science					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To be acquainted with computational techniques required for performing operations in Data Science.
- To gain advanced algebraic skills essential for Data Science.
- To acquire mathematical understanding of linear systems.
- To formulate and solve problems and present solutions for Data Science applications.

Unit 1 MATRICES AND BASIC OPERATIONS 10 Hrs.

Matrices and Basic Operations, interpretation of matrices as linear mappings, and some examples, Properties of determinants, singular and non-singular matrices, examples, finding an inverse matrix, The Range and the Null space of a Matrix, Characteristic Polynomial, Definition of Left/right Eigenvalues and Eigenvectors, Interpretation of eigenvalues/vectors, Caley-Hamilton theorem, Quadratic forms.

Unit 2 NORMED SPACES, VECTOR SPACES AND MATRIX TRANSFORMATIONS 10 Hrs.

Definition of complete normed and vector spaces and some examples. Matrix norms and properties, - Definition and basic properties, Orthogonality, Orthogonal transformations, Gram-Schmidt algorithm, Singular Value Decomposition: Principal Component Analysis, Gaussian elimination, LU and QR factorization, Definition of positive-definiteness and the role of the eigenvalues, Eigenvalue problems in dimensionality reduction.

Unit 3 LINEAR SYSTEMS 10 Hrs.

Definition, applications, solving linear systems, linear inequalities, linear programming, Real-valued functions of two or more variables, Analysis elements: Distance, Limits, continuity, differentiability, the gradient and the Hessian.

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Unit 4 OPTIMIZATION PROBLEMS 10 Hrs.

Motivation, the role of the Hessian, maxima and minima and related extrema conditions, Elements of Convex Optimization Functions of n variables. Convex sets, convex functions, convex problems, and their basic properties. Examples of convex problems, convexity versus non-convexity, Why We Need Gradient Descent, Convergence of Gradient Descent, The Divergence Problem, Bivariate Optimization, Multivariate Optimization

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Interpret existence and uniqueness of solutions using matrix algebra.

CO2 - Apply equivalent forms to identify matrices and solve linear systems.

CO3 - Apply basic properties of subspaces and vector spaces.

CO4 - Compute the orthogonal projection of a vector onto a subspace, given a basis for the subspace.

CO5 - Critically analyze and construct mathematical arguments that relate to the study of introductory linear algebra.

CO6 - Apply optimization methods and algorithms developed for solving various types of optimization problem.

TEXT/REFERENCE BOOKS

1. Lloyd N. Trefethen and David Bau, “Numerical Linear Algebra” III, SIAM, Philadelphia, ISBN 0-89871-361-7
2. Charu C. Agarwal, Linear Algebra & Optimization for Machine Leaning, Springer, 2020.
3. Gilbert Strang, Linear Algebra and Its Applications, Thomson/Brooks Cole
4. Stephen Boyd, Lieven Vandenberghe , Introduction to Applied Linear Algebra, Cambridge University press, 2018.

20MA504T					Numerical Methods and Geostatistics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs. / Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand and acquaint the concept of various numerical methods.
- To develop numerical skills in solving problem of engineering interest.
- To enrich the concept of geostatistics
- To extract the applications of geostatistics in petroleum exploration techniques

UNIT 1 INTERPOLATION, SIMULTENOUSE LINEAR EUQATIONS 10 Hrs.

Interpolation by polynomials, divided differences, error of the interpolating polynomial, piecewise linear and cubic spline interpolation. Numerical integration, composite rules, error formulae. Solution of a system of linear equations, implementation of Gaussian elimination and Gauss-seidel methods, partial pivoting, row echelon form, LU factorization Cholesky's method, ill-conditioning, norms.

UNIT 2 NUMERICAL SOLUTION OF ODE AND PDE 14 Hrs.

Solution of a nonlinear equation, bisection and secant methods. Newton's method, rate of convergence, solution of a system of nonlinear equations, numerical solution of ordinary differential equations, Euler and Runge-Kutta methods, multi-step methods, predictorcorrector methods, order of convergence, finite difference methods, numerical solutions of elliptic, parabolic, and hyperbolic partial differential equations. Eigenvalue problem, power method, QR method, Gershgorin's theorem. Exposure to software packages like IMSL subroutines, MATLAB.

UNIT 3 INTRODUCTION OF GEOSTATISTICS AND PROBABILITY THEORY 08 Hrs.

Introduction to Geostatistics , Probability Theory review, Spatial Analysis, Variogram Modelling, Estimation (Global and Local).

UNIT 4 INTRODUCTION TO FINITE ELEMENT METHOD 08 Hrs.

Cross validation, Estimators (Simple kriging, Indicator kirging, Block kriging); Geostatistical simulation (Cholesky decomposition, conditional simulation, sequential gaussian simulation- SGS)

40Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Apply a suitable numerical technique to extract approximate solution to the problem whose solution cannot be obtained by routine methods.
CO2 – Analyze the accuracy of numerical methods by estimating error.
CO3 – Analyze / interpret the achieved numerical solution of problems by reproducing it in graphical or tabular form.
CO4 – Evaluate a basic theory of geostatistics and probability theory
CO5 – Evaluate a sufficiently accurate solution of various physical models of science as well as engineering interest whose governing equations can be approximated by linear/nonlinear ODEs or PDEs or system of ODEs or PDEs.
CO6 – Design /develop an appropriate geostatistical model and simulation

TEXT/REFERENCE BOOKS

1. B.S. Grewal, Numerical Methods in Engineering and Science with Programs in C & C++, Khanna Publishers, 2010.
2. S.S. Sastry, Introductory Methods for Numerical Analysis, 4th ed. Prentice Hall of India, 2009.
3. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 5th ed., New Age International, 2007.
4. C F Gerald and P O Wheatley, Applied Numerical analysis, 7th ed., Pearson education, 2003.
5. Erwin Kreyszig, Advanced Engineering Mathematics, 9th ed., Wiley publication, 2005.
6. R.K. Jain & S.R.K. Iyengar, Advanced Engineering Mathematics, 3rd ed. Narosa, 2002.
7. **S**. D. Conte and Carl de Boor, Elementary Numerical Analysis- An Algorithmic Approach (3rd Edition), McGraw-Hill, 1980.
8. C. E. Froberg, Introduction to Numerical Analysis (2nd Edition),Addison-Wesley, 1981
9. E. Kreyszig, Advanced engineering mathematics (8th Edition), John Wiley (1999)

<table>
<tr><td colspan="5">20MA504T</td><td colspan="6">Probability & Statistics for Data Science</td></tr>
<tr><td colspan="5">Teaching Scheme</td><td colspan="6">Examination Scheme</td></tr>
<tr><td rowspan="2">L</td><td rowspan="2">T</td><td rowspan="2">P</td><td rowspan="2">C</td><td rowspan="2">Hrs/Week</td><td colspan="3">Theory</td><td colspan="2">Practical</td><td rowspan="2">Total Marks</td></tr>
<tr><td>MS</td><td>ES</td><td>IA</td><td>LW</td><td>LE/Viva</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td><td>25</td><td>50</td><td>25</td><td>---</td><td>---</td><td>100</td></tr>
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COURSE OBJECTIVES

- Identify the independent and dependent variables in a research problem.
- To equip students with consequently requisite quantitative skills that they can employ and build on in flexible ways
- To identify the concept of estimation of parameter.
- To apply the hypothesis test and t, F and Chi square test to real world problems

Unit 1 PROBABILITY THEORY & RANDOM VARIABLES 10 Hrs.

Basics: sample space, outcomes, probability, Events: mutually exclusive, independent, Calculating probability: sets, counting, tree diagram, Conditional probability, Law of total probability, Bayes' theorem

Random variables: Overview and Discrete RVs, Discrete and Continuous RVs, Mean, Moments, Variance pmf, pdf, cdf, Discrete RVs: Bernoulli, Binomial, Geometric, Indicator, Uniform (a, b), Exponential(λ), Normal (μ, σ2), and its several properties

Unit 2 PROBABILITY DISTRIBUTIONS & MARKOV CHAINS 10 Hrs.

Joint distributions & conditioning, Joint probability distribution, Linearity and product of expectation, Conditional expectation, Probability Inequalities: Weak Law of Large Numbers, Central Limit Theorem, Markov chains, Stochastic processes, Setting up Markov chains, Balance equations

UNIT 3 PARAMETRIC & NON-PARAMETRIC INFERENCES 10 Hrs.

Basics of inference, Empirical PMF, Sample mean, bias, se, MSE, Empirical Distribution Function (or eCDF)

Kernel Density Estimation (KDE), Statistical Functionals, Plug-in estimator, Confidence intervals-Percentiles, quantiles, Normal-based confidence intervals, DKW inequality, Parametric inference: Consistency, Asymptotic Normality, Basics of parametric inference, Method of Moments Estimator (MME), Properties of MME, Basics of MLE, Maximum Likelihood Estimator (MLE), Properties of MLE

UNIT 4 HYPOTHESES TESTING & REGRESSION 10 Hrs.

Basics of hypothesis testing , Wald Test, Type I and Type II errors , Z-test, t-test, ANOVA, Kolmogorov-Smirnov test (KS test), p-values, permutation test, Pearson correlation coefficient, Chi-square test for independence, Bayesian reasoning & inference, Simple Linear Regression , Multiple Linear Regression

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Understand theoretical foundations of probability theory and mathematical statistics

CO2 - Understand the concepts of various parameter estimation methods, like method of moments, maximum likelihood estimation and confidence intervals.

CO3 - Apply the central limit theorem to sampling distribution.

CO4 - Identify the appropriate hypothesis testing procedure based on type of outcome variable and number of samples

CO5 - Analyze hypotheses tests of means, proportions and variances using both one-and two-sample data sets.

CO6 - Implement basic simulation methods using statistical software to investigate sampling distributions.

TEXT/REFERENCE BOOKS

1. Wasserman, Larry, “All of Statistics: A Concise Course in Statistical Inference” Springer, 2004.
2. S.M. Ross, Introduction to Probability Models, Academic Press
3. Miller & Freund’ Probability and statistics for engineers, ninth edition, Richard a. Johnson, Pearson.
4. Devore. J.L., “Probability and Statistics for Engineering and the Sciences”, Cengage Learning, New Delhi, 8th Edition, 2012.
5. S.M. Ross, Stochastic Processes, Wiley