Computational Mathematics

BS Computational Mathematics

Department of Mathematics
University of Karachi

Four year Degree Program of

Computational Mathematics

BS

(Computational Mathematics)

DEPARTMENT OF MATHEMATICS
UNIVERSITY OF KARACHI

Program overview

Mathematics pervades several applications in a variety of business and industries as well as government sector. Various sophisticated mathematical tools are increasingly utilized to develop new models, modify existing ones, and analyze system performance. This includes applications of mathematics to problems in management science, biology, portfolio planning, facilities planning, control of dynamic systems, and design of composite materials. The goal is to find computable solutions to real-world problems arising from these types of situations.

The fouryear degree in computational mathematics provides students with the capability to apply mathematical models and methods to study various problems that arise in industry and business, with an emphasis on developing computable solutions that can be implemented. This program trained students in mathematical modeling, scientific computing, and advanced computational algorithms. Many prestigious universities all over the world offer this degree program such as:

- *Stanford University*
- *Johns Hopkins University*
- *University of Derby*
- *University of Notre Dame*
- *University of Heriot-Watt etc.*

Student Learning Outcomes

- Our student learning outcomes are focus around knowledge areas, skills, and attitudes. Students must acquire both a conceptual and operational understanding of computational techniques, discrete mathematics, optimization, statistics and computational biological/chemical/social sciences etc.

- Students will become proficient in the following skills and attitudes:

    - Effective use of non-classroom resources to gain knowledge
    - Precision and clarity in the oral and written communication of mathematical ideas
    - Capable of design different computer programs
    - Effectiveness in reasoning with and between concrete and abstract ideas

- During coursework and research, students are expected to cultivate mathematical skills and knowledge. They may able to understand the dynamic role of mathematics in science, society, and history and create possible interrelations among various areas of mathematics.

Eligibility: Intermediate(Pre-Engineering)

Total Credit Hours: 126

Minimum CGPR Qualification: 2.20

DEPARTMENT OF MATHEMATICS
UNIVERSITY OF KARACHI
Module of BS Computational Mathematics

SEMESTER I			SEMESTER II		
300.1	Compulsory	3+0	300.2	Compulsory	3+0
CM-301	Algebra	3+0	CM-302	Calculus	3+0
CM-303	Number Theory	3+0	CM-304	Discrete Mathematics	3+0
	Subsidiary-I			Subsidiary-I	
	Subsidiary-II			Subsidiary-II	

SEMESTER III			SEMESTER IV		
400.1	Compulsory	3+0	400.2	Compulsory	3+0
CM-401	Multivariable Calculus and Geometry	3+0	CM-402	Mechanics	3+0
CM-403	Tensors and Fourier Analysis	3+0	CM-404	Set Topology	3+0
CM 405	Functional Biology-I	3+0	CM 406	Functional Biology-II	3+0
	Subsidiary-I			Subsidiary-I	
	Subsidiary-II			Subsidiary-II	

SEMESTER V			SEMESTER VI		
CM–501	Mathematical Analysis	3+0	CM-502	Functional Analysis	3+0
CM–503	Linear Algebra	3+0	CM-504	Probability & Statistics	3+0
CM–505	Differential Equations	3+0	CM-506	Numerical Analysis	3+0
CM–507	Fluid Dynamics-I	3+0	CM-508	Fluid Dynamics-II	3+0
CM–509	Programming Language-I	2+1	CM-510	Programming Language-II	2+1

SEMESTER VII			SEMESTER VIII		
CM-601	Advanced Partial Differential Equations	3+0	CM-602	Integral Equations	3+0
CM-603	Advanced Numerical Analysis	3+0	CM-604	Stochastic Process	3+0
CM-605	Modelling & Simulation	3+0	CM-606	Wavelets	3+0
CM-607	Software Applications-I	2+1	CM-608	Software Applications-II	2+1
	Optional-I			Optional-II	

Optional Courses

Optional Courses for Seventh Semester

			Credit Hours
1.	CM – 609	Perturbation Methods – I	3 + 0
2.	CM – 611	Fractional Calculus – I	3 + 0
3.	CM – 613	Boundary Layer Theory– I	3 + 0
4.	CM – 615	Fuzzy Mathematics – I	3 + 0
5.	CM – 617	Graph Theory & Applications – I	2 + 1
6.	CM – 619	Bioinformatics	2 + 1
7.	CM – 621	Computational Finance	2 + 1
8.	CM – 623	Operations Research – I	2 + 1
9.	CM – 625	Computational Fluid Dynamics – I	2 + 1
10	CM – 627	Numerical Linear Algebra – I	2 + 1

Optional Courses for Eight Semester			Credit Hours
1.	CM – 610	Perturbation Methods – II	3 + 0
2.	CM – 612	Fractional Calculus – II	3 + 0
3.	CM – 614	Boundary Layer Theory – II	3 + 0
4.	CM – 616	Fuzzy Mathematics – II	3 + 0
5.	CM – 618	Graph Theory & Applications – II	2 + 1
6.	CM – 620	Cryptography	2 + 1
7.	CM – 622	Data Mining	2 + 1
8.	CM – 624	Operations Research – II	2 + 1
9.	CM – 626	Computational Fluid Dynamics –II	2 + 1
10.	CM – 628	Numerical Linear Algebra – II	2 + 1

(Computational Mathematics)

First Year

SEMESTER I			SEMESTER II		
300.1	**Compulsory**	**3+0**	**300.2**	**Compulsory**	**3+0**
CM-301	**Algebra**	**3+0**	**CM-302**	**Calculus**	**3+0**
CM-303	**Number Theory**	**3+0**	**CM-304**	**Discrete Mathematics**	**3+0**
	Subsidiary-I	**3+0**		**Subsidiary-I**	**3+0**
	Subsidiary-II	**3+0**		**Subsidiary-II**	**3+0**

First Semester

CM-301 Algebra(3 + 0)

Complex Numbers: Complex number representation in Cartesian and polar coordinates, Trigonometric Form, Polar Coordinates and Graphs, De-Moivers Theorem and its applications, Hyperbolic and inverse functions.

Group Theory: Groups and their properties, subgroups, order of a group, cyclic groups, cosets, Lagrange's theorem, permutation groups, rings, fields.

Matrices and Determinants: Elementary row operations, echelon and reduced echelon forms, inverse, rank and normal form of a matrix, matrix of linear transformation, partitioning of a matrix, system of linear equations, Gaussian methods, Axiomatic definition of a determinant, determinant as sum of product of elements, Adjoint and inverse of a matrix.

Linear Programming: Introduction of Linear Programming (LP), LP and allocation of resources, Graphical Linear Programming – Minimization solution, Linear Programming – Simplex Method for Maximizing.

Equations: Solutions of cubic and biquadratic equations, numerical solution of equations, Newton-Raphson, Regula-falsi and bisection methods.

Recommended Books:

01. Jain, R. K. and Lyengar, S.R.K., Advanced Engineering Mathematics, Narosa Publishing House, New Delhi,3rdEdition, 2007.
02. Kreyszig, E., Advanced Engineering Mathematics, John Wiley & Sons Pte Ltd, Singapore, 9thEdition 2005.
03. Lay, David C., Linear Algebra and its Application, Addison-Wesley, 4th Edition, 2012.
04. Mathews, J. H. and Howell, R. W., Complex Analysis for Mathematics and Engineering, Jones and Bartlett Publishers, Boston, 5thEdition 2006.
05. O'Neil, P. V., Advanced Engineering Mathematics,Cengage learning,5thEdition, 2003

CM-303 Number Theory(3+0)

Introduction to Set theory operations with fundamental concepts, Divisibility, Linear Diophantine Equations, Unique Factorization, Applications of Unique Factorization, Congruences, Fermat, Euler, Wilson, Cryptographic Applications, Order and Primitive Roots, More Cryptographic Applications, Quadratic Reciprocity, Primality and Factorization, Sums of Squares, Arithmetic Functions, Continued Fractions, Recent Developments.

Prime Factorization, The Sequence of Prime Numbers, The Ring of Integers Modulo n, Congruences Modulo n, The Chinese Remainder theorem, Primality testing, Public key cryptosystem, The RSA cryptosystem, Continued fraction system, Finite continued fractions, The continued fractions of exponent (e).

Recommended Books:

01. Boulagouaz M., Tignol J-P, Algebra and Number Theory, Chapman and Hall/CRC, 1st Edition, 1999.
02. G. H. Hardy and E. M. Wright, An Introduction to the Theory of Numbers Oxford University Press, 2008.
03. Kraft JS, Washington LC, Elementary Number Theory, Chapman and Hall/CRC, 1st Edition, 2014.
04. Stein William, Elementary Number Theory: Primes, congruence and Secrets, Springer, 2008.
05. Anthony Vazzana, Martin Erickson,David Garth, Introduction to Number Theory, Chapman and Hall/CRC, 1st Edition,2007.

CM-302 Calculus(3 + 0)

Limits & Continuity: Limits, Continuity, Tangent lines & Rate of Change
Sequence and Series: Sequence and Their Divergence and Convergence Test, Introduction to Infinite Series, Taylor and Maclaurin Series.

Convergence and Divergence Test for Series: Limit comparison test, Ratio test, Root test.

Derivatives: Techniques of differentiation, Chain rule and implicit differentiation, derivatives of Inverse functions, hyperbolic functions, inverse trigonometric & hyperbolic functions, Applications of differentiation, Maxima and Minima of a function of single variable, Marginal analysis and approximations using increments, Indeterminate forms and L' Hospital Rule.

The Integral: Riemann integral, Integration techniques, Integration by substitution, differentiation & integration of logarithmic & exponential function, Integrals of inverse trigonometric & hyperbolic function, Integration of Power of sine, cosine, secant and tangent, by parts, trigonometric substitution, Improper integrals, Beta and gamma integrals.

Differential Equations: Differential equations, formation and solution, equations of first order, initial and boundary value problems, various methods of solving first order differential equations: Separable, Exact & Homogeneous equation, integration factor and orthogonal trajectories. Non-Linear First Order Equations, Envelopes and Singular solutions

Recommended Books:

01. Hoffmann K, Calculus for Business, Economics and the social and the life sciences, McGraw Hill, 10thEdition, 2007.
02. Anton, H. and C. Rorres, Calculus, Wiley (7thEdition), 2001.
03. Kreyszig, E., Advanced Engineering Mathematics, John Wiley, 9thEdition, 2005.
04. Morris Tenenbaum, Harry Pollard, Ordinary Differential Equations, Dover Publications, Incorporated, 2012.
05. Thomas, G. B. and R. L. Finney, Calculus and Analytic Geometry, Addision Wesley Publishing Company, 2005.

CM-304 Discrete Mathematics (3+0)

Computer codes and Number system: Number systems, binary, octal and hexadecimal system. 4 bit, 6 bit and 8 bit BCD codes. Zone decimal and packed decimal formats.Computer arithmetic, errors. Logic, Truth tables: Conjunction, disjunction, negation, propositions and truth tables, tautologies and contradictions, logical equivalence, algebra and propositions, conditional and biconditional statements, logical implication. Algorithms, flowcharts, pseudocode, and programs: Computer programs variables, constants, flowcharts and their language. Loops, initialization counters, accumulators, DO loops pseudocode programs. Boolean algebra, Logic gates: Boolean algebra, duality, basic theorems, Order and Boolean algebra. Boolean expressions, sum of product form. Logic gates, logic circuits, Minimal Boolean expressions, combinatorial analysis, Graph Theory: Graphs and multi graphs, Degree of a vertex, deterministic and non-deterministic automata

Recommended Books:

01. Bogart K., et al., Discrete Math for Computer Science Students, Kenneth Bogart P, Scot Drysdale, and Cliff Stein, 2004.
02. Rosen, K H, Discrete Mathematics and its Applications, AT and T Laboratories, 2014.New Jersey, Mc Graw Hill, 7th Edition , 2001.
03. Garding and Tambour, Algebra and Switching Circuits, Mc Graw Hill 1988.
04. Lennox, S. C., Chadwick, M., Computer Mathematics for Applied Scientists,Heinemann Educational Books Ltd., London,2nd Edition 1985.
05. Epp S S, Discrete mathematics with applications, Cengage learning, 2010.

Second Year

SEMESTER III			SEMESTER IV		
400.1	**Compulsory**	**3+0**	**400.2**	**Compulsory**	**3+0**
CM-401	**Multivariable Calculus and Geometry**	**3+0**	**CM-402**	**Mechanics**	**3+0**
CM-403	**Tensors and Fourier Analysis**	**3+0**	**CM-404**	**Set Topology**	**3+0**
CM 405	**Functional Biology-I**	**3+0**	**CM 406**	**Functional Biology-II**	**3+0**
	Subsidiary-I			**Subsidiary-I**	
	Subsidiary-II			**Subsidiary-II**	

Third Semester

CM-401 Multivariable Calculus and Geometry (3 + 0)

Polar Coordinates: Polar Coordinate & Sketching the graph of polar coordinates, Slope of tangent line and arc length for parametric and polar curve, Area in polar Coordinates.

Introduction to Vectors, Line and Plane: Product of vectors, Projection of vectors, Parametric equation of line, Plane in three spaces, Quadratic surfaces, Cylindrical & Spherical coordinate.

Derivatives of function of two variables: Partial derivative, Tangent plane, Euler's theorem with applications, Total differential for function of two variables, Directionalderivatives and gradient for function of two variables, Maxima and minima for the function of two variablesand Jacobians.

The Integral: Introduction of double and triple integrals and their application.

Recommended Books:

Dineen S, Multivariate calculus and geometry,Springer,2001.
Walschap, G.,Multivariable calculus and differential geometry, Walter de Gruyter GmbH & Co KG, 2015.
Larson, R. and B. H. Edwards.,Multivariable calculus, Cengage Learning, 2013.
Marsden, J. E., et al., Basic multivariable calculus,Springer, 1993.
Lax, P. D. and M. S. Terrell., Multivariable calculus with applications, Springer, 2017.

CM-403 Tensors and Fourier Analysis (3 + 0)

Tensors: Curvilinear Coordinate System, Determinants, Affine Tensors, Orthogonal Transformations in E_3, Affine Vectors, Tensor Calculus on manifolds, Repeated Covariant Differentiation, Rank of Tensor, Christofell symbols, Tensors in Physics.

Fourier series: Periodic function, Harmonics, periodic extensions, even and odd functions. Fourier coefficients, Criterion for the convergence of Fourier Series, Expansion of functions in Fourier series, Functions with arbitrary periods. Fourier sine and cosine series, Orthogonal System, Fourier Series with respect to orthogonal system, Fourier Transformation with applications.

Recommended Books:

Itskov M., Tensor Algebra and Tensor Analysis for Engineers withApplications to Continuum Mechanics, Springer, 2015.
Kendall P.C., Bourne D.E., Vector Analysis and Cartesian Tensors, 3rdEdition, 1992.
Tolstov, G. P, Silverman R. A., Fourier series, Dover Publication,2000.
Bishop, L Richard,Tensor Analysis on Manifolds,Dover Publications, Later Printing Edition, 1980.
McConnell, A. J, Applications of Tensor Analysis, Courier Corporation, 2014

CM 405 Functional Biology (3+0)

Biological Methods, Principles of cellular life, Chemical Basis, structure and function, Principles of Metabolism, Energy of Acquisition, Principles of Inheritance, Mitosis and Miosis, Chromosomes, Observable Inheritance Pattern, DNA Structure and function, RNA and Proteins, Genes, Genetic Engineering and biotechnology, Biodiversity, Examples from the organism: Prions, Viruses, Bacteria, Protistans, Algae, Fungai, Plants, Crops, Animals, Invertibrates, Vertibrates

Recommended Books (CM 405 &CM 406):

1. Roberts, M., M. Reiss, Advanced Biology. Nelson, 2000.
2. Starr, C., R. Taggart., Biology: The Unity and Diversity of Life. Brooks and Cole, 2001
3. Campbell, N. A., J. B. Reece., Biology: Concepts and Connections. Prentice-hall, 2001.
4. Soyibo.K., Ekpunobi EN, Functional Biology, Thomas & Nelson and Sons Ltd., London, UK, Revised Edition, 2000.
5. Micheal.R., Biology: A Functional Approach, Thomas & Nelson and Sons Ltd., London, UK., 1972

Fourth Semester

CM-402 Mechanics(3 + 0)

Vectors: Differentiation of vectors and vector fields,Gradient, divergence and curl of a vector field, Vector integration, Applications of Green's, Stoke's and divergence theorems.

Statics: Composition of forces, equilibrium problems, moments and couples, centre of mass and gravity, friction, virtual work, flexible cables, Catenaries.

Dynamics: Galilean-Newtonian principle, inertial frames, Galilean transformations, kinematics, rectilinear motion with variable accelerations, simple harmonic motion, methods of dynamics, principles of energy and momentum, Motion of a projectile, orbital motion, moment of inertia, motion of a rigid body, plane impulsive motion Compound pendulum.

Recommended Books:

Chorlton, F., Mechanics, Van Nostrand, Reinhold, 1970.
Ghori, Q. K., (Ed.), Introduction to Mechanics, West Pakistan Publishing Co. 1971.
Kleppner D., An Introduction to Mechanics, McGraw-Hill, 2nd Edition, 2013.
Meirovitch L., Methods of Analytical Dynamics,McGraw Hill, New York,1st Edition, 2007.
Meriam, J. L. and L. G. Kraige, Engineering mechanics: dynamics, John Wiley & Sons, 2012.

CM-404 Set Topology (3 + 0)

Theory of sets and subsets, set operations, Functions, Inverse function, Binary relations, Equivalence relations.

Topological spaces; open and closed sets; bases for the topology; subspaces; limit points; continuous and locally continuous functions; metric space and metric topology; product topology; homeomorphism and locally homeomorphic spaces; Zariski topology; T0-spaces, Hausdorff spaces.

Recommended Books:

01. Armstrong, M. A., Basic Topology, Springer,1983.
02. Donald W. K., An Introduction to the Point Set and Algebraic Areas, The Williams &Wilkins Company,2013.
03. Kinsey, L. Christine, Topology of Surfaces, Springer-Verlag, 1993.
04. Mendelson.B., Introduction to Topology,Dover Publications, 3rd Edition,2010.
05. Munkeres, James R., Topology, Pearson Education,2000.

CM 406 Functional Biology (3+0)

Myths and relatives of evolution, Microevolution, Specification, Macroevolution, Level of organization, Plants, Tissues, Nutrition and transport, Reproduction, Growth and development, Animals, Tissues, Organs system and homeostasis, Information flow and neuron, Nervous system, Circulation and immunity, Nutrition and respiration, Reproduction and development, Ecology and behavior, Ecosystem, Biosphere, Social Interactions, Community Interactions, Human Impact on Biosphere, Environment Conversation

Third Year

SEMESTER V			SEMESTER VI		
CM– 501	**Mathematical Analysis**	**3+0**	**CM-502**	**Functional Analysis**	**3+0**
CM–503	**Linear Algebra**	**3+0**	**CM-504**	**Probability & Statistics**	**3+0**
CM–505	**Differential Equations**	**3+0**	**CM-506**	**Numerical Analysis**	**3+0**
CM–507	**Fluid Dynamics-I**	**3+0**	**CM-508**	**Fluid Dynamics-II**	**3+0**
CM–509	**Programming Language-I**	**2+1**	**CM-510**	**Programming Language-II**	**2+1**

Fifth Semester

CM-501 Mathematical Analysis(3 + 0)

Real Functions, Sequences and Series, Continuous Functions on Intervals, Differentiation, The Riemann Integral, Function Spaces, Differentiable Maps, Measures, Integration, Manifolds, Differential Forms, Integration on Manifolds, Complex variables, Cauchy-Riemann equation, Cauchy Integral formula, Residue Theorem, Contour Integration.

Recommended Books:

01. Andrew Browder, Mathematical Analysis: An Introduction, Springer, 2012.
02. Bernd S. W. Schröder, Mathematical Analysis,A Concise Introduction, John Wiley & Sons, 2008.
03. Claudio Canuto, Anita Tabacco, Mathematical Analysis I, Springer, 2015.
04. Mangatiana A. Robdera, A Concise Approach to Mathematical Analysis, Springer, 2011.
05. Richard Johnsonbaugh, W.E. Pfaffenberger, Foundations of Mathematical Analysis, Dover Publications, 2010.

CM-503 Linear Algebra (3 + 0)

Linear systems, Vector equations, Row reduction and echelon forms, The matrix equation Ax = b, Solution sets of linear systems, Applications of linear systems, Linear independence, Linear transformations, Matrix of a linear transformation, Linear models in business, science, and engineering, Matrix operations, Inverse of a matrix, Characterization of invertible matrices, Matrix factorization, Introduction to determinants, Properties of determinants, Cramer's rule, volume and linear transformations, Vector spaces and subspaces, Null spaces, column spaces, and linear transformations, Linearly independent sets; bases, Coordinate system, The dimension of a vector space, Rank, Change of basis, Eigenvectors and eigenvalues, The characteristic equation, Diagonalization, Diagonalization of symmetric matrices, Eigenvectors and linear transformations, Review of complex numbers, Complex eigenvalues, Applications to Markov chains, Applications to differential equations, Inner product, length and orthogonality, Orthogonal sets, Orthogonal projections, The Gram–Schmidt process, Least-squares problems, Application to linear models in Finance, Inner product spaces, The singular value decomposition, Iterative methods for solutions of the system of linear equations by Jacobi and Gauss-Seidal method.

Recommended Books:

01. David C. Lay, Steven R. Lay, and Judi J. McDonald, Linear Algebra and Its Applications, Pearson Education, 5th Edition, 2014.
02. Elliott Ward Cheney, David Ronald Kincaid, Linear Algebra, Theory and Applications, Jones & Bartlett Publishers, 2009.
03. Anton, H. and C. Rorres, Elementary Linear algebra: applications version, John Wiley & Sons, 7th Edition, 2010
04. Lee W. Johnson, Riess, Ronald Dean Riess, Jimmy Thomas Arnold, Introduction to Linear Algebra, Pearson Education, 6th Edition, 2015.
05. T. W. Körner,A General Introduction to Linear Algebra, Cambridge University Press, 2013.

CM-505 Differential Equations (3 + 0)

Introduction to Differential Equations, First-Order Differential Equations, Modeling with First-Order Differential Equations, Higher-Order Differential Equations, Modeling with Higher-Order Differential Equations,Cauchy-Euler's equations, systems of two first order linear homogenous equations, nonlinear equations.Series Solutions of Linear Equations, Special functions; Bessel's Equation, Legendre's Equation, The Laplace Transform, The Dirac Delta function, Systems of Linear First-Order Differential Equations.

Recommended Books:

01. Zill, D. G., Differential equations with boundary-value problems, Nelson Education, 2016

02. Kreyszig E, Advanced Engineering Mathematics, Wiley,8th Edition, 2005.
03. Morris Tenenbaum, Harry Pollard, Ordinary Differential Equations, Dover Publications, Incorporated, 2012.
04. William E. Boyce, Differential Equations, An Introduction to Modern Methods and Applications, John Wiley & Sons Inc, 2nd Edition, 2007.
05. Zill, D. G, A First Course In Differential Equations With Modelling Applications, Cole Publishing Company, 10th Edition, 2013.

CM-507 Fluid Dynamics-I (3 + 0)

Introduction to fluid mechanics, real and ideal fluids, steady, unsteady, uniform, non-uniform, one, two, three dimensional, compressible, incompressible, rotational, irrotational flows etc., Differentiation following the motion of fluid particles, Langrangian, Eulerian method, Equations of motion and continuity for incompressible inviscid fluids, Velocity potentials and stokes stream functions Properties of stream function, Bernoulli's equation with application to flow along curve paths, Kinetic energy: kinetic induced by a moving body, induced mass, Sources, sinks, doubles in 2- and 3- dimensions, limiting stream lines, Images and rigid planes.

Recommended Books:

01. Donald F. Young, Bruce R. Munson, Theodore H. Okiishi, A brief Introduction to Fluid Mechanics, Don Fawly Publishers, 5th Edition, 2010.
02. Frank M. White, Fluid Mechanics, McGraw Hill, 2011.
03. Peter S. Bernard, Fluid Dynamics, Cambridge University Press, 2015.
04. Tsutomu Kambe, Elementary Fluid Mechanics, World Scientific Publishing, 2007.
05. F.Chorlton, Textbook of Fluid Dynamics, G.K. Publications Private Limited , 2012.

CM-509 Programming Language-I (2 + 1)

Introduction to Computer Programming, Beginning the Problem-Solving Process, Variables, Constants and operators, Completing the Problem-Solving Process, The Selection case decision structure, More on the Selection case decision structure, The Repetition Structure (For-Next loop), More on the Repetition Structure (Do While and Do Until loop), Nested Loop, Conditional statements: (If, Else, Else-if), Functions and procedures, Value-Returning Functions, One-Dimensional Arrays, Two-Dimensional Arrays, Multidimensional Arrays.

Labs:

Usage of basic variables, operators and constant of C and C++, Generating the Problem-solving process, Usage of Repetition structure (For-Next loop, Do While and Do Until loop, Nested Loop), Conditional statements: (If, Else, Else-if), Generating One, two and multi-dimensional array.

Recommended Books:

01. W.Brian. K, The C programming language, Prentice Hall,2nd Edition, 2005.
02. Perry.G, The Absolute Beginner's Guide to C", Pearson Education Inc,3rd Edition, 2013.
03. Harry H. Chaudhary, C Programming, Step By Step Beginner's To Experts Edition, First MIT-Creatspace Inc. D-Publishing ,2014.
04. Threja. R, Introduction to C Programming, Oxford University Press,2nd Edition, 2015.
05. Kelley, A. and I. Pohl., A book on C; Programming in C, Benjamin-Cummings Publishing Co., Inc..1994

Sixth Semester

CM-502 Functional Analysis (3 + 0)

Hahn-Banach Theorem and Applications, Banach Spaces, Hilbert Spaces and Applications, Locally Convex Spaces, Weak Convergence and Weak Topology, Convexity, Krein-Milman and Stone-Weierstrass, Choquet type theorems, Bounded Linear Maps, Compact Linear Maps, Fredholm alternative, Spectral Theory of Compact Maps, Compact Linear Maps in Hilbert Space, Compact Symmetric Operators, Min-Max, Functional calculus and polar decomposition

Recommended Books:

01. Barbara MacCluer, Elementary Functional Analysis, Springer, 2008.
02. John B. Conway, A Course in Functional Analysis, Springer,2nd Edition ,2014.
03. Kreyszig, E., Introductory functional analysis with applications, Wiley New York, 1978
04. Peter D. Lax, Functional Analysis, WileyNew York, 2002.
05. Rudin, W., Functional Analysis, McGrawHill Inc, New York, 1991

CM-504 Probability & Statistics (3 + 0)

Introduction to Statistics, Statistical Measures of Data, Statistical Inference of Data, Probability, Distributions of Random Variables, Discrete/Continuous Probability distributions, Normal Distribution, Sampling Theory, Estimation of Parameters, Test of Hypothesis, Regression & Correlation, Analysis of Variance.

Recommended Books:

01. Walpole, R. E., et al., Probability and statistics for engineers and scientists, Macmillan New York, 2013
02. J. L. Devore, Probability and Statistics, Brooks/Cole,8th Edition, 2011.
03. Montgomery, D. C. and G. C. Runger.,Applied statistics and probability for engineers, John Wiley & Sons, 2010
04. Mario Lefebvre, Applied Probability and Statistics, Springer, 2007.
05. DeGroot, M. H. and M. J. Schervish., Probability and statistics, Pearson Education, 2012

CM-506 Numerical Analysis (3 + 0)

Preliminaries of Computing, Error analysis

Numerical Solution of Nonlinear Equation: Bisection method, fixed-point iteration, Newton's method, Secant Method.

Interpolation and polynomial Approximation: Newton's Method, Lagrange Polynomial, Divided differences, Hermite Interpolation, Spline Interpolation.

Direct Method for Solving System of Linear Equations: LU decomposition method, numerical factorizations, Eigen value problems, Approximating Eigen values, Power method, Householder's method.

Indirect Method for Solving System of Linear Equations: GuassSiedel Method, Jacobi's Method, Relaxation Method.

Numerical Integration: Trapezoidal Rule, Simpsons Rules, Gaussian quadrature method.

Numerical solution of Ordinary Differential Equation: Euler Method, Modified Euler, Taylor'sseries, Runge-Kutta method.

Recommended Books:

01. Gerald, C. F., Applied numerical analysis, Pearson Education, 2004
02. EndreSüli, David F. Mayers, An Introduction to Numerical Analysis, Cambridge University Press, 2003.
03. John H. Mathews, Kurtis D Fink, Numerical Method Using Matlab, Pearson Prentice Hall ,4th Edition, 2004.
04. Burden, R. L., et al., Numerical analysis, Brooks/cole Pacific Grove, CA.,2001
05. Richard L. Burden, J. Douglas Faires, Annette M. Burden, Numerical Analysis, Cengage Learning, 10th Edition, 2015.

CM-508 Fluid Dynamics-II (3 + 0)

Introduction of incompressible viscous fluid, Navier-Stokes and energy equations for viscous incompressible fluids, Dynamical similarity and Reynolds number, Steady one-dimensional flow of viscous fluid, Two-dimensional flow and small disturbance theory, Radial flow between plane walls, Open channel flow, axi-symmetric jets, Inviscid compressible flow, energy equation and compressibility effect, Unsteady one-dimensional flow, Equations of motion for some specific types of flow and ensuring solutions, gas dynamics.

Recommended Books:

01. E. George, Analytical Fluid Dynamics, CRC Press, 2nd Edition,2000.
02. Frank M. W, Viscous Fluid Flow, McGraw Hill Higher Education, 2nd Edition, 2006.
03. Joseph Spurk, Nuri.A, Fluid Mechanics, Springer, 2nd Edition, 2008.
04. K. K. Pijush and M. C. Ira, Fluid Mechanics, Elsevier, 4th Edition, 2010.
05. Yunus A. Cengel, Fluid Mechanics, Fundamentals and Applications (in SI Units), McGraw Hill,2nd Edition, 2010.

CM-510 Programming Language-II (2 + 1)

Introduction to Programming (C++/Matlab/Python), Basic environment, operators and simple calculations, Formulas and functions, Working with numbers, Software hierarchy, A First Program, Expressions, Constants, Variables and assignment statement, Arrays, Graph Plots, Basic plotting, Built in functions, Procedures and Functions, Arguments and return values, M-files, Formatted console input-output String handling, Control Statements, Conditional statements: (If, Else, Elseif), Repetition statements: (While, For-Next), Select case decision structure, Manipulating Text, Writing to a text file, Reading from a text file, Randomizing and sorting a list, Searching a list, GUI Interface, Attaching buttons to actions, Getting Input, Setting Output.

Labs:

C++/MATLAB/Python environment, Operators, Formulas and functions ,Usage of different expressions, constants, variables and assignment statement, Working with numbers, Graph plotting, Creating M and script files, Working with different arguments and return values, Writing to a text file, Input-Output string, Creating buttons for getting Input, and Output.

Recommended Books:

01. Amos Gilat, MATLAB, An introduction with applications, Wiley,5th Edition, 2014.
02. Hanselmann.D, Mastering MATLAB,Prentice Hall, 2012.
03. Barry P, Head First Python: A Brain-Friendly Guide, O'Reilly Media Inc,2nd Edition, 2016.
04. Meyers Scott,Effective Modern C++, O'Reilly,2014.
05. StroustrupBjarne, The C++ Programming Language, Addison-Wesley, 1985.

Fourth Year

SEMESTER VII			SEMESTER VIII		
CM-601	**Advanced Partial Differential Equations**	**3+0**	**CM-602**	**Integral Equations**	**3+0**
CM-603	**Advanced Numerical Analysis**	**3+0**	**CM-604**	**Stochastic Process**	**3+0**
CM-605	**Modelling & Simulation**	**3+0**	**CM-606**	**Wavelets**	**3+0**
CM-607	**Software Applications-I**	**2+1**	**CM-608**	**Software Applications-II**	**2+1**
	Optional-I			**Optional-II**	

Seventh Semester

CM-601 Advanced Partial Differential Equations (3 + 0)

Solution of PDEs and principle of superposition, Boundary conditions and their types, Homogeneous PDEs with constant coefficient and separation of variables, Holomorphic functions, Classification of second order linear PDEs, The Heat equation and diffusion equation, Wave equation and vibrating string, Initial and boundary conditions for heat and wave equations, Laplace's Equation, Solutions of Heat, wave and Laplace's equations by separation of variables, Fourier transform and properties, Convolution theorem for Fourier transform, Solution of PDEs by Fourier transform, Laplace transform and its properties, Convolution theorem for Laplace transform, Laplace transform of Heaviside unit step and Direct Delta functions, Solutions of partial differential equations by Laplace transform method, Green's function and its properties, Method of Green's function, Nonlinear partial differential equations, Method of characteristics, Solution of nonlinear partial differential equations by method of characteristics.

Recommended Books:

01. Mark A. Pinsky, Partial Differential Equations and Boundary-value Problems with Applications, American Mathematical Society, 3rdEdition, 2011.
02. Matthew P. Coleman, An Introduction to Partial Differential Equations with MATLAB, Taylor & Francis, 2004.
03. Michael Shearer, Rachel Levy, Partial Differential Equations, An Introduction to Theory and Applications, Princeton University Press, 2015.
04. Richard Haberman, Applied Partial Differential Equations with Fourier series and Boundary values Problems, Pearson, 5thEdition, 2013.
05. Sandro Salsa, Partial Differential Equations in Action, From Modelling to Theory, Springer,2ndEdition, 2015.

CM-603 Advanced Numerical Analysis (3 + 0)

Approximation: Lagrange, Pades and Chebyshev approximation.

Initial Value Problems(ODE-IVPs): Analytic Solutions of Linear ODE-IVP, Taylor series based and RungeKutta methods, Multi-step (predictor-corrector) approaches; Milnes Method, Adams Method, stability of ODE-IVP solvers, choice of step size and stability envelops, stiffness and variable step, size implementation, Introduction to the solutions of differential algebraic equations (DAEs).

Boundary Value Problems(ODE-BVPs): Single shooting method, Pades Equation, Chebychev Equation, Finite difference Method for solving ODE-BVPs. Orthogonal Collocations method for solving ODE-BVPs, least square approximation, Gauss Newton Method, Method of least squares for solving ODE-BVP, Gelarkin's method and generic equation forms arising in problem discretization, Errors in Discretization.

Solving Partial Differential Equation: Problem Discretization Using Approximation Theory, Weierstrass theorem and polynomial approximations, Taylor series approximation, Newton's Method for solving non-linear algebraic equation as an application of multivariable Taylor series, Introduction to polynomial interpolation, polynomial and function interpolations.

Boundary Value Problems(PDE-BVPs): Finite difference Method for solving PDE-BVPs; Heat Equation, wave Equation, Laplace Equation.

Recommended Books:

01. Ackleh, A. S., et al.,Classical and modern numerical analysis: Theory, methods and practice, Chapman and Hall/CRC, 2009

02. Eugene I., Analysis of Numerical Methods, Courier Corporation, 2012.

03. Argyros, I. K., et al.,Numerical methods for equations and its applications, CRC Press., 2012

04. J. C. Butcher, Numerical Methods for Ordinary Differential Equations, Wiley, 2004.

05. Peter Linz, Theoretical Numerical Analysis, an Introduction to Advanced Techniques, Courier Corporation, 2001.

CM-605 Modelling &Simulation(3 + 0)

Introduction to modelling: Introduction, model: approximation of real world events, history of modelling and simulation, properties of useful model, model development process, static and dynamic models, model selection, model validation, ethics in modeling

Introduction to systems: System boundary**,** classification of systems, linear systems, mathematical point of view of linear systems, time varying vs time-interval systems, continuous time and discrete time systems, deterministic vs stochastic systems.

System modelling: Need of system modelling, classification od models: mathematical vs descriptive models, static vs dynamic models, deterministic vs stochastic models, continuous discrete models, Mathematical modelling of physical systems, model order reduction.

Introduction to simulation: Advantages of simulations, applications of simulation, Numerical methods for simulation.

Nonlinear and Chaotic systems: Linear vs nonlinear systems, types of nonlinearities, Introduction to chaotic systems, first order continuous-time systems, bifurcations, second order systems.

Discrete Event Modelling and Simulation: Introduction, some important definitions, discrete event system simulation, input data modelling, random number generation, chi-square test.

Training on Lab View software etc.

Recommended Books:

01. Daniel P., MaynardT.,Mathematical Modeling and Computer Simulation, Thomson Brooks/Cole, 2006.
02. K. D. Chaturvedi, Modeling and Simulation of Systems Using MATLAB and Simulink, CRC, 2009.
03. Giordano F., et al, A First Course in Mathematical Modeling, Cengage Learning, 2013.
04. Velten.K, Mathematical Modeling and Simulation: Introduction for Scientists and Engineers,John Wiley & Sons, 2009.
05. Louis G. Birta, Gilbert A., Modelling and Simulation: Exploring Dynamic System Behaviour, Springer,2nd Edition, 2013.

CM-607 Software Applications-I (2 + 1)

Fundamentals of Software Engineering, Phases of software development, Overview of computer systems and the MATLAB/MATHEMATICA environment, Pseudo-code, flowcharts, and documentation, Algorithm analysis, Mathematical Modeling and Problem Solving, Modeling, Computers, and Error Analysis, Programming and Software, Precision and Accuracy, Approximations and Round-Off Errors, Absolute and Relative Error, Truncation Errors, Significant Digits, Finding Roots of Equations, Linear Programming (Optimization), Designing an algorithm to find roots, Implementing the plan using MATLAB/MATHEMATICA, Including comments in the program, Checking for reasonableness, Debugging the program, Solving Linear Algebraic Equations, Designing an algorithm to solve linear algebraic equations, Implementing the plan using MATLAB/MATHEMATICA, Including comments in the program, Checking for reasonableness, Debugging the program, Curve Fitting, Designing an algorithm for curve fitting, Implementing the plan using MATLAB/MATHEMATICA, Including comments in the program, Checking for reasonableness, Debugging the program, Numerical Integration and Differentiation, Designing an algorithm for integration and differentiation, Implementing the plan using MATLAB/MATHEMATICA, Including comments in the program, Checking for reasonableness, Debugging the program, Solving Ordinary Differential Equations, Designing an algorithm for solving ordinary differential equations, Implementing the plan using MATLAB/MATHEMATICA, Including comments in the program, Checking for reasonableness, Debugging the program, GUI Interface, Attaching buttons to actions, Getting Input, Output, Debugging and Validate, Maintaining the software, Introduction to Maple, Solving Ordinary Differential Equations, Implementing the plan using Maple. Use any software to cover the above contents.

Labs:

Usage of MATLAB/MATHEMATICA environment, Functions, Operators, Pseudo-code, flowcharts, and documentation, Designing an algorithm to find roots and solving ordinary differential equations (ODE), Mathematical models for problem solving,GUI Interface, basic function of Maple and its usage to solving ODE.

Recommended Books:

01. Andre HECK, Introduction to Maple, Springer,3rdEdition, 2003.
02. Attaway, S. MATLAB: A Practical Introduction to Programming and Problem Solving,Butterworth-Heinemann,3rdEdition,2013.
03. C.Hastings, K.Misho., Hands-On Start to Mathematica: And Programming with the Wolfram Language, Wolfram Media, 2015.
04. Palm, W., Introduction to MATLAB for Engineers,New York, NY, McGraw-Hill,3rdEdition, 2010.
05. K.M.Heal.,Maple: Learning Guide, Springer, 3rd Edition, 1998.

CM-602 Integral Equations (3 + 0)

Integral equations: Fredholm integral equation, Volterra integral equation, boundary value problem, singular integral equation, conversion of ordinary differential equations into integral equations.

Method of successive approximations: Homogeneous Fredholm integral equations of the second kind, Iterated kernels of functions, solution of Fredholm integral equations of second kind by successive substitution, solution of volterra integral equations of second kind by successive substitution, Neumann series.

Classical Fredholmtheory: Fredholm's first fundamental theorem, Fredholm's second fundamental theorem, Fredholm's third fundamental theorem.

Some other Integral equations: Integral equations with symmetric kernels, Some fundamental properties of eigenvalues and eigenfunctions for symmetric kernels, Singular integral equations, Abel integral equation.

Integral transform methods: Laplace transform, Integro-differential equations, application of Laplace transform to determine the solution of Volterra integral equations, Application of Fourier transform to determine the solution of integral equations, Hilbert transform, Mellin transform, selfadjoint operator, dirac delta function, Green's formula, Bessel function.

Application of integral equation to ordinary differential equations: Green's function, Conversion of a boundary value problem into Fredholm integral equation, Green's function approach, Application of integral equations to partial differential equations, Application of integral equations to mixed boundary value problem.

Recommended Books:

01. Majid. A, Linear and Nonlinear Integral Equations, Methods and Applications, Springer, 2011.
02. Andrei D. Polyanin, Alexander V. M, Handbook of Integral Equations, CRC Press,2nd Edition,2008.
03. B. L. Moiseiwitsch, Integral Equations, Courier Corporation, 2005.
04. M. D. Raisinghania, Integral Equations & Boundary Value Problems, S. Chand & Company Ltd, 2007.
05. M. Masujima, Applied Mathematical Methods of Theoretical Physics - Integral Equations,McGraw-Hill2006.

CM-604 Stochastic Process (3 + 0)

Review of probability and random variables, random walk, Stochastic Processes, Definition, methods of description, time averaging and ergodicity, Continuity, integration and differentiation, autocorrelation, power spectral density, Response of linear systems to stochastic inputs, classes of stochastic processes, Shot noise, thermal noise, point processes, Markov processes, Gaussian processes, orthogonally, smoothing, prediction, Stochastic Integration, Ito's Integral and Ito's Lemma, Black-Scholes-Merton (BSM) PDE, stochastic differential equations (SDEs), Interest Rate SDEs.

Recommended Books:

01. David Stirzaker, Stochastic Processes and Model, Oxford University Press, 2005.
02. E. P.C. Kao, An introduction to Stochastic Processes, Duxbury Press, 1997.
03. Erhan.C, Introduction to Stochastic Processes, Courier Corporation, 2013.
04. F. Solomon, Probability and Stochastic Processes, Prentice-Hall, 1987.
05. John L. Teall, Financial Market Analytics, Quorum Books, 1999.

CM-606 Wavelets (3 + 0)

Introduction to Wavelets: The Essence of Wavelet Analysis, Beyond the CWT: the Discrete Wavelet Transform, Review of Fourier Theory and Filters, Fourier Transform of Finite Sequences, Periodized Filters, Orthonormal Transforms of Time Series, The Projection Theorem, Complex-Valued Transforms, The Orthonormal Discrete Fourier Transform, The Discrete Wavelet Transform, Qualitative Description of the DWT, The Wavelet Filter, The Scaling Filter, First Stage of the Pyramid Algorithm, Second Stage of the Pyramid Algorithm, General Stage of the Pyramid Algorithm, The Partial Discrete Wavelet Transform, Daubechies Wavelet and Scaling Filters: Form and Phase, Coiflet Wavelet and Scaling Filters: Form and Phase, The Maximal Overlap Discrete Wavelet Transform, Effect of Circular Shifts on the DWT, MODWT Wavelet and Scaling Filters, The Discrete Wavelet Packet Transform, Time Shifts for Wavelet Packet Filters.

HaarWavelet: Haar wavelet and their integrals, Haar matrices, Expanding functions into the Haar wavelet series, Non-uniform Haar wavelet, Solutions of Differential and Integral equations

Recommended Books:

01. Albert Boggess, Francis J. Narcowich, A First Course in Wavelets with Fourier Analysis, Prentice Hall, 2001.
02. Charles K. Chui, An Introduction to Wavelets, Elsevier Science, 2014.
03. Donald B. Percival, Andrew T. Walden, Wavelet Methods for Time Series Analysis Cambridge University Press,2006.
04. Stephane.M, A Wavelet Tour of Signal Processing, Third Edition, The Sparse Way', Academic Press, 2008.
05. ÜloLepik, Helle Hein, Haar Wavelets, With Applications, Springer, 2014.

CM-608 Software Applications-II (2 + 1)

The components of MATLAB/MAPLE (command window, editor, figures, toolboxes), Simple MATLAB/MAPLE programming, Data types (single, double, integer, character arrays, records, cells), Variables and arrays, Control flow (loops, while, if-then-else, switch (case) statements), Simple I/0 (reading/writing binary, ASCII and mat files), Some built-in mathematical MATLAB/MAPLE functions, Scripts and functions (*.m files), Arrays and simple array operations, Multidimensional arrays, Simple 2D/3D plots and the print statement, Matrix algebra, Serialization versus Vectorization, JIT compilation, Serialized versus Vectorized I/O, Graphical User Interfaces (GUIs) using GUIDE, MATLAB/MAPLE Programming Interfaces (such as C, Fortran and Java), Object Oriented MatLab, Basic Data Visualization, Setting the camera and the lighting model, Mesh and surface plots, Colormaps and texture, Representation arbitrary shaped 3D objects using patches, Using transparency to display data, Volume Visualization: scalar values, slice planes, iso surfaces, vector data, Stream lines/ribbons and tubes, Images, movies and sound Module, Basic Data Analysis, Some basic operations: mean, standard deviation, weighted average, median, covariance matrices, Random number generation, Histograms, Data correlation (Pearson's coefficient), Hypothesis testing (z-test and t-test) 6. Chi-square goodness-of-fit and other variance, Regression analysis (including linear, nonlinear and robust regression), Scatter/Box/Distribution plotting, Probability Density/Cumulative distributions, Normal, Exponential, Poisson, Rayleigh, Rican distributions, Performance curves.

Use of any software to cover the above contents.

Labs:

Usage ofvarious components of MATLAB/MAPLE programming, Control flow (loops, while, if-then-else, switch (case) statements), some built-in mathematical MATLAB/MAPLEscripts and M-file functions, 2D/3D plots and the print statement, Basic Data Visualization, Basic Data Analysis.

Recommended Books:

01. Amos Gilat, MATLAB: An Introduction with Applications, Wiley, 5th Edition, 2014.
02. McMahon.D, Introduction of Maple, CRC, 2007.
03. Duane Hanselman, Bruce.L, Mastering MATLAB, Pearson, Prentice Hall, 2012.
04. Harris, F.E, Mathematics for Physical Science and Engineering: Symbolic Computing Applications in Maple and Mathematica, CRC, 2014.
05. Stephen J. Chapman,MatLab Programming for Engineers Cenage Learning, 5tEdition,2016.

OPTIONALCOURSES(7th SEMESTER)

CM – 609 Perturbation Methods – I (3 + 0)

Introduction: Dimensional analysis, Gauge functions, asymptotic series, asymptotic expansions and sequences.

Algebraic Equations: Quadratic equations, cubic equations, higher order equations, transcendental equations.

Integrals: Expansion of integral, Integration by parts, Laplace's method, the method of stationary phase, The method of steepest descent.

The Duffing Equation: Straightforward expansion, exact solution, the Lindstedt- Poincare technique, method of renormalization, method of multiple scales, variation of parameters, method of averaging.

Linear Damped Oscillator: Straightforward expansion, exact solution, the Lindstedt-Poincare technique, method of multiple scales, method of averaging.

Recommended Books:

01. Nayfeh.A.H., Perturbation Methods, John Wiley & Sons, 2008.
02. Bhimsen K. Shivamoggi, Perturbation Methods for Differential Equations, Springer,2002.
03. Carl.M.B, Steven A. O.,Advanced Mathematical Methods for Scientists and Engineers I: Asymptotic Methods and Perturbation Theory, Springer, 2013.
04. Jirair Kevorkian, J.D. Cole, Perturbation Methods in Applied Mathematics, Academic Press, 2013.
05. Nayfeh.A.H., Introduction to Perturbation Techniques, John Wiley & Sons, 2011.

CM – 611 Fractional Calculus – I (3 + 0)

Special Functions of the Fractional Calculus. Gamma Function.Mittag-Leffler Function.Wright Function.

Fractional Derivatives and Integrals. Grünwald-Letnikov Fractional Derivatives.Riemann-Liouville Fractional Derivatives.Some Other Approaches.Geometric and Physical Interpretation of Fractional Integration and Fractional Differentiation.Sequential Fractional Derivatives. Left and Right Fractional Derivatives. Properties of Fractional Derivatives. Laplace Transforms of Fractional Derivatives. Fourier Transforms of Fractional Derivatives.Mellin Transforms of Fractional Derivatives.

Linear Fractional Differential Equations. Fractional Differential Equation of a General Form.Existence and Uniqueness Theorem as a Method of Solution.Dependence of a Solution on Initial Conditions.The Laplace Transform Method.Standard Fractional Differential Equations.Sequential Fractional Differential Equations.

Fractional Green's Function. Definition and Some Properties.One-Term Equation.TwoTerm Equation.Three-Term Equation.Four-Term Equation. General Case: n-term Equation.

Recommended Books:

01. Kilbas.A.A, Srivastava.H, Theory and Applications of Fractional Differential Equations, Elsevier, 2006.
02. Dumitru.B.,Fractional Calculus, Models and Numerical Methods, World Scientific, 2012.
03. Manuel Duarte., Fractional Calculus for Scientists and Engineers, Springer, 2011.
04. R. Figueiredo.et al., On some fractional Green's functions, UNICAMP, 2008.
05. Shantanu Das, Functional Fractional Calculus, Springer, 2011.

CM – 613 Boundary Layer Theory– I (3 + 0)

Introduction: Boundary Layer (BL), BL Parameters (BL thickness, BL Displacement, Momentum Thickness), BL wall friction and friction drag, Derivation of Prandtl's Laminar BL equations, Application of the Prandtl's BL equations to a flat plate, Similarity solutions to the BL equations (other than flat plate), Similarity solutions to thermal BL, BL Separation with pressure-gradient, Energy Equation in thermal BL, Prandtl Number and dissipation in thermal BL.

Recommended Books:

01. D.A. Nield, Adrian Bejan, Convection in Porous Media, Springer, 3rdEdition, 2006.
02. H. Schlichting, K Gersten,Boundary Layer Theory, Springer,8th Revised Edition, 2003.
03. Ian John S., Introduction to Interactive Boundary Layer Theory, Oxford University Press, 2000.
04. Jean Cousteix, Jacques Mauss, Asymptotic Analysis and Boundary Layers, Springer, 2007.
05. Victor I. Terekhov, Maksim A. Pakhomov, Flow and Heat and Mass Transfer in Laminar, Springer, 2012.

CM – 615 Fuzzy Mathematics – I (3 + 0)

Crisp Set Theory: Introduction, Relation between sets, operations on sets, Characteristic functions, Cartesian products of crisp sets, crisp relation on sets.

Propositional Logic (PL): Introduction, Syntax of PL(1), Semantics of PL(1), certain semantics properties, certain properties satisfied by the connectives, inference rules, derivation.

Predicate Logic: Introduction, Syntax of PL(2), Semantics of PL(2), semantics properties, certain properties satisfied by the connectives and quantifiers, derivations, resolution in PL(2).

Switching Functions and switching circuits: Introduction, switching functions, disjunctive normal form, switching circuits, relation between switching functions and switching circuits, equivalence of circuits, simplification of circuits.

Boolean Algebra: Introduction, Boolean algebra, identification, complete disjuctive normal form (CDNF).

Fuzzy Calculus: Derivatives and Integration in Fuzzy Sense.

Recommended Books:

01. George J. Klir, Tina A., Fuzzy sets, Uncertainty & Information, PHI Learning Pvt.Ltd, 2010.
02. Guanrong Chen, Trung.T.P, Introduction to Fuzzy Sets, Fuzzy Logic, and Fuzzy Control Systems, CRC Press, 2000.
03. Buckley.J.J, Esfandiar.E., An Introduction to Fuzzy Logic and Fuzzy Sets, Springer, 2013.
04. Jang J.S.R. Sun C.T., MizutaniE.,"Neuro fuzzy and Soft Computing", PHI Learning Pvt. Ltd., 2008.
05. M. Ganesh, Introduction to Fuzzy Sets and Fuzzy Logic, Prentice Hall, 2006.

CM – 617 Graph Theory & Applications – I (2 + 1)

Fundamental Concepts Basic definitions, paths, cycles, trails, degree, directed graphs, Trees and Distance Basic properties, spanning trees and enumeration, optimization, Matchings and Factors Matchings, covers, algorithms, Connectivity and Paths Cuts, connectivity, k-connected graphs, network flow, Coloring of Graphs Vertex colorings, structure of k-chromatic graphs, enumerative aspects, Planar Graphs Embeddings and Euler's formula, characterizations and parameters of planarity, Graph Pebbling: A mathematical model for the transportation of consumable resources History, pebbling number, Class 0 graphs.

Labs:

Basic concepts of cycles, paths, degree, trails, directed graphs, Different algorithms for Matchings, Connectivity and Paths Cuts, basic structures of k-connected and k-chromatic graphs.

Recommended Books:

01. Douglas B. West, Introduction to Graph Theory, Prentice Hall,2nd Edition, 2001.
02. Gary Chartrand, Ping.Z, A First Course in Graph Theory, Courier Corporation, 2012.
03. Bondy.J.A, Murty.U.S, Graph Theory, Springer, 2008.
04. Iqbal.M.A, Graph Theory & Algorithms, Electronic Edition,2010.
05. R. Balakrishnan, K. Ranganathan, A Textbook of Graph Theory, Springer ,2nd Edition, 2012.

CM – 619 Bioinformatics (2 + 1)

Bioinformatics: What and why? Genomic and Protein sequences, Online databases (GenBank, Swiss-Prot), Introduction to sequence alignment, Sequence alignment, Scoring Matrices, Pairwise alignment, Multiple sequence alignment Gaps, Database searching; BLAST, Limits of detection, significance, Advanced BLAST: (PSI-BLAS), Find-a-gene project, Relevance to inferences about evolution, Molecular phylogeny and evolution, mRNA and gene expression introduction, Uni gene, Differential expression intro, normalization, visualization/clustering, Gene Pattern, Statistics for differential expression, multiple testing, Finding differentially expressed genes, Characterizing eukaryotic genomes, Human variation and disease, Sequence variation, phenologs, comparative genomics.

Labs:

Making search for the scientific literature (PubMed) and sequences using database (Nucleotide, Protein), Searching similarity of a Gene using Blast program, Nucleotide Blast (Blastn), Protein Blast (Blastp).

Recommended Books:

01. Andreas D. Baxevanis, B. F. Francis, Introduction of Bioinformatics,John Wiley & Sons, 2004.
02. Jonathan Pevsner,Bioinformatics and Functional Genomics, John Wiley &Sons,2nd Edition, 2009.
03. M. Zvelebil, J. O. Baum, Understanding Bioinformatics, Garland Science, 2008.
04. David.W.M, Bioinformatics: Sequence and Genome Analysis,Spring Harbor Laboratory Press, 2nd Edition, August 16, 2004.
05. Nello.C, Matthew W. Hahn, Introduction to Computational Genomics: A Case Studies Approach,Cambridge University Press, 2006.

CM – 621 Computational Finance (2 + 1)

Introduction to compound interest, Marginal Revenue and Cost, Overview of Products and Markets, Forms of Analysis: Introduction to Quantitative analysis, Topics in financial economics, Random Walk, Assets as random walks, properties, Wiener process, Markov Property, Brownian motion, Examples, Properties of Brownian motion, Ito Calculus: Ito Integral, Ito Lemma, Interpretation of Ito Lemma, How to apply Ito lemma? Binomial Tree, Black Scholes Model: Black Scholes equation and assumptions for Black Scholes equation, Finite difference methods, Solution of European options, Methods for American options

Labs:

Application of compound interest, Marginal Revenue and Cost in real world, Quantitative analysis, Markov method, Brownian motion, Black Scholes Model.

Recommended Books:

01. Binder.A, Aichinger.M, A Workout in Computational Finance, John Wiley & Sons, 2013.
02. Cornelis A. Los, Computational Finance: A Scientific Perspective, World Scientific, 2001.
03. George Levy, Computational Finance: Numerical Methods for Pricing Financial instruments,Butterworth-Heinemann,Volume 1, 2004.
04. McNeil, A. J., Quantitative Risk Management, Princeton University Press, 2005.
05. Ruppert.M., David.S.,Statistics and Data Analysis for Financial Engineering, Springer,2nd Edition, 2015.

CM – 623 Operations Research – I (2 + 1)

Introduction to Operations Research (OR): Introduction to Foundation mathematics and statistics, Linear Programming (LP), LP and allocation of resources, LP definition, Linearity requirement, Maximization Then Minimization problems, Graphical LP Minimization solution, Introduction, Simplex method definition, formulating the, Simplex model, Linear Programming – Simplex Method for Maximizing, Simplex maximizing example for similar limitations, Mixed limitations, Example containing mixed constraints, Minimization example for similar limitations, Sensitivity Analysis, Changes in Objective Function, Changes in RHS, The Transportation Model, Basic Assumptions, Solution Methods: (Feasible Solution: The Northwest Method, The Lowest Cost Method), Optimal Solution: The Stepping Stone Method, Modified Distribution (MODI) Method, The Assignment Model:- Basic Assumptions, Solution Methods: Different Combinations Method, Short-Cut Method (Hungarian Method), MSPT

Labs:

Linear Programming and its graphical minimizationsolution,Simplex model,Sensitivity Analysis, Basic Transportation and Assignment model and its solutions.

Recommended Books:

01. Frederick S. Hillier, Gerald J. Lieberman, Introduction to Operations Research, 9th Edition, McGraw Hill, 2010.

02. F.A. Ficken, The Simplex Method of Linear Programming, Dover Publications, 2015.

03. IstvánMaros, Computational Techniques of the Simplex Method, Springer, 2012.

04. P Rama Murthy, Operations Research, Linear Programming, Bohem Press, 2005.

05. Taha.H, An introduction to operations research, Prentice Hall, 2007.

CM – 625 Computational Fluid Dynamics – I (2 + 1)

Introduction: Typical partial differential equations in fluid dynamics, types of second order equations, well posed problems, properties of linear and Quasilinear equations, physical characters of subsonic and supersonic flows, second order wave equations, system of first order equations, weak solutions.

Finite Difference and Finite Volume Discretization: Finite difference discretization, discretization of derivatives, consistency, convergence and stability, finite volume discretization, face area and cell volume.

Equation of Parabolic Type: Finite difference scheme for heat conduction equation, Crank-Nicholson implicit scheme, analogy with schemes for ordinary differential equations, a note on implicit methods, Leap-frog and DuFrot-Frankel schemes, operator notation, the Alternating Direction Implicit (ADI) method.

Equation of Hyperbolic Type: Explicit scheme, Lax-Wendroff scheme and variants, implicit schemes, more on upwind schemes, scalar conservation law: Lax-Wenderoff and related schemes, hyperbolic system of conservation laws, second-order wave equation, method of characteristics for second-order hyperbolic equations, model convection-diffusion equation.

Equation of Elliptic Type: The Laplace equation in two dimension, iterative methods for solution of linear algebraic systems, solution of the Penta diagonal system, approximate factorization schemes, grid generation example, body-fitted grid generation using elliptic-type equations some observations of AF schemes, multi-grid method.

Equation of Mixed Elliptic-Hyperbolic Type: Tricomi equation, transonic computations based on TSP model.

Labs:

Usage of partial differential equations in fluid dynamics, solution of Quasilinear equations, Discretization of face area and cell volume, Lax-Wendroff scheme and its variants, Method of characteristics for second-order hyperbolic equations, The Laplace equation, TSP model.

Recommended Books:

01. E. George, Analytical Fluid Dynamics, CRC Press,2nd Edition,2000.
02. Frank M. White, Viscous Fluid Flow, McGraw Hill Higher Education, 2nd Edition, 2006.
03. Jiyuan Tu, Guan.H.Y, Computational Fluid Dynamics, A Practical Approach, Butterworth-Heinemann, 2nd Edition, 2012.
04. Wendt.J, Computational Fluid Dynamics,An Introduction, Springer, 3rd Edition, 2008.
05. Oleg.Z, Essential Computational Fluid Dynamics, John Wiley & Sons, 2010.

CM – 627 Numerical Linear Algebra – I (2 + 1)

Stability of Algorithms and Conditioning of Problems: Introduction, Efficiency of an algorithm, definition and concept of stability, conditioning of the problem and perturbation analysis, perturbation analysis of the linear system problem, effect of perturbation on RHS vector b, Effect of perturbation in the Matrix A, effect of perturbation in both Matrix A and vector B, some well-known ill-conditioned matrices, The condition number and nearness to singularity, example of ill-conditioned Eigenvalue problems.

Numerical Solutions of Linear Systems: A computational template in numerical linear algebra, creating zeros in a vector matrix using elementary matrix, triangularization using Gaussian elimination, Gauss elimination with partial pivoting, Gaussian stability, Gauss elimination with complete pivoting, of Gaussian elimination, Basic results to existence and uniqueness, some applications giving rise to linear system problems, solution of Ax=b using LU factorization, solution $Ax=b$ using factorization $MA=U$, solution of $Ax=b$ without explicit factorization, solution of linear system with multiple right hand sides.

Effects of Condition Number on Accuracy of the Computed Solution: Computing and estimating condition number, component-wise perturbations and the errors, iterative refinement, special systems: positive definite; diagonally dominant; Hessenberg and tridiagonal, symmetric positive definite systems.

QR Factorization, Singular Value Decomposition, and Projection: Introduction, Householder's method for QR factorization, complex QR factorization, classical and Gram – Schmid algorithms for QR factorization, solution of $Ax=b$ using QR factorization, projections using QR factorization, singular value decomposition and its projection, SVD of a complex matrix, some practical applications of SVD, geometric mean and generalized triangular decompositions.

Labs:

Efficiency of an algorithm, Perturbation analysis of the linear system problem, Component-wise perturbations, Numerical solution of Gaussian elimination, Complex QR factorization, Classical and Gram – Schmid algorithms, Decomposition methods.

Recommended Books:

01. Datta.B.N, Numerical Linear Algebra and Applications, SIAM publisher ,2nd Edition, 2010.
02. Grégoire.A, Kaber.M,Numerical Linear Algebra, Springer, 2008.
03. SUNDARAPANDIAN.V, Numerical Linear Algebra, PHI Learning, 2008.
04. William Ford, Numerical Linear Algebra with Applications: Using MATLAB, Academic Press, 2014.
05. William Layton, Myron.S, Numerical Linear Algebra, Lulu publishers, 2014.

OPTIONALCOURSES(8th Semester)

CM – 610 Perturbation Methods – II (3 + 0)

Self-Excited Oscillator: Straightforward expansion, method of renormalization, method of multiple scales, method of averaging.
System with Quadratic and Cubic Nonlinearities: Straightforward expansion, method of renormalization, the Lindstedt- Poincare technique, method of multiple scales, method of averaging, generalized method of averaging, Krylov-Bogoliubov-Mitropolsky technique.
General Weakly Nonlinear Systems: Straightforward expansion, method of renormalization, method of multiple scales, method of averaging, Applications.
Forced Oscillations of Duffing Equation: Straightforward expansion, method of multiple scales, method of averaging.
Multi-frequency Excitations: Straightforward expansion, method of multiple scales, method of averaging.
The Mathieu Equations: Straightforward expansion, the Floquet theory, method of strained parameters, Whittakers method, method of multiple scales, method of averaging.

Recommended Books:

01. Nayfeh.A.H, Introduction to Perturbation Techniques, John Wiley & Sons, 2011.
02. Shivamoggi.K.B, Perturbation Methods for Differential Equations, 2002.
03. Kelvin.R.P, Introduction to Perturbation Methods, Springer, 2002.
04. Carl.M.B, Steven.A.O,Advanced Mathematical Methods for Scientists and Engineers, CRC,2014.
05. Jan A. Sanders, Ferdinand Verhulst, Averaging Methods in Nonlinear Dynamical Systems, Springer, 2013.

CM – 612 Fractional Calculus – II (3 + 0)

Fractional Integrals. Geometric and Physical Interpretation of Fractional Integration and Properties of Fractional Integrals. Laplace Transforms of Fractional Integrals, Fourier Transforms of Fractional Derivatives, Mellin Transforms of Fractional Derivatives.
Solution of Fractional-order Equations The Mellin Transform Method, Integral Transform Methods and Power Series Solutions for Fractional Partial Differential Equations, Babenko's Symbolic Calculus Method, Method of Orthogonal Polynomials.Numerical Evaluation of Fractional Derivatives, Approximation of Fractional Derivatives, The "Short-Memory" Principle, Calculation of Heat Load Intensity Change in Blast Furnace Walls.Order of Approximation, Computation of Coefficients, Higher-order Approximations
Numerical Solution of Fractional Differential Equations: Fraction Derivatives and Integrals, Green's Functions of Fractional Differential Operators and Applications, Integral Transform Methods and Power Series Solutions for Fractional Ordinary Differential Equations and Fractional Integral Equations, FDM for Fractional Ordinary Differential Equations, Integral Transform Methods and Power Series Solutions for Fractional Partial Differential Equations, FDM for Fractional Partial Differential Equations.

Recommended Books:

01. Boling Guo, XuekePu, Fenghui Huang, Fractional Partial Differential Equations and Their Numerical Solutions, World Scientific, 2015.
02. Kilbas.A.A, Srivastava.H, Theory and Applications of Fractional Differential Equations, Elsevier, 2006.
03. Dumitru.B.,Fractional Calculus: Models and Numerical Methods, World Scientific ,2nd Edition, 2016.
04. Kai Diethelm, The Analysis of Fractional Differential Equations, Springer, 2010.
05. Manuel Duarte., Fractional Calculus for Scientists and Engineers, Springer, 2011.

CM – 614 Boundary Layer Theory – II (3 + 0)

Exact solution of viscous flows, Laminar boundary layers, Thermal Boundary Layer, Laminar-Turbulent transition, Instability and Transition to Turbulence, Equations for Turbulent Flows Introduction to Turbulence Models, Turbulent boundary layers, Boundary layer separation, Numerical solutions of boundary layer flows, Basics of Boundary Layer Separation and Control Advanced Topics on Boundary Layers.

Recommended Books:

01. H. Schlichting, K Gersten,Boundary Layer Theory,8th Revised Edition 2003.
02. Ian John Sobey, Introduction to Interactive Boundary Layer Theory 2000.
03. Jean Cousteix, Jacques Mauss, Asymptotic Analysis and Boundary Layers Springer, 2007.
04. John H Lienhard, A Heat Transfer Textbook: Courier Corporation,4thEdition, 2013.
05. Bernard P. Boudreau, Bo Barker Jorgensen, The Benthic Boundary Layer: Transport Processes and Biogeochemistry, Oxford University Press, 2001.

CM – 616 Fuzzy Mathematics – II (3 + 0)

Fuzzy Set Theory: Concept of a fuzzy set, relation between fuzzy sets, operations on fuzzy sets, properties of standard operations, certain numbers associated with a fuzzy set, certain crisp sets associated with fuzzy sets, certain fuzzy sets associated with a given fuzzy set.

Fuzzy Relations: Introduction, operation on fuzzy relations, α-cuts of a fuzzy relation, composition of fuzzy relations, projections of fuzzy relations, cylindrical extensions, fuzzy relation on a domain.

Fuzzy Logic: Three-valued logics, N-valued logics for $N \geq 4$, Infinite-valued logics, Fuzzy propositions and their interpretations in terms of fuzzy sets, Fuzzy rules and their interpretation in terms of fuzzy relations, fuzzy inference or approximate reasoning, generalization of fuzzy logics.

Fuzzy Methods in Control Theory: Fuzzy and knowledge-based control methods in systems with uncertain data, prediction, classification, prioritisation, control, uncertainty techniques, Fuzzy measures, Belief and Plausibility measures, Probability measures, Possibility and Necessity measures- Relationship among classes of Fuzzy measures, Types of Uncertainty, Measures of Fuzziness, Classical measures of Uncertainty.

Fuzzy Methods in Decision Making: Introduction to decision making, Measures of Dissonance, Measures of confusion, Measures of Non-specificity, Uncertainty and information, Information and complexity, principles of uncertainty and information, Fuzzy methods in decision making,Fuzzy numerical analysis, other applications.

Recommended Books:

01. Didier Dubois, Henri Prade, Fundamentals of Fuzzy Sets, Springer, 2012.
02. Dimiter.D., Hellendoorn.H., An Introduction to Fuzzy Control, Springer, 2013.
03. George J. Klir, Tina A., Fuzzy sets Uncertainty & Information, PHI Learning Pvt.Ltd, 2010.
04. Jang J.S.R. Sun C.T., MizutaniE.,Neuro fuzzy and Soft Computing, PHI Learning Pvt. Ltd., 2012.
05. Jonathan.L, Enrique.M., Soft Methods for Integrated Uncertainty Modelling, Springer, 2006.

CM – 618 Graph Theory & Applications – II (2 + 1)

Ramsey theory for graphs, Algebraic graph theory (Cayley graphs, the Laplacian, strongly regular graphs, isoperimetric inequalities, Colin de Verdiere's invariant), Random walks on graphs (electrical networks and random walks, hitting times, conductance and rapid mixing), The Tutte polynomial (special values of the Tutte polynomial, spanning tree expansion, polynomials of knots and links, other graph polynomials), Planar graphs (MacLane's and Whitney's criteria, planarity algorithms, uniqueness and flexibility of planar embeddings, Tutte'shamiltonicity theorem, circumference of planar graphs, separators, wye-delta reductions and applications), Geometric graph theory (crossing number, Andreev-Koebe-Thurston theorem, string graphs), Perfect graphs (polyhedral aspects, perfect matrices, Shannon capacity, Lovasz theta function, computing the chromatic and clique number of a perfect graph, graph entropy and application to sorting, imperfection ratio and the channel assignment problem), Signed graphs (totally odd K4's, nearly bipartite graphs and odd K5's, Guenin's theorem and Seymour's conjecture), Graphs on surfaces (representativity, minors and disjoint paths on surfaces, locally planar graphs, planarizing cycles), Tree-width and relatives (tree-decompositions, tree-width, excluding a planar graph, brambles, computing tree-width, algorithms, branch-width, path-width), The graph minor theorem (tree-decompositions, the tangle decomposition, surfaces, vortices, excluding a general graph, application to algorithms and well-quasi-ordering), Directed graphs (packing directed cycles and directed cuts, even cycles, disjoint branchings, orientations, directed minors, tree-width for directed graphs).

Labs:

Algebraic and Planar graph, Random walks on graphs, Geometric graph, Surface graph, Different directed graphs, Computing the chromatic and clique number of a perfect graph,Tree decomposition.

Recommended Books:

01. Douglas B. West, Introduction to Graph Theory, 2nd Edition, 2001.
02. Bondy.J.A, Murty.U.S, Graph Theory, Springer, 2008.
03. Jonathan L. Gross, Jay Yellen, Graph Theory and Its Applications, CRC ,2nd Edition, 2005.
04. Jonathan L. Gross, Jay Yellen, Ping Zhang, Handbook of Graph Theory, CRC ,2nd Edition, 2012.
05. L.R. Foulds, Graph Theory Applications, Springer, 2012.

CM – 620 Cryptography (2 + 1)

Background and overview: One-time encryption using stream ciphers, Semantic security, block Cipher and its principles, pseudorandom functions, Chosen plaintext and cipher text security and modes of operation, DES and AES block cipher, Message integrity, Hash function, CBC-MAC, HMAC, PMAC and CW-MAC, Collision resistant hashing.

Classical Encryption Techniques: Symmetric and asymmetric cipher models, Substitution and Transposition techniques, Authenticated encryption: CCM, GCM, TLS and IPSec, Key derivation function, Deterministic encryption, non-expanding encryption and format preserving encryption, fully homomorphic encryption.

Basic Key exchange: Diffie-Hellman, RSA and Merkle puzzles, Computational number theory, Number theoretic hardness assumptions, Authenticated and TLS key exchange.

Public Key Cryptography: Principles of Public Key Cryptosystem, Public key encryption, Trapdoor permutation and RSA, The ElGamal system and variants, Digital Signatures and certificate, Identification Protocols, Authentication Protocols, Zero Knowledge Protocols and proof of knowledge.

Privacy Mechanism: Group signatures and credential systems, Private information retrieval and oblivious transfer.

Two Party Computations: Yao's protocol and its applications, Elliptic curve cryptography (ECC), Quantum computing, Pairing-based cryptography, Lattice based cryptography.

Labs:

Usage of different Encryption and Decryption cipher, Symmetric and asymmetric cipher models, Different private and public key cryptosystem algorithms, RSA algorithms, Different protocols, Digital signature, Yao's protocol, Elliptic curve cryptography (ECC).

Recommended Books:

01. Alexander Stanoyevitch, Introduction to Cryptography with Mathematical foundations and computer implementations, CRC, 2011.
02. C.Paar and J. Pelzl, Understanding Cryptography, Springer-Verlag, 2010.
03. D.T. Lee, S. P. Shieh.,Computer Security in the 21st Century, Springer, 2005.
04. Jonath.K.,Yehuda.L., Introduction to Modern Cryptography, CRC, 2nd Edition,2014.
05. Stalling.W, Cryptography and Network Security: Principles and Practices, Pearson Education,3rd Edition, 2004.

CM – 622 Data Mining (2 + 1)

Introductionto data mining: Data preparation and integration, Graphic representation, Attribute selection and Attribute transformation, Bayes' theorem, Naive Bayes, Bayesian networks, Clustering.

IntroductionDistance K-nearest neighbors: K-means, SOM, DBSCAN, Grid clustering, Hierarchical clustering, Dimensionality reduction, Singular value decomposition.

Factor analysis: Principal component analysis, Regression, Neural Networks, Genetic algorithms.

Relationaland structural methods: Model Evaluation, Classifiers evaluation, Regression evaluation, clustering evaluation, Association Rules evaluation, Combination of models, Comparing several models.

Labs:

Graphic representation of Data, selection of different transformation of data mining attributes, Clustering of data, Principal component analysis, Regression analysis, Neural Networks and various Genetic algorithms.

Recommended Books:

01. Rajaram.A, Leskovec.J., Mining of Massive Data Sets, Cambridge University Press ,2nd Edition, 2014.
02. Aggarwal.C, Data Mining: The Textbook, Springer, 2015.
03. Bishop.C, Pattern Recognition and Machine Learning, Springer, 2006.
04. Ian H. Witten, Eibe Frank, Data Mining: Practical Machine Learning Tools and Techniques, Elsevier,2nd Edition, 2005.
05. Margaret Dunham, Data Mining: Introductory and Advanced Topics, Prentice Hall, 2003.

CM – 624 Operations Research – II (2 + 1)

Multiple Objective LP Problems Goal Programming (Pre-emptive, Non pre-emptive), Integer Programming, Binary Integer Programming (BIP) Applications, Use of Binary Auxiliary Variables, Branch and Bound Technique for BIP, Mixed Integer Programming (MIP) Branch and Bound Technique for MIP, Introduction to Meta Heuristics, Tabu Search, Simulated Annealing, Genetic Algorithm, Game Theory Two Person Zero Sum games, Two Person Constant Sum games, Using LP for Solving Games with Mix Strategies, Dual LP for Column Player Strategies, Prisoners Dilemma Problems, Decision Analysis, Decision Making under Uncertainty, Expected Monetary Value Criterion Value of Perfect Information, Decision Making with Experimentation, Value of Information, Posterior Probabilities Utility Theory in Decision Analysis, Developing Risk Profiles, Simulation Applications of Monte Carlo Simulation Models, Queuing Theory Queuing Models with multiple servers, Simulation Models for Queuing, Data Envelopment Analysis (DEA), Inventory Management Economic Order Quantity (EOQ) Inventory Model, Deterministic Periodic-Review Inventory Model, Deterministic Continuous-Review Inventory Model, Stochastic Continuous-Review Inventory Model, Aggregation Inventory Models, Forecasting Models, Time Series Models, Exponential Smoothing, Trend Models, Seasonal Models, Forecasting Errors, Tracking Signals in Forecast.

Labs:

Integer, Binary Integer and Mixed IntegerProgramming, Game Theory,Monte Carlo Simulation, Simulation Models for Queuing theory,Stochastic Time Series Models, Data Different Trend models.

Recommended Books:

01. Henggeler.C Antunes., Multi-objective Linear and Integer Programming, Springer, 2016.
02. DinhThe Luc, Multi-objective Linear Programming: An Introduction, Springer, 2015.
03. Frederick S. Hillier, Gerald J. Lieberman, Introduction to Operations Research, McGraw Hill, 9thEdition,2010.
04. H.A. Eiselt, C.-L. Sandblom, Linear Programming and its Applications, Springer, 2007.
05. Steven Tadelis, Game Theory: An Introduction, Princeton University Press, 2013.

CM – 626 Computational Fluid Dynamics – II (2 + 1)

Introduction: Basic conservation principle, unsteady Navier-stokes equations in integral form, Navier-stokes equations in differential form, Euler equations for inviscid flows, full potential equation, inviscid incompressible irrotational flow.

Grid Generation: Introduction, co-ordinate transformation, differential equation methods, algebraic methods, transfinite interpolation methods, unstructured grid generation, mesh adaptation.

Inviscid Incompressible flow: Introduction, potential flow problem, panel methods, panel methods for subsonic and supersonic flows.

Inviscid Compressible flow: Introduction, small-perturbation flow, numerical solution of the full potential equation, full potential solution in generalized coordinates, Euler model, computed examples based on Euler model, supersonic flow field computation.

Viscous Incompressible Flow: Introduction, Incompressible flow computation, stream-function vorticity approach, primitive variable approach, The MAC method, solution scheme, Case study: separated flow in a constructed channel.

Viscous Compressible Flow: Introduction, dynamic similarity, Reynolds Averaged Compressible Navier-stokes) RANS equations, Turbulence modelling, basic computational methods for compressible flow, finite volume computation in 2D, solution procedure, computational results.

Labs:

Solvingunsteady Navier-stokes equations, Inviscid incompressible irrotational flow, Numerical solution of the full potential equation, Euler model, Incompressible flow algorithms, Reynolds Averaged Compressible Navier-stokes) RANS equations, Finite volume computation in 2D,Turbulence modelling

Recommended Books:

01. E. George, Analytical Fluid Dynamics, CRC Press ,2nd Edition,2000.
02. Frank M. White, Viscous Fluid Flow, McGraw Hill Higher Education, 2nd Edition, 2006.
03. JiyuanTu, Guan HengYeoh, Chaoqun Liu, Computational Fluid Dynamics: A Practical Approach, Butterworth-Heinemann,2nd Edition, 2012.
04. John Wendt, Computational Fluid Dynamics: An Introduction, Springer ,3rd Edition, 2008.
05. Oleg Zikanov, Essential Computational Fluid Dynamics, John Wiley & Sons, 2010.

CM – 628 Numerical Linear Algebra – II (2 + 1)

Least-Squares Solutions to Linear Systems: Introduction, geometric interpretation of the Least-Squares problem, polynomial-fitting to experimental data, predicting future sales, pseudoinverse and least square problem, computational methods for over determined problems: normal equations; QR and SVD method, Undermined Linear Systems, QR approach for the minimum-norm solution, SVD approach for the minimum-norm solution, least-squares iterative refinement.

Numerical Matrix Eigenvalue Problems: Introduction, stability problems for differential and difference equations, phenomenon of resonance, buckling problem (a boundary value problem), simulating transient current for an electric circuit, localization of eigenvalues, computing selected eigenvalues and eigenvectors, similarity transformations and eigenvalue computations, eigenvalue sensitivity, eigenvector sensitivity, real Schur from and QR iterations, computing eigenvectors.

Numerical Symmetric Eigenvalues Problem and Singular Value Decomposition: Introduction, computational methods for the symmetric eigenvalue problem, some special properties of the symmetric eigenvalue problem, Bisection method for the symmetric tridiagonal matrix, symmetric QR iteration method, divide –and–conquer method, singular value decomposition and its computation, computing variance – covariance matrix with SVD, computing pseudoinverse with SVD, computing SVD, Golub – Kahan – Reinsch algorithm, Chan SVD algorithm, generalized SVD.

Generalized and Quadratic Eigenvalue Problem: Introduction, Eigenvalent pencils, generalized Schur and real Schur decompositions, QZ algorithm, computations of generalized eigenvectors, symmetric positive definite generalized eigenvalue problem, QZ method for symmetric definite pencil, Cholesky QR algorithm for the symmetric definite pencil, diagonalization of the symmetric definite pencil: simultaneous diagonalization of A and B, generalized Rayleigh Quotient, symmetric definite generalized eigenvalue problems arising in vibrations of structures, applications of symmetric positive definite generalized eigenvalue problem to decoupling and model reduction, quadratic eigenvalue problem.

Labs:

Geometric interpretation of the Least-Squares methods, Polynomial-fitting to experimental data, QR and SVD method, Simulation of electric circuit, localization of Eigenvalues, Computing Eigenvalues and Eigenvectors,real Schur from and QR iterations, Different computational methods for the symmetric Eigenvalue problem, Generalized Schur and real Schur decompositions.

Recommended Books:

01. Datta.B, Numerical Linear Algebra and Applications, SIAM publisher ,2nd Edition, 2010.
02. Grégoire Allaire Kaber.S.,Numerical Linear Algebra, Springer, 2008.
03. Sundarapandian.V., Numerical Linear Algebra, PHI Learning, 2008.
04. William Ford, Numerical Linear Algebra with Applications: Using MATLAB, Academic Press, 2014.
05. William Layton, Myron Sussman, Numerical Linear Algebra, Lulu publishers, 2014.