**C6.1 Metric Spaces and Complex Analysis 6 Credits (5L+1 P)**

**Duration 3hrs Marks : 100( 70+30 ) 75 Lectures + 15 Tutorials**

**UNIT-1**

Metric spaces: definition and examples. Sequences in metric spaces, Cauchy sequences.

Complete Metric Spaces. Open and closed balls, neighbourhood, open set, interior of a set.

Limit point of a set, closed set, diameter of a set, Cantor’s theorem. Subspaces, dense sets, separable spaces.

**UNIT-2**

Continuous mappings, sequential criterion and other characterizations of continuity. Uniform continuity.vHomeomorphism, Contraction mappings, Banach Fixed point Theorem. Connectedness, connected subsets of R.

**UNIT-3**

Limits, Limits involving the point at infinity, continuity. Properties of complex numbers, regions in the complex plane, functions of complex variable, mappings. Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability.

**UNIT-4**

Analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function, derivatives of functions, definite integrals of functions. Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. CauchyGoursat theorem, Cauchy integral formula.

**UNIT-5**

Liouville’s theorem and the fundamental theorem of algebra. Convergence of sequences and series, Taylor series and its examples. Laurent series and its examples, absolute and uniform convergence of power series.

**Books Recommended**

1. Satish Shirali and Harikishan L. Vasudeva, *Metric Spaces*, Springer Verlag, London, 2006.
2. S. Kumaresan, *Topology of Metric Spaces*, 2nd Ed., Narosa Publishing House, 2011.
3. G.F. Simmons, *Introduction to Topology and Modern Analysis*, McGraw-Hill, 2004.
4. James Ward Brown and Ruel V. Churchill, *Complex Variables and Applications,* 8th Ed., McGraw – Hill International Edition, 2009.
5. Joseph Bak and Donald J. Newman, *Complex Analysis,* 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., NewYork, 1997.

**C6.2 Ring Theory and Linear Algebra II 6 Credits (5L+1 P)**

**Duration 3hrs Marks : 100( 70+30 ) 75 Lectures + 15 Tutorials**

**UNIT-1**

Polynomial rings over commutative rings, division algorithm and consequences, principal ideal domains, factorization of polynomials, reducibility tests, irreducibility tests,

**UNIT-2**

Eisenstein criterion, unique factorization in Z[x]**.** Divisibility in integral domains, irreducibles, primes, unique factorization domains, Euclidean domains.

**UNIT-3**

Dual spaces, dual basis, double dual, transpose of a linear transformation and its matrix in the dual basis, annihilators, Eigen spaces of a linear operator, diagonalizability, invariant subspaces

**UNIT-4**

Cayley-Hamilton theorem, the minimal polynomial for a linear operator.Inner product spaces and norms, Gram-Schmidt orthogonalisation process, orthogonal complements, Bessel’s inequality, the adjoint of a linear operator,

**UNIT-5**

Least Squares Approximation, minimal solutions to systems of linear equations, Normal and self-adjoint operators, Orthogonal projections and Spectral theorem.

**Books Recommended**

1. John B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Pearson, 2002**.**
2. M. Artin, *Abstract Algebra*, 2nd Ed., Pearson, 2011.
3. Joseph A. Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa Publishing House, 1999.
4. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, *Linear Algebra,* 4th Ed., PrenticeHall of India Pvt. Ltd., New Delhi, 2004.
5. S. Lang, *Introduction to Linear Algebra,* 2nd Ed., Springer, 2005.
6. Gilbert Strang, *Linear Algebra and its Applications*, Thomson, 2007.
7. S. Kumaresan, *Linear Algebra- A Geometric Approach*, Prentice Hall of India, 1999.
8. Kenneth Hoffman, Ray Alden Kunze, *Linear Algebra,* 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
9. S.H. Friedberg, A.L. Insel and L.E. Spence, *Linear Algebra*, Prentice Hall of India Pvt. Ltd., 2004.

**DSE3.1 Theory of Equations 6 Credits (5L+1 P)**

**Duration 3hrs Marks : 100( 70+30 ) 75Lectures+15 Tutorials**

**UNIT-1**

General properties of polynomials, Graphical representation of a polynomial, maximum and minimum values of a polynomials,

General properties of equations,

**UNIT-2**

Descarte’s rule of signs positive and negative rule, Relation between the roots and the coefficients of equations.

**UNIT-3**

Symmetric functions, Applications of symmetric function of the roots, Transformation of equations.

Solutions of reciprocal and binomial equations. Algebraic solutions of the cubic and biquadratic.

Properties of the derived functions.

**UNIT-4**

Symmetric functions of the roots, Newton’s theorem on the sums of powers of roots,

homogeneous products, limits of the roots of equations.

**UNIT-5**

Separation of the roots of equations, Strums theorem, Applications of Strum’s theorem,

Conditions for reality of the roots of an equation and biquadratic. Solution of numerical equations.

**Books Recommended**

1. W.S. Burnside and A.W. Panton, *The Theory of Equations*, Dublin University Press, 1954.
2. C. C. MacDuffee, *Theory of Equations*, John Wiley & Sons Inc., 1954.

**DSE3.2 Bio-Mathematics 6 Credits (5L+1 P)**

**Duration 3hrs Marks : 100( 70+30 ) 75Lectures+15 Tutorials**

**UNIT-1**

Mathematical Biology and the modeling process: an overview. Continuous models: Malthus model, logistic growth, Allee effect, Gompertz growth, Michaelis-Menten Kinetics, Holling type growth,

**UNIT-2**

Bacterial growth in a Chemostat, Harvesting a single natural population, Prey predator systems and Lotka Volterra equations, Populations in competitions, Epidemic Models (SI, SIR, SIRS, SIC), Activator-Inhibitor system, Insect Outbreak Model: Spruce Budworm,

**UNIT-3**

Numerical solution of the models and its graphical representation. Qualitative analysis of continuous models:Steady state solutions, stability and linearization, multiple species communities and Routh-Hurwitz Criteria, Phase plane methods and qualitative solutions, bifurcations and limit cycles with examples in the context of biological scenario.

**UNIT-4**

Spatial Models: One species model with diffusion, Two species model with diffusion, Conditions for diffusive instability, Spreading colonies of microorganisms, Blood flow in circulatory system, Travelling wave solutions,Spread of genes in a population. Discrete Models: Overview of difference equations, steady state solution and linear stability analysis,

**UNIT-5**

Introduction to Discrete Models, Linear Models, Growth models, Decay models, Drug Delivery Problem, Discrete Prey-Predator models, Density dependent growth models with harvesting, Host-Parasitoid systems (Nicholson-Bailey model), Numerical solution of the models and its graphical representation. Case Studies: Optimal Exploitation models, Models in Genetics, Stage Structure Models, Age Structure Models.

**Books Recommended**

1. L.E. Keshet, *Mathematical Models in Biology*, SIAM, 1988.
2. J. D. Murray, *Mathematical Biology*, Springer, 1993.
3. Y.C. Fung, *Biomechanics*, Springer-Verlag, 1990.
4. F. Brauer, P.V.D. Driessche and J. Wu, *Mathematical Epidemiology*, Springer, 2008.
5. M. Kot, *Elements of Mathematical Ecology*, Cambridge University Press, 2001.

**DSE3.3 Linear Programming 6 Credits (5L+1 P)**

**Duration 3hrs Marks : 100( 70+30 ) 75Lectures+15 Tutorials**

**UNIT-1**

Introduction to linear programming problem, Theory of simplex method, optimality and unboundedness,

the simplex algorithm, simplex method in tableau format, introduction to artificial variables,

two‐phase method, Big‐M method and their comparison.

**UNIT-2**

Duality, formulation of the dual problem, primal‐dual relationships, economic interpretation of the dual.

**UNIT-3**

Transportation problem and its mathematical formulation, northwest‐corner method least cost method

and Vogel approximation method for determination of starting basic solution,

**UNIT-4**

Algorithm for solving transportation problem, assignment problem and its mathematical

formulation, Hungarian method for solving assignment problem.

**UNIT-5**

Game theory: formulation of two person zero sum games, solving two person zero sum games,

games with mixed strategies, graphical solution procedure, linear programming solution of games.

**Books Recommended**

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, *Linear Programming and Network Flows,* 2nd Ed., John Wiley and Sons, India, 2004.
2. F.S. Hillier and G.J. Lieberman, *Introduction to Operations Research,* 9th Ed., Tata McGraw Hill, Singapore, 2009.
3. Hamdy A. Taha, *Operations Research, An Introduction,* 8th Ed., Prentice‐Hall India, 2006.
4. G. Hadley, *Linear Programming*, Narosa Publishing House, New Delhi, 2002.

**DSE4.1 Mathematical Modeling 6 Credits (5L+1 P)**

**Duration 3hrs Marks : 100( 70+30 ) 75Lectures+15 Tutorials**

**UNIT-1**

Power series solution of a differential equation about an ordinary point, solution about a regular singular point, Bessel’s equation and Legendre’s equation,

**UNIT-2**

Laplace transform and inverse transform, application to initial value problem up to second order.

**UNIT-3**

Monte Carlo Simulation Modeling: simulating deterministic behavior (area under a curve, volume under a surface),

**UNIT-4**

Generating Random Numbers: middle square method, linear congruence, Queuing Models: harbor system, morning rush hour, Overview of optimization modeling,

**UNIT-5**

Linear Programming Model: geometric solution algebraic solution, simplex method, sensitivity analysis

**List of Practicals (using any software)**

* 1. Plotting of Legendre polynomial for n = 1 to 5 in the interval [0,1]. Verifying graphically that all the roots of Pn (x) lie in the interval [0,1].
  2. Automatic computation of coefficients in the series solution near ordinary points.
  3. Plotting of the Bessel’s function of first kind of order 0 to 3.
  4. Automating the Frobenius Series Method.
  5. Random number generation and then use it for one of the following (a) Simulate area under a curve (b) Simulate volume under a surface.
  6. Programming of either one of the queuing model (a) Single server queue (e.g. Harbor system) (b) Multiple server queue (e.g. Rush hour).
  7. Programming of the Simplex method for 2/3 variables.

**Books Recommended**

1. Tyn Myint-U and Lokenath Debnath, *Linear Partial Differential Equation for Scientists and Engineers*, Springer, Indian reprint, 2006.
2. Frank R. Giordano, Maurice D. Weir and William P. Fox, *A First Course in Mathematical Modeling*, Thomson Learning, London and New York, 2003.

**DSE4.2 Mechanics 6 Credits (5L+1 P)**

**Duration 3hrs Marks : 100( 70+30 ) 75 Lectures + 15 Tutorials**

**UNIT-1**

Moment of a force about a point and an axis, couple and couple moment, Moment of a couple about a line,

resultant of a force system, distributed force system, free body diagram, free body involving interior sections,

general equations of equilibrium, two point equivalent loading, problems arising from structures, static indeterminacy.

**UNIT-2**

Laws of Coulomb friction, application to simple and complex surface contact friction problems, transmission of power through belts,

screw jack, wedge, first moment of an area and the centroid, other centers,

**UNIT-3**

Theorem of Pappus-Guldinus, second moments and the product of area of a plane area, transfer theorems,

relation between second moments and products of area, polar moment of area, principal axes.

**UNIT-4**

Conservative force field, conservation for mechanical energy, work energy equation,

kinetic energy and work kinetic energy expression based on center of mass, moment of momentum equation for a single particle and a system of particles,

translation and rotation of rigid bodies,

**UNIT-5**

Chasles’ theorem, general relationship between time derivatives of a vector for different references,

relationship between velocities of a particle for different references, acceleration of particle for different references.

**Books Recommended**

1. I.H. Shames and G. Krishna Mohan Rao, *Engineering Mechanics: Statics and Dynamics,* (4th Ed.), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2009.
2. R.C. Hibbeler and Ashok Gupta, *Engineering Mechanics: Statics and Dynamics,* 11th Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi.

**DSE 4.3 Differential Geometry 6 Credits (5L+1 P)**

**Duration 3hrs Marks : 100( 70+30 ) 75 Lectures + 15 Tutorials**

**UNIT-1**

Theory of Space Curves: Space curves, Planer curves, Curvature, torsion and Serret-Frenet formulae. Osculating circles, Osculating circles and spheres. Existence of space curves. Evolutes and involutes of curves.

**UNIT-2**

Theory of Surfaces: Parametric curves on surfaces. Direction coefficients. First and second Fundamental forms. Principal and Gaussian curvatures. Lines of curvature, Euler’s theorem. Rodrigue’s formula, Conjugate and Asymptotic lines.

**UNIT-3**

Developables: Developable associated with space curves and curveson surfaces, Minimal surfaces.

**UNIT-4**

Geodesics: Canonical geodesic equations. Nature of geodesics on a surface of revolution. Clairaut’s theorem. Normal property of geodesics. Torsion of a geodesic. Geodesic curvature. Gauss-Bonnet theorem.

Surfaces of constant curvature. Conformal mapping. Geodesic mapping. Tissot’s theorem.

**UNIT-5**

Tensors: Summation convention and indicial notation, Coordinate transformation and Jacobian, Contra-variant and Covariant vectors, Tensors of different type, Algebra of tensors and contraction, Metric tensor and 3-index Christoffel symbols, Parallel propagation of vectors, Covariant and intrinsic derivatives, Curvature tensor and its properties, Curl, Divergence and Laplacian operators in tensor form, Physical components.

**Books Recommended**

1. T.J. Willmore, *An Introduction to Differential Geometry*, Dover Publications, 2012.
2. B. O'Neill, *Elementary Differential Geometry*, 2ndEd., Academic Press, 2006.
3. C.E. Weatherburn, *Differential Geometry of Three Dimensions*, Cambridge University Press 2003.
4. D.J. Struik, *Lectures on Classical Differential Geometry*, Dover Publications, 1988.
5. S. Lang, *Fundamentals of Differential Geometry*, Springer, 1999.
6. B. Spain, *Tensor Calculus: A Concise Course*, Dover Publications, 2003.