Revised
SYLLABUS FOR
Bachelor of Science (Honours)

MATHEMATICS

THREE YEAR DEGREE COURSE
SEMESTER SYSTEM

(Under New UGC CBCS Guidelines)

2021

COURSE STRUCTURE

SEMESTER	COURSE	COURSE NAME	COURSE CODE	CREDIT
I	Core 1	Calculus (Theory)	MAC 1.11	4
		Calculus (Practical)	MAC 1.12	2
	Core 2	Algebra (Theory)	MAC 1.21	5
		Algebra (Tutorial)		1
II	Core 3	Real Analysis (Theory)	MAC 2.11	5
		Real Analysis (Tutorial)		1
	Core 4	Differential Equations (Theory)	MAC 2.21	4
		Differential Equations (Practical)	MAC 2.22	2
III	Core 5	Theory of Real Functions (Theory)	MAC 3.11	5
		Theory of Real Functions (Tutorial)		1
	Core 6	Group Theory I (Theory)	MAC 3.21	5
		Group Theory I (Tutorial)		1
	Core 7	PDE and Systems of ODE (Theory)	MAC 3.31	4
		PDE and Systems of ODE (Practical)	MAC 3.32	2
	Skill Enhancement Course 1	Logic and Sets (Theory) OR Computer Graphics (Theory)	MAS 3.11(a) MAS 3.11(b)	2
IV	Core 8	Numerical Methods (Theory)	MAC 4.11	4
		Numerical Methods (Practical)	MAC 4.12	2
	Core 9	Riemann Integration and Series of Functions (Theory)	MAC 4.21	5
		Riemann Integration and Series of Functions (Tutorial)		1
	Core 10	Ring Theory and Linear Algebra I (Theory)	MAC 4.31	5
		Ring Theory and Linear Algebra I (Tutorial)		1
	Skill Enhancement Course 2	Graph Theory OR Operating System - Linux	MAS 4.11(a) MAS 4.11(b)	2
V	Core 11	Multivariate Calculus (Theory)	MAC 5.11	5
		Multivariate Calculus (Tutorial)		1
	Core 12	Group Theory II (Theory)	MAC 5.21	5
		Group Theory II (Tutorial)		1
	Discipline Specific Elective 1	Portfolio Optimization (Theory) OR Number Theory (Theory) OR Analytical Geometry (Theory)	MAD 5.11(a) MAD 5.11(b) MAD 5.11(c)	5
		Portfolio Optimization (Tutorial) OR Number Theory (Tutorial) OR Analytical Geometry (Tutorial)		1
	Discipline Specific Elective 2	Industrial Mathematics (Theory) OR Boolean Algebra and Automata Theory (Theory) OR	MAD 5.21(a) MAD 5.21(b) MAD 5.21(c)	5

		Probability and Statistics (Theory)		
		Industrial Mathematics (Tutorial) OR Boolean Algebra and Automata Theory (Tutorial) OR Probability and Statistics (Tutorial)		1
VI	Core 13	Metric Spaces and Complex Analysis (Theory)	MAC 6.11	5
		Metric Spaces and Complex Analysis (Tutorial)		1
	Core 14	Ring Theory and Linear Algebra II (Theory)	MAC 6.21	5
		Ring Theory and Linear Algebra II (Tutorial)		1
	Discipline Specific Elective 3	Theory of Equations (Theory) OR Bio-Mathematics (Theory) OR Linear Programming (Theory)	MAD 6.11(a) MAD 6.11(b) MAD 6.11(c)	5
		Theory of Equations (Tutorial) OR Bio-Mathematics (Tutorial) OR Linear Programming (Tutorial)		1
	Discipline Specific Elective 4	Mathematical Modelling (Theory) OR Mechanics (Theory) OR Differential Geometry (Theory)	MAD 6.21(a) MAD 6.21(b) MAD 6.21(c)	4 5 5
		Mathematical Modelling (Practical) OR Mechanics (Tutorial) OR Differential Geometry (Tutorial)	MAD 6.22(a)	2 1 1

SEMESTER - I

CORE 1 (MAC 1.11)
CALCULUS

Theory Credit: 4

UNIT I Hyperbolic functions, higher order derivatives, Leibniz rule and its applications to problems of type $e^{ax+b}\sin x$, $e^{ax+b}\cos x$, $(ax+b)^n\sin x$, $(ax+b)^n\cos x$, concavity and inflection points, asymptotes.

UNIT II Curve tracing in Cartesian coordinates, introduction to polar coordinates and curve tracing in polar coordinates of standard curves (cycloid, cardioid, other simple curves), L'Hospital's rule, applications in business, economics and life sciences.

UNIT III Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin^n x\,dx, \int \cos^n x\,dx, \int \tan^n x\,dx, \int \sec^n x\,dx$, $\int x^m (\log x)^n dx$, $\int \sin^m x \cos^n x\,dx$, Volumes by slicing disks and washers methods, volumes by cylindrical shells, volumes by parametric equations, Parameterizing a curve, arc length, arc length of parametric curves, area of surface of revolution.

UNIT IV Techniques of sketching conics, reflection properties of conics, rotation of axes and second degree equations, classification into conics using the discriminant, polar equations of conics.

UNIT V Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions, tangent and normal components of acceleration, modeling ballistics and planetary motion, Kepler's second law.

CORE 1 (MAC 1.12)
CALCULUS

Practical Credit: 2

List of Practicals (using any software)

(i) Plotting of graphs of function e^{ax+b}, log(ax + b), 1/(ax + b), sin(ax + b), cos(ax + b), |ax + b| and to illustrate the effect of a and b on the graph.
(ii) Plotting the graphs of polynomial of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.
(iii) Sketching parametric curves (Eg. Trochoid, cycloid, epicycloids, hypocycloid).
(iv) Obtaining surface of revolution of curves.
(v) Tracing of conics in cartesian coordinates/ polar coordinates.
(vi) Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic, paraboloid, hyperbolic paraboloid using cartesian coordinates.
(vii) Matrix operation (addition, multiplication, inverse, transpose).

Recommended Books and References:

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.

2. M.J. Strauss, G.L. Bradley and K. J. Smith, *Calculus,* 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.
3. H. Anton, I. Bivens and S. Davis, *Calculus,* 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.
4. R. Courant and F. John, *Introduction to Calculus and Analysis* (Volumes I & II), Springer-Verlag, New York, Inc., 1989.

CORE 2 (MAC 1.21)
ALGEBRA

Theory Credit: 5
Tutorial Credit: 1

UNIT I Polar representation of complex numbers, n^{th} roots of unity, De Moivre's theorem for rational indices and its applications.

UNIT II Equivalence relations, Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set, Well-ordering property of positive integers, Division algorithm, Divisibility and Euclidean algorithm, Congruence relation between integers, Principles of Mathematical Induction, statement of Fundamental Theorem of Arithmetic.

UNIT III Systems of linear equations, row reduction and echelon forms, the matrix equation Ax=b, solution sets of linear systems, applications of linear systems.

UNIT IV Introduction to vector space, vector equations, linear independence of vectors, Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices.

UNIT V Dimension of a vector space, subspaces of R^n, dimension of subspaces of R^n and rank of a matrix, Eigen values, Eigen Vectors and Characteristic Equation of a matrix.

Recommended Books and References:

1. Titu Andreescu and Dorin Andrica, *Complex Numbers from A to Z*, Birkhauser, 2006.
2. Edgar G. Goodaire and Michael M. Parmenter, *Discrete Mathematics with Graph Theory,* 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005**.**
3. David C. Lay, *Linear Algebra and its Applications,* 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.

SEMESTER - II

CORE 3 (MAC 2.11)
REAL ANALYSIS

Theory Credit: 5
Tutorial Credit: 1

UNIT I Review of Algebraic and Order Properties of *R,* -neighborhood of a point in *R,* Idea of countable sets, uncountable sets and uncountability of *R.* Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets, Suprema and Infima,

UNIT II The Completeness Property of *R,* The Archimedean Property, Density of Rational (and Irrational) numbers in *R,* Intervals. Limit points of a set, Isolated points, Illustrations of Bolzano-Weierstrass theorem for bounded sets.

UNIT III Sequences, Bounded sequence, Convergent sequence, Limit of a sequence. Limit Theorems, Monotone Sequences, Monotone Convergence Theorem.

UNIT IV Subsequences, Divergence Criteria, Monotone Subsequence Theorem (statement only), Bolzano Weierstrass Theorem for Sequences. Cauchy sequence, Cauchy's Convergence Criterion.

UNIT V Infinite series, convergence and divergence of infinite series, Cauchy Criterion, Tests for convergence: Comparison test, Limit Comparison test, Ratio Test, Cauchy's n^{th} root test, Integral test, Alternating series, Leibniz test, Absolute and Conditional convergence.

Recommended Books and References:

1. R.G. Bartle and D. R. Sherbert, *Introduction to Real Analysis,* 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
2. Gerald G. Bilodeau, Paul R. Thie, G.E. Keough, *An Introduction to Analysis,* 2nd Ed., Jones & Bartlett, 2010.
3. Brian S. Thomson, Andrew. M. Bruckner and Judith B. Bruckner, *Elementary Real Analysis,* Prentice Hall, 2001.
4. S.K. Berberian, *A First Course in Real Analysis*, Springer Verlag, New York, 1994.

CORE 4 (MAC 2.21)
DIFFERENTIAL EQUATIONS

Theory Credit: 4

UNIT I Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations.

UNIT II Introduction to compartmental model, exponential decay model, lake pollution model (case study of Lake Burley Griffin), drug assimilation into the blood (case of a single cold pill, case of a course of cold pills), exponential growth of population, limited growth of population, limited growth with harvesting.

UNIT III General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications.

UNIT IV Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters.

UNIT V Equilibrium points, Interpretation of the phase plane, predatory-prey model and its analysis, epidemic model of influenza and its analysis, battle model and its analysis.

CORE 4 (MAC 2.22)
DIFFERENTIAL EQUATIONS

Practical Credit: 2

List of Practical (using any software)

1. Plotting of second order solution family of differential equation.
2. Plotting of third order solution family of differential equation.
3. Growth model (exponential case only).
4. Decay model (exponential case only).
5. Lake pollution model (with constant/seasonal flow and pollution concentration).
6. Case of single cold pill and a course of cold pills.
7. Limited growth of population (with and without harvesting).
8. Predatory-prey model (basic volterra model, with density dependence, effect of DDT, two prey one predator).
9. Epidemic model of influenza (basic epidemic model, contagious for life, disease with carriers).
10. Battle model (basic battle model, jungle warfare, long range weapons).
11. Plotting of recursive sequences.
12. Study the convergence of sequences through plotting.
13. Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot.
14. Study the convergence/divergence of infinite series by plotting their sequences of partial sum.
15. Cauchy's root test by plotting n^{th} roots.
16. Ratio test by plotting the ratio of n^{th} and $(n+1)^{th}$ term.

Recommended Books and References:

1. Belinda Barnes and Glenn R. Fulford, *Mathematical Modeling with Case Studies, A Differential Equation Approach using Maple and Matlab,* 2nd Ed., Taylor and Francis group, London and New York, 2009.
2. C.H. Edwards and D.E. Penny, *Differential Equations and Boundary Value problems Computing and Modeling,* Pearson Education India, 2005.
3. S.L. Ross, *Differential Equations,* 3rd Ed., John Wiley and Sons, India, 2004.
4. Martha L Abell, James P Braselton, *Differential Equations with MATHEMATICA,* 3rd Ed., Elsevier Academic Press, 2004.

SEMESTER - III

CORE 5 (MAC 3.11)
THEORY OF REAL FUNCTIONS

Theory Credit: 5
Tutorial Credit: 1

UNIT I Limits of functions ($\varepsilon-\delta$ approach), sequential criterion for limits, divergence criteria. Limit theorems, one sided limits. Infinite limits and limits at infinity.

UNIT II Continuous functions, sequential criterion for continuity and discontinuity. Algebra of continuous functions. Continuous functions on an interval, intermediate value theorem, location of roots theorem, preservation of intervals theorem.
Uniform continuity, non-uniform continuity criteria, uniform continuity theorem.

UNIT III Differentiability of a function at a point and in an interval, Caratheodory's theorem, algebra of differentiable functions. Relative extrema, interior extremum theorem. Rolle's theorem, Mean value theorem. Cauchy's mean value theorem.

UNIT IV L'Hospital's rule. Intermediate value property of derivatives, Darboux's theorem. Applications of mean value theorem to inequalities and approximation of polynomials. Taylor's theorem to inequalities.

UNIT V Taylor's theorem with Lagrange's form of remainder, Taylor's theorem with Cauchy's form of remainder, application of Taylor's theorem to convex functions, relative extrema. Taylor's series and Maclaurin's series expansions of exponential and trigonometric functions, $\ln(1+x)$, $\frac{1}{ax+b}$, and $(1+x)^n$.

Recommended Books and References:

1. R. Bartle and D.R. Sherbert, *Introduction to Real Analysis*, John Wiley and Sons, 2003.
2. S.R. Ghorpade and B.V. Limaye, *A Course in Calculus and Real Analysis,* Springer, 2006.
3. K.A. Ross, *Elementary Analysis: The Theory of Calculus*, Springer, 2004.
4. A. Mattuck, *Introduction to Analysis*, Prentice Hall, 1999.

CORE 6 (MAC 3.21)
GROUP THEORY I

Theory Credit: 5
Tutorial Credit: 1

UNIT I Definition and examples of groups including permutation groups and quaternion groups (illustration through matrices),Symmetries of a square, Dihedral groups, elementary properties of groups.

UNIT II Subgroups and examples of subgroups, centralizer, normalizer, center of a group, product of two subgroups. Properties of cyclic groups, classification of subgroups of cyclic groups.

UNIT III Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group, properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem.

UNIT IV External direct product of a finite number of groups, normal subgroups, factor groups, Cauchy's theorem for finite abelian groups.

UNIT V Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of isomorphisms, First, Second and Third isomorphism theorems.

Recommended Books and References:

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, New Delhi, 1999.
4. Joseph J. Rotman, *An Introduction to the Theory of Groups,* 4th Ed., Springer Verlag, 1995.
5. I.N. Herstein, *Topics in Algebra*, Wiley Eastern Limited, India, 1975.

CORE 7 (MAC 3.31)
PDE AND SYSTEMS OF ODE

Theory Credit: 4

UNIT I Partial Differential Equations – Basic concepts and Definitions, Mathematical Problems. First-Order Equations: Classification, Construction and Geometrical Interpretation. Method of Characteristics for obtaining General Solution of Quasi Linear Equations. Canonical Forms of First-order Linear Equations. Method of Separation of Variables for solving first order partial differential equations.

UNIT II Derivation of Heat equation, Wave equation and Laplace equation. Classification of second order linear equations as hyperbolic, parabolic or elliptic. Reduction of second order Linear Equations to canonical forms.

UNIT III The Cauchy problem. The Cauchy-Kowaleewskaya theorem. Homogeneous wave equation. Cauchy problem of an infinite string. Initial Boundary Value Problems, Semi-Infinite String with a fixed end, Semi-Infinite String with a Free end. Equations with non-homogeneous boundary conditions, Non-Homogeneous Wave Equation. Method of separation of variables, Solving the Vibrating String Problem, Solving the Heat Conduction problem.

UNIT IV Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients, Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions.

UNIT V The method of successive approximations. The Euler method. The modified Euler method. The Runge-Kutta method.

CORE 7 (MAC 3.32)
PDE AND SYSTEMS OF ODE

Practical Credit: 2

List of Practicals (using any software)

(i) Solution of Cauchy problem for first order PDE.

(ii) Finding the characteristics for the first order PDE.

(iii) Plot the integral surfaces of a given first order PDE with initial data.

(iv) Solution of wave equation $\frac{\partial^2 u}{\partial t^2} - c^2 \frac{\partial^2 u}{\partial x^2} = 0$ for the following associated conditions

(a) $u(x,0) = \phi(x), u_t(x,0) = \psi(x), x \in R, t > 0$

(b) $u(x,0) = \phi(x), u_t(x,0) = \psi(x), u(0,t) = 0, x \in (0,\infty), t > 0$

(c) $u(x,0) = \phi(x), u_t(x,0) = \psi(x), u_x(0,t) = 0, x \in (0,\infty), t > 0$

(d) $u(x,0) = \phi(x), u_t(x,0) = \psi(x), u(0,t) = 0, u(1,0) = 0, x \in (0,\infty), t > 0$

(v) $\frac{\partial u}{\partial t} - k^2 \frac{\partial^2 u}{\partial x^2} = 0$ for the following associated conditions

(a) $u(x,0) = \phi(x), u(0,t) = a, u(l,t) = b, 0 < x < l, t > 0$

(b) $u(x,0) = \phi(x), x \in R, 0 < t < T$

(c) $u(x,0) = \phi(x), u(0,t) = a, x \in (0,\infty), t \geq 0$

Recommended Books and References:

1. Tyn Myint-U and Lokenath Debnath, *Linear Partial Differential Equations for Scientists and Engineers,* 4th edition, Springer, Indian reprint, 2006.
2. S.L. Ross, *Differential equations,* 3rd Ed., John Wiley and Sons, India, 2004.
3. Martha L Abell, James P Braselton, *Differential equations with MATHEMATICA,* 3rd Ed., Elsevier Academic Press, 2004.

SEMESTER - IV

CORE 8 (MAC 4.11)
NUMERICAL METHODS

Theory Credit: 4

Use of Scientific Calculator is allowed.

UNIT I Algorithms, Convergence, Errors: Relative, Absolute, Round off, Truncation.

UNIT II Transcendental and Polynomial equations: Bisection method, Newton's method, Secant method. Rate of convergence of these methods.

UNIT III System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis.

UNIT IV Interpolation: Lagrange and Newton's methods. Error bounds. Finite difference operators. Gregory forward and backward difference interpolation.

UNIT V Numerical Integration: Trapezoidal rule, Simpson's $1/3^{rd}$rule, Simpsons $3/8^{th}$rule, Boole's Rule. Midpoint rule, Composite Trapezoidal rule, Composite Simpson's rule.
Ordinary Differential Equations: Euler's method. Runge-Kutta methods of orders two and four.

CORE 8 (MAC 4.12)
NUMERICAL METHODS

Practical Credits: 2

List of Practicals (using any software)

(i) Calculate the sum $1+\frac{1}{2}+\frac{1}{3}+.....+\frac{1}{N}$
(ii) To find the absolute value of an integer.
(iii) Enter 100 integers into an array and sort them in an ascending order.
(iv) Bisection Method.
(v) Newton Raphson Method.
(vi) Secant Method.
(vii) Regula Falsi Method.
(viii) LU decomposition Method.
(ix) Gauss-Jacobi Method.
(x) SOR Method or Gauss-Siedel Method.
(xi) Lagrange Interpolation or Newton Interpolation.
(xii) Simpson's rule.

Note: *For any of the CAS (Computer aided software) Data types-simple data types, floating datatypes, character data types, arithmetic operators and operator precedence, variables and constant declarations, expressions, input/output, relational operators, logical operators and logical expressions, control statements and loop statements, Arrays should be introduced to the students.*

Recommended Books and References:

1. Brian Bradie, *A Friendly Introduction to Numerical Analysis*, Pearson Education, India, 2007.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain, *Numerical Methods for Scientific and Engineering Computation*, 6th Ed., New age International Publisher, India, 2007.
3. C.F. Gerald and P.O. Wheatley, *Applied Numerical Analysis*, Pearson Education, India, 2008.
4. Uri M. Ascher and Chen Greif, *A First Course in Numerical Methods*, 7th Ed., PHI Learning Private Limited, 2013.
5. John H. Mathews and Kurtis D. Fink, *Numerical Methods using Matlab*, 4th Ed., PHI Learning Private Limited, 2012.

CORE 9 (MAC 4.21)
RIEMANN INTEGRATION AND SERIES OF FUNCTIONS

Theory Credit: 5
Tutorial Credit: 1

UNIT I Riemann integration; inequalities of upper and lower sums; Riemann conditions of integrability. Riemann sum and definition of Riemann integral through Riemann sums; equivalence of two definitions.

UNIT II Riemann integrability of monotone and continuous functions, Properties of the Riemann integral; definition and integrability of piecewise continuous and monotone functions. Intermediate Value theorem for Integrals; Fundamental theorems of Calculus.

UNIT III Improper integrals; Types of improper integrals, Comparison test, Limit comparison test; Convergence of Beta and Gamma functions; Problems based on Beta and Gamma functions.

UNIT IV Pointwise and uniform convergence of sequence of functions. Theorems on continuity, derivability and integrability of the limit function of a sequence of functions. Series of functions; Theorems on the continuity and derivability of the sum function of a series of functions; Cauchy criterion for uniform convergence and Weierstrass M-Test.

UNIT V Limit superior and Limit inferior. Power series, radius of convergence, Cauchy Hadamard Theorem, Differentiation and integration of power series; Abel's Theorem; Weierstrass Approximation Theorem (statement only).

Recommended Books and References:

1. K.A. Ross, *Elementary Analysis, The Theory of Calculus*, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
2. R.G. Bartle D.R. Sherbert, *Introduction to Real Analysis,* 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
3. Charles G. Denlinger, *Elements of Real Analysis*, Jones & Bartlett (Student Edition), 2011.

CORE 10 (MAC 4.31)
RING THEORY AND LINEAR ALGEBRA I

Theory Credit: 5
Tutorial Credit: 1

UNIT I Definition and examples of rings, properties of rings, subrings, integral domains and fields, characteristic of a ring.

UNIT II Ideal, ideal generated by a subset of a ring, factor rings, operations on ideals, prime and maximal ideals.

UNIT III Ring homomorphisms, properties of ring homomorphisms, Isomorphism theorems I, II and III, field of quotients.

UNIT IV Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces.

UNIT V Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations. Isomorphisms, Isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix.

Recommended Books and References:

1. John B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Pearson, 2002**.**
2. M. Artin, *Abstract Algebra*, 2nd Ed., Pearson, 2011.
3. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, *Linear Algebra,* 4th Ed., Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.
4. Joseph A. Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa Publishing House, New Delhi, 1999.
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. D.A.R. Wallace, *Groups, Rings and Fields*, Springer Verlag London Ltd., 1998.

SEMESTER – V

CORE 11 (MAC 5.11)
MULTIVARIATE CALCULUS

Theory Credit: 5
Tutorial Credit: 1

Use of Scientific calculator is allowed.

UNIT I Functions of several variables, limit and continuity of functions of two variables Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters.

UNIT II Directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes, Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems, Definition of vector field, divergence and curl

UNIT III Double integration over rectangular region, double integration over non-rectangular region, Double integrals in polar co-ordinates, Triple integrals, Triple integral over a parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical co-ordinates.

UNIT IV Change of variables in double integrals and triple integrals. Line integrals, Applications of line integrals: Mass and Work. Fundamental theorem for line integrals, conservative vector fields, independence of path.

UNIT V Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stoke's theorem, The Divergence theorem.

Recommended Books and References:

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. M.J. Strauss, G.L. Bradley and K. J. Smith, *Calculus,* 3rd Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.
3. E. Marsden, A.J. Tromba and A. Weinstein, *Basic Multivariable Calculus*, Springer (SIE), Indian reprint, 2005.
4. James Stewart, *Multivariable Calculus, Concepts and Contexts*, 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001.

CORE 12 (MAC 5.21)
GROUP THEORY II

Theory Credit: 5
Tutorial Credit: 1

UNIT I Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinite cyclic groups, applications of factor groups to automorphism groups, Characteristic subgroups, Commutator subgroup and its properties.

UNIT II Properties of external direct products, the group of units modulo n as an external direct product, internal direct products, Fundamental Theorem of finite abelian groups.

UNIT III Group actions, stabilizers and kernels, permutation representation associated with a given group action, Applications of group actions: Generalized Cayley's theorem, Index theorem.

UNIT IV Groups acting on themselves by conjugation, class equation and consequences, conjugacy in S_n, p-groups.

UNIT V Sylow's theorems and consequences, Cauchy's theorem, Simplicity of $A_n$for n≥5,non-simplicity tests.

Recommended Books and References:

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. David S. Dummit and Richard M. Foote, *Abstract Algebra*, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2004.
5. J.R. Durbin, *Modern Algebra*, John Wiley & Sons, New York Inc., 2000.
6. D. A. R. Wallace, *Groups, Rings and Fields*, Springer Verlag London Ltd., 1998.

SEMESTER - VI

CORE 13 (MAC 6.11)
METRIC SPACES AND COMPLEX ANALYSIS

Theory Credit: 5
Tutorial Credit: 1

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

UNIT III 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 IV 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. Cauchy-Goursat theorem, Cauchy integral formula.

UNIT V 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.

Recommended Books and References:

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., New York, 1997.

CORE 14 (MAC 6.21)
RING THEORY AND LINEAR ALGEBRA II

Theory Credit: 5
Tutorial Credit: 1

UNIT I Polynomial rings over commutative rings, division algorithm and consequences, principal ideal domains, factorization of polynomials, reducibility tests, irreducibility tests, Eisenstein criterion.

UNIT II Unique factorization in Z[x]**.** Divisibility in integral domains, irreducibles, primes, unique factorization domains, Euclidean domains.

UNIT III 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 and Cayley-Hamilton theorem. The minimal polynomial for a linear operator.

UNIT IV Inner product spaces and norms, Gram-Schmidt orthogonalisation process, orthogonal complements, Bessel's inequality, the adjoint of a linear operator.

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

Recommended Books and References:

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., Prentice-Hall 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.
5. S. Kumaresan, *Linear Algebra- A Geometric Approach*, Prentice Hall of India, 1999.
6. Kenneth Hoffman, Ray Alden Kunze, *Linear Algebra,* 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
7. S.H. Friedberg, A.L. Insel and L.E. Spence, *Linear Algebra*, Prentice Hall of India Pvt. Ltd., 2004.

DISCIPLINE SPECIFIC ELECTIVE

DISCIPLINE SPECIFIC ELECTIVE 1 (MAD 5.11(a))
PORTFOLIO OPTIMIZATION

Theory Credit: 5
Tutorial Credit: 1

UNIT I Financial markets. Investment objectives. Measures of return and risk. Types of risks. Risk free assets.

UNIT II Mutual funds. Portfolio of assets. Expected risk and return of portfolio. Diversification.

UNIT III Mean-variance portfolio optimization- the Markowitz model and the two-fund theorem, risk-free assets and one fund theorem, efficient frontier.

UNIT IV Portfolios with short sales. Capital market theory.

UNIT V Capital assets pricing model- the capital market line, beta of an asset, beta of a portfolio, security market line. Index tracking optimization models. Portfolio performance evaluation measures.

Recommended Books and References:

1. F. K. Reilly, Keith C. Brown, *Investment Analysis and Portfolio Management*, 10th Ed., South-Western Publishers, 2011.
2. H.M. Markowitz, *Mean-Variance Analysis in Portfolio Choice and Capital Markets*, Blackwell, New York, 1987.
3. M.J. Best, *Portfolio Optimization*, Chapman and Hall, CRC Press, 2010.
4. D.G. Luenberger, *Investment Science*, 2nd Ed., Oxford University Press, 2013.

DISCIPLINE SPECIFIC ELECTIVE 1(MAD 5.11(b))
NUMBER THEORY

Theory Credit: 5
Tutorial Credit: 1

UNIT I Linear Diophantine equation, prime counting function, statement of prime number theorem, Goldbach conjecture, linear congruences, complete set of residues, Chinese Remainder theorem, Fermat's Little theorem, Wilson's theorem.

UNIT II Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Mobius Inversion formula

UNIT III The greatest integer function, Euler's phi-function, Euler's theorem, reduced set of residues, some properties of Euler's phi-function.

UNIT IV Order of an integer modulo n, primitive roots for primes, composite numbers having primitive roots, Euler's criterion, the Legendre symbol and its properties, quadratic reciprocity, quadratic congruences with composite moduli.

UNIT V Public key encryption, RSA encryption and decryption, the equation $x^2 + y^2 = z^2$, Fermat's Last theorem.

Recommended Books and References:

1. David M. Burton, *Elementary Number Theory,* 6th Ed., Tata McGraw-Hill, Indian reprint, 2007.
2. Neville Robinns, *Beginning Number Theory,* 2nd Ed., Narosa Publishing House Pvt. Ltd., Delhi, 2007.

DISCIPLINE SPECIFIC ELECTIVE 1(MAD 5.11(c))
ANALYTICAL GEOMETRY

Theory Credit: 5
Tutorial Credit: 1

UNIT I Techniques for sketching parabola, ellipse and hyperbola.

UNIT II Reflection properties of parabola, ellipse and hyperbola.

UNIT III Classification of quadratic equations representing lines, parabola, ellipse and hyperbola.

UNIT IV Spheres, Cylindrical surfaces.

UNIT V Illustrations of graphing standard quadric surfaces like cone, ellipsoid.

Recommended Books and References:

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. H. Anton, I. Bivens and S. Davis, *Calculus*, John Wiley and Sons (Asia) Pvt. Ltd. 2002.
3. S.L. Loney, *The Elements of Coordinate Geometry*, McMillan and Company, London.
4. R.J.T. Bell, *Elementary Treatise on Coordinate Geometry of Three Dimensions*, McMillan India Ltd., 1994.

DISCIPLINE SPECIFIC ELECTIVE 2(MAD 5.21(a))
INDUSTRIAL MATHEMATICS

Theory Credit: 5
Tutorial Credit: 1

UNIT I Medical Imaging and Inverse Problems. The content is based on Mathematics of X-ray and CT scan based on the knowledge of calculus, elementary differential equations, complex numbers and matrices.

UNIT II Introduction to Inverse problems: Why should we teach Inverse Problems? Illustration of Inverse problems through problems taught in Pre-Calculus, Calculus, Matrices and differential equations. Geological anomalies in Earth's interior from measurements at its surface (Inverse problems for Natural disaster) and Tomography.

UNIT III X-ray: Introduction, X-ray behavior and Beers Law (The fundament question of image construction) Lines in the place.

UNIT IV Radon Transform: Definition and Examples, Linearity, Phantom (Shepp - Logan Phantom - Mathematical phantoms).

UNIT V Back Projection: Definition, properties and examples.
CT Scan: Revision of properties of Fourier and inverse Fourier transforms and applications of their properties in image reconstruction. Algorithms of CT scan machine. Algebraic reconstruction techniques abbreviated as ART with application to CT scan.

Recommended Books and References:

1. Timothy G. Feeman, *The Mathematics of Medical Imaging, A Beginners Guide*, Springer Under graduate Text in Mathematics and Technology, Springer, 2010.
2. C.W. Groetsch, *Inverse Problems,* Activities for Undergraduates, The Mathematical Association of America, 1999.
3. Andreas Kirsch, *An Introduction to the Mathematical Theory of Inverse Problems*, 2nd Ed., Springer, 2011.

DISCIPLINE SPECIFIC ELECTIVE 2 (MAD 5.21(b))
BOOLEAN ALGEBRA AND AUTOMATA THEORY

Theory Credit: 5
Tutorial Credit: 1

UNIT I Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle, lattices as ordered sets, lattices as algebraic structures, sublattices, products and homomorphisms.

UNIT II Definition, examples and properties of modular and distributive lattices, Boolean algebras, Boolean polynomials, minimal forms of Boolean polynomials, Quinn-McCluskey method, Karnaugh diagrams, switching circuits and applications of switching circuits.

UNIT III Introduction: Alphabets, strings, and languages. Finite Automata and Regular Languages: deterministic and non-deterministic finite automata, regular expressions, regular languages and their relationship with finite automata, pumping lemma and closure properties of regular languages.

UNIT IV Context Free Grammars and Pushdown Automata: Context free grammars (CFG), parse trees, ambiguities in grammars and languages, pushdown automaton (PDA) and the language accepted by PDA, deterministic PDA, Non- deterministic PDA, properties of context free languages; normal forms, pumping lemma, closure properties, decision properties.

UNIT V Turing Machines: Turing machine as a model of computation, programming with a Turing machine, variants of Turing machine and their equivalence.

Undecidability: Recursively enumerable and recursive languages, undecidable problems about Turing machines: halting problem, Post Correspondence Problem, and undecidability problems About CFGs.

Recommended Books and References:

1. B A. Davey and H. A. Priestley, *Introduction to Lattices and Order*, Cambridge University Press, Cambridge, 1990.
2. Edgar G. Goodaire and Michael M. Parmenter, *Discrete Mathematics with Graph Theory,* (2nd Ed.), Pearson Education (Singapore) P.Ltd., Indian Reprint 2003.
3. Rudolf Lidl and Günter Pilz, *Applied Abstract Algebra*, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
4. J. E. Hopcroft, R. Motwani and J. D. Ullman, *Introduction to Automata Theory, Languages and Computation,* 2nd Ed., Addison-Wesley, 2001.
5. H.R. Lewis, C.H. Papadimitriou, C. Papadimitriou, *Elements of the Theory of Computation*, 2nd Ed., Prentice-Hall, NJ, 1997.
6. J.A. Anderson, *Automata Theory with Modern Applications*, Cambridge University Press, 2006.

DISCIPLINE SPECIFIC ELECTIVE 2(MAD 5.21(c))
PROBABILITY AND STATISTICS

Theory Credit: 5
Tutorial Credit: 1

UNIT I Sample space, probability axioms, real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moment generating function, characteristic function.

UNIT II Discrete distributions: uniform, binomial, Poisson, geometric, negative binomial, continuous distributions: uniform, normal, exponential. Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions.

UNIT III Expectation of function of two random variables, conditional expectations, independent random variables. Bivariate normal distribution, correlation coefficient, joint moment generating function (jmgf) and calculation of covariance (from jmgf), linear regression for two variables.

UNIT IV Chebyshev's inequality, statement and interpretation of (weak) law of large numbers and strong law of large numbers, Central Limit theorem for independent and identically distributed random variables with finite variance,

UNIT V Markov Chains, Chapman-Kolmogorov equations, classification of states.

Recommended Books and References:

1. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, Introduction to Mathematical Statistics, Pearson Education, Asia, 2007.
2. Irwin Miller and Marylees Miller, John E. Freund, Mathematical Statistics with Applications, 7th Ed., Pearson Education, Asia, 2006.
3. Sheldon Ross, Introduction to Probability Models, 9th Ed., Academic Press, Indian Reprint, 2007.

4. Alexander M. Mood, Franklin A. Graybill and Duane C. Boes, Introduction to the Theory of Statistics, 3rd Ed., Tata McGraw- Hill, Reprint 2007

DISCIPLINE SPECIFIC ELECTIVE 3(MAD 6.11(a))
THEORY OF EQUATIONS

Theory Credit: 5
Tutorial Credit: 1

UNIT I General properties of polynomials, Graphical representation of a polynomial, maximum and minimum values of a polynomials, General properties of equations, Descarte's rule of signs positive and negative rule, Relation between the roots and the coefficients of equations.

UNIT II Symmetric functions, Applications of symmetric function of the roots, Transformation of equations. Solutions of reciprocal and binomial equations.

UNIT III Algebraic solutions of the cubic and biquadratic. Properties of the derived functions.

UNIT IV Symmetric functions of the roots, Newton's theorem on the sums of powers of roots, homogeneous products, limits of the roots of equations.

UNIT V 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.

Recommended Books and References:

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.

DISCIPLINE SPECIFIC ELECTIVE 3(MAD 6.11(b))
BIO-MATHEMATICS

Theory Credit: 5
Tutorial Credit: 1

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

UNIT II 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, Numerical solution of the models and its graphical representation.

UNIT III 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 IV 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.

UNIT V Discrete Models: Overview of difference equations, steady state solution and linear stability analysis, 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.

Recommended Books and References:

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.

DISCIPLINE SPECIFIC ELECTIVE 3(MAD 6.11(c))
LINEAR PROGRAMMING

Theory Credit: 5
Tutorial Credit: 1

UNIT I 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 II Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual.

UNIT III Transportation problem and its mathematical formulation, northwest-corner method least cost method and Vogel approximation method for determination of starting basic solution.

UNIT IV Algorithm for solving transportation problem, assignment problem and its mathematical formulation, Hungarian method for solving assignment problem.

UNIT V 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.

Recommended Books and References:

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.

DISCIPLINE SPECIFIC ELECTIVE 4(MAD 6.21(a))
MATHEMATICAL MODELING

Theory Credit: 4

UNIT I Power series solution of a differential equation about an ordinary point, solution about a regular singular point.

UNIT II Bessel's equation and Legendre's equation, Laplace transform and inverse transform, application to initial value problem up to second order.

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

UNIT IV Generating Random Numbers: middle square method, linear congruence, Queuing Models: harbor system, morning rush hour.

UNIT V Overview of optimization modeling, Linear Programming Model: geometric solution algebraic solution, simplex method, sensitivity analysis

DISCIPLINE SPECIFIC ELECTIVE 4(MAD 6.22(a))
MATHEMATICAL MODELING

Practical Credit: 2

List of Practicals (using any software)

(i) 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].
(ii) Automatic computation of coefficients in the series solution near ordinary points.
(iii) Plotting of the Bessel's function of first kind of order 0 to 3.
(iv) Automating the Frobenius Series Method.
(v) Random number generation and then use it for one of the following (a) Simulate area under a curve (b) Simulate volume under a surface.
(vi) Programming of either one of the queuing model (a) Single server queue (e.g. Harbor system) (b) Multiple server queue (e.g. Rush hour).
(vii) Programming of the Simplex method for 2/3 variables.

Recommended Books and References:

1. TynMyint-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 MathematicalModeling*, Thomson Learning, London and New York, 2003.

DISCIPLINE SPECIFIC ELECTIVE 4(MAD 6.21(b))
MECHANICS

Theory Credit: 5
Tutorial Credit: 1

UNIT I 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 II 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 III 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 IV 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 V 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.

Recommended Books and References:

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.

DISCIPLINE SPECIFIC ELECTIVE 4(MAD 5.21(c))
DIFFERENTIAL GEOMETRY

Theory Credit: 5
Tutorial Credit: 1

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

UNIT III 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 IV Tensors: Summation convention and indicial notation, Coordinate transformation and Jacobian, Contra-variant and Covariant vectors, Tensors of different type, Algebra of tensors and contraction.

UNIT V 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.

Recommended Books and References:

1. T.J. Willmore, *An Introduction to Differential Geometry*, Dover Publications, 2012.
2. B. O'Neill, *Elementary Differential Geometry*, 2nd Ed., 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.

SKILL ENHANCEMENT COURSE

SKILL ENHANCEMENT COURSE 1 (MAS 3.11(a))
LOGIC AND SETS

Theory Credit: 2

UNIT I Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators.

UNIT II Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.

UNIT III Sets, subsets, Set operations and the laws of set theory and Venn diagrams. Examples of finite and infinite sets. Finite sets and counting principle. Empty set, properties of empty set. Standard set operations.

UNIT IV Classes of sets. Power set of a set. Difference and Symmetric difference of two sets. Set identities, Generalized union and intersections.

UNIT V Relation: Product set, Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation, Partial ordering relations, n-ary relations.

Recommended Books and References:

1. R.P. Grimaldi, *Discrete Mathematics and Combinatorial Mathematics*, Pearson Education, 1998.
2. P.R. Halmos, *Naive Set Theory*, Springer, 1974.
3. E. Kamke, *Theory of Sets*, Dover Publishers, 1950.

SKILL ENHANCEMENT COURSE 1 (MAS 3.11(b))
COMPUTER GRAPHICS

Theory Credit: 2

UNIT I Development of computer Graphics: Raster Scan and Random Scan graphics storages, displays processors and character generators.

UNIT II Colour display techniques, interactive input/output devices.

UNIT III Points, lines and curves: Scan conversion, line-drawing algorithms.

UNIT IV Circle and ellipse generation, conic-section generation, polygon filling anti aliasing.

UNIT V Two-dimensional viewing: Coordinate systems, linear transformations, line and polygon clipping algorithms.

Recommended Books and References:

1. D. Hearn and M.P. Baker, *Computer Graphics,* 2nd Ed., Prentice–Hall of India, 2004.
2. J.D. Foley, A van Dam, S.K. Feiner and J.F. Hughes, *Computer Graphics: Principals and Practices,* 2nd Ed., Addison-Wesley, MA, 1990.
3. D.F. Rogers, *Procedural Elements in Computer Graphics,* 2nd Ed., McGraw Hill Book Company, 2001.
4. D.F. Rogers and A.J. Admas, *Mathematical Elements in Computer Graphics,* 2nd Ed., McGraw Hill Book Company, 1990.

SKILL ENHANCEMENT COURSE 2 (MAS 4.11(a))
GRAPH THEORY

Theory Credit: 2

UNIT I Definition, examples and basic properties of graphs, pseudo graphs, complete graphs.

UNIT II Bi-partite graphs, weighted graph, adjacency and incidence matrices,

UNIT III Isomorphism of graphs paths and circuits, Eulerian circuits.

UNIT IV Hamiltonian cycles, Travelling salesman's problem.

UNIT V Shortest path, Dijkstra's algorithm, Floyd-Warshall algorithm.

Recommended Books and References:

1. B.A. Davey and H.A. Priestley, *Introduction to Lattices and Order*, Cambridge University Press, Cambridge, 1990.
2. Edgar G. Goodaire and Michael M. Parmenter, *Discrete Mathematics with Graph Theory,* 2nd Edition, Pearson Education (Singapore) P. Ltd., Indian Reprint 2003.
3. Rudolf Lidl and Gunter Pilz, Applied Abstract Algebra, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.

SKILL ENHANCEMENT COURSE 2 (MAS 4.11(b))
OPERATING SYSTEM: LINUX

Theory Credit: 2

UNIT I Linux – The Operating System: Linux history, Linux features, Linux distributions, Linux's relationship to Unix.

UNIT II Overview of Linux architecture, Installation, Start up scripts, system processes (an overview), Linux Security, The Ext2 and Ext3 File systems: General Characteristics of, The Ext3 File system, file permissions.

UNIT III User Management: Types of users, the powers of Root, managing users (adding and deleting): using the command line and GUI tools.

UNIT IV Resource Management in Linux: file and directory management, system calls for files Process Management, Signals.

UNIT V IPC: Pipes, FIFOs, System V IPC, Message Queues, system calls for processes, Memory Management, library and system calls for memory.

Recommended Books and References:

1. Arnold Robbins, *Linux Programming by Examples The Fundamentals*, 2nd Ed., Pearson Education, 2008.
2. Cox K, *Red Hat Linux Administrator's Guide*, PHI, 2009.
3. R. Stevens, *UNIX Network Programming*, 3rd Ed., PHI, 2008.
4. Sumitabha Das, *Unix Concepts and Applications*, 4th Ed., TMH, 2009.
5. Ellen Siever, Stephen Figgins, Robert Love, Arnold Robbins, *Linux in a Nutshell*, 6th Ed., O'Reilly Media, 2009.
6. Neil Matthew, Richard Stones, Alan Cox, *Beginning Linux Programming*, 3rd Ed., 2004.