SYLLABUS FOR B.A/B.SC. (HONOURS)
IN
MATHEMATICS

Under Choice Based Credit System (CBCS)

Effective from 2017-2018

The University of Burdwan
Burdwan-713104
West Bengal

Outlines of Course Structures

The main components of this syllabus are as follows:

1. **Core Course**
2. **Elective Course**
3. **Ability Enhancement Course**

1. **Core Course (CC)**

A course, that should compulsorily be studied by a candidate as a core requirement, is termed as a core course.

2. **Elective Course**

   2.1 Discipline Specific Elective (DSE) Course: A course, which may be offered by the main discipline/subject of study, is referred to as Discipline Specific Elective.

   2.2 Generic Elective (GE) Course: An elective course, chosen generally from an unrelated discipline/subject of study with intention to seek an exposure, is called a Generic Elective Course.

3. **Ability Enhancement Course (AEC)**

   The Ability Enhancement Course may be of two kinds:

   3.1 Ability Enhancement Compulsory Course (AECC)

   3.2 Skill Enhancement Course (SEC)

Details of Courses of B.A./B.Sc. (Honours) under CBCS

	Course	Credit		Marks
1.	Core Course (14 papers)	Theory + Practical 14×(4+2)=84	Theory +Tutorial 14×(5+1)=84	14×75= 1050
2.	Elective Course (8 Papers)			
	A. DSE (4 Papers)	4×(4+2)=24	4×(5+1)=24	4×75= 300
	B. GE (4 Papers)	4×(4+2)=24	4×(5+1)=24	4×75= 300
3.	Ability Enhancement Course			
	A. AECC (2 Papers) AECC1 (ENVS) AECC2 (English/MIL)	4×1=4 2×1=2	4×1=4 2×1=2	100 50
	B. SEC (2 Papers)	2×2=4	2×2=4	2×50= 100
	Total Credit :	**142**	**142**	**Total Marks = 1900**

Semester wise Course Structures

Semester	Course Type	Course Code	Name of the Course	Credit Pattern (L:T:P)	Total class hrs./week	Marks	Credit
I	CC	BMH1CC01	Calculus, Geometry & Differential Equations	5:1:0	6	75	6
		BMH1CC02	Algebra	5:1:0	6	75	6
	AECC		Environmental Studies	4:0:0	4	100	4
	GE		**To be offered by other discipline.**				6
II	CC	BMH2CC03	Real Analysis	5:1:0	6	75	6
		BMH2CC04	Differential Equations and Vector Calculus	5:1:0	6	75	6
	AECC		English/Modern Indian Language	2:0:0	2	50	2
	GE		**To be offered by other discipline.**				6
III	CC	BMH3CC05	Theory of Real Functions & Introduction to Metric Spaces	5:1:0	6	75	6
		BMH3CC06	Group Theory I	5:1:0	6	75	6
		BMH3CC07	Numerical Methods & Numerical Methods Lab	4:0:2	8	75 (50+25)	6
	SEC	**Choose any one from the following courses for Skill Enhancement Courses (SECs).**					
		BMH3SEC11	Logic and Sets	2:0:0	2	50	2
		BMH3SEC12	Computer Graphics	2:0:0	2	50	2
		BMH3SEC13	Object Oriented Programming in C++	2:0:0	2	50	2
	GE		**To be offered by other discipline.**				6
IV	CC	BMH4CC08	Riemann Integration and Series of Functions	5:1:0	6	75	6
		BMH4CC09	Multivariate Calculus	5:1:0	6	75	6
		BMH4CC10	Ring Theory and Linear Algebra I	5:1:0	6	75	6
	SEC	**Choose any one from the following courses for Skill Enhancement Courses (SECs).**					
		BMH4SEC21	Graph Theory	2:0:0	2	50	2
		BMH3SEC22	Operating System (Linux)	2:0:0	2	50	2
		BMH3SEC23	MATLAB Programming	2:0:0	2	50	2
	GE		**To be offered by other discipline.**				6

Sem ester	Course Type	Course Code	Name of the Course	Credit Pattern (L:T:P)	Total class hrs. /week	Marks	Credit
V	CC	BMH5CC11	Partial Differential Equations and Applications	5:1:0	6	75	6
		BMH5CC12	Mechanics I	5:1:0	6	75	6
	Choose any one from the following courses for Discipline Specific Electives.						
	DSE	BMH5DSE11	Linear Programming	5:1:0	6	75	6
		BMH5DSE12	Number Theory	5:1:0	6	75	6
		BMH5DSE13	Point Set Topology	5:1:0	6	75	6
	Choose any one from the following courses for Discipline Specific Electives.						
	DSE	BMH5DSE21	Probability & Statistics	5:1:0	6	75	6
		BMH5DSE22	Portfolio Optimization	5:1:0	6	75	6
		BMH5DSE23	Boolean Algebra and Automata Theory	5:1:0	6	75	6
VI	CC	BMH5CC13	Metric Spaces and Complex Analysis	5:1:0	6	75	6
		BMH5CC14	Ring Theory and Linear Algebra II	5:1:0	6	75	6
	Choose any one from the following courses for Discipline Specific Electives.						
	DSE	BMH6DSE31	Mathematical Modeling	5:1:0	6	75	6
		BMH6DSE32	Industrial Mathematics	5:1:0	6	75	6
		BMH6DSE33	Group Theory II	5:1:0	6	75	6
	Choose any one from the following courses for Discipline Specific Electives.						
	DSE	BMH6DSE41	Bio Mathematics	5:1:0	6	75	6
		BMH6DSE42	Differential Geometry	5:1:0	6	75	6
		BMH6DSE43	Mechanics II	5:1:0	6	75	6
	Optional Dissertation or project work in place of one Discipline Specific Elective (DSE) Paper.						
	PW	BMH6PW01	Project Work	0:0:6	6	75	6

Detailed Syllabus

Course: BMH1CC01

Calculus, Geometry & Differential Equations (Marks: 75)

Total Lecture Hours: 60

Unit -1: Hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to problems of type $e^{ax+b}\sin x$, $e^{ax+b}\cos x$, $(ax+b)^n$ sinx, $(ax+b)^n$ cosx, concavity and inflection points, envelopes, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L'Hospital's rule, applications in business, economics and life sciences. **12L**

Unit-2 : Reduction formulae, derivations and illustrations of reduction formulae for the integration of sin nx, cosnx, tan nx, sec nx, $(\log x)^n$, $\sin^n x \sin^m x$, parametric equations, parametrizing a curve, arc length, arc length of parametric curves, area of surface of revolution.

Techniques of sketching conics. **12L**

Unit -3: Reflection properties of conics, translation and rotation of axes and second degree equations, classification of conics using the discriminant, polar equations of conics.

Spheres.Cylindrical surfaces. Central conicoids, paraboloids, plane sections of conicoids, Generating lines, classification of quadrics, Illustrations of graphing standard quadric surfaces like cone, ellipsoid. **12L**

Unit – 4: 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. **12L**

Graphical Demonstration (Teaching Aid) 12L

1. *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*
2. *Plotting the graphs of polynomial of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.*
3. *Sketching parametric curves (Eg. Trochoid, cycloid, epicycloids, hypocycloid).*

4. *Obtaining surface of revolution of curves.*
5. *Tracing of conics in Cartesian coordinates/polar coordinates.*
6. *Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic, paraboloid, and hyperbolic paraboloid using Cartesian coordinates.*

Books Recommended :

➢ G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
➢ M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.
➢ H. Anton, I. Bivens and S. Davis, Calculus, 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.
➢ R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer- Verlag, New York, Inc., 1989.
➢ S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
➢ Murray, D., Introductory Course in Differential Equations, Longmans Green and Co. 1897.
➢ G.F.Simmons, Differential Equations, Tata Mcgraw Hill, 1991.
➢ T. Apostol, Calculus, Volumes I and II. Vol-I, 1966, Vol-II, 1968.
➢ S. Goldberg, Calculus and Mathematical analysis, 1989.

Course: BMH1CC02

Algebra (Marks: 75)

Total Lecture Hours: 60

Unit -1 : Polar representation of complex numbers, n-th roots of unity, De Moivre's theorem for rational indices and its applications. **5L**

Theory of equations: Relation between roots and coefficients, Transformation of equation, Descartes rule of signs, Cubic and biquadratic equations. Reciprocal equation, separation of the roots of equations, Strum,s theorem. **8L**

Inequality: The inequality involving AM≥GM≥HM, Cauchy-Schwartz inequality. **4L**

Unit -2 : Equivalence relations and partitions, 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. **15L**

Unit -3: Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation Ax=b, solution sets of linear systems, applications of linear systems, linear independence. **10L**

Unit 4: Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices. Vector Spaces of R^n, Subspaces of R^n, dimension of subspaces of R^n, rank of a matrix, Eigen values, Eigen Vectors and Characteristic Equation of a matrix. Cayley-Hamilton theorem and its use in finding the inverse of a matrix. **18L**

Books Recommended :
- ➢ Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser, 2006.
- ➢ Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.
- ➢ David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
- ➢ K.B. Dutta, Matrix and linear algebra, 2004.
- ➢ K. Hoffman, R. Kunze, Linear algebra, 1971.
- ➢ W.S. Burnstine and A.W. Panton, Theory of equations, 2007.

Course: BMH2CC03

Real Analysis (Marks: 75)

Total Lecture Hours: 60

Unit-1: Review of Algebraic and Order Properties of ℝ, ε-neighbourhood 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.Completeness Property of ℝ and its equivalent properties. The Archimedean Property, Density of Rational (and Irrational) numbers in ℝ, Intervals. Limit points of a set, Isolated points, Open set, closed set, derived set, Illustrations of Bolzano-Weierstrass theorem for sets, compact sets in ℝ, Heine-Borel Theorem. **20L**

Unit-2 : Sequences, Bounded sequence, Convergent sequence, Limit of a sequence, liminf, lim sup. Limit Theorems. Monotone Sequences, Monotone Convergence Theorem. Subsequences, Divergence Criteria.Monotone Subsequence Theorem (statement only), Bolzano Weierstrass Theorem for Sequences.Cauchy sequence, Cauchy's Convergence Criterion. **15L**

Unit-3 : Infinite series, convergence and divergence of infinite series, Cauchy Criterion, Tests for convergence: Comparison test, Limit Comparison test, Ratio Test, Cauchy's nth root test, Integral test. Alternating series, Leibniz test. Absolute and Conditional convergence. **15L**

Graphical Demonstration (Teaching Aid) 10L

1. Plotting of recursive sequences.
2. Study the convergence of sequences through plotting.
3. Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot**.**
4. Study the convergence/divergence of infinite series by plotting their sequences of partial sum**.**
5. Cauchy's root test by plotting nth roots.
6. Ratio test by plotting the ratio of nth and (n+1)th term.

Books Recommended:

➢ R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
➢ Gerald G. Bilodeau , Paul R. Thie, G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones & Bartlett, 2010.
➢ Brian S. Thomson, Andrew. M. Bruckner and Judith B. Bruckner, Elementary Real Analysis, Prentice Hall, 2001.
➢ S.K. Berberian, a First Course in Real Analysis, Springer Verlag, New York, 1994.
➢ Tom M. Apostol, Mathematical Analysis, Narosa Publishing House, 1981.
➢ Courant and John, Introduction to Calculus and Analysis, Vol I, Springer, 1999.
➢ W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill, 1953.
➢ Terence Tao, Analysis I, Hindustan Book Agency, 2006
➢ S. Goldberg, Calculus and mathematical analysis, 1989.

Course: BMH2CC04

Differential Equation and Vector Calculus (Marks: 75)

Total Lecture Hours: 60

Unit-1: Lipschitz condition and Picard's Theorem (Statement only). General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters. **20L**

Unit -2: 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. **20L**

Unit-3: Equilibrium points, Interpretation of the phase plane
Power series solution of a differential equation about an ordinary point, solution about a regular singular point. **6L**

Unit- 4 : Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions. **10L**

Graphical Demonstration (Teaching Aid) : **4L**

1. Plotting of family of curves which are solutions of second order differential equation.
2. Plotting of family of curves which are solutions of third order differential equation.

Books Recommended :

- 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.
- C.H. Edwards and D.E. Penny, Differential Equations and Boundary Value problems Computing and Modeling, Pearson Education India, 2005.
- S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
- Martha L Abell, James P Braselton, Differential Equations with MATHEMATICA, 3rd Ed., Elsevier Academic Press, 2004.
- Murray, D., Introductory Course in Differential Equations, Longmans Green and Co, 1897.
- Boyce and Diprima, Elementary Differential Equations and Boundary Value Problems, Wiley, 2012.
- G.F.Simmons, Differential Equations, Tata McGraw Hill, 1991.
- Marsden, J., and Tromba, Vector Calculus, McGraw Hill, 1987.
- Maity, K.C. and Ghosh, R.K., Vector Analysis, New Central Book Agency (P) Ltd. Kolkata (India), 1999.
- M.R. Speigel, Schaum's outline of Vector Analysis, McGraw Hill, 1980.

Course: BMH3CC05

Theory of Real Functions & Introduction to Metric Space (Marks: 75)

Total Lecture Hours: 60

Unit -1:Limits of functions (ε - δ approach), sequential criterion for limits, divergence criteria. Limit theorems, one sided limits. Infinite limits and limits at infinity. 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, theorems on uniform continuity. **25L**

Unit -2 :Differentiability of a function at a point and in an interval, Caratheodory's theorem, algebra of differentiable functions. Relative extrema, interior extremum, Rolle's theorem. Mean value theorem, intermediate value property of derivatives, Darboux's theorem. Applications of mean value theorem to inequalities and approximation of polynomials, Application of differential calculus : Curvature **15L**

Unit-3:Cauchy's mean value theorem. 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, $\ln(1 + x)$, $1/ax+b$ and $(1 +x)^n$. Application of Taylor's theorem to inequalities. **10L**

Unit-4 :Metric spaces: Definition and examples. Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set, subspaces, dense sets, separable spaces. **10L**

Books Recommended :

1. R. Bartle and D.R. Sherbert, Introduction to Real Analysis, John Wiley and Sons, 2003.
2. K.A. Ross, Elementary Analysis: The Theory of Calculus, Springer, 2004.
3. A, Mattuck, Introduction to Analysis, Prentice Hall, 1999.
4. S.R. Ghorpade and B.V. Limaye, a Course in Calculus and Real Analysis, Springer, 2006.
5. Tom M. Apostol, Mathematical Analysis, Narosa Publishing House, 2002.
6. R. Courant and F. John, Introduction to Calculus and Analysis, Vol II, Springer, 1999.
7. W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill, 2017.
8. Terence Tao, Analysis II, Hindustan Book Agency, 2006
9. Satish Shirali and Harikishan L. Vasudeva, Metric Spaces, Springer Verlag, London, 2006
10. S. Kumaresan, Topology of Metric Spaces, 2nd Ed., Narosa Publishing House, 2011.
11. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 2004.

Course: BMH3CC06

Group Theory–I (Marks: 75)

Total Lecture Hours: 60

Unit-1 : Symmetries of a square, Dihedral groups, definition and examples of groups including permutation groups and quaternion groups (through matrices), elementary properties of groups. **10L**

Unit-2: Subgroups and examples of subgroups, centralizer, normalizer, center of a group, product of two subgroups. **5L**

Unit-3 : Properties of cyclic groups, classification of subgroups of cyclic groups, 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. **20L**

Unit-4: External direct product of a finite number of groups, normal subgroups, factor groups, Cauchy's theorem for finite abelian groups. **10L**

Unit-5: Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of isomorphisms, First, Second and Third isomorphism theorems. **15L**

.**Books Recommended :**
- ➢ John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
- ➢ M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
- ➢ Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., 1999.
- ➢ Joseph J. Rotman, An Introduction to the Theory of Groups, 4th Ed., 1995.
- ➢ I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.
- ➢ D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of Abstract Algebra, 1997.

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Course: BMH3CC07

Numerical Methods & Numerical Methods Lab

(Theory: 50 & Practical: 25)

Total Lecture Hours: 60(Theory-40, Practical-20)

Unit-1: Algorithms, Convergence, Errors: Relative, Absolute. Round off, Truncation. **2L**

Unit-2 : Transcendental and Polynomial equations: Bisection method, Newton's method, Secant method, Regula-falsi method, fixed point iteration, Newton-Raphson method. Rate of convergence of these methods. **6L**

Unit -3 : System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis, LU Decomposition.   **8L**

Unit-4: Interpolation: Lagrange and Newton's methods, Error bounds, Finite difference operators. Gregory forward and backward difference interpolations.

Numerical differentiation: Methods based on interpolations, methods based on finite differences. **9L**

Unit – 5 : Numerical Integration: Newton Cotes formula, Trapezoidal rule, Simpson's 1/3rd rule, Simpsons 3/8th rule, Weddle's rule, Boole's rule. Midpoint rule, Composite Trapezoidal rule, Composite Simpson's 1/3rd rule, Gauss quadrature formula.

The algebraic eigenvalue problem: Power method.   **10L**

Unit – 6: Ordinary Differential Equations: The method of successive approximations, Euler's method, the modified Euler method, Runge-Kutta methods of orders two and four.   **5L**

Unit -7: Numerical Practical   20L

Lab notebook & Viva Voce : 5 marks
Numerical Problem : 15 marks (Program:10, Result:5)

List of practical (using C programming)

   1. Solution of transcendental and algebraic equations by

       (a) Newton Raphson method.

       (b) Regula Falsi method.

   2. Solution of system of linear equations

        (a)   Gaussian elimination method

        (b) Gauss-Seidel method

   3. Interpolation : Lagrange Interpolation

   4. Numerical Integration

       (a) Trapezoidal Rule

       (b) Simpson's one third rule

   5. Solution of ordinary differential equations : Runge Kutta method

Books Recommended :

   ➢   Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.
   ➢   M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering, 2012.
   ➢   Computation, 6th Ed., New age International Publisher, India, 2007.
   ➢   C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 2008.
   ➢   Uri M. Ascher and Chen Greif, A First Course in Numerical Methods, 7th Ed., PHI Learning Private Limited, 2013.

- John H. Mathews and Kurtis D. Fink, Numerical Methods using Matlab, 4th Ed., PHI Learning Private Limited, 2012.
- Scarborough, James B., Numerical Mathematical Analysis, Oxford and IBH publishing co, 1966.
- Atkinson, K. E., An Introduction to Numerical Analysis, John Wiley and Sons, 1978.
- Yashavant Kanetkar, Let Us C , BPB Publications, 2016.

Course: BMH3SEC11

Logic and Sets (Marks: 50)

Total Lecture Hours: 40

Unit 1 : Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators. Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations. **18L**

Unit 2 : 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. Classes of sets. Power set of a set. **7L**

Unit 3 : Difference and Symmetric difference of two sets. Set identities, Generalized union and intersections. Relation: Product set. Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation. Partial ordering relations, n- ary relations. **15L**

Books Recommended :

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

Course: BMH3SEC12

Computer Graphics (Marks: 50)

Total Lecture Hours: 40

Unit 1 : Development of Computer Graphics: Raster Scan and Random Scan graphics storages, displays processors and character generators, colour display techniques, interactive input/output devices. **10L**

Unit 2 : Points, lines and curves: Scan conversion, line-drawing algorithms, circle and ellipse generation, conic-section generation, polygon filling anti-aliasing. **15L**

Unit 3 : Two-dimensional viewing: Coordinate systems, linear transformations, line and polygon clipping algorithms. **15L**

Books Recommended :

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

Course: BMH3SEC13

Object Oriented Programming in C++   (Marks: 50)

Total Lecture Hours: 40

Unit 1 : Programming paradigms, characteristics of object oriented programming languages, brief history of C++, structure of C++ program, differences between C and C++, basic C++ operators, Comments, working with variables, enumeration, arrays and pointer. **15L**

Unit 2 : Objects, classes, constructor and destructors, friend function, inline function, encapsulation, data abstraction, inheritance, polymorphism, dynamic binding, operator overloading, method overloading, overloading arithmetic operator and comparison operators. **15L**

Unit 3 : Template class in C++, copy constructor, subscript and function call operator, concept of namespace and exception handling. **10L**

Books Recommended:

- ➢ A. R. Venugopal, Rajkumar, and T. Ravishanker, Mastering C++, TMH, 1997.
- ➢ S. B. Lippman and J. Lajoie, C++ Primer, 3rd Ed., Addison Wesley, 2000.
- ➢ Bruce Eckel, Thinking in C++, 2nd Ed., President, Mindview Inc., Prentice Hall, 2000.
- ➢ D. Parasons, Object Oriented Programming with C++, BPB Publication, 2008.
- ➢ Bjarne Stroustrup, The C++ Programming Language, 3rd Ed., Addison Welsley, 1997.
- ➢ E. Balaguruswami, Object Oriented Programming In C++, Tata McGrawHill, 2011.
- ➢ Herbert Scildt, C++, The Complete Reference, Tata McGrawHill, 2003.

Course: BMH4CC08

Riemann Integration and Series of Functions (Marks: 75)

Total Lecture Hours: 60

Unit -1 : Riemann integration: inequalities of upper and lower sums, Darbaux integration, Darbaux theorem, Riemann conditions of integrability, Riemann sum and definition of Riemann integral through Riemann sums, equivalence of two Definitions.

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 theorem of Integral Calculus. **20L**

Unit-2 : Improper integrals, Convergence of Beta and Gamma functions. **7L**

Unit-3 : 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. **15L**

Unit 4: Fourier series: Definition of Fourier coefficients and series, Riemann- Lebesgue lemma, Bessel's inequality, Parseval's identity, Dirichlet's condition.
Examples of Fourier expansions and summation results for series. **10L**

Unit – 5: Power series, radius of convergence, Cauchy Hadamard Theorem.
Differentiation and integration of power series; Abel's Theorem; Weierstrass Approximation Theorem. **8L**

Books Recommended:

- ➢ K.A. Ross, Elementary Analysis, The Theory of Calculus, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
- ➢ R.G. Bartle and D.R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
- ➢ Charles G. Denlinger, Elements of Real Analysis, Jones & Bartlett (Student Edition), 2011.
- ➢ S. Goldberg, Calculus and Mathematical analysis.
- ➢ Santi Narayan, Integral calculus, S Chand, 2005..
- ➢ T. Apostol, Calculus I, II, Wiley, 2007.

Course: BMH4CC09

Multivariate Calculus (Marks: 75)

Total Lecture Hours: 60

Unit-1: Functions of several variables, limit and continuity of functions of n variables, Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters, directional derivatives, the gradient, Jacobian, maximal and normal property of gradient, tangent planes, Extrema of functions of n variables with necessary and sufficient conditions, method of Lagrange multipliers. **25L**

Unit-2: 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 coordinates. Change of variables in double integrals and triple integrals.

15L

Unit-3: Vector operators, Gradient of a scalar function, directional derivatives, Definition of vector field, divergence and curl. Line integrals, Fundamental theorem for line integrals, conservative vector fields, , Application of line integral to Workdone. **10L**

Unit-4: Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stoke's theorem, The Divergence theorem. **10L**

Books Recommended:

➢ G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
➢ M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.
➢ E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer (SIE), Indian reprint, 2005.
➢ James Stewart, Multivariable Calculus, Concepts and Contexts, 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001
➢ Tom M. Apostol, Mathematical Analysis, Narosa Publishing House, 2nd Ed.,2002
➢ Courant and John, Introduction to Calculus and Analysis, Vol II, Springer New York, 2012
➢ W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill, 3rd Ed.,2013
➢ Marsden, J., and Tromba, Vector Calculus, McGraw Hill, 6th revised international Ed, 2012
➢ Maity, K.C. and Ghosh, R.K. Vector Analysis, New Central Book Agency (P) Ltd. Kolkata (India).

- Terence Tao, Analysis II, Hindustan Book Agency, 3rd Ed., 2015.
- M.R. Speigel, Schaum's outline of Vector Analysis. Tata McGraw-Hill, 2009.

Course: BMH4CC10

Ring Theory and Linear Algebra I (Marks: 75)

Total Lecture Hours: 60

Unit 1: Definition and examples of rings, properties of rings, subrings, integral domains and fields, characteristic of a ring. Ideal, ideal generated by a subset of a ring, factor rings, operations on ideals, prime and maximal ideals. **15L**

Unit 2 : Ring homomorphisms, properties of ring homomorphisms. Isomorphism theorems I, II and III, field of quotients. **10L**

Unit 3 : Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces, extension, deletion and replacement theorems. **12L**

Unit 4 : 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. **23L**

Books Recommended

- John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
- M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
- Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, 4th Ed., Prentice- Hall of India Pvt. Ltd., New Delhi, 2004.
- Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi, 1999.
- S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2005.
- Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.
- S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999
- Kenneth Hoffman, Ray Alden Kunze, Linear Algebra, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
- D.A.R. Wallace, Groups, Rings and Fields, Springer Verlag London Ltd., 1998.
- D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of Abstract Algebra,1997.

Course: BMH4SEC21

Graph Theory (Marks: 50)

Total Lecture Hours: 40

Unit 1 : Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bi-partite graphs isomorphism of graphs. **10L**

Unit 2 : Eulerian circuits, Eulerian graph, semi-Eulerian graph and theorems, Hamiltonian cycles and theorems Representation of a graph by a matrix, the adjacency matrix, incidence matrix, weighted graph, **15L**

Unit 3 : Travelling salesman's problem, shortest path, Tree and their properties, spanning tree, Dijkstra's algorithm, Warshall algorithm. **15L**

Books Recommended:

➢ J. Clark and D. A. Holton: A First Look at Graph Theory, Allied Publishers Ltd., 1995.
➢ D. S. Malik, M. K. Sen and S. Ghosh: Introduction to Graph Theory, Cengage Learning Asia, 2014.
➢ Nar Sing Deo : *Graph Theory,* Prentice-Hall, 1974.
➢ J. A. Bondy and U.S.R. Murty: Graph Theory with Applications, Macmillan, 1976.
➢ Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 2nd Edition, Pearson Education (Singapore) P. Ltd., Indian Reprint 2003.

Course: BMH4SEC22

Operating System: Linux (Marks: 50)

Total Lecture Hours: 40

Unit 1 : Linux – The Operating System: Linux history, Linux features, Linux distributions, Linux's relationship to Unix, Overview of Linux architecture, Installation, Start up scripts, system processes (an overview), Linux Security. **10L**

Unit 2 : The Ext2 and Ext3 File systems: General Characteristics of The Ext3 File system, file permissions. User Management: Types of users, the powers of Root, managing users (adding and deleting): using the command line and GUI tools. **15L**

Unit 3 : Resource Management in Linux: file and directory management, different editors, system calls for files Process

Management, Signals, IPC: Pipes, FIFOs, System V IPC, Message Queues, system calls for processes, Memory Management, library and system calls for memory. **15L**

Books Recommended:

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

Course: BMH4SEC23

MATLAB Programming (Marks: 50)

Total Lecture Hours: 40

MATLAB basics: The MATLAB environment - Basic computer programming - Variables and constants, operators and simple calculations - Formulas and functions - MATLAB toolboxes. **5L**

Matrices and vectors: Matrix and linear algebra review - Vectors and matrices in MATLAB - Matrix operations and functions in MATLAB. **10L**

Computer programming: Algorithms and structures - MATLAB scripts and functions (m-files) - Simple sequential algorithms - Control structures (if…then, loops) **10L**

MATLAB programming: Reading and writing data, file handling - Personalized functions - Toolbox structure - MATLAB graphic functions. **5L**

Numerical simulations : Numerical methods and simulations - Random number generation - Montecarlo methods. **10L**

Books Recommended:

- ➤ Stephen J. Chapman, Essentials of MATLAB Programming, Cengage Learning, Inc, Mason, OH, United States, 2017.
- ➤ Marc E. Herniter, Programming in MATLAB, Thomson Learning, 2001

Course: BMH5CC11

Partial Differential Equations and Applications (Marks : 75)

Total Lecture Hours: 60

Unit 1: 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. **22L**

Unit 2: Derivation of Heat equation, Wave equation and Laplace equation. Classification of second order linear equations as hyperbolic, parabolic, elliptic. Reduction of second order Linear Equations to canonical forms. **12L**

Unit 3: The Cauchy problem of 2nd order partial differential equation, Cauchy-Kowalewskaya theorem, Cauchy problem of an infinite string, Initial and 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. **17L**

Graphical Demonstration (Teaching Aid)   9L

1. Solution of Cauchy problem for first order PDE.

2. Finding the characteristics for the first order PDE.

3. Plot the integral surfaces of a given first order PDE with initial data.

4. Solution of wave equation $\frac{\partial^2 u}{\partial t^2} - \frac{\partial^2 u}{\partial x^2} = 0$ for the following associated conditions:

(a) $u(x,0) = \phi(x)$, $u_x(x,0) = \psi(x)$, $x \in R$, $t > 0$.
(b) $u(x,0) = \phi(x)$, $u_x(x,0) = \psi(x)$, $u(0, t) = 0$ $x \in (0,\infty)$, $t > 0$.

5. 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) $u(x,0) = \phi(x)$, $u(0, t) = a$, $u(l, t) = b$, $0 < x < l$, $t > 0$.
(b) $u(x,0) = \phi(x)$, $x \in R$, $0 < t < T$.

Books Recommended :

> ➢ Tyn Myint-U and Lokenath Debnath, Linear Partial Differential Equations for Scientists and Engineers, 4th Edition, Springer, Indian reprint, 2006.

- S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
- Martha L Abell, James P Braselton, Differential equations with MATHEMATICA, 3rd Ed., Elsevier Academic Press, 2004.
- Sneddon, I. N., Elements of Partial Differential Equations, McGraw Hill,2013.
- Miller, F. H., Partial Differential Equations, John Wiley and Sons,2013.
- Loney, S. L., An Elementary Treatise on the Dynamics of particle and of Rigid Bodies, Loney Press,2007.

Course: BMH5CC12

Mechanics I (Marks: 75)

Total Lecture Hours: 60

Unit 1 : Co-planar forces. Astatic equilibrium. Friction. Equilibrium of a particle on a rough curve. Virtual work. Forces in three dimensions. General conditions of equilibrium. Centre of gravity for different bodies. Stable and unstable equilibrium, equilibrium of flexible string. **20L**

Unit 2 : Simple harmonic motion, Damped and forced vibrations, Components of velocity and acceleration, Equations of motion referred to a set of rotating axes. Motion of a projectile in a resisting medium. Motion of a particle under central force, Keplar's laws of motion, Motion under the inverse square law, Stability of nearly circular orbits, Slightly disturbed orbits, Motion of artificial satellites. Varying mass, constrained, Motion of a particle in three dimensions. Motion on a smooth sphere, cone, and on any surface of revolution. **25L**

Unit 3 : Degrees of freedom, Moments and products of inertia, Momental Ellipsoid, Principal axes, D'Alembert's Principle, Motion about a fixed axis, Compound pendulum, Motion of a system of particles, Motion of a rigid body in two dimensions under finite and impulsive forces, Conservation of momentum and energy. **15L**

Books Recommended :

- I.H. Shames and G. Krishna Mohan Rao, Engineering Mechanics: Statics and Dynamics, 2006. Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2009.
- R.C. Hibbeler and Ashok Gupta, Engineering Mechanics: Statics and Dynamics, 11th Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2010.
- Chorlton, F., Textbook of Dynamics CBS Publishers & Distributors, 2005.
- Loney, S. L., An Elementary Treatise on the Dynamics of particle and of Rigid Bodies, 2017
- Loney, S. L., Elements of Statics and Dynamics I and II, 2004.
- Ghosh, M. C, Analytical Statics.
- Verma, R. S., A Textbook on Statics, Pothishala, 1962 .
- Matiur Rahman, Md., Statics, New Central Book Agancy (P) Ltd, 2004.
- Ramsey, A. S., Dynamics (Part I), Cambridge University Press, 1952.

Course: BMH5DSE11

Linear Programming (Marks: 75)

Total Lecture Hours: 60

Unit 1 : Introduction to linear programming problem. Theory of simplex method, graphical solution, convex sets, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two-phase method. Big-M method and their comparison. **22L**

Unit 2 : Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual, Dual Simplex method. **8L**

Unit 3 : Transportation problem and its mathematical formulation, northwest-corner method, least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem, assignment problem and its mathematical formulation, Hungarian method for solving assignment problem, Travelling salesman problem. **15L**

Unit 4 : 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. **15L**

Books Recommended :

- ➢ Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, Linear Programming and Network Flows, 2nd Ed., John Wiley and Sons, India, 2004.
- ➢ F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 9th Ed., Tata McGraw Hill, Singapore, 2009.
- ➢ Hamdy A. Taha, Operations Research, An Introduction, 8th Ed., Prentice-Hall India, 2006.
- ➢ G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.
- ➢ K. Swarup, P. K. Gupta and M. Mohan, Operations Research, Sultan Chand & Sons, 1978.
- ➢ A. K. Bhunia and L. Sahoo, Advanced Operations Research, Asian Books Private Limited, New Delhi, 2011.

Course : BMH5DSE12

Number Theory (Marks : 75)

Total Lecture Hours: 60

Unit 1 : 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. **15L**

Unit 2 : Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Mobius Inversion formula, the greatest integer function, Euler's phi-function, Euler's theorem, reduced set of residues. some properties of Euler's phi-function. **20L**

Unit 3 : 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, Public key encryption, RSA encryption and decryption, the equation $x^2 + y^2 = z^2$, Fermat's Last theorem (Statement only). **25L**

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

Course : BMH5DSE13

Point Set Topology (Marks : 75)

Total Lecture Hours: 60

Unit 1 : Countable and Uncountable Sets, Schröeder-Bernstein Theorem, Cantor's Theorem, Cardinal Numbers and Cardinal Arithmetic, Continuum Hypothesis. Zorn's Lemma, Axiom of Choice, Well-Ordered Sets, Hausdorff's Maximality Principle. Ordinal Numbers. **15L**

Unit 2 : Topological spaces, Basis and Subbasis for a topology, subspace Topology, Interior Points, Limit Points, Derived Set, Boundary of a set, Closed Sets, Closure and Interior of a set. Continuous Functions, Open maps, Closed maps and Homeomorphisms, Product Topology, Quotient Topology, Metric Topology, Baire Category Theorem. **25L**

Unit 3 : Connected and Path Connected Spaces, Connected Sets in R, Components and Path Components, Local Connectedness, Compact Spaces, Compact Sets in R, Compactness in Metric Spaces, Totally Bounded Spaces, Ascoli-Arzela Theorem, The Lebesgue Number Lemma, Local Compactness. **20L**

Books Recommended :

- ➢ Munkres, J.R., Topology, A First Course, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
- ➢ Dugundji, J., Topology, Allyn and Bacon, 1966.
- ➢ Simmons, G.F., Introduction to Topol**ogy** and Modern Analysis, McGraw Hill, 1963.
- ➢ Kelley, J.L., General Topology, Van Nostrand Reinhold Co., New York, 1995.
- ➢ Hocking, J., Young, G., Topology, Addison-Wesley Reading, 1961.
- ➢ Steen, L., Seebach, J., Counter Examples in Topology, Holt, Reinhart and Winston, New York, 1970.
- ➢ Abhijit Dasgupta, Set Theory, Birkhäuser, 2013.

Course : BMH5DSE21
Probability and Statistics (Marks : 75)

Total Lecture Hours: 60

Unit 1 : 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, discrete distributions: uniform, binomial, Poisson, geometric, negative binomial, continuous distributions: uniform, normal, exponential. **15L**

Unit 2 : Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions, 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. **15L**

Unit 3 : 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, Markov Chains, Chapman-Kolmogorov equations, classification of states. **10L**

Unit 4 : Random Samples, Sampling Distributions, Estimation of parameters, Testing of hypothesis. **20L**

Books Recommended :

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

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

➤ A. Gupta, Ground work of Mathematical Probability and Statistics, Academic publishers, 1983.

Course : BMH5DSE22
Portfolio Optimization (Marks : 75)

Total Lecture Hours: 60

Unit 1 : Financial markets. Investment objectives. Measures of return and risk. Types of risks. Risk free assets. Mutual funds. Portfolio of assets. Expected risk and return of portfolio. Diversification. **20L**

Unit 2 : Mean-variance portfolio optimization- the Markowitz model and the two-fund theorem, risk-free assets and one fund theorem, efficient frontier. Portfolios with short sales. Capital market theory. **20L**

Unit 3 : 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. **20L**

Books Recommended :

➤ F. K. Reilly, Keith C. Brown, Investment Analysis and Portfolio Management, 10th Ed., South-Western Publishers, 2011.

➤ H.M. Markowitz, Mean-Variance Analysis in Portfolio Choice and Capital Markets, Blackwell, New York, 1987.

➤ M.J. Best, Portfolio Optimization, Chapman and Hall, CRC Press, 2010.

➤ D.G. Luenberger, Investment Science, 2nd Ed., Oxford University Press, 2013.

Course : BMH5DSE23
Boolean Algebra and Automata Theory (Marks : 75)

Total Lecture Hours: 60

Unit 1 : 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. **10L**

Unit 2 : Definition, examples and properties of modular and distributive lattices, Boolean algebras, Boolean polynomials, minimal and maximal forms of Boolean polynomials, Quinn-McCluskey method, Karnaugh diagrams, Logic Gates, switching circuits and applications of switching circuits. **10L**

Unit 3 : 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. **10L**

Unit 4 : 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. **10L**

Unit 5 : Turing Machines: Turing machine as a model of computation, programming with a Turing machine, variants of Turing machine and their equivalence. **10L**

Unit 6 : Undecidability: Recursively enumerable and recursive languages, undecidable problems about Turing machines: halting problem. Post Correspondence Problem, and undecidability problems about CFGs. **10L**

Books Recommended :

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

Course : BMH6CC13

Metric Spaces and Complex Analysis (Marks : 75)

Total Lecture Hours: 60

Unit 1 : Metric spaces: Sequences in Metric Spaces, Cauchy sequences. Complete Metric Spaces, Cantor's theorem. **5L**

Unit 2 : Continuous mappings, sequential criterion and other characterizations of continuity, Uniform continuity, Connectedness, connected subsets of R.

Compactness: Sequential compactness, Heine-Borel property, Totally bounded spaces, finite intersection property,

and continuous functions on compact sets.

Homeomorphism, Contraction mappings, Banach Fixed point Theorem and its application to ordinary differential equation. **25L**

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. **7L**

Unit 4 : Analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function, derivatives of functions, and definite integrals of functions. Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. Cauchy- Goursat theorem, Cauchy integral formula. **13L**

Unit 5 : Liouville's theorem and the fundamental theorem of algebra. Convergence of sequences and series, Taylor series and its examples. **6L**

Unit 6 : Laurent series and its examples, absolute and uniform convergence of power series. **4L**

Books Recommended :

- ➢ Satish Shirali and Harikishan L. Vasudeva, Metric Spaces, Springer Verlag, London, 2006.
- ➢ S. Kumaresan, Topology of Metric Spaces, 2nd Ed., Narosa Publishing House, 2011.
- ➢ G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 2004.
- ➢ James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, 8th Ed., McGraw – Hill International Edition, 2009.
- ➢ Joseph Bak and Donald J. Newman, Complex Analysis, 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., NewYork, 1997.
- ➢ S. Ponnusamy, Foundations of omplex Analysis, Alpha Science International, 2005.
- ➢ E.M.Stein and R. Shakrachi, Complex Analysis, Princeton University Press,2010.

Course : BMH6CC14

Ring Theory and Linear Algebra II (Marks : 75)

Total Lecture Hours: 60

Unit 1 : Polynomial rings over commutative rings, division algorithm and consequences, principal ideal domains, factorization of polynomials, reducibility tests, irreducibility tests, Eisenstein criterion, and unique factorization in Z [x]. Divisibility in integral domains, irreducible, primes, unique factorization domains, Euclidean domains. **20L**

Unit 2 : 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, canonical forms. **20L**

Unit 3 : Inner product spaces and norms, Gram-Schmidt orthogonalisation process, orthogonal complements, Bessel's inequality, the adjoint of a linear operator, Least Squares Approximation, minimal solutions to systems of linear equations, Normal and self-adjoint operators, Orthogonal projections and Spectral theorem. **20L**

Books Recommended :

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

Course : BMH6DSE31
Mathematical Modelling (Marks : 75)

Total Lecture Hours: 60

The modeling process. Arguments from scales: Dimensional analysis **5L**

Arguments from data: Least squares, parameter estimation. **5L**

Linear models: Generalized least squares estimators. **10L**

Mathematical models in biology: Population models, predator-prey systems. **15L**

Stability analysis: Equilibria, oscillations, growth and decay. **10L**

Difference equations: Modeling of traffic flows. **5L**

Poisson process and single server queueing models. **10L**

Books Recommended :

- R. Illner et al., Mathematical Modelling: A Case Studies Approach. AMS, 2005.
- E. Bender, Introduction to Mathematical Modelling. Dover, 2000.
- J. Kapur, Maximum-entropy Models in Science and Engineering. Wiley, 1989.
- P. Brockwell and R. Davis, Introduction to Time Series and Forecasting, Springer, 2010.
- D. Higham, Modeling and Simulating Chemical Reactions. In: SIAM Review, 347-368, 2008

Course : BMH6DSE32
Industrial Mathematics (Marks : 75)

Total Lecture Hours: 60

Unit 1 : 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. **10L**

Unit 2 : 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. **15L**

Unit 3 : X-ray: Introduction, X-ray behavior and Beers Law (The fundamental question of image construction) Lines in the place. **10L**

Unit 4 : Radon Transform: Definition and Examples, Linearity, Phantom (Shepp - Logan Phantom - Mathematical phantoms). **10L**

Unit 5 : Back Projection: Definition, properties and examples. **5L**

Unit 6 : 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. **10L**

Books Recommended :

- Timothy G. Feeman, The Mathematics of Medical Imaging, A Beginners Guide, Springer Under graduate Text in Mathematics and Technology, Springer, 2010.
- C.W. Groetsch, Inverse Problems, Activities for Undergraduates, The Mathematical Association of America, 1999.

➢ Andreas Kirsch, An Introduction to the Mathematical Theory of Inverse Problems, 2nd Ed., Springer, 2011.

Course : BMH6DSE33

Group Theory II (Marks : 75)

Total Lecture Hours: 60

Unit 1: 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. **15L**

Unit 2 : 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. **10L**

Unit 3 : Group actions, stabilizers and kernels, permutation representation associated with a given group action. Applications of group actions. Generalized Cayley's theorem. Index theorem. **15L**

Unit 4 : Groups acting on themselves by conjugation, class equation and consequences, conjugacy in Sn, p-groups, Sylow's theorems and consequences, Cauchy's theorem, Simplicity of A_n for n ≥ 5, non-simplicity tests. **20L**

Books Recommended:

➢ John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
➢ M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
➢ Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., 1999.
➢ David S. Dummit and Richard M. Foote, Abstract Algebra, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2004.
➢ J.R. Durbin, Modern Algebra, John Wiley & Sons, New York Inc., 2000.
➢ D. A. R. Wallace, Groups, Rings and Fields, Springer Verlag London Ltd., 1998
➢ D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of Abstract Algebra, Tata McGraw Hill,1997.
➢ I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.

Course : BMH6DSE41
Bio Mathematics   (Marks : 75)

Total Lecture Hours: 60

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, 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) **15L**

Unit 2 : Activator-Inhibitor system, Insect Outbreak Model: Spruce Budworm, 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.
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. **20L**

Unit 3 : 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. **15L**

Graphical Demonstration (Teaching Aid) 10L

1. Growth model (exponential case only).

2. Decay model (exponential case only).

3. Lake pollution model (with constant/seasonal flow and pollution concentration).

4. Case of single cold pill and a course of cold pills.

5. Limited growth of population (with and without harvesting).

6. Predatory-prey model (basic volterra model, with density dependence, effect of DDT, two prey one predator).

7. Epidemic model of infuenza (basic epidemic model, contagious for life, disease with carriers).

8. Battle model (basic battle model, jungle warfare, long range weapons).

Books Recommended :

➢ L.E. Keshet, Mathematical Models in Biology, SIAM, 1988.
➢ J. D. Murray, Mathematical Biology, Springer, 1993.
➢ Y.C. Fung, Biomechanics, Springer-Verlag, 1990.
➢ F. Brauer, P.V.D. Driessche and J. Wu, Mathematical Epidemiology, Springer, 2008.

➤ M. Kot, Elements of Mathematical Ecology, Cambridge University Press, 2001.

Course : BMH6DSE42
Differential Geometry (Marks : 75)

Total Lecture Hours: 60

Unit 1 : Theory of Space Curves: Space curves, Planer curves, Curvature, torsion and Serret-Frenet formula. Osculating circles, Osculating circles and spheres, Existence of space curves. Evolutes and involutes of curves. **15L**

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. **20L**

Unit 3 : Developables: Developable associated with space curves and curves on surfaces, Minimal surfaces.

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. **25L**

Books Recommended :
- ➤ T.J. Willmore, An Introduction to Differential Geometry, Dover Publications, 2012.
- ➤ B. O'Neill, Elementary Differential Geometry, 2nd Ed., Academic Press, 2006.
- ➤ C.E. Weatherburn, Differential Geometry of Three Dimensions, Cambridge University Press 2003.
- ➤ D.J. Struik, Lectures on Classical Differential Geometry, Dover Publications, 1988.
- ➤ S. Lang, Fundamentals of Differential Geometry, Springer, 1999.
- ➤ B. Spain, Tensor Calculus: A Concise Course, Dover Publications, 2003

Course : BMH6DSE43

Mechanics-II (Marks : 75)

Total Lecture Hours: 60

Unit-1 : Interpretation of Newton's laws of motion, Galilean transformation, Concept of absolute length and time, Limitations of Newton's laws in solving problems. **15L**

Unit-2 : Equilibrium of fluid in a given field of force, Pressure in a heavy homogeneous liquid, Equilibrium of floating bodies, Isothermal and adiabatic changes in Gases, Convective equilibrium, Stress in continuum body, Stress quadric. **25L**

Unit-3 : Constraints and their classifications, Lagrange's equation of motion for holonomic system, Gibbs-Appell's principle of least constraint, Work energy relation for constraint forces of shielding friction. **20L**

Course : BMH6PW01

Project Work (Marks : 75)

Any student may choose Project Work in place of one Discipline Specific Elective (DSE) paper of Semester -VI. Project Work will be done considering any topic on Mathematics and its Applications. The marks distribution of the Project work is 40 Marks for written submission, 20 Marks for Seminar presentation and 15 Marks for Viva-Voce.

SYLLABUS FOR

GENERIC ELECTIVES OF MATHEMATICS

(For Other Honours Descipline)

Under Choice Based Credit System (CBCS)

Effective from 2017-2018

The University of Burdwan

Burdwan-713104

West Bengal

Generic Electives of Mathematics

Semester	Course Type	Course Code	Name of the Course	Credit Pattern (L:T:P)	Total class hrs./week	Marks	Credit
I	GE	MATH-GE1	Differential Calculus	5:1:0	6	75	6
II	GE	MATH-GE2	Differential Equations	5:1:0	6	75	6
III	GE	MATH-GE3	Real Analysis	5:1:0	6	75	6
IV	GE	MATH-GE4	Algebra	5:1:0	6	75	6

Note : The detailed syllabi of MATH-GE1, MATH-GE2, MATH-GE3 and MATH-GE4 will be same as BMG1CC1A, BMG2CC1B, BMG3CC1C and BMG4CC1D of B.A./B.SC. (General) in Mathematics respectively.

Course : BMOHD1GE1

Differential Calculus (Marks : 75)

Total lecture hours: 60

Limit and Continuity (ε and δ definition), Types of discontinuities, Differentiability of functions, Successive differentiation, Leibnitz's theorem, Partial differentiation, Euler's theorem onhomogeneous functions. 20L

Tangents and normals, Curvature, Asymptotes, Singular points, Tracing of curves. Parametric representation of curves and tracing of parametric curves, Polar coordinates and tracing of curves in polar coordinates. 15L

Rolle's theorem, Mean Value theorems, Taylor's theorem with Lagrange's and Cauchy's forms of remainder, Taylor's series, Maclaurin's series of sin x, cos x, e^x, log(l+x), $(l+x)^n$, Maxima and Minima, Indeterminate forms. 25L

Books Recommended:

1. H. Anton, I. Birens and S. Davis, *Calculus*, John Wiley and Sons, Inc., 2002.
2. G.B. Thomas and R.L. Finney, *Calculus*, Pearson Education, 2007.

Course : BMOHD2GE2

Differential Equations (Marks : 75)

Total lecture hours: 60

First order exact differential equations. Integrating factors, rules to find an integrating factor.First order higher degree equations solvable for x, y, p. Methods for solving higher-orderdifferential equations. Basic theory of linear differential equations, Wronskian, and its properties.
Solving a differential equation by reducing its order.   20L

Linear homogenous equations with constant coefficients, Linear non-homogenous equations,The method of variation of parameters, The Cauchy-Euler equation, Simultaneous differentialequations, Total differential equations.   16L

Order and degree of partial differential equations, Concept of linear and non-linear partialdifferential equations, Formation of first order partial differential equations, Linear partialdifferential equation of first order, Lagrange's method, Charpit's method.   15L

Classification of second order partial differential equations into elliptic, parabolic and hyperbolicthrough illustrations only.   9L

Books Recommended:

1. Shepley L. Ross, *Differential Equations*, 3rd Ed., John Wiley and Sons, 1984.
2. I. Sneddon, *Elements of Partial Differential Equations*, McGraw-Hill, International Edition,1967.

Course : BMOHD3GE3

Real Analysis (Marks : 75)

Total lecture hours: 60

Finite and infinite sets, examples of countable and uncountable sets.Real line, bounded sets,suprema and infima, completeness property of R, Archimedean property of R, intervals.Conceptof cluster points and statement of Bolzano-Weierstrass theorem.   15L

Real Sequence, Bounded sequence, Cauchy convergence criterion for sequences. Cauchy'stheorem on limits, order preservation and squeeze theorem, monotone sequences and theirconvergence (monotone convergence theorem without proof).   15L

Infinite series. Cauchy convergence criterion for series, positive term series, geometric series,comparison test, convergence of p-series, Root test, Ratio test, alternating series, Leibnitz's

test(Tests of Convergence without proof). Definition and examples of absolute and conditionalconvergence.   15L

Sequences and series of functions, Pointwise and uniform convergence.M_n-test, M-test,Statements of the results about uniform convergence and integrability and differentiability offunctions, Power series and radius of convergence.   15L

Books Recommended :

1. T. M. Apostol, *Calculus* (Vol. I), John Wiley and Sons (Asia) P. Ltd., 2002.
2. R.G. Bartle and D. R Sherbert, *Introduction to Real Analysis,* John Wiley and Sons (Asia) P.Ltd., 2000.
3. E. Fischer, *Intermediate Real Analysis*, Springer Verlag, 1983.
4. K.A. Ross, *Elementary Analysis- The Theory of Calculus Series-* Undergraduate Texts inMathematics, Springer Verlag, 2003.

Course : BMOHD4GE4

Algebra (Marks : 75)

Total lecture hours: 60

Definition and examples of groups, examples of abelian and non-abelian groups, the group Z_n ofintegers under addition modulo n and the group $U(n)$ of units under multiplication modulo n.Cyclic groups from number systems, complex roots of unity, circle group, the general lineargroup $GL_n(n,R)$, groups of symmetries of (i) an isosceles triangle, (ii) an equilateral triangle,(iii) a rectangle, and (iv) a square, the permutation group Sym (n), Group of quaternions.   20L

Subgroups, cyclic subgroups, the concept of a subgroup generated by a subset and thecommutator subgroup of group, examples of subgroups including the center of a group.Cosets,Index of subgroup, Lagrange's theorem, order of an element, Normal subgroups: their definition,examples, and characterizations, Quotient groups.   20L

Definition and examples of rings, examples of commutative and non-commutative rings: ringsfrom number systems, Z_n the ring of integers modulo n, ring of real quaternions, rings ofmatrices, polynomial rings, and rings of continuous functions. Subrings and ideals, Integraldomains and fields, examples of fields: Z_p, Q, R, and C. Field of rational functions.   20L

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, 1999.
4. George E Andrews, *Number Theory*, Hindustan Publishing Corporation, 1984.