UNIVERSITY OF CALCUTTA

Notification No. CSR/ 12 /18

It is notified for information of all concerned that the Syndicate in its meeting held on 28.05.2018 (vide Item No.14) approved the Syllabi of different subjects in Undergraduate Honours / General / Major courses of studies (CBCS) under this University, as laid down in the accompanying pamphlet:

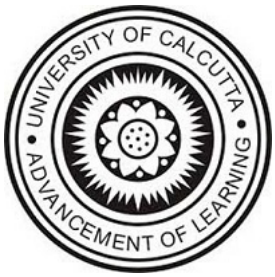
List of the subjects

Sl. No.	Subject	Sl. No.	Subject
1	Anthropology (Honours / General)	29	Mathematics (Honours / General)
2	Arabic (Honours / General)	30	Microbiology (Honours / General)
3	Persian (Honours / General)	31	Mol. Biology (General)
4	Bengali (Honours / General /LCC2 /AECC1)	32	Philosophy (Honours / General)
5	Bio-Chemistry (Honours / General)	33	Physical Education (General)
6	Botany (Honours / General)	34	Physics (Honours / General)
7	Chemistry (Honours / General)	35	Physiology (Honours / General)
8	Computer Science (Honours / General)	36	Political Science (Honours / General)
9	Defence Studies (General)	37	Psychology (Honours / General)
10	Economics (Honours / General)	38	Sanskrit (Honours / General)
11	Education (Honours / General)	39	Social Science (General)
12	Electronics (Honours / General)	40	Sociology (Honours / General)
13	English ((Honours / General/ LCC1/ LCC2/AECC1)	41	Statistics (Honours / General)
14	Environmental Science (Honours / General)	42	Urdu (Honours / General /LCC2 /AECC1)
15	Environmental Studies (AECC2)	43	Women Studies (General)
16	Film Studies (General)	44	Zoology (Honours / General)
17	Food Nutrition (Honours / General)	45	Industrial Fish and Fisheries – IFFV (Major)
18	French (General)	46	Sericulture – SRTV (Major)
19	Geography (Honours / General)	47	Computer Applications – CMAV (Major)
20	Geology (Honours / General)	48	Tourism and Travel Management – TTMV (Major)
21	Hindi (Honours / General /LCC2 /AECC1)	49	Advertising Sales Promotion and Sales Management –ASPV (Major)
22	History (Honours / General)	50	Communicative English –CMEV (Major)
23	Islamic History Culture (Honours / General)	51	Clinical Nutrition and Dietetics CNDV (Major)
24	Home Science Extension Education (General)	52	Bachelor of Business Administration (BBA) (Honours)
25	House Hold Art (General)	53	Bachelor of Fashion and Apparel Design – (B.F.A.D.) (Honours)
26	Human Development (Honours / General)	54	Bachelor of Fine Art (B.F.A.) (Honours)
27	Human Rights (General)	55	B. Music (Honours / General) and Music (General)
28	Journalism and Mass Communication (Honours / General)		

The above shall be effective from the academic session 2018-2019.

SENATE HOUSE
KOLKATA-700073
The 4th June, 2018

Paul 4/6/18
(Dr. Santanu Paul)
Deputy Registrar



University of Calcutta

Syllabus for three-year B.Sc. in Mathematics

(Honours)

under

CBCS System

2018

1. Credit Distribution across Courses

Course Type	Total Papers	Credits		
		Theory + Tutorial	Theory + Practical	Total
Core Courses	14	$13 \times 5 = 65$ $13 \times 1 = 13$	$1 \times 4 = 4$ $1 \times 2 = 2$	84
Discipline Specific Electives	4	$4 \times 5 = 20$ $4 \times 1 = 4$	—	24
Generic Electives	4	$4 \times 6 = 24$	—	24
Ability Enhancement Language Courses	2	$2 \times 2 = 4$	—	4
Skill Enhancement Courses	2	$2 \times 2 = 4$	—	4
Totals	26	134	6	140

2. Course Structure : Semester-wise distribution of Courses

Semester	Course Name	Course Detail	Credits	Page No.
1	Ability Enhancement Compulsory Course-1	AECC(1)	2	
	Core Course-1	Calculus, Geometry & Vector Analysis	6	4
	Core Course-2	Algebra	6	6
	Generic Elective-1	GE(1)/CC(1) *	6	
		Total	**20**	
2	Ability Enhancement Compulsory Course-2	AECC(2)	2	
	Core Course-3	Real Analysis	6	8
	Core Course-4	Group Theory-I	6	10
	Generic Elective-2	GE(2)/CC(2) *	6	
		Total	**20**	
3	Core Course-5	Theory of Real Functions	6	11
	Core Course-6	Ring Theory & Linear Algebra-I	6	13
	Core Course-7	ODE & Multivariate Calculus-I	6	14
	Skill Enhancement Course-A	See SEC A	2	3
	Generic Elective-3	GE(3)/CC(3) *	6	
		Total	**26**	
4	Core Course-8	Riemann Integration & Series of Functions	6	16
	Core Course-9	PDE & Multivariate Calculus-II	6	18
	Core Course-10	Mechanics	6	20
	Skill Enhancement Course-B	See SEC B	2	3
	Generic Elective-4	GE(4)/CC(4) *	6	
		Total	**26**	
5	Core Course-11	Probability & Statistics	6	22
	Core Course-12	Group Theory-II & Linear Algebra-II	6	24
	Discipline Specific Elective- A	See DSE A(1)	6	3
	Discipline Specific Elective-B	See DSE B (1)	6	3
		Total	**24**	
6	Core Course-13	Metric Space & Complex Analysis	6	26
	Core Course-14	Numerical Methods	4	28
	Core Course-14 Practical	Numerical Methods Lab	2	30
	Discipline Specific Elective- A	See DSE A(2)	6	3
	Discipline Specific Elective-B	See DSE B(2)	6	3
		Total	**24**	
		Grand Total	**140**	

*These courses are to be taken by the students of **other discipline.** These are the 4 **Core Courses** of **General Courses** of other disciplines.

Course Structure | Credit Distribution | DSE | SEC | GE

3. Choices for Discipline Specific Electives (DSE)

DSE-A(1)	DSE-B(1)	DSE-A(2)	DSE-B(2)
For Semester -5	**For Semester-5**	**For Semester-6**	**For Semester-6**
Advanced Algebra [31]	Discrete Mathematics [35]	Differential Geometry [41]	Point Set Topology [46]
Bio Mathematics [32]	Linear Programming & Game Theory [37]	Mathematical Modelling [43]	Astronomy & Space Science [47]
Industrial Mathematics [34]	Boolean Algebra & Automata Theory [39]	Fluid Statics [44] & Elementary Fluid Dynamics	Advanced Mechanics [49]

The number within the bracket [ ] refers to page number. A student has to opt for any one of the subjects in DSE-A(1) and any one in DSE-B(1) in Semester 5. The student has to opt for any one of the subjects in DSE-A(2) and any one in DSE-B(2) in Semester 6.

Course Structure | Credit Distribution | SEC

4. Choices for Skill Enhancement Courses (SEC)

SEC-A (for Semester 3)	SEC-B (for Semester 4)
C Programming Language [51]	Mathematical Logic [53]
Object Oriented Programming in C++ [52]	Scientific computing with SageMath & R [54]

The number within the bracket [ ] refers to page number. A student has to opt for any one of the subjects available under each category.

Course Structure | Credit Distribution | DSE

Calculus, Geometry & Vector Analysis

Semester : 1 Core Course-1 Paper Code(Theory): MTM-A-CC-1-1-TH Paper Code (Tutorial):MTM-A-CC-1-1-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial ***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1 : Calculus [25 classes]

- Hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to problems of type $e^{ax+b}\sin x$, $e^{ax+b}\cos x$, $(ax+b)^n\sin x$, $(ax+b)^n\cos x$, curvature, concavity and points of inflection, envelopes, rectilinear asymptotes (Cartesian & parametric form only), curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L'Hospital's rule, applications in business, economics and life sciences.
- Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin^n x dx$, $\int \cos^n x dx$, $\int \tan^n x dx$, $\int \sec^n x dx$, $\int (\log x)^n dx$, $\int \sin^n x \sin mx dx$, $\int \sin^n x \cos^m x dx$. Parametric equations, parametrizing a curve, arc length of a curve, arc length of parametric curves, area under a curve, area and volume of surface of revolution.

Unit-2 : Geometry [30 classes]

- Rotation of axes and second degree equations, classification of conics using the discriminant, tangent and normal, polar equations of conics.
- Equation of Plane : General form, Intercept and Normal forms. The sides of a plane. Signed distance of a point from a plane. Equation of a plane passing through the intersection of two planes. Angle between two intersecting planes. Parallelism and perpendicularity of two planes.
- Straight lines in 3D: Equation (Symmetric & Parametric form). Direction ratio and direction cosines. Canonical equation of the line of intersection of two intersecting planes. Angle between two lines. Distance of a point from a line. Condition of coplanarity of two lines. Equation of skew lines. Shortest distance between two skew lines.
- Spheres. Cylindrical surfaces. Central conicoids, paraboloids, plane sections of conicoids, generating lines, classification of quadrics, illustrations of graphing standard quadric surfaces like cone, ellipsoid. Tangent and normals of conicoids.

Unit-3 : Vector Analysis [15 classes]

- Triple product, vector equations, applications to geometry and mechanics — concurrent forces in a plane, theory of couples, system of parallel forces. Introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions of one variable.

Graphical Demonstration (Teaching Aid**) [5 classes]

- 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.

- Plotting the graphs of polynomial of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.
- Sketching parametric curves (Eg. trochoid, cycloid, epicycloids, hypocycloid).
- Obtaining surface of revolution of curves.
- Tracing of conics in cartesian coordinates/ polar coordinates.
- Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic, paraboloid, and hyperbolic paraboloid using cartesian coordinates.

** **Preferably by free softwares but can be taught through drawing on black board/white board etc. in case of unavailability.**

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.

[5] T. Apostol, Calculus, Volumes I and II.

[6] S. Goldberg, Calculus and mathematical analysis.

[7] Marsden, J., and Tromba, Vector Calculus, McGraw Hill.

[8] M.R. Speigel, SchaumÃââs outline of Vector Analysis.

[9] S. L. Loney, Co-ordinate Geometry.

[10] Robert J. T. Bell, Co-ordinate Geometry of Three Dimensions.

Course Structure | DSE | SEC | Credit Distribution

Algebra

Semester : 1 Core Course-2 Paper Code(Theory): MTM-A-CC-1-2-TH Paper Code (Tutorial):MTM-A-CC-1-2-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial ***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1

[30 classes]

- Polar representation of complex numbers, n-th roots of unity, De Moivre's theorem for rational indices and its applications. Exponential, logarithmic, trigonometric and hyperbolic functions of complex variable.
- Theory of equations : Relation between roots and coefficients, transformation of equation, Descartes rule of signs, Sturm's theorem, cubic equation (solution by Cardan's method) and biquadratic equation (solution by Ferrari's method).
- Inequality : The inequality involving $AM \geq GM \geq HM$, Cauchy-Schwartz inequality.
- Linear difference equations with constant coefficients (up to 2nd order).

Unit-2

[30 classes]

- Relation : equivalence relation, equivalence classes & partition, partial order relation, poset, linear order relation.
- Mapping : injective, surjective, one to one correspondence, invertible mapping, composition of mappings, relation between composition of mappings and various set theoretic operations. Meaning and properties of $f^{-1}(B)$, for any mapping $f : X \to Y$ and $B \subseteq Y$.
- Well-ordering property of positive integers, Principles of Mathematical induction, division algorithm, divisibility and Euclidean algorithm. Prime numbers and their properties, Euclid's theorem. Congruence relation between integers. Fundamental Theorem of Arithmetic. Chinese remainder theorem. Arithmetic functions, some arithmetic functions such as ϕ, τ, σ and their properties.

Unit-3

[15 classes]

- Rank of a matrix, inverse of a matrix, characterizations of invertible matrices.
- 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.

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.

[4] K. Hoffman, R. Kunze, Linear algebra.

[5] W.S. Burnstine and A.W. Panton, Theory of equations.

Course Structure | DSE | SEC | Credit Distribution

Real Analysis

Semester : 2 Core Course-3 Paper Code(Theory): MTM-A-CC-2-3-TH Paper Code (Tutorial):MTM-A-CC-2-3-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial ***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1

[30 classes]

- Intuitive idea of real numbers. Mathematical operations and usual order of real numbers revisited with their properties (closure, commutative, associative, identity, inverse, distributive). Idea of countable sets, uncountable sets and uncountability of $\mathbb{R}$. Concept of bounded and unbounded sets in $\mathbb{R}$. L.U.B. (supremum), G.L.B. (infimum) of a set and their properties. L.U.B. axiom or order completeness axiom. Archimedean property of $\mathbb{R}$. Density of rational (and Irrational) numbers in $\mathbb{R}$.
- Intervals. Neighbourhood of a point. Interior point. Open set. Union, intersection of open sets. Limit point and isolated point of a set. Bolzano-Weirstrass theorem for sets. Existence of limit point of every uncountable set as a consequence of Bolzano-Weirstrass theorem. Derived set. Closed set. Complement of open set and closed set. Union and intersection of closed sets as a consequence. No nonempty proper subset of $\mathbb{R}$ is both open and closed. Dense set in $\mathbb{R}$ as a set having non-empty intersection with every open intervals. $\mathbb{Q}$ and $\mathbb{R} \setminus \mathbb{Q}$ are dense in $\mathbb{R}$.

Unit-2

[30 classes]

- Real sequence. Bounded sequence. Convergence and non-convergence. Examples. Boundedness of convergent sequence. Uniqueness of limit. Algebra of limits.
- Relation between the limit point of a set and the limit of a convergent sequence of distinct elements. Monotone sequences and their convergence. Sandwich rule. Nested interval theorem. Limit of some important sequences : $\left\{n^{\frac{1}{n}}\right\}_n$, $\{x^n\}_n$, $\left\{x^{\frac{1}{n}}\right\}_n$, $\{x_n\}_n$ with $\frac{x_{n+1}}{x_n} \to l$ and $|l| < 1$, $\left\{\left(1+\frac{1}{n}\right)^n\right\}_n$, $\left\{1+\frac{1}{1!}+\frac{1}{2!}+\cdots+\frac{1}{n!}\right\}_n$, $\{a^{x_n}\}_n\,(a>0)$. Cauchy's first and second limit theorems.
- Subsequence. Subsequential limits, $\limsup$ as the L.U.B. and $\liminf$ as the G.L.B of a set containing all the subsequential limits. Alternative definition of limsup and liminf of a sequence using inequality or as $\limsup x_n = \inf_n \sup\{x_n, x_{n+1}, \ldots,\}$ and $\liminf x_n = \sup_n \inf\{x_n, x_{n+1}, \ldots,\}$ [Equivalence between these definitions is assumed]. A bounded sequence $\{x_n\}$ is convergent if and only if $\limsup x_n = \liminf x_n$. Every sequence has a monotone subsequence. Bolzano-Weirstrass theorem for sequence. Cauchy's convergence criterion. Cauchy sequence.

Unit-3

[10 classes]

- Infinite series, convergence and non-convergence of infinite series, Cauchy criterion, tests for convergence : comparison test, limit comparison test, ratio test, Cauchy's n-th root test, Kummer's test and Gauss test (statements only). Alternating series, Leibniz test. Absolute and conditional convergence.

Graphical Demonstration (Teaching aid**)

[5 classes]

- Plotting of recursive sequences.

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

** **Preferably by computer softwares but can be taught through drawing on black board/white board etc. in case of unavailability.**

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.

[5] T. Apostol, Mathematical Analysis, Narosa Publishing House

[6] Courant and John, Introduction to Calculus and Analysis, Vol I, Springer

[7] W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill

[8] C. C. Pugh, Real Mathematical Analysis, Springer, 2002.

[9] Terence Tao, Analysis I, Hindustan Book Agency, 2006.

[10] S. Goldberg, Calculus and mathematical analysis.

[11] Horst R. Beyer, Calculus and Analysis, Wiley, 2010.

Course Structure | DSE | SEC | Credit Distribution

Group Theory-I

Semester : 2 Core Course-4 Paper Code(Theory): MTM-A-CC-2-4-TH Paper Code (Tutorial):MTM-A-CC-2-4-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial ***20 Mark are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1

[30 classes]

- Symmetries of a square, definition of group, examples of groups including permutation groups, dihedral groups and quaternion groups (through matrices), elementary properties of groups, examples of commutative and non-commutative groups. Subgroups and examples of subgroups, necessary and sufficient condition for a nonempty subset of a group to be a subgroup. Normalizer, centralizer, center of a group, product of two subgroups.

Unit-2

[25 classes]

- 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, order of an element, order of a group. Lagrange's theorem and consequences including Fermat's Little theorem.

Unit-3

[20 classes]

- Normal subgroup and its properties. Quotient group. Group homomorphisms, properties of homomorphisms, correspondence theorem and one one correspondence between the set of all normal subgroups of a group and the set of all congruences on that group, Cayley's theorem, properties of isomorphisms. First, Second and Third isomorphism theorems.

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.

[6] D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra.

Course Structure | DSE | SEC | Credit Distribution

Theory of Real Functions

Semester : 3 Core Course-5 Paper Code(Theory): MTM-A-CC-3-5-TH Paper Code (Tutorial):MTM-A-CC-3-5-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial ***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1 : Limit & Continuity of functions [40 classes]

- Limits of functions ($\epsilon - \delta$ approach), sequential criterion for limits. Algebra of limits for functions, effect of limit on inequality involving functions, one sided limits. Infinite limits and limits at infinity. Important limits like $\frac{\sin x}{x}$, $\frac{\log(1+x)}{x}$, $\frac{a^x-1}{x}$ $(a > 0)$ as $x \longrightarrow 0$.
- Continuity of a function on an interval and at an isolated point. Sequential criteria for continuity. Concept of oscillation of a function at a point. A function is continuous at x if and only if its oscillation at x is zero. Familiarity with the figures of some well known functions : $y = x^a$ $(a = 2, 3, \frac{1}{2}, -1)$, $|x|$, $\sin x$, $\cos x$, $\tan x$, $\log x$, e^x. Algebra of continuous functions as a consequence of algebra of limits. Continuity of composite functions. Examples of continuous functions. Continuity of a function at a point does not necessarily imply the continuity in some neighbourhood of that point.
- Bounded functions. Neighbourhood properties of continuous functions regarding boundedness and maintenance of same sign. Continuous function on $[a, b]$ is bounded and attains its bounds. Intermediate value theorem.
- Discontinuity of functions, type of discontinuity. Step functions. Piecewise continuity. Monotone functions. Monotone functions can have only jump discontinuity. Monotone functions can have atmost countably many points of discontinuity. Monotone bijective function from an interval to an interval is continuous and its inverse is also continuous.
- Uniform continuity. Functions continuous on a closed and bounded interval is uniformly continuous. A necessary and sufficient condition under which a continuous function on a bounded open interval I will be uniformly continuous on I. A sufficient condition under which a continuous function on an unbounded open interval I will be uniformly continuous on I(statement only). Lipschitz condition and uniform continuity.

Unit-2 : Differentiability of functions [35 classes]

- Differentiability of a function at a point and in an interval, algebra of differentiable functions. Meaning of sign of derivative. Chain rule.
- Darboux theorem, Rolle's theorem, Mean value theorems of Lagrange and Cauchy — as an application of Rolle's theorem. Taylor's theorem on closed and bounded interval with Lagrange's and Cauchy's form of remainder deduced from Lagrange's and Cauchy's mean value theorem respectively. Expansion of e^x, $\log(1 + x)$, $(1 + x)^m$, $\sin x$, $\cos x$ with their range of validity (assuming relevant theorems). Application of Taylor's theorem to inequalities.
- Statement of L' Hospital's rule and its consequences. Point of local extremum (maximum, minimum) of a function in an interval. Sufficient condition for the existence of a local maximum/minimum of a function at a point (statement only). Determination of local extremum using first order derivative. Application of the principle of maximum/minimum in geometrical problems.

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.

[5] T. Apostol, Mathematical Analysis, Narosa Publishing House

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[7] W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill

[8] C. C. Pugh, Real Mathematical Analysis, Springer, 2002.

[9] Terence Tao, Analysis I, Hindustan Book Agency, 2006.

[10] S. Goldberg, Calculus and mathematical analysis.

[11] Horst R. Beyer, Calculus and Analysis, Wiley, 2010.

Course Structure | DSE | SEC | Credit Distribution

Ring Theory & Linear Algebra-I

Semester : 3 Core Course-6 Paper Code(Theory): MTM-A-CC-3-6-TH Paper Code (Tutorial):MTM-A-CC-3-6-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial ***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1 : Ring theory [35 classes]

- Definition and examples of rings, properties of rings, subrings, necessary and sufficient condition for a nonempty subset of a ring to be a subring, integral domains and fields, subfield, necessary and sufficient condition for a nonempty subset of a field to be a subfield, characteristic of a ring. Ideal, ideal generated by a subset of a ring, factor rings, operations on ideals, prime and maximal ideals. Ring homomorphisms, properties of ring homomorphisms. First isomorphism theorem, second isomorphism theorem, third isomorphism theorem, Correspondence theorem, congruence on rings, one-one correspondence between the set of ideals and the set of all congruences on a ring.

Unit-2 : Linear algebra [40 classes]

- Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces. Subspaces of $\mathbb{R}^n$, dimension of subspaces of $\mathbb{R}^n$. Geometric significance of subspace.
- Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, change of coordinate matrix. Algebra of linear transformations. Isomorphisms. Isomorphism theorems, invertibility and isomorphisms. Eigen values, eigen vectors and characteristic equation of a matrix. Cayley-Hamilton theorem and its use in finding the inverse of a matrix,

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.

[10] D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra.

Course Structure | DSE | SEC | Credit Distribution

Ordinary Differential Equation & Multivariate Calculus-I

Semester : 3 Core Course-7 Paper Code(Theory): MTM-A-CC-3-7-TH Paper Code (Tutorial):MTM-A-CC-3-7-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial ***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1 : Ordinary differential equation [40 classes]

- First order differential equations : Exact differential equations and integrating factors, special integrating factors and transformations, linear equations and Bernoulli equations, the existence and uniqueness theorem of Picard (Statement only).
- Linear equations and equations reducible to linear form. First order higher degree equations solvable for x, y and p. Clairaut's equations and singular solution.
- Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions.
- Linear differential equations of second order, Wronskian : its properties and applications, Euler equation, method of undetermined coefficients, method of variation of parameters.
- System of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients.
- Planar linear autonomous systems : Equilibrium (critical) points, Interpretation of the phase plane and phase portraits.
- Power series solution of a differential equation about an ordinary point, solution about a regular singular point (up to second order).

Unit-2 : Multivariate Calculus-I [35 classes]

- Concept of neighbourhood of a point in R^n (n $>$ 1), interior point, limit point, open set and closed set in R^n (n $>$ 1).
- Functions from R^n($n > 1$) to R^m($m \geq 1$), limit and continuity of functions of two or more variables. Partial derivatives, total derivative and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters, 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.

References

[1] D.A. Murray, Introductory course in Differential Equations, Orient and Longman

[2] H.T. H.Piaggio, Elementary Treaties on Differential Equations and their applications, C.B.S Publisher & Distributors, Delhi,1985.

[3] G.F.Simmons, Differential Equations, Tata Mc Graw Hill

[4] S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.

[5] M.R. Speigel, Schaum's outline of Laplace Transform

[6] Horst R. Beyer, Calculus and Analysis, Wiley, 2010.

Course Structure | DSE | SEC | Credit Distribution

Riemann Integration & Series of Functions

Semester : 4 Core Course-8 Paper Code(Theory): MTM-A-CC-4-8-TH Paper Code (Tutorial):MTM-A-CC-4-8-TU	Credits : 5+1*=6 Full Marks 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial ***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1 : Riemann integration [35 classes]

- Partition and refinement of partition of a closed and bounded interval. Upper Darboux sum $U(P, f)$ and lower Darboux sum $L(P, f)$ and associated results. Upper integral and lower integral. Darboux's theorem. Darboux's definition of integration over a closed and bounded interval. Riemann's definition of integrability. Equivalence with Darboux definition of integrability (statement only). Necessary and sufficient condition for Riemann integrability.
- Concept of negligible set (or zero set) defined as a set covered by countable number of open intervals sum of whose lengths is arbitrary small. Examples of negligible sets : any subset of a negligible set, finite set, countable union of negligible sets. A bounded function on closed and bounded interval is Riemann integrable if and only if the set of points of discontinuity is negligible. Example of Riemann integrable functions.
- Integrability of sum, scalar multiple, product, quotient, modulus of Riemann integrable functions. Properties of Riemann integrable functions arising from the above results.
- Function defined by definite integral $\int_a^x f(t)dt$ and its properties. Antiderivative (primitive or indefinite integral). Properties of Logarithmic function defined as the definite integral $\int_1^x \frac{dt}{t},\ x > 0$.
- Fundamental theorem of Integral Calculus. First Mean Value theorem of integral calculus.

Unit-2 : Improper integral [10 classes]

- Range of integration, finite or infinite. Necessary and sufficient condition for convergence of improper integral in both cases.
- Tests of convergence : Comparison and M-test. Absolute and non-absolute convergence and inter-relations. Statement of Abel's and Dirichlet's test for convergence on the integral of a product.
- Convergence and working knowledge of Beta and Gamma function and their interrelation $\Big[\Gamma(n)\Gamma(1-n) = \frac{\pi}{\sin n\pi}, 0 < n < 1$, to be assumed$\Big]$. Computation of the integrals $\int_0^{\pi/2} \sin^n x dx$, $\int_0^{\pi/2} \cos^n x dx$, $\int_0^{\pi/2} \tan^n x dx$ when they exist (using Beta and Gamma function).

Unit-3 : Series of functions [30 classes]

- Sequence of functions defined on a set, Pointwise and uniform convergence. Cauchy criterion of uniform convergence. Weirstrass' M-test. Boundedness, continuity, integrability and differentiability of the limit function of a sequence of functions in case of uniform convergence.

- Series of functions defined on a set, Pointwise and uniform convergence. Cauchy criterion of uniform convergence. Weierstrass' M-test. Passage to the limit term by term. Boundedness, continuity, integrability, differentiability of a series of functions in case of uniform convergence.
- Power series : Fundamental theorem of power series. Cauchy-Hadamard theorem. Determination of radius of convergence. Uniform and absolute convergence of power series. Properties of sum function. Differentiation and integration of power series. Abel's limit theorems. Uniqueness of power series having sum function.
- Fourier series : Trigonometric series. Statement of sufficient condition for a trigonometric series to be a Fourier series. Fourier coefficients for periodic functions defined on $[-\pi, \pi]$. Statement of Dirichlet's condition of convergence. Statement of theorem of sum of Fourier series.

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.

[5] T. Apostol, Mathematical Analysis, Narosa Publishing House

[6] Courant and John, Introduction to Calculus and Analysis, Vol I, Springer

[7] W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill

[8] C. C. Pugh, Real Mathematical Analysis, Springer, 2002.

[9] Terence Tao, Analysis I, Hindustan Book Agency, 2006.

[10] S. Goldberg, Calculus and mathematical analysis.

[11] Horst R. Beyer, Calculus and Analysis, Wiley, 2010.

Course Structure | DSE | SEC | Credit Distribution

Partial differential equation & Multivariate Calculus-II

Semester : 4 Core Course-9 Paper Code(Theory): MTM-A-CC-4-9-TH Paper Code (Tutorial):MTM-A-CC-4-9-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial ***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1 : Partial differential equation [40 classes]

- Partial differential equations of the first order, Lagrange's solution, non linear first order partial differential equations, Charpit's general method of solution, some special types of equations which can be solved easily by methods other than the general method.
- 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.
- The Cauchy problem, Cauchy-Kowalewskaya theorem, Cauchy problem of finite and 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-2 : Multivariate Calculus-II [35 classes]

- Multiple integral: Concept of upper sum, lower sum, upper integral, lower-integral and double integral (no rigorous treatment is needed). Statement of existence theorem for continuous functions. Iterated or repeated integral, change of order of integration. Triple integral. Cylindrical and spherical coordinates. Change of variables in double integrals and triple integrals. Transformation of double and triple integrals (problems only). Determination of volume and surface area by multiple integrals (problems only). Differentiation under the integral sign, Leibniz's rule (problems only).
- Definition of vector field, divergence and curl. Line integrals, applications of line integrals : mass and work. Fundamental theorem for line integrals, conservative vector fields, independence of path.
- Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stoke's theorem, The Divergence theorem.

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), 2005.

[4] James Stewart, Multivariable Calculus, Concepts and Contexts, 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001

[5] T. Apostol, Mathematical Analysis, Narosa Publishing House.

[6] Courant and John, Introduction to Calculus and Analysis, Vol II, Springer

[7] W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill.

[8] Horst R. Beyer, Calculus and Analysis, Wiley, 2010.

[9] Ian Sneddon, Elements of Partial Differential equations, Mcgraw-Hill International Edition, 1957.

[10] M.D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand Higher Academic, 19th Edition, 2017.

[11] K.Sankara Rao, Introduction to Partial Differential Equations, PHI, Third Edition, 2015.

Course Structure | DSE | SEC | Credit Distribution

Mechanics

Semester : 4 Core Course- 10 Paper Code(Theory): MTM-A-CC-4-10-TH Paper Code (Tutorial):MTM-A-CC-4-10-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial **20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1

[15 classes]

- **Coplanar forces in general :** Resultant force and resultant couple, Special cases, Varignon's theorem, Necessary and sufficient conditions of equilibrium. Equilibrium equations of the first, second and third kind.
- **An arbitrary force system in space :** Moment of a force about an axis, Varignon's theorem. Resultant force and resultant couple, necessary and sufficient conditions of equilibrium. Equilibrium equations, Reduction to a wrench, Poinsot's central axis, intensity and pitch of a wrench, Invariants of a system of forces. Statically determinate and indeterminate problems.
- **Equilibrium in the presence of sliding Friction force :** Contact force between bodies, Coulomb's laws of static Friction and dynamic friction. The angle and cone of friction, the equilibrium region.

Unit-2

[10 classes]

- **Virtual work :** Workless constraints - examples, virtual displacements and virtual work. The principle of virtual work, Deductions of the necessary and sufficient conditions of equilibrium of an arbitrary force system in plane and space, acting on a rigid body.
- **Stability of equilibrium :** Conservative force field, energy test of stability, condition of stability of a perfectly rough heavy body lying on a fixed body. Rocking stones.

Unit-3

[20 classes]

- **Kinematics of a particle :** velocity, acceleration, angular velocity, linear and angular momentum. Relative velocity and acceleration. Expressions for velocity and acceleration in case of rectilinear motion and planar motion - in Cartesian and polar co-ordinates, tangential and normal components. Uniform circular motion.
- **Newton laws of motion and law of gravitation :** Space, time, mass, force, inertial reference frame, principle of equivalence and g. Vector equation of motion.

  Work, power, kinetic energy, conservative forces - potential energy. Existence of potential energy function. Energy conservation in a conservative field. Stable equilibrium and small oscillations: Approximate equation of motion for small oscillation. Impulsive forces

Unit-4

[20 classes]

- **Problems in particle dynamics :** Rectilinear motion in a given force field - vertical motion under uniform gravity, inverse square field, constrained rectilinear motion, vertical motion under gravity in a resisting medium, simple harmonic motion, Damped and forced oscillations, resonance of an oscillating system, motion of elastic strings and springs.

- **Planar motion of a particle :** Motion of a projectile in a resisting medium under gravity, orbits in a central force field, Stability of nearly circular orbits. Motion under the attractive inverse square law, Kepler's laws on planetary motion. Slightly disturbed orbits, motion of artificial satellites. Constrained motion of a particle on smooth and rough curves. Equations of motion referred to a set of rotating axes.
- **Motion of a particle in three dimensions :** Motion on a smooth sphere, cone, and on any surface of revolution.

Unit-5

[10 classes]

- **Many particles system**

  The linear momentum principle : Linear momentum, linear momentum principle, motion of the centre of mass, conservation of linear momentum.
- **The angular momentum principle :** Moment of a force about a point, about an axis. Angular momentum about a point, about an axis. Angular momentum principle about centre of mass. Conservation of angular momentum (about a point and an axis). Impulsive forces.
- **The energy principle :** Configurations and degrees of freedom of a multi-particle system, energy principle, energy conservation.

  Rocket motion in free space and under gravity, collision of elastic bodies. The two-body problem.

References

[1] Gregory R.D., Classical mechanics, Cambridge UP

[2] K. R. Symon, Mechanics, Addison Wesley

[3] Mary Lunn; A First Course in Mechanics, OUP

[4] J. L. Synge, B. A. Griffith, Principles of Mechanics, Mcgraw Hill

[5] T. W. B. Kibble, F. H. Berkshire, Classical Mechanics, Imperial College Press

[6] D. T. Greenwood, Principle of Dynamics, PHI

[7] Chorlton, F., Textbook of Dynamics.

[8] D. Kleppner & R. Kolenkow, Introduction to Mechanics, Tata Mcgraw Hill

[9] A. P. French, Newtonian Mechanics, Viva Books

[10] Timoshenko and Young, Engineering Mechanics, Mcgraw Hill

[11] D. Chernilevski, E. Lavrova, V. Romanov, Mechanics for Engineers, MIR Publishers

[12] I.H. Shames and G. Krishna Mohan Rao, Engineering Mechanics: Statics and Dynamics, (4th Ed.), Dorling Kindersley(India) Pvt. Ltd. (Pearson Education), Delhi, 2009.

[13] R.C. Hibbeler and Ashok Gupta, Engineering Mechanics: Statics and Dynamics, 11th Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi.

[14] Loney, S. L., An Elementary Treatise on the Dynamics of particle and of Rigid Bodies, Loney Press .

[15] Loney, S. L., An Elementary Treatise on Statics

[16] Verma, R. S., A Textbook on Statics, Pothishala, 1962

[17] Ramsey, A. S., Dynamics (Part I & II).

Course Structure | DSE | SEC | Credit Distribution

Probability & Statistics

Semester : 5 Core Course-11 Paper Code(Theory): MTM-A-CC-5-11-TH Paper Code (Tutorial):MTM-A-CC-5-11-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial ***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1

[20 classes]

- Random experiment, σ-field, Sample space, probability as a set function, probability axioms, probability space. Finite sample spaces. Conditional probability, Bayes theorem, independence. 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.

Unit-2

[15 classes]

- Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions, expectation of function of two random variables, moments, covariance, correlation coefficient, independent random variables, joint moment generating function (jmgf) and calculation of covariance from jmgf, characteristic function. Conditional expectations, linear regression for two variables, regression curves. Bivariate normal distribution.

Unit-3

[5 classes]

- Markov and Chebyshev's inequality, Convergence in Probability, 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-4

[15 classes]

- Sampling and Sampling Distributions : Populations and Samples, Random Sample, distribution of the sample, Simple random sampling with and without replacement. Sample characteristics.
- Sampling Distributions : Statictic, Sample moments. Sample variance, Sampling from the normal distributions, Chi-square, t and F-distributions, sampling distribution of $\overline{X}$, s^2, $\frac{\sqrt{n}}{s}(\overline{X}-\mu)$
- Estimation of parameters : Point estimation. Interval Estimation- Confidence Intervals for mean and variance of Normal Population. Mean-squared error. Properties of good estimators - unbiasedness, consistency, sufficiency, Minimum-Variance Unbiased Estimator (MVUE).
- Method of Maximum likelihood : likelihood function, ML estimators for discrete and continuous models.

Unit-5

[15 classes]

- Statistical hypothesis : Simple and composite hypotheses, null hypotheses, alternative hypotheses, one-sided and two-sided hypotheses. The critical region and test statistic, type I error and type II error, level of significance. Power function of a test, most powerful test. The p-value (observed level of significance), Calculating p-values.

- Simple hypothesis versus simple alternative : Neyman-Pearson lemma (Statement only).
- Bivariate frequency Distribution : Bivariate data, Scatter diagram, Correlation, Linear Regression, principle of least squares and fitting of polynomials and exponential curves.

Graphical Demonstration (Teaching Aid**) [5 classes]

- Graphical representation of data - how to load data, plot a graph viz. histograms (equal class intervals and unequal class intervals), frequency polygon, pie chart, ogives with graphical summaries of data.
- Measures of central tendency and measures of dispersion ,moments, skewness and kurtosis.
- Karl Pearson correlation coefficient.
- Correlation coefficient for a bivariate frequency distribution.
- Lines of regression, angle between lines and estimated values of variables.
- Fitting of polynomials, exponential curves by method of least squares.
- Confidence interval for the parameters of a normal distribution (one sample and two sample problems).

** **Preferably by free softwares (e.g. R/ Python / SageMath etc.) but can be taught through black board/white board / square sheet etc. in case of unavailability.**

References

[1] William Feller, An introduction to Probability Theory and its Application, Volume 1, 3e.

[2] Robert V. Hogg, Joseph W. McKean and Allen T. Craig, Introduction to Mathematical Statistics, Pearson Education, Asia, 2007.

[3] Irwin Miller and Marylees Miller, John E. Freund, Mathematical Statistics with Applications, 7th Ed., Pearson Education, Asia, 2006.

[4] Sheldon Ross, Introduction to Probability Models, 9th Ed., Academic Press, Indian Reprint, 2007.

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

[6] A.M. Goon, M.K.Gupta and B.Dasgupta, Fundamental of Statistics, Vol 1 & Vol 2, World Press.

[7] A. Gupta, Ground work of Mathematical Probability and Statistics, Academic publishers .

Course Structure | DSE | SEC | Credit Distribution

Group Theory-II & Linear Algebra-II

Semester : 5 Core Course-12 Paper Code(Theory): MTM-A-CC-5-12-TH Paper Code (Tutorial):MTM-A-CC-5-12-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial ***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1 : Group theory [35 classes]

- Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinite cyclic groups, applications of factor groups to automorphism groups.
- External direct product and its properties, the group of units modulo n as an external direct product, internal direct product, converse of Lagrange's theorem for finite abelian group, Cauchy's theorem for finite abelian group, Fundamental theorem of finite abelian groups.

Unit-2 : Linear algebra [40 classes]

- Inner product spaces and norms, Gram-Schmidt orthonormalisation process, orthogonal complements, Bessel's inequality, the adjoint of a linear operator and its basic properties.
- Bilinear and quadratic forms, Diagonalisation of symmetric matrices, Second derivative test for critical point of a function of several variables, Hessian matrix, Sylvester's law of inertia. Index, signature.
- Dual spaces, dual basis, double dual, transpose of a linear transformation and its matrix in the dual basis, annihilators. Eigenspaces of a linear operator, diagonalizability, invariant subspaces and Cayley-Hamilton theorem, the minimal polynomial for a linear operator, canonical forms (Jordan & rational).

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.

[6] D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra.

[7] Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, 4th Ed., Prentice- Hall of India Pvt. Ltd., New Delhi, 2004.

[8] S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2005.

[9] Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.

[10] S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999.

[11] Kenneth Hoffman, Ray Alden Kunze, Linear Algebra, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.

[12] D.A.R. Wallace, Groups, Rings and Fields, Springer Verlag London Ltd., 1998.

Course Structure | DSE | SEC | Credit Distribution

Metric Space & Complex Analysis

Semester : 6 Core Course-13 Paper Code(Theory): MTM-A-CC-6-13-TH Paper Code (Tutorial):MTM-A-CC-6-13-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial ***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1 : Metric space [40 classes]

- Definition and examples of metric spaces. Open ball. Open set. Closed set as complement of open set. Interior point and interior of a set. Limit point and closure of a set. Boundary point and boundary of a set. Properties of interior, closure and boundary. Bounded set and diameter of a set. Distance between two sets. Subspace of a metric space.
- Convergent sequence. Cauchy sequence. Every convergent sequence is Cauchy and bounded, but the converse is not true. Completeness. Cantor's intersection theorem. $\mathbb{R}$ is a complete metric space. $\mathbb{Q}$ is not complete.
- Continuous mappings, sequential criterion of continuity. Uniform continuity.
- Compactness, Sequential compactness, Heine-Borel theorem in $\mathbb{R}$. Finite intersection property, continuous functions on compact sets.
- Concept of connectedness and some examples of connected metric space, connected subsets of $\mathbb{R}, \mathbb{C}$.
- Contraction mappings, Banach Fixed point Theorem and its application to ordinary differential equations.

Unit-2 : Complex analysis [35 classes]

- Stereographic projection. Regions in the complex plane. Limits, limits involving the point at infinity. Continuity of functions of complex variable.
- Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability. Analytic functions, exponential function, logarithmic function, trigonometric functions, hyperbolic functions. Möbius transformation.
- Power series : Cauchy-Hadamard theorem. Determination of radius of convergence. Uniform and absolute convergence of power series. Analytic functions represented by power series. Uniqueness of power series.
- Contours, complex integration along a contour and its examples, upper bounds for moduli of contour integrals. Cauchy- Goursat theorem (statement only) and its consequences, Cauchy integral formula.

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] P. K. Jain and K. Ahmad, Metric Spaces, Narosa Publishing House.

[4] G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 2004.

[5] James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, 8th Ed., McGraw Ãâåœ Hill International Edition, 2009.

[6] Joseph Bak and Donald J. Newman, Complex Analysis, 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., NewYork, 1997.

[7] S. Ponnusamy, Foundations of complex analysis.

[8] E. M. Stein and R. Shakrachi, Complex Analysis, Princeton University Press.

Course Structure | DSE | SEC | Credit Distribution

Numerical Methods

Semester : 6 Core Course-14 Paper Code(Theory): MTM-A-CC-6-14-TH	Credits : 4 Full Marks : 50+20**=70
Number of classes required : 55	
***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1

[5 classes]

- Representation of real numbers, Machine Numbers - floating point and fixed point. Sources of Errors, Rounding of numbers, significant digits and Error Propagation in machine arithmetic operations. Numerical Algorithms - stability and convergence.

Unit-2

[15 classes]

- Approximation : Classes of approximating functions, Types of approximations- polynomial approximation, The Weierstrass polynomial approximation theorem (statement only).
- Interpolation : Lagrange and Newton's methods. Error bounds. Finite difference operators. Newton (Gregory) forward and backward difference interpolation.
- Central Interpolation : Stirling's and Bessel's formulas. Different interpolation zones, Error estimation. Hermite interpolation.

Unit-3

[10 classes]

- Numerical differentiation : Methods based on interpolations, methods based on finite differences.
- Numerical Integration : Newton Cotes formula, Trapezoidal rule, Simpson's $\frac{1}{3}$-rd rule, Simpson's $\frac{3}{8}$-th rule, Weddle's rule, Boole's Rule, midpoint rule. Composite trapezoidal rule, composite Simpson's $\frac{1}{3}$-rd rule, composite Weddle's rule. Gaussian quadrature formula.

Unit-4

[10 classes]

- Transcendental and polynomial equations : Bisection method, Secant method, Regula-falsi method, fixed point iteration, Newton-Raphson method. Condition of convergence (if any), Order of convergence, Rate of convergence of these methods. Modified Newton-Raphson method for multiple roots, Complex roots of an algebraic equation by Newton-Raphson method.

  Numerical solution of system of nonlinear equations - Newton's method.

Unit-5

[10 classes]

- System of linear algebraic equations :
  Direct methods : Gaussian elimination and Gauss Jordan methods, Pivoting strategies.
- Iterative methods : Gauss Jacobi method, Gauss Seidel method and their convergence analysis. LU decomposition method (Crout's LU decomposition method).
- Matrix inversion : Gaussian elimination and LU decomposition method (Crout's LU decomposition method) (operational counts).
- The algebraic eigen value problem : Power method.

Unit-6

[5 classes]

- Ordinary differential equations : Single-step difference equation methods- error, convergence. The method of successive approximations (Picard), Euler's method, the modified Euler method, Runge-Kutta methods of orders two and four.

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

[3] Computation, 6th Ed., New age International Publisher, India, 2007.

[4] C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 2008.

[5] Uri M. Ascher and Chen Greif, A First Course in Numerical Methods, 7th Ed., PHI Learning Private Limited, 2013.

[6] John H. Mathews and Kurtis D. Fink, Numerical Methods using Matlab, 4th Ed., PHI Learning Private Limited, 2012.

[7] Scarborough, James B., Numerical Mathematical Analysis, Oxford and IBH publishing co.

[8] Atkinson, K. E., An Introduction to Numerical Analysis, John Wiley and Sons, 1978.

[9] Yashavant Kanetkar, Let Us C, BPB Publications.

Course Structure | DSE | SEC | Credit Distribution

Numerical Methods Lab

Semester : 6 Core Course-14 Practical Paper Code(Practical): MTM-A-CC-6-14-P	Credits : 2 Full Marks : 30
Number of contact hours required : 50	

Course Structure | DSE | SEC | Credit Distribution

List of practicals (using C/ C++/ FORTRAN 90)

1. Calculate the sum $\frac{1}{1} + \frac{1}{2} + \frac{1}{3} + \cdots + \frac{1}{N}$
2. Enter 100 integers into an array and sort them in an ascending order.
3. Solution of transcendental and algebraic equations by
   i) Bisection method
   ii) Newton Raphson method (Simple root, multiple roots, complex roots).
   iii) Secant method.
   iv) Regula Falsi method.
4. Solution of system of linear equations
   i) LU decomposition method
   ii) Gaussian elimination method
   iii) Gauss-Jacobi method
   iv) Gauss-Seidel method
5. Interpolation
   i) Lagrange Interpolation
   ii) Newton's forward, backward and divided difference interpolations
6. Numerical Integration
   i) Trapezoidal Rule
   ii) Simpson's one third rule
   iii) Weddle's Rule
   iv) Gauss Quadrature
7. Method of finding Eigenvalue by Power method (up to 4×4)
8. Fitting a Polynomial Function (up to third degree)
9. Solution of ordinary differential equations
   i) Euler method
   ii) Modified Euler method
   iii) Runge Kutta method (order 4)
   iv) The method of successive approximations (Picard)

Note : For any of the CAS (Computer aided software), Data types-simple data types, floating data types, 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.

Course Structure | DSE | SEC | Credit Distribution

Advanced Algebra

Semesters : 5 Discipline Specific Elective- DSE-A (1) Paper Code(Theory):MTM-A-DSE-A-5-1-TH Paper Code(Tutorial):MTM-A-DSE-A-5-1-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial ***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1: Group Theory [25 classes]

- Group actions, stabilizers, permutation representation associated with a given group action, Applications of group actions: Generalized Cayley's theorem, Index theorem.
- Groups acting on themselves by conjugation, class equation and consequences, conjugacy in S_n, p-groups, Sylow's theorems and consequences, Cauchy's theorem, Simplicity of A_n for $n \geq 5$, non-simplicity tests.

Unit-2: Ring Theory [50 classes]

- Principal ideal domain, principal ideal ring, prime element, irreducible element, greatest common divisor (gcd), least common multiple (lcm), expression of gcd, examples of a ring R and a pair of elements $a, b \in R$ such that $\gcd(a, b)$ does not exist, Euclidean domain, relation between Euclidean domain and principal ideal domain.
- Polynomial rings, division algorithm and consequences, factorization domain, unique factorization domain, irreducible and prime elements in a unique factorization domain, relation between principal ideal domain, unique factorization domain, factorization domain and integral domain, Eisenstein criterion and unique factorization in $\mathbb{Z}[x]$.
- Ring embedding and quotient field, regular rings and their examples, properties of regular ring, ideals in regular rings.

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] D.A.R. Wallace, Groups, Rings and Fields, Springer Verlag London Ltd., 1998.

[6] D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra.

Course Structure | DSE | SEC | Credit Distribution

Bio Mathematics

Semesters : 5 Discipline Specific Elective- DSE-A(1) Paper Code(Theory):MTM-A-DSE-A-5-1-TH Paper Code(Tutorial):MTM-A-DSE-A-5-1-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial ***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1

[25 classes]

- 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)

Unit-2

[30 classes]

- 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.

Unit-3

[15 classes]

- 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.

Graphical Demonstration (Teaching Aid)[using any software]

[5 classes]

- Growth model (exponential case only).
- Decay model (exponential case only).
- Lake pollution model (with constant/seasonal flow and pollution concentration).
- Case of single cold pill and a course of cold pills.
- Limited growth of population (with and without harvesting).
- Predatory-prey model (basic Volterra model, with density dependence, effect of DDT, two prey one predator).
- Epidemic model of influenza (basic epidemic model, contagious for life,disease with carriers).
- Battle model (basic battle model, jungle warfare, long range weapons).

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.

Course Structure | DSE | SEC | Credit Distribution

Industrial Mathematics

Semester : 5 Discipline Specific Elective-A(1) Paper Code(Theory):MTM-A-DSE-A-5-1-TH Paper Code(Tutorial):MTM-A-DSE-A-5-1-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial ***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1

[20 classes]

- 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-2

[20 classes]

- 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-3

[10 classes]

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

Unit-4

[05 classes]

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

Unit-5

[05 classes]

- Back Projection: Definition, properties and examples.

Unit-6

[15 classes]

- 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.

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

Course Structure | DSE | SEC | Credit Distribution

Discrete Mathematics

Semesters : 5 Discipline Specific Elective-DSE-B(1) Paper Code(Theory):MTM-A-DSE-B-5-1-TH Paper Code(Tutorial):MTM-A-DSE-B-5-1-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial ***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1 : Graph Theory [40 classes]

- Definition of undirected graphs, Using of graphs to solve different puzzles and problems. Multigraphs. Walks, Trails, Paths, Circuits and cycles, Eulerian circuits and paths. Eulerian graphs, example of Eulerian graphs. Hamiltonian cycles and Hamiltonian graphs.
- Weighted graphs and Travelling salespersons Problem. Dijkstra's algorithm to find shortest path.
- Definition of Trees and their elementary properties. Definition of Planar graphs, Kuratowski's graphs.
- Partial Order relations and lattices, Chains and antichains. Pigeon hole Principle.

Unit-2 : Number Theory [35 classes]

- Application of techniques of groups and rings to prove some theorems in number theory : Fermat's Theorem, Euler's Theorem, Willson's Theorem, Chinese Remainder Theorem.
- The Arithmetic of $\mathbb{Z}_p$, p a prime, pseudo prime and Carmichael Numbers, Fermat Numbers, Perfect Numbers, Mersenne Numbers.
- Primitive roots, the group of units $\mathcal{Z}_n^*$, the existence of primitive roots, applications of primitive roots, the algebraic structure of $\mathcal{Z}_n^*$.
- Quadratic residues and non quadratic residues, Legendre symbol, proof of the law of quadratic reciprocity, Jacobi symbols.
- Arithmetic functions, Multiplicative functions, definitions and examples.

References

[1] N. Deo; Graph Theory with Application to Engineering and Computer Science; Prentice Hall of India, New Delhi, 1990.

[2] John Clark and Derek Allan Holton; A First Look at Graph Theory; World Scientific, New Jersey, 1991.

[3] F. Harary; Graph Theory; Narosa Publishing House, New Delhi, 2001.

[4] J. A. Bondy and U. S. R. Murty; Graph theory and related topics; Academic Press, New York, 1979.

[5] Adhikari M R and Adhikari A: Basic Modern Algebra with Applications, Springer, 2014.

[6] Gareth A Jones and J Mary Jones : Elementary Number Theory, Springer International Edition.

[7] Neal Koblitz : A course in number theory and cryptography, Springer-Verlag, 2nd edition.

[8] D. M. Burton : Elementary Number Theory, Wm. C. Brown Publishers, Dulreque, Lowa, 1989.

[9] Kenneth. H. Rosen : Elementary Number Theory & Its Applications, AT&T Bell Laboratories, Addition-Wesley Publishing Company, 3rd Edition.

[10] Kenneth Ireland & Michael Rosen : A Classical Introduction to Modern Number Theory, 2nd edition, Springer-verlag.

[11] Richard A Mollin : Advanced Number Theory with Applications, CRC Press, A Chapman & Hall Book.

Course Structure | DSE | SEC | Credit Distribution

Linear Programming & Game Theory

Semesters : 5 Discipline Specific Elective- DSE-B(1) Paper Code(Theory):MTM-A-DSE-B-5-1-TH Paper Code(Tutorial):MTM-A-DSE-B-5-1-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial ***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1

[15 classes]

- Definition of Linear Programming Problem (L.P.P.). Formation of L.P.P. from daily life involving inequations. Graphical solution of L.P.P. Basic solutions and Basic Feasible Solution (B.F.S) with reference to L.P.P. Matrix formulation of L.P.P. Degenerate and Non-degenerate B.F.S.
- Hyperplane, Convex set, Cone, extreme points, convex hull and convex polyhedron. Supporting and Separating hyperplane. The collection of a feasible solutions of an L.P.P. constitutes a convex set. The extreme points of the convex set of feasible solutions correspond to its B.F.S. and conversely. The objective function has its optimal value at an extreme point of the convex polyhedron generated by the set of feasible solutions (the convex polyhedron may also be unbounded). In the absence of degeneracy, if the L.P.P. admits of an optimal solution then at least one B.F.S. must be optimal. Reduction of a F.S. to a B.F.S.

Unit-2

[20 classes]

- Slack and surplus variables. Standard form of L.P.P. theory of simplex method. Feasibility and optimality conditions.
- The algorithm. Two phase method. Degeneracy in L.P.P. and its resolution.

Unit-3

[10 classes]

- Duality theory: The dual of dual is the primal. Relation between the objective values of dual and the primal problems. Relation between their optimal values. Complementary slackness, Duality and simplex method and their applications.

Unit-4

[30 classes]

- Transportation and Assignment problems. Mathematical justification for optimality criterion. Hungarian method. Traveling Salesman problem.
- Concept of game problem. Rectangular games. Pure strategy and Mixed strategy. Saddle point and its existence. Optimal strategy and value of the game. Necessary and sufficient condition for a given strategy to be optimal in a game. Concept of Dominance. Fundamental Theorem of rectangular games. Algebraic method. Graphical method and Dominance method of solving Rectangular games. Inter-relation between theory of games and L.P.P.

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.

Course Structure | DSE | SEC | Credit Distribution

Boolean Algebra & Automata Theory

Semester : 5 Discipline Specific Elective-B(1) Paper Code(Theory):MTM-A-DSE-B-5-1-TH Paper Code(Tutorial):MTM-A-DSE-B-5-1-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial ***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1

[10 classes]

- 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-2

[15 classes]

- 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.

Unit-3

[15 classes]

- 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-4

[15 classes]

- 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-5

[10 classes]

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

Unit-6

[10 classes]

- Undecidability : Recursively enumerable and recursive languages, undecidable problems about Turing machines: halting problem. Post correspondence problem, and undecidability problems about CFGs.

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 G$\ddot{u}$nter 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

Course Structure | DSE | SEC | Credit Distribution

Differential Geometry

Semesters : 6 Discipline Specific Elective- DSE-A(2) Paper Code(Theory):MTM-A-DSE-A-6-2-TH Paper Code(Tutorial):MTM-A-DSE-A-6-2-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial ***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1

[10 classes]

- Tensor : Different transformation laws, Properties of tensors, Metric tensor, Riemannian space, Covariant Differentiation, Einstein space.

Unit-2

[35 classes]

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

Unit-3

[30 classes]

- 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.

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.

[7] An Introduction to Differential Geometry (with the use of tensor Calculus), L. P. Eisenhart, Princeton University Press, 1940.

[8] Tensor Analysis, Theory and Applications to Geometry and Mechanics of Continua, 2nd Edition, I. S. Sokolnikoff, John Wiley and Sons., 1964.

Mathematical Modelling

Semesters : 6 Discipline Specific Elective-DSE-A(2) Paper Code(Theory):MTM-A-DSE-A-6-2-TH Paper Code(Tutorial):MTM-A-DSE-A-6-2-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial ***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1

[20 classes]

- Power series solution of Bessel's equation and Legendre's equation, Laplace transform and inverse transform, application to initial value problem up to second order.

Unit-2

[45 classes]

- Monte Carlo simulation modelling: simulating deterministic behavior (area under a curve, volume under a surface), generating random numbers: middle square method, linear congruence, queuing models: harbor system, morning rush hour, Overview of optimization modelling. Linear programming model: geometric solution algebraic solution, simplex method, sensitivity analysis

Graphical demonstration (Teaching aid **)

[10 classes]

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

** **Preferably by free softwares e.g. R / SageMath / Python etc.**

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 Mathematical Modeling, Thomson Learning, London and New York, 2003.

Course Structure | DSE | SEC | Credit Distribution

Fluid Statics & Elementary Fluid Dynamics

Semester : 6 Discipline Specific Elective-A(2) Paper Code(Theory):MTM-A-DSE-A-6-2-TH Paper Code(Tutorial):MTM-A-DSE-A-6-2-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial ***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1

[20 classes]

- **Introduction and Fundamental Concepts:**
  Definition of Fluid, Distinction Between Solid and Fluid, Concept of Continuum, Fluid Properties : Density, Specific Weight, Specific Volume, Specific Gravity. Stress field [(Normal stress: $\sigma_n = lim_{\delta A_n \to 0}(\delta F_n / \delta A_n)$ and Shear stress: $\tau_n = lim_{\delta A_n \to 0}(\delta F_t / \delta A_n)$], Viscosity, Vapor pressure,. Newtonian fluid, Non-Newtonian Fluids. Ideal Fluid, Compressibility, Distinction between an Incompressible and a Compressible Flow, Surface Tension of Liquids.

  Forces on Fluid Elements: Definition of Fluid Elements, Body Force, Surface Force, Normal Stress in a Stationary Fluid, Pascal's Law of Hydrostatics, Fundamental Equation of Fluid Statics: $\vec{\nabla} p = \rho \vec{F}$, Fundamental Fluid Static Equations in Scalar Form: $\frac{\partial p}{\partial z} = \rho g$, Constant Density Solution.

Unit-2

[25 classes]

- **Hydrostatics**
  Hydrostatic Thrusts on Submerged Plane Surface: Centre of pressure, determination of coordinates of centre of pressure. Hydrostatic Thrusts on Submerged Curved Surfaces. Buoyancy: Center of the buoyancy. Archimedes principle. Stability of Unconstrained Submerged Bodies in Fluid: Stable Equilibrium, Unstable Equilibrium, Neutral Equilibrium. Stability of Floating Bodies in Fluid: Metacentre, Metacentric height.
- **Gas**
  Pressure of gases, The Atmosphere, Relation between pressure, density and temperature, Pressure in an isothermal atmosphere, Atmosphere in convective equilibrium.

Unit-3

[15 classes]

- **Kinematics of Fluid:**
  Scalar and Vector Fields, flow field, Description of Fluid Motion: Lagrangian Method, Eulerian Method, Relation between Eulerian and Lagrangian Method, Variation of Flow Parameters in Time and Space: Steady and Unsteady Flow, Uniform and Non-uniform Flows. Material Derivative and Acceleration: temporal derivative, convective derivative

Unit-4

[15 classes]

- **Conservation Equations:**
  Control Mass System, Control Volume System, Isolated System. Conservation of Mass - The Continuity Equation: Differential Form and Vector Form, Integral form. Conservation of Momentum: Momentum Theorem, Reynolds Transport Theorem. Conservation of energy.

References

[1] Fox and McDonalds INTRODUCTION TO FLUID MECHANICS (8th edition) Philips J. Pritchard, JOHN WILEY AND SONS INC .

[2] Fluid Mechanics (7th edition) Frank M. White, McGraw Hill.

[3] An Elementary Text-Book on Hydrostatics: William Briggs and G.H. Bryan , London: W.B.Clive.

[4] Hydrostatics : A.S.Ramsey, Cambridge University Press, 2017.

[5] Hydrostatics : J.M.Kar, Krishna Prakashan, India.

[6] Elementary Fluid Dynamics : D.J.Acheson, Oxford Applied Mathematics and Computing Science Series.

[7] Introduction to Mathematical Fluid Dynamics : Richard E.Meyer, Dover Publication.

Course Structure | DSE | SEC | Credit Distribution

Point Set Topology

Semesters : 6 Discipline Specific Elective-DSE-B(2) Paper Code(Theory):MTM-A-DSE-B-6-2-TH Paper Code(Tutorial):MTM-A-DSE-B-6-2-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial ***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1

[35 classes]

- Topological spaces, basis and subbasis for a topology, neighbourhoods of a point, interior points, limit points, derived set, boundary of a set, closed sets, closure and interior of a set, dense subsets, subspace topology, finite Product topology, Continuous functions, open maps, closed maps, homeomorphisms, topological invariants, metric topology, isometry and metric invariants.

Unit-2

[15 classes]

- First countability, T_1 and T_2 separation axioms of topological spaces, convergence and cluster point of a sequence in topological spaces and some related concepts on first countable as well as on T_2 spaces. Heine's continuity criterion.

Unit-3

[25 classes]

- Connected spaces, connected sets in $\mathbb{R}$, components, Compact spaces, compactness and T_2, compact sets in $\mathbb{R}$, Heine-Borel Theorem for $\mathbb{R}^n$, real valued continuous function on connected and compact spaces, the concept of compactness in metric space, sequentially compactness of a metric space X and the Bolzano-Weiertrass property of X are equivalent.

References

[1] Munkres, J.R., Topology, A First Course, Prentice Hall of India Pvt.Ltd.,New Delhi, 2000.

[2] Dugundji, J., Topology, Allyn and Bacon, 1966.

[3] Simmons, G.F., Introduction to Topology and Modern Analysis, McGraw Hill, 1963.

[4] Kelley, J.L., General Topology, Van Nostrand Reinhold Co., New York,1995.

[5] Hocking, J., Young, G., Topology, Addison-Wesley Reading, 1961.

[6] Steen, L., Seebach, J., Counter Examples in Topology, Holt, Reinhart andWinston, New York, 1970.

Course Structure | DSE | SEC | Credit Distribution

Astronomy & Space Science

Semesters : 6 Discipline Specific Elective-DSE-B(2) Paper Code(Theory):MTM-A-DSE-B-6-2-TH Paper Code(Tutorial):MTM-A-DSE-B-6-2-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial ***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1

[25 classes]

- Celestial Sphere, various Coordinate Systems, transformation formulae among various coordinate systems, formulae of spherical triangle : cosine formula, sine formula, four parts formula , analogous cosine formula, hour angle, sidereal day, sidereal time, equation of time. Exercises.

Unit-2

[10 classes]

- Light and its properties, Optical , absorption, emission and continuous spectra, radio and Hubble Space Telescopes (HST), Photometry, Spectrometry, Spectrophotometry (definitions only), magnification, resolution, f/a ratio , refractors and reflectors. Exercises.

Unit-3

[10 classes]

- Various magnitudes of stars: apparent, absolute, photovisual, photographic, bolometric etc. Distance measurements of stars: Parallax method, Statistical Palallax Method, Moving Cluster Method. Radial and proper motion. Exercises.
- Morphological structure of Sun, solar cycles, sunspots, solar corona, solar wind, solar neutrino puzzle (Merely descriptive models). Solar system.

Unit-4

[5 classes]

- Interstellar matter, elastic collisions and kinetic equilibrium, Jeans Mass for gravitational collapse, radiative process (statement only).

Unit-5

[10 classes]

- Morphological classification of galaxies, rotation curves and mass modelling, missing mass and dark matter, distance determination by various methods. Our Galaxy. Exercises.

Unit-6

[15 classes]

- Space agencies around the world – The history of space agencies – Indian space exploration – First missions – Remarkable achievements.
- Rocket Propulsion; Rocket Equation and Staging, Optimal Rocket. Element of Aerodynamics; Aerodynamics Force and Moment, Fluid dynamics (Governing equations: Interpretations and Statements only), Flow regime, Continuum Flow, Continuum Viscous Flow and Boundary Layer, Rarefied Flow. Airbreathing Propulsion; Ideal Momentum Theory, Propeller Engine, Jet Engine.

References

[1] T. Padmanabhan, Theoretical Astrophysics, vols. 1-3, Cambridge University Press, 2002.

[2] S. Weinberg, Gravitation and Cosmology, Wiley, 2001.

[3] J.V. Narlikar, Introduction to Cosmology, Cambridge University Press, 2002.

[4] J.V. Narlikar, An Introduction to Relativity, Cambridge University Press, 2010.

[5] B.Basu, T.Chattopadhyay and S.N.Biswas, An Introduction to Astrophysics, Prentice Hall of India, 2010.

[6] Physical Processes in the Interstellar Medium, Lyman Spitzer, Jr. Wiley, 1998.

[7] Astrophysics for Physicists, Arnab Rai Choudhuri, Cambridge University Press, 2010.

[8] Extragalactic Astronomy and Cosmology: An Introduction, Peter Scineider, Springer, 2006.

[9] Textbook on Spherical Astronomy, W.M. Smart , Cambridge University Press.

[10] A Text Book on Astronomy, K.K. De, Books Syndicate (P) Ltd. 2013.

[11] Twentieth-century Space And Astronomy: A History of Notable Research And Discovery (Twentieth-Century Science): Marianne J. Dyson.

[12] International Space Olympiad: NASA.

[13] Rönnmark, Kjell Space Physics from the Sun to the Aurora.

[14] https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-522-space-propulsion-spring-2015/lecture-notes/
(Online tutorial, assignments and lecture notes).

[15] Tewari A (2007), Atmospheric and Space Flight Dynamics : Birkhäuser Basel.

[16] Schmidt L. V. (1998), Introduction to Aircraft Flight Dynamics, AIAA Education Series.

[17] Francis J, Hale (1994) Introduction to Spaceflight.

Course Structure | DSE | SEC | Credit Distribution

Advanced Mechanics

Semester : 6 Discipline Specific Elective-B(2) Paper Code(Theory):MTM-A-DSE-B-6-2-TH Paper Code(Tutorial):MTM-A-DSE-B-6-2-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Number of classes required : 75	
*1 Credit for Tutorial	
**15 Marks are reserved for Tutorial ***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1

[20 classes]

- Degrees of freedom, reactions due to constraints. D' Alembert's principle; Lagranges first kind equations; Generalized coordinates; Generalized forces; Lagrangian; Second kind Lagrange's equations of motion; cyclic coordinates; velocity dependent potential; Principle of energy; Rayleigh's dissipation function.

Unit-2

[20 classes]

- Action Integral; Hamilton's principle; Lagrange's equations by variational methods; Hamilton's principle for non-holonomic system; Symmetry properties and conservation laws; Noether's theorem. Canonically conjugate coordinates and momenta; Legendre transformation; Routhian approach; Hamiltonian.

Unit-3

[15 classes]

- Hamilton's equations from variational principle; Poincare-Cartan integral invariant; Principle of stationary action; Fermat's principle;

Unit-4

[20 classes]

- Canonical transformation; Generating function; Poisson Bracket; Equations of motion; Action-angle variables; Hamilton-Jacobi's equation; Hamilton's principal function; Hamilton's characteristics function; Liouville's theorem.

References

[1] H. Goldstein, Classical Mechanics, Narosa Publ., New Delhi, 1998.

[2] N.C. Rana and P.S. Joag, Classical Mechanics, Tata McGraw Hill, New Delhi, 2002.

[3] E.T. Whittaker, A Treatise of Analytical Dynamics of Particles and Rigid Bodies, Cambridge Univ. Press, Cambridge, 1977.

[4] F. Gantmacher, Lectures in Analytical Mechanics, Mir Publ., 1975.

[5] T.W.B. Kibble and F.H. Berkshire, Classical Mechanics, 4th ed., Addison-Wesley Longman, 1996.

[6] V.I. Arnold, Mathematical Methods of Classical Mechanics, 2nd ed., Springer-Verlag, 1997.

[7] N.G. Chetaev, Theoretical Mechanics, Springer-Verlag, 1990.

[8] M. Calkin, Lagrangian and Hamiltonian Mechanics, World Sci. Publ., Singapore, 1996.

[9] J.L. Synge and B.A. Griffith, Principles of Mechanics, McGraw Hill, Singapore, 1970.

[10] E.C.G. Sudarshan and N. Mukunda, Classical Dynamics: A Modern Perspectives, John Wiley & Sons, 1974.

[11] J.R. Taylor, Classical Mechanics, University Science Books, California, 2005.

[12] L.D. Landau and E.M. Lifshitz, Mechanics, 3rd ed., Pergamon Press, 1982.

C Programming Language

Semester : 3 Skill Enhancement Course- SEC A Paper Code (Theory) : MTM-A-SEC-A-TH	Credits : 2 Full Marks : 100 (=80+20*)
Number of contact hours required : 50 *20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

[30 classes]

- An overview of theoretical computers, history of computers, overview of architecture of computer, compiler, assembler, machine language, high level language, object oriented language, programming language and importance of C programming.
- Constants, Variables and Data type of C-Program : Character set. Constants and variables data types, expression, assignment statements, declaration.
- Operation and Expressions : Arithmetic operators, relational operators, logical operators.
- Decision Making and Branching : decision making with if statement, if-else statement, Nesting if statement, switch statement, break and continue statement.
- Control Statements : While statement, do-while statement, for statement.
- Arrays : One-dimension, two-dimension and multidimensional arrays, declaration of arrays, initialization of one and multi-dimensional arrays.
- User-defined Functions : Definition of functions, Scope of variables, return values and their types, function declaration, function call by value, Nesting of functions, passing of arrays to functions, Recurrence of function.
- Introduction to Library functions: stdio.h, math.h, string.h stdlib.h, time.h etc.
- **Some hands on examples should be included.**

References

[1] B. W. Kernighan and D. M. Ritchi : The C-Programming Language, 2nd Edi.(ANSI Refresher), Prentice Hall, 1977.

[2] E. Balagurnsamy : Programming in ANSI C, Tata McGraw Hill, 2004.

[3] Y. Kanetkar : Let Us C ; BPB Publication, 1999.

[4] C. Xavier : C-Language and Numerical Methods, New Age International.

[5] V. Rajaraman : Computer Oriented Numerical Methods, Prentice Hall of India, 1980.

Course Structure | DSE | SEC | Credit Distribution

Object Oriented Programming in C++

Semester : 3 Skill Enhancement Course - SEC A Paper Code(Theory): MTM-A-SEC-A-TH	Credits : 2 Full Marks : 100(=80+20*)
Number of contact hours required : 50 *20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1

[10 classes]

- 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.

Unit-2

[10 classes]

- 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.

Unit-3

[10 classes]

- Template class in C++, copy constructor, subscript and function call operator, concept of namespace and exception handling.
- **List of hands on examples (using C++)**
  1. Calculate the sum $\frac{1}{1} + \frac{1}{2} + \frac{1}{3} + \cdots + \frac{1}{N}$
  2. Enter 100 integers into an array and sort them in an ascending order.
  3. HCF and LCM of three positive integers.
  4. Separate even and odd numbers from first N natural numbers.
  5. Find all the prime numbers between 1 and N (N being a positive integer).
  6. Find the binary representation of a decimal number (up to 3 digits).
  7. Addition , subtraction, multiplication of two matrices (order up to 4×4).
  8. Compute the value of the determinant of a square matrix (order up to 4×4).

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.

Course Structure | DSE | SEC | Credit Distribution

Mathematical Logic

Semester : 4 Skill Enhancement Course- SEC-B Paper Code (Theory): MTM-A-SEC-B-TH	Credits : 2 Full Marks : 100 (=80+20*)
Number of classes required : 50 *20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

Unit-1

[5 classes]

- Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators.
- General Notions : Formal language, object and meta language, general definition of a Formal Theory/Formal Logic.

Unit-2

[15 classes]

- Propositional Logic : Formal theory for propositional calculus, derivation, proof, theorem, deduction theorem, conjunctive and disjunctive normal forms, semantics, truth tables, tautology, adequate set of connectives, applications to switching circuits, logical consequence, consistency, maximal consistency, Leindenbaum lemma, soundness and completeness theorems, algebraic semantics.

Unit-3

[10 classes]

- Predicate Logic : First order language, symbolizing ordinary sentences into first order formulae, free and bound variables, interpretation and satisfiability, models, logical validity, formal theory for predicate calculus, theorems and derivations, deduction theorem, equivalence theorem, replacement theorem, choice rule, Prenex normal form, soundness theorem, completeness theorem, compactness theorem, First Order Theory with equality, examples of First Order Theories (groups, rings, fields etc.).

References

[1] Elliott Mendelson; Introduction to mathematical logic; Chapman & Hall; London(1997)

[2] Angelo Margaris; First order mathematical logic; Dover publications, Inc, New York (1990).

[3] S.C.Kleene; Introduction to Metamathematics; Amsterdam; Elsevier (1952).

[4] J.H.Gallier; Logic for Computer Science; John.Wiley & Sons (1987).

[5] H.B.Enderton; A mathematical introduction to logic; Academic Press; New York (1972).

Course Structure | DSE | SEC | Credit Distribution

Scientific computing with SageMath & R

Semester : 4 Skill Enhancement Course- SEC B Paper Code (Theory): MTM-A-SEC-B-TH	Credits : 2 Full Marks : 100 (=80 + 20*)
Number of contact hours required : 50 *20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)	

Course Structure | DSE | SEC | Credit Distribution

[30 classes]

- Introduction to SageMath and R , Installation Procedure, Use of SageMath & R as a Calculator, Numerical and symbolic computations using mathematical functions such as square root, trigonometric functions, logarithms, exponentiations etc.
- Graphical representations of few functions through plotting in a given interval, like plotting of polynomial functions, trigonometric functions, Plots of functions with asymptotes, superimposing multiple graphs in one plot like plotting a curve along with a tangent on that curve (if it exists), polar plotting of curves.
- SageMath & R commands for differentiation, higher order derivatives, plotting $f(x)$ and $f'(x)$ together, integrals, definite integrals etc.
- Introduction to Programming in SageMath & R , relational and logical operators, conditional statements, loops and nested loops, without using inbuilt functions write programs for average of integers, mean, median, mode, factorial, checking primes, checking next primes, finding all primes in an interval, finding gcd, lcm, finding convergence of a given sequence, etc.
- Use of inbuilt functions that deal with matrices, determinant, inverse of a given real square matrix (if it exists), solving a system of linear equations, finding roots of a given polynomial, solving differential equations.
- **Some hands on examples should be included.**

  Note : The goal of this course is to introduce students to the fundamental commands and structure of SageMath & R The course covers the basic syntax and semantics of SageMath & R , including basic data types, variables, control structures and functions or similar concepts, and visualization of results and processed data.

References

[1] An Introduction to R: W. N. Venables, D. M. Smith and the R Core Team (available online).

[2] https://www.datacamp.com/courses/free-introduction-to-r
(Online tutorial on R)

[3] https://www.datacamp.com/community/open-courses/kaggle-r-tutorial-on-machine-learning (Online PDF tutorial)

[4] http://data.princeton.edu/R/introducingR.pdf (Online PDF: Princeton University)

[5] M. Crawley, Basic Statistics: An Introduction using R

[6] P. Dalgaard, Introductory Statistics with R

[7] B.S. Everitt T. Hothorn, A Handbook of Statistical Analyses Using R (2nd ed.) **

[8] J.J. Faraway, Linear Models with R

[9] J.J. Faraway, Extending the Linear Model with R: Generalized Linear, Mixed Effects and Nonparametric Regression Models

[10] J. Maindonald J. Braun, Data Analysis and Graphics Using R: An Example-based Approach

[11] An Introduction to SAGE Programming : With Applications to SAGE, Razvan A. Mezei, Wiley,

[12] http://doc.sagemath.org/pdf/en/tutorial/SageTutorial.pdf

Course Structure | DSE | SEC | Credit Distribution

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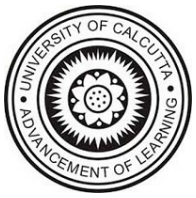
University of Calcutta

Syllabus for three-year B.Sc. in Mathematics

(General)

Under

CBCS System



2018

1. Credit Distribution across Courses

Course Type	Total Papers	Credits		
		Theory + Tutorial	Theory + Practical	Total
Core Courses	4 (Mathematics)	$4 \times 5 + 4 \times 1 = 24$	—	72
	8 (Other disciplines)	To be decided	To be decided	
Discipline Specific Electives	2 (Mathematics)	$2 \times 5 + 2 \times 1 = 12$	—	36
	4 (Other disciplines)	To be decided	To be decided	
Ability Enhancement Language Courses	2	$2 \times 2 = 4$	—	4
Skill Enhancement Courses	4 (at least one from each discipline)	$4 \times 2 = 8$	—	8
Totals	24			120

2. Course Structure : Semester-wise distribution of Courses

Semester	Course Name	Course Detail	Credits	Page No.
1	Ability Enhancement Compulsory Course-I	AECC(1)	2	
	Core Course-1A	Mathematics-CC1/GE1	6	4
	Core Course-2A	Other Discipline	6	
	Core Course-3A	Other Discipline	6	
		Total	**20**	
2	Ability Enhancement Compulsory Course-2	AECC(2)	2	
	Core Course-1B	Mathematics- CC2/GE2	6	7
	Core Course-2B	Other Discipline	6	
	Core Course-3B	Other Discipline	6	
		Total	**20**	
3	Core Course-1C	Mathematics- CC3/GE3	6	9
	Core Course-2C	Other Discipline	6	
	Core Course-3C	Other Discipline	6	
	Skill Enhancement Course-1	For Mathematics Course see SEC-A *	2	3
		Total	**20**	
4	Core Course-1D	Mathematics- CC4/GE4	6	11
	Core Course-2D	Other Discipline	6	
	Core Course-3D	Other Discipline	6	
	Skill Enhancement Course-2	For Mathematics Course see SEC-B *	2	3
		Total	**20**	
5	Skill Enhancement Course-3	For Mathematics Course see SEC-A *	2	3
	Discipline Specific Elective-1A	Mathematics-5 (See DSE-A)	6	3
	Discipline Specific Elective-2A	Other Discipline	6	
	Discipline Specific Elective-3A	Other Discipline	6	
		Total	**20**	
6	Skill Enhancement Course-4	For Mathematics Course see SEC-B *	2	3
	Discipline Specific Elective-1B	Mathematics-6 (See DSE-B)	6	??
	Discipline Specific Elective-2B	Other Discipline	6	
	Discipline Specific Elective-3B	Other Discipline	6	
		Total	**20**	
		Grand Total	**120**	

* A student has to opt for 4 Skill Enhancement Courses in four Semesters (3rd to 6th) taking **at least one Course from each discipline.**

Course Structure | Credit Distribution | DSE | SEC

3. Choices for Skill Enhancement Courses in Mathematics (SEC)

	Course Detail
Skill Enhancement Course (Semester 3)-SEC A	C Programming Language [13]
Skill Enhancement Course (Semester 4)-SEC B	Mathematical Logic [14]
Skill Enhancement Course (Semester 5) -SEC A	Object Oriented Programming in C++ [15]
Skill Enhancement Course (Semester 6)-SEC B	Boolean Algebra [16]

The number within the bracket [ ] refers to page number.

Course Structure | Credit Distribution | DSE

4. Choices for Discipline Specific Electives
. DSE-A & B (Mathematics)

DSE-A: (Semesters 5/6)	**DSE-B: (Semesters 5/6)**
Particle Dynamics [17]	Advanced Calculus [19]
Graph Theory [18]	Mathematical Finance [20]

The number within the bracket [ ] refers to page number. A student has to opt for at least one of the subjects available under each category.

Course Structure | Credit Distribution | SEC

Mathematics - CC1/GE1

Semester : 1 Core Course-CC1/GE1 Paper Code (Theoretical) : MTM-G-CC-1-1-TH / MTM-G-GE-1-1-TH Paper Code (Tutorial):MTM-G-CC-1-1-TU / MTM-G-GE-1-1-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Minimum number of classes required : 60	
*1 Credit for Tutorial	
**15 Mark is reserved for Tutorial ***20 Mark is reserved for Internal Assessment & Attendance of 10 mark each	

Course Structure | SEC | DSE | Credit Distribution

Unit-1 : Algebra-I (15 Marks) [10 classes]

- Complex Numbers : De Moivre's Theorem and its applications. Exponential, Sine, Cosine and Logarithm of a complex number. Definition of a^z $(a \neq 0)$. Inverse circular and Hyperbolic functions.
- Polynomials : Fundamental Theorem of Algebra (Statement only). Polynomials with real coefficients, the n-th degree polynomial equation has exactly n roots. Nature of roots of an equation (surd or complex roots occur in pairs). Statement of Descarte's rule of signs and its applications.
- Statements of : (i) If a polynomial $f(x)$ has opposite signs for two real values a and b of x, the equation $f(x) = 0$ has odd number of real roots between a and b. If $f(a)$ and $f(b)$ are of same sign, either no real root or an even number of roots lies between a and b.

  (ii) Rolle's Theorem and its direct applications. Relation between roots and coefficients, symmetric functions of roots, transformations of equations. Cardan's method of solution of a cubic equation.
- Rank of a matrix : Determination of rank either by considering minors or by sweep-out process. Consistency and solution of a system of linear equations with not more than 3 variables by matrix method.

Unit-2 : Differential Calculus-I (25 Marks) [20 classes]

- Rational numbers, Geometrical representations, Irrational number, Real number represented as point on a line — Linear Continuum. Acquaintance with basic properties of real number (No deduction or proof is included).
- Real-valued functions defined on an interval, limit of a function (Cauchy's definition). Algebra of limits. Continuity of a function at a point and in an interval. Acquaintance (on proof) with the important properties of continuous functions no closed intervals. Statement of existence of inverse function of a strictly monotone function and its continuity.
- Derivative - its geometrical and physical interpretation. Sign of derivative-Monotonic increasing and decreasing functions. Relation between continuity and derivability. Differential - application in finding approximation.
- Successive derivative - Leibnitz's theorem and its application.
- Functions of two and three variables : their geometrical representations. Limit and Continuity (definitions only) for function of two variables. Partial derivatives. Knowledge and use of chain Rule. Exact differentials (emphasis on solving problems only). Functions of two variables - Successive partial Derivatives : Statement of Schwarz's Theorem on Commutative property of mixed derivatives. Euler's Theorem on homogeneous function of two and three variables.

- Applications of Differential Calculus : Curvature of plane curves. Rectilinear Asymptotes (Cartesian only). Envelope of family of straight lines and of curves (problems only). Definitions and examples of singular points (Viz. Node. Cusp, Isolated point).

Unit-3 : Differential Equation-I (15 Marks) [10 classes]

- Order, degree and solution of an ordinary differential equation (ODE) in presence of arbitrary constants, Formation of ODE.
- First order equations : (i) Exact equations and those reducible to such equation. (ii) Euler's and Bernoulli's equations (Linear). (iii) Clairaut's Equations : General and Singular solutions.
- Second order linear equations : Second order linear differential equation with constant coefficients. Euler's Homogeneous equations.
- Second order differential equation : (i) Method of variation of parameters, (ii) Method of undetermined coefficients.

Unit-4 : Coordinate Geometry (25 Marks) [20 classes]

- Transformations of Rectangular axes : Translation, Rotation and their combinations. Invariants.
- General equation of second degree in x and y : Reduction to canonical forms. Classification of conic.
- Pair of straight lines : Condition that the general equation of 2nd degree in x and y may represent two straight lines. Point of intersection of two intersecting straight lines. Angle between two lines given by $ax^2 + 2hxy + by^2 = 0$. Equation of bisectors. Equation of two lines joining the origin to the points in which a line meets a conic.
- Equations of pair of tangents from an external point, chord of contact, poles and polars in case of General conic : Particular cases for Parabola, Ellipse, Circle, Hyperbola.
- Polar equation of straight lines and circles. Polar equation of a conic referred to a focus as pole. Equation of chord joining two points. Equations of tangent and normal.
- Sphere and its tangent plane. Right circular cone.

Course Structure | SEC | DSE | Credit Distribution

Mathematics - CC2/GE2

Semester : 2 Core Course-CC2/GE2 Paper Code (Theoretical) : MTM-G-CC-2-2-TH / MTM-G-GE-2-2-TH Paper Code (Tutorial):MTM-G-CC-2-2-TU / MTM-G-GE-2-2-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Minimum number of classes required : 60	
*1 Credit for Tutorial	
**15 Mark is reserved for Tutorial ***20 Mark is reserved for Internal Assessment & Attendance of 10 mark each	

Course Structure | SEC | DSE | Credit Distribution

Unit-1 : Differential Calculus-II (20 Marks) [15 classes]

- Sequence of real numbers : Definition of bounds of a sequence and monotone sequence. Limit of a sequence. Statements of limit theorems. Concept of convergence and divergence of monotone sequences-applications of the theorems, in particular, definition of e. Statement of Cauchy's general principle of convergence and its application.
- Infinite series of constant terms; Convergence and Divergence (definitions). Cauchy's principle as applied to infinite series (application only). Series of positive terms : Statements of comparison test. D.AIembert's Ratio test. Cauchy's nth root test and Raabe's test Applications. Alternating series. Statement of Leibnitz test and its applications.
- Real-Valued functions defined on an interval: Statement of Rolle's Theorem and its geometrical interpretation. Mean value theorems of Lagrange and Cauchy. Statements of Taylor's and Maclaurin's Theorems with Lagrange's and Cauchy's from of remainders. Taylor's and Maclaurin's Infinite series of functions like $e^x, \sin x, \cos x, (1+x)^n, \log(1+x)$ with restrictions wherever necessary.
- Indeterminate Forms : L'Hospital's Rule : Statement and Problems only.
- Application of the principle of Maxima and Minima for a function of single variable in geometrical, physical and to other problems.
- Maxima and minima of functions of not more than three variables Lagrange's Method of undetermined multiplier - Problems only.

Unit-2 : Differential Equation-II (15 Marks) [10 classes]

- Linear homogeneous equations with constant coefficients, Linear non-homogeneous equations, The method of variation of parameters, The Cauchy-Euler equation, Simultaneous differential equations, Simple eigenvalue problem.
- Order and degree of partial differential equations, Concept of linear and non-linear partial differential equations, Formation of first order partial differential equations, Linear partial differential equation of first order, Lagrange's method, Charpit's method.

Unit-3 : Vector Algebra (15 Marks) [10 classes]

- Addition of Vectors, Multiplication of a Vector by a Scalar. Collinear and Coplanar Vectors. Scalar and Vector products of two and three vectors. Simple applications to problems of Geometry. Vector equation of plane and straight line. Volume of Tetrahedron. Applications to problems of Mechanics (Work done and Moment).

Unit-4 : Discrete Mathematics (30 Marks) [25 classes]

- Integers : Principle of Mathematical Induction. Division algorithm. Representation of integer in an arbitrary base. Prime Integers. Some properties of prime integers. Fundamental theorem of Arithmetic. Euclid's Theorem. Linear Diophantine equations. [Statement of Principle of Mathematical Induction, Strong form of Mathematical induction. Applications in different problems. Proofs of division algorithm. Representation of an integer uniquely in an arbitrary base, change of an integer from one base to another base. Computer operations with integers â“ Divisor of an integer, g.c.d. of two positive integers, prime integer, Proof of Fundamental theorem, Proof of Euclid's Theorem. To show how to find all prime numbers less than or equal to a given positive integer. Problems related to prime number. Linear Diophantine equation â“ when such an equation has solution, some applications.]
- Congruences : Congruence relation on integers, Basic properties of this relation. Linear congruences, Chinese Remainder Theorem. System of Linear congruences. [Definition of Congruence â“ to show it is an equivalence relation, to prove the following : $a \equiv b$ (mod m) implies
(i) $(a + c) \equiv (b + c)$ (mod m)
(ii) $ac \equiv bc$ (mod m)
(iii) $a^n \equiv b^n$ (mod m), for any polynomial $f(x)$ with integral coefficients $f(a) \equiv f(b)$ (mod m) etc. Linear Congruence, to show how to solve these congruences, Chinese remainder theorem â“ Statement and proof and some applications. System of linear congruences, when solution exists â“ some applications.]
- Application of Congruences : Divisibility tests. Check-digit and an ISBN, in Universal product Code, in major credit cards. Error detecting capability. [Using Congruence, develop divisibility tests for integers based on their expansions with respect to different bases, if d divides $(b - 1)$ then $n = (a_k a_{k-1} a_1 b)$ is divisible by d if and only if the sum of the digits is divisible by d etc. Show that congruence can be used to schedule Round-Robin tournaments. Check digits for different identification numbers â“ International standard book number, universal product code etc. Theorem regarding error detecting capability.]
- Congruence Classes : Congruence classes, addition and multiplication of congruence classes. Fermat's little theorem. Euler's theorem. Wilson's theorem. Some simple applications. [Definition of Congruence Classes, properties of Congruence classes, addition and multiplication, existence of inverse. Fermat's little theorem. Euler's theorem. Wilson's theorem - Statement, proof and some applications.]
- Boolean algebra : Boolean Algebra, Boolean functions, Logic gates, Minimization of circuits.

Course Structure | SEC | DSE | Credit Distribution

Mathematics - CC3/GE3

Semester : 3 Core Course-CC3/GE3 Paper Code (Theoretical) : MTM-G-CC-3-3-TH / MTM-G-GE-3-3-TH Paper Code (Tutorial):MTM-G-CC-3-3-TU / MTM-G-GE-3-3-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Minimum number of classes required : 60	
*1 Credit for Tutorial	
**15 Mark is reserved for Tutorial ***20 Mark is reserved for Internal Assessment & Attendance of 10 mark each	

Course Structure | SEC | DSE | Credit Distribution

Unit-1 : Integral Calculus (20 Marks) [10 classes]

- Evaluation of definite integrals.
- Integration as the limit of a sum (with equally spaced as well as unequal intervals).
- Reduction formulae of $\int \sin^n x \cos^m x dx$, $\int \frac{\sin^m x}{\cos^n x} dx$, $\int \tan^n x dx$ and associated problems (m and n are non-negative integers).
- Definition of Improper Integrals : Statements of (i) μ-test (ii) Comparison test (Limit from excluded) - Simple problems only. Use of Beta and Gamma functions (convergence and important relations being assumed).
- Working knowledge of double integral.
- Applications : Rectification, Quadrature, volume and surface areas of solids formed by revolution of plane curve and areas problems only.

Unit-2 : Numerical Methods (30 Marks) [25 classes]

- Approximate numbers, Significant figures, Rounding off numbers. Error : Absolute, Relative and percentage.
- Operators - Δ, ∇ and E (Definitions and some relations among them).
- Interpolation : The problem of interpolation Equispaced arguments Difference Tables, Deduction of Newton's Forward Interpolation Formula, remainder term (expression only). Newton's Backward interpolation Formula (Statement only) with remainder term. Unequally- spaced arguments Lagrange's Interpolation Formula (Statement only). Numerical problems on Interpolation with both equally and unequally spaced arguments.
- Numerical Integration : Trapezoidal and Simpson's $\frac{1}{3}$-rd formula (statement only). Problems on Numerical Integration.
- Solution of Numerical Equation : To find a real root of an algebraic or transcendental equation. Location of root (tabular method), Bisection method, Newton-Raphson method with geometrical significance, Numerical Problems. (Note : Emphasis should be given on problems)

Unit-3 : Linear Programming (30 Marks) [25 classes]

- Motivation of Linear Programming problem. Statement of L.P.P. Formulation of L.P.P. Slack and Surplus variables. L.P.P. is matrix form. Convex set, Hyperplane, Extreme points, convex Polyhedron, Basic solutions and Basic Feasible Solutions (B.F.S.). Degenerate and Non-degenerate B.F.S.
- The set of all feasible solutions of an L.P.P. is a convex set. The objective function of an L.P.P. assumes its optimal value at an extreme print of the convex set of feasible solutions, A.B.F.S. to an L.P.P. corresponds to an extreme point of the convex set of feasible solutions.
- Fundamental Theorem of L.P.P. (Statement only) Reduction of a feasible solution to a B.F.S. Standard form of an L.P.P. Solution by graphical method (for two variables), by simplex method and method of penalty. Concept of Duality. Duality Theory. The dual of the dual is the primal. Relation between the objective values of dual and the primal problems. Dual problems with at most one unrestricted variable, one constraint of equality. Transportation and Assignment problem and their optimal solutions.

Course Structure | SEC | DSE | Credit Distribution

Mathematics - CC4/GE4

Semester : 4 Core Course-CC4/GE4 Paper Code (Theoretical) : MTM-G-CC-4-4-TH / MTM-G-GE-4-4-TH Paper Code (Tutorial):MTM-G-CC-4-4-TU / MTM-G-GE-4-4-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Minimum number of classes required : 60	
*1 Credit for Tutorial	
**15 Mark is reserved for Tutorial ***20 Mark is reserved for Internal Assessment & Attendance of 10 mark each	

Course Structure | SEC | DSE | Credit Distribution

Unit-1 : Algebra-II (20 Marks) [10 classes]

- Introduction of Group Theory : Definition and examples taken from various branches (example from number system, roots of Unity, 2×2 real matrices, non singular real matrices of a fixed order). Elementary properties using definition of Group. Definition and examples of sub- group - Statement of necessary and sufficient condition and its applications.
- Definitions and examples of (i) Ring, (ii) Field, (iii) Sub-ring, (iv) Sub- field.
- Concept of Vector space over a Field : Examples, Concepts of Linear combinations, Linear dependence and independence of a finite number of vectors, Sub- space, Concepts of generators and basis of a finite-dimensional vector space. Problems on formation of basis of a vector space (No proof required).
- Real Quadratic Form involving not more than three variables (problems only).
- Characteristic equation of square matrix of order not more than three determination of Eigen Values and Eigen Vectors (problems only). Statement and illustration of Cayley-Hamilton Theorem.

Unit-2 : Computer Science & Programming (30 Marks) [25 classes]

- Computer Science and Programming : Historical Development, Computer Generation, Computer Anatomy Different Components of a computer system. Operating System, hardware and Software.
- Positional Number System. Binary to Decimal and Decimal to Binary. Other systems. Binary Arithmetic. Octal, Hexadecimal, etc. Storing of data in a Computer - BIT, BYTE, WORD etc. Coding of a data- ASCII, etc.
- Programming Language : Machine language, Assembly language and High level language, Compiler and interpreter. Object Programme and source Programme. Ideas about some HLL– e.g. BASIC, FORTRAN, C, C++, COBOL, PASCAL, etc.
- Algorithms and Flow Charts– their utilities and important features, Ideas about the complexities of an algorithm. Application in simple problems. FORTRAN 77/90: Introduction, Data Type– Keywords, Constants and Variables - Integer, Real, Complex, Logical, character, subscripted variables, Fortran Expressions.

Unit-3 : Probability & Statistics (30 Marks) [25 classes]

- Elements of probability Theory : Random experiment, Outcome, Event, Mutually Exclusive Events, Equally likely and Exhaustive. Classical definition of probability, Theorems of Total Probability, Conditional probability and Statistical Independence. Baye's Theorem. Problems, Shortcoming of the classical definition. Axiomatic approach problems, Random Variable and its Expectation, Theorems on mathematical expectation. Joint distribution of two random variables.

- Theoretical Probability Distribution Discrete and Continuous (p.m.f., p.d.f.) Binomial, Poisson and Normal distributions and their properties.
- Elements of Statistical Methods. Variables, Attributes. Primary data and secondary data, Population and sample. Census and Sample Survey. Tabulation Chart and Diagram, Graph, Bar diagram, Pie diagram etc. Frequency Distribution Un-grouped and grouped cumulative frequency distribution. Histogram, Frequency curve, Measures of Central tendencies. Averages : AM,; GM, HM, Mean, Median and Mode (their advantages and disadvantages). Measures of Dispersions - Range, Quartile Deviation, Mean Deviation, Variance / S.D., Moments, Skewness and Kurtosis.
- Sampling Theory : Meaning and objects of sampling. Some ideas about the methods of selecting samples, Statistic and parameter, Sampling Proportion. Four fundamental distributions, derived from the normal: (i) standard Normal Distribution, (ii) Chi-square distribution (iii) Student's distribution (iv) Snedecor's F-distribution. Estimation and Test of Significance. Statistical Inference. Theory of estimation Point estimation and Interval estimation. Confidence Interval / Confidence Limit. Statistical Hypothesis - Null Hypothesis and Alternative Hypothesis. Level of significance. Critical Region. Type I and II error. Problems.
- Bivariate Frequency Distribution. Scatter Diagram, Co-relation co-efficient Definition and properties. Regression lines.

Course Structure | SEC | DSE | Credit Distribution

C Programming Language

Semester : 3 Skill Enhancement Course- SEC A Paper Code (Theory) : MTM-G-SEC-A-TH	Credits : 2 Full Marks : 100 (= 80 + 20*)
Minimum number of classes required : 30 *20 Mark is reserved for Internal Assessment & Attendance of 10 mark each	

Course Structure | DSE | SEC | Credit Distribution

Unit-1

[30 classes]

- An overview of theoretical computers, history of computers, overview of architecture of computer, compiler, assembler, machine language, high level language, object oriented language, programming language and importance of C programming.
- Constants, Variables and Data type of C-Program : Character set. Constants and variables data types, expression, assignment statements, declaration.
- Operation and Expressions : Arithmetic operators, relational operators, logical operators.
- Decision Making and Branching : decision making with if statement, if-else statement, Nesting if statement, switch statement, break and continue statement.
- Control Statements : While statement, do-while statement, for statement.
- Arrays : One-dimension, two-dimension and multidimensional arrays, declaration of arrays, initialization of one and multi-dimensional arrays.
- User-defined Functions : Definition of functions, Scope of variables, return values and their types, function declaration, function call by value, Nesting of functions, passing of arrays to functions, Recurrence of function.
- Introduction to Library functions: stdio.h, math.h, string.h stdlib.h, time.h etc.

References

[1] B. W. Kernighan and D. M. Ritchi : The C-Programming Language, 2nd Edi.(ANSI Refresher), Prentice Hall, 1977.

[2] E. Balagurnsamy : Programming in ANSI C, Tata McGraw Hill, 2004.

[3] Y. Kanetkar : Let Us C ; BPB Publication, 1999.

[4] C. Xavier : C-Language and Numerical Methods, New Age International.

[5] V. Rajaraman : Computer Oriented Numerical Methods, Prentice Hall of India, 1980.

Course Structure | DSE | SEC | Credit Distribution

Mathematical Logic

Semester : 4 Skill Enhancement Course-SEC B Paper Code (Theory) :MTM-G-SEC-B-TH	Credits : 2 Full Marks : 100 (=80+20*)
Minimum number of classes required : 30 *20 Mark is reserved for Internal Assessment & Attendance of 10 mark each	

Course Structure | DSE | SEC | Credit Distribution

Unit-1

[5 classes]

- Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators.
- General Notions : Formal language, object and meta language, general definition of a Formal Theory/Formal Logic.

Unit-2

[15 classes]

- Propositional Logic : Formal theory for propositional calculus, derivation, proof, theorem, deduction theorem, conjunctive and disjunctive normal forms, semantics, truth tables, tautology, adequate set of connectives, applications to switching circuits, logical consequence, consistency, maximal consistency, Leindenbaum lemma, soundness and completeness theorems, algebraic semantics.

Unit-3

[10 classes]

- Predicate Logic : First order language, symbolizing ordinary sentences into first order formulae, free and bound variables, interpretation and satisfiability, models, logical validity, formal theory for predicate calculus, theorems and derivations, deduction theorem, equivalence theorem, replacement theorem, choice rule, Prenex normal form, soundness theorem, completeness theorem, compactness theorem, First Order Theory with equality, examples of First Order Theories (groups, rings, fields etc.).

References

[1] Elliott Mendelson; Introduction to mathematical logic; Chapman & Hall; London(1997)

[2] Angelo Margaris; First order mathematical logic; Dover publications, Inc, New York (1990).

[3] S.C.Kleene; Introduction to Metamathematics; Amsterdam; Elsevier (1952).

[4] J.H.Gallier; Logic for Computer Science; John.Wiley & Sons (1987).

[5] H.B.Enderton; A mathematical introduction to logic; Academic Press; New York (1972).

Course Structure | DSE | SEC | Credit Distribution

Object Oriented Programming in C++

Semester : 5 Skill Enhancement Course-SEC A Paper Code (Theory): MTM-G-SEC-A-TH	Credits : 2 Full Marks : 100 (=80 +20*)
Minimum number of classes required : 30 *20 Mark is reserved for Internal Assessment & Attendance of 10 mark each	

Course Structure | DSE | SEC | Credit Distribution

Unit-1

[10 classes]

- 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.

Unit-2

[10 classes]

- 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.

Unit-3

[10 classes]

- Template class in C++, copy constructor, subscript and function call operator, concept of namespace and exception handling.

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.

Course Structure | DSE | SEC | Credit Distribution

Boolean Algebra

Semester : 6 Skill Enhancement Course- SEC B Paper Code (Theory) : MTM-G-SEC-B-TH	Credits : 2 Full Marks : 100 (= 80+20*)
Minimum number of classes required : 30 *20 Mark is reserved for Internal Assessment & Attendance of 10 mark each	

Course Structure | DSE | SEC | Credit Distribution

[30 classes]

- Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle, maximal and minimal elements, lattices as ordered sets, complete lattices, lattices as algebraic structures, sublattices, products and homomorphisms. 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 minimization of switching circuits using Boolean algebra.

References

[1] B A. Davey and H. A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge, 1990.

[2] Rudolf Lidl and Günter Pilz, Applied Abstract Algebra, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.

Course Structure | DSE | SEC | Credit Distribution

Particle Dynamics

Semesters : 5/6 Discipline Specific Elective-DSE-A Paper Code (Theory): MTM-G-DSE-A-TH Paper Code (Tutorial)MTM-G-DSE-A-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Minimum number of classes required : 60	
*1 Credit for Tutorial	
**15 Mark is reserved for Tutorial ***20 Mark is reserved for Internal Assessment & Attendance of 10 mark each	

Course Structure | DSE | SEC | Credit Distribution

[60 classes]

- Velocity and Acceleration of a particle. Expressions for velocity and acceleration in rectangular Cartesian and polar co-ordinates for a particle moving in a plane. Tangential and normal components of velocity and acceleration of a particle moving along a plane curve.
- Concept of Force : Statement and explanation of Newton's laws of motion. Work, power and energy. Principles of conservation of energy and momentum. Motion under impulsive forces. Equations of motion of a particle (i) moving in a straight line, (ii) moving in a plane.
- Study of motion of a particle in a straight line under (i) constant forces, (ii) variable forces (S.H.M., Inverse square law, Damped oscillation, Forced and Damped oscillation, Motion in an elastic string). Equation of Energy. Conservative forces.
- Motion in two dimensions : Projectiles in vacuum and in a medium with resistance varying linearly as velocity. Motion under forces varying as distance from a fixed point.
- Central orbit. Kepler's laws of motion. Motion under inverse square law.

References

[1] Loney, S. L., An Elementary Treatise on the Dynamics of particle and of Rigid Bodies, Loney Press.

[2] A.S. Ramsey; Dynamics, Part-II; ELBS.

Course Structure | DSE | SEC | Credit Distribution

Graph Theory

Semesters : 5/6 Discipline Specific Elective-DSE-A Paper Code (Theory): MTM-G-DSE-A-TH Paper Code (Tutorial):MTM-G-DSE-A-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Minimum number of classes required : 60	
*1 Credit for Tutorial	
**15 Mark is reserved for Tutorial ***20 Mark is reserved for Internal Assessment & Attendance of 10 mark each	

Course Structure | DSE | SEC | Credit Distribution

Unit-1

[60 classes]

- Definition, examples and basic properties of graphs, pseudographs, complete graphs, bi-partite graphs, isomorphism of graphs
- Paths and circuits, Eulerian circuits, Hamiltonian cycles, the adjacency matrix, weighted graph, travelling salesman's problem, shortest path, Dijkstra's algorithm, Floyd-Warshall algorithm.
- Definition of Trees and their elementary properties. Definition of Planar graphs, Kuratowski's graphs.

References

[1] Robin J. Wilson; Introduction to Graph Theory; 4th edition, Pearson, 2007.

[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.

Course Structure | DSE | SEC | Credit Distribution

Advanced Calculus

Semesters : 5/6 Discipline Specific Elective: DSE-B Paper Code (Theory): MTM-G-DSE-B-TH Paper Code (Tutorial)MTM-G-DSE-B-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Minimum number of classes required : 60	
*1 Credit for Tutorial	
**15 Mark is reserved for Tutorial ***20 Mark is reserved for Internal Assessment & Attendance of 10 mark each	

Course Structure | DSE | SEC | Credit Distribution

[60 classes]

- Concept of Point-wise and Uniform convergence of sequence of functions and series of functions with special reference of Power Series. Statement of Weierstrass M-Test for Uniform convergence of sequence of functions and of series of functions. Simple applications. Statement of important properties like boundedness, continuity, differentiability and integrability of the limit function of uniformly convergent sequence of functions and of the sum function of uniformly convergent series of functions. Determination of Radius of convergence of Power Series. Statement of properties of continuity of sum function power series. Term by term integration and Term by term differentiation of Power Series. Statements of Abel's Theorems on Power Series. Convergence of Power Series. Expansions of elementary functions such as $e^x, \sin x, \log(1+x), (1+x)^n$. Simple problems.
- Periodic Fourier series on $(-\pi, \pi)$: Periodic function. Determination of Fourier coefficients. Statement of Dirichlet's conditions of convergence and statement of the theorem on convergence of Fourier Sine and Cosine series.
- Laplace Transform and its application to ordinary differential equation. Laplace Transform and Inverse Laplace Transform. Statement of Existence theorem. Elementary properties of Laplace Transform and its Inverse. Application to the solution of ordinary differential equation of second order with constant coefficients.

References

[1] David Widder; Advance Calculus; Prentice Hall.

[2] Angus E. Taylor and W. Robert Mann; Advanced Calculus (3rd Edition); John Wiley & Sons, Inc.

[3] Robert C. Wrede and Murray Spiegel; Advanced Calculus, (Schaum's outline series); McGraw - Hill.

Course Structure | DSE | SEC | Credit Distribution

Mathematical Finance

Semesters : 5/6 Discipline Specific Elective: DSE-B Paper Code (Theory): MTM-G-DSE-B-TH Paper Code (Tutorial)MTM-G-DSE-B-TU	Credits : 5+1*=6 Full Marks : 65+15**+20***=100
Minimum number of classes required : 60	
*1 Credit for Tutorial	
**15 Mark is reserved for Tutorial ***20 Mark is reserved for Internal Assessment & Attendance of 10 mark each	

Course Structure | DSE | SEC | Credit Distribution

Unit-1

[60 classes]

- Basic principles: Comparison, arbitrage and risk aversion, Interest (simple and compound, discrete and continuous), time value of money, inflation, net present value, internal rate of return (calculation by bisection and Newton-Raphson methods)
- Comparison of NPV and IRR. Bonds, bond prices and yields. Floating-rate bonds, immunization. Asset return, short selling, portfolio return, (brief introduction to expectation, variance, covariance and correlation), random returns, portfolio mean return and variance, diversification, portfolio diagram, feasible set, Markowitz model (review of Lagrange multipliers for 1 and 2 constraints).

References

[1] David G. Luenberger; Investment Science; Oxford University Press, Delhi, 1998.

[2] John C. Hull; Options, Futures and Other Derivatives, 6th Ed.; Prentice-Hall India, Indian reprint, 2006.

[3] Sheldon Ross; An Elementary Introduction to Mathematical Finance, 2nd Ed.; Cambridge University Press, USA, 2003.

Course Structure | DSE | SEC | Credit Distribution

UNIVERSITY OF CALCUTTA

NotificationNo.CSR/13/2023

It is notified for information of all concerned that in terms of the provisions of Section 54 of the Calcutta University Act, 1979, (as amended), and, in exercise of his powers under 9(6) of the said Act, the Vice-Chancellor has, by an order dated 11.07.2023 approved the Syllabi of the under mentioned subjects for semester wise Four-year (Honours & Honours with Research) / Three-year (Multidisciplinary) programme of U.G. courses of studies, as applicable under CCF,2022 . under this University, as laid down in the accompanying pamphlet.

Name of Subject:

1.Anthropology
2.BBA
3.Bengali
4.BFAD
5.Bio Chemistry
6.Botany
7.Chemistry
8.Commerce
9.Economics
10.Education
11.English
12.Geology
13.Hindi
14.History,Islamic History & Culture
15.Home Science
16.Human Rights
17.Journalism & Mass Communication
18.Mathematics
19.Microbiology (Honours)
20.Molecular Biology
21.Philosophy
22.Physiology
23.Political Science
24.Psychology
25.Social Science
26.Sociology
27.Urdu
28.Women's Studies
29.Zoology

The above shall be effective from the academic session 2023-2024.

12/7/2023

SENATE HOUSE

KOLKATA-700 073

Prof.(Dr.) Debasis Das

Registrar

SYLLABUS
FOR
FOUR -YEAR (EIGHT-SEMESTER) B.SC. DEGREE COURSE IN MATHEMATICS
UNDER THE UNIVERSITY OF CALCUTTA

Odd Semester: July to December

Even Semester: January to June

Syllabus for the 4 Year B.Sc. course in Mathematics effective from the academic year **2023-2024.**

COURSE STRUCTURE-CCF

	DSC/ Core	Minor (m1 & m2)	IDC/MDC	AEC	SEC	CVAC	Summer Internship	Dissertation/ Research work	Total Credit
Semester	22x4= 88	8x4= 32	3x3= 9	4x2= 8	3x4= 12	4x2= 8	1x3= 3	(1x4= 4)+(1x8= 8)= 12	172
1	1x4= 4 3TH+1P/TU	1x4= 4 (m1) 3TH+1P/TU	1x3= 3 2TH +1P/TU	1x2= 2 2TH +0P/TU	1x4= 4	2x2= 4			21
2	1x4= 4 3TH+1P/TU	1x4= 4 (m1) 3TH+1P/TU	1x3= 3 2TH +1P/TU	1x2= 2 2TH +0P/TU	1x4= 4	2x2= 4			21
3	2x4= 8 2x(3TH+1P/TU)	1x4= 4 (m2) 3TH+1P/TU	1x3= 3 2TH +1P/TU	1x2= 2 2TH +0P/TU	1x4= 4				21
4	4x4= 16 4x(3TH+1P/TU)	1x4= 4 (m2) 3TH+1P/TU		1x2= 2 2TH +0P/TU					22
5	4x4= 16 4x(3TH+1P/TU)	m1+m2 2x4= 8 2x(3TH+1P/TU)							24
6	3x4= 12 3x(3TH+1P/TU)	2x4= 8 m1+m2 2x(3TH+1P/TU)					1x3		23
7	4x4= 16 4x(3TH+1P/TU)							1x4*	20
8	3x4= 12 3x(3TH+1P/TU)							1x8 *	20
Credits	22x4= 88	8x4= 32	3x3= 9	4x2= 8	3x4= 12	4x2= 8	1x3=3	(1x4)+(1X8)= 12	172
Marks	22x100=2200	8x100=800	3x75=225	4x50=200	3x100=300	4x50=200	1x75=75	1x100+1x200=300	Total Marks =4300

Marks= 25 marks per credit. Credit for Summer Internship has been adjusted from 4 to 3 to adjust the total marks

*Candidates who will not pursue Dissertation/ Research work then he/she will have to study additional 1 DSC/Core paper o f 4 credits in the 7th Semester & 2 DSC/ Core Papers of 4 Credits each in the 8th Semester.

Note: Tutorial marks will be awarded based on internal assessment– byevaluation of internal assignments for SEC papers and by internal examination for Core, Minor, IDC papers.

NAMES OF DSCC/ MAJOR PAPERS (Each carries 4 credits or 100 marks)

SEMESTER	COURSE CODE	COURSE NAME
I	MATh-H-CC1-1-Th	Calculus, Geometry & Vector Analysis
II	MATH-H-CC2-2-Th	Basic Algebra
III	MATH-H-CC3-3-Th MATH-H-CC4-3-Th	Real Analysis Ordinary Differential Equations – I & Group Theory - I
IV	MATH-H-CC5-4-Th MATH-H-CC6-4-Th MATH-H-CC7-4-Th MATH-H-CC8-4-Th	Theory of Real Functions Mechanics – I Partial Differential Equations -I & Multi-variate Calculus – I Group Theory – II & Ring Theory - I
V	MATH-H-CC9-5-Th MATH-H-CC10-5-Th MATH-H-CC11-5-Th MATH-H-CC12-5-Th	Probability & Statistics Ring Theory -II & Linear Algebra – I Riemann Integration & Series of Functions Mechanics - II

NAMES OF MINOR PAPERS(Each carries 4 credits or 100 marks)

SEMESTER	COURSE CODE	COURSE NAME
I	MINOR 1	Calculus, Geometry & Vector Analysis
II	MINOR 2	Basic Algebra
III	MINOR 3	Ordinary Differential Equations – I & Group Theory - I
IV	MINOR 4	Mechanics – I
V	MINOR 5	Real Analysis
VI	MINOR 6	Partial Differential Equations -I & Multi-variate Calculus – I

NAMES OF SEC PAPERS(Each carries 4 credits or 100 marks)

SEMESTER	COURSE CODE	COURSE NAME
I	MATH-H-SEC1-1-Th	C Language with Mathematical Applications
II	MATH-H-SEC2-2-Th (Any one out of 2 Courses on Right Column)	SEC 2.1 : Python Programming and Introduction to Latex SEC 2.2 :Artificial Intelligence
III	MATH-H-SEC3-3-Th	Linear Programming & Rectangular Games

NAMES OF IDC PAPERS (Each carries 3 credits or 75 marks)

SEMESTER	COURSE CODE	COURSE NAME
I	MATH-H-IDC1-1-Th	Mathematical Logic
II	MATH-H-IDC2-2-Th	Financial Mathematics
III	MATH-H-IDC3-3-Th	Bio – Mathematics

SYLLABUS IN DETAIL

MATH-H-CC1-1-Th
Calculus, Geometry & Vector Analysis

Full Marks: 100 (Theory: 75 and Tutorial: 25)

Group A: Calculus
[Marks:20] [16 classes]

• Differentiability of a function at a point and in an interval. Meaning of sign of derivative. Differentiating hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to functions of type e^{ax+b}sin x, e^{ax+b}cos x, $(ax + b)^n$ sin x, $(ax + b)^n$ cos x. Indeterminate forms. L'Hospital's rule (statement and example).
• Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin^n x\, dx$, $\int \cos^n x\, dx$, $\int \tan^n x\, dx$, $\int \sec^n x\, dx$, $\int (log\, x)^n dx$, $\int \sin^n x \sin^m x\, dx$, $\int \sin^n x \cos^m x\, dx$. Parametric equations, parametrizing a curve, arc length of a curve, arc length of parametric curves, area under a curve, area and volume of surface of revolution.

Group B: Geometry
[Marks:35] [28 classes]

• Rotation of axes and second degree equations, classification of conics using the discriminant, reduction to canonical form, tangent and normal, polar equations of conics.
• Spheres. Cylindrical surfaces. Central conicoids, paraboloids, plane sections of conicoids, generating lines, identification of quadric surfaces like cone, cylinder, ellipsoid, hyperboloid, classification of quadrics.

Group C: Vector Analysis
[Marks: 20] [16 classes]
• Triple product, vector equations, applications to geometry and mechanics — concurrent forces in a plane, theory of couples, system of parallel forces. Introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions of one variable.

References:

[1] G.B. Thomas and R.L. Finney, Calculus, 14th Ed., Pearson Education, Delhi, 2018.
[2] M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley

(India) P. Ltd. (Pearson Education), Delhi, 2022.
[3] H. Anton, I. Bivens and S. Davis, Calculus, 10th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2015.
[4] R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer- Verlag, New York, Inc., 1998.
[5] T. Apostol, Calculus, Volumes I and II, Wileyand Sons, 1969
[6] R. R. Goldberg, Methods of Real Analysis, Oxford & IBH Publishing, 2020.
[7] Marsden, J., and Tromba, Vector Calculus, W. H. Freeman & Co., 6th edition, 2011.
[8] M.R. Speigel, Schaum's outline of Vector AnalysisTata McGraw Hill Ed., 2011.
[9] S. L. Loney, Co-ordinate Geometry, 6th Edition, Arihant Publications, 2016.
[10] Robert J. T. Bell, Co-ordinate Geometry of Three Dimensions, Macmillan and Co., Ltd., London, 2018.

MATH-H-CC2-2-TH
Basic Algebra

Full Marks: 100 (Theory: 75 and Tutorial:25)

Group A
[Marks:25[] [20 classes]

• Polar representation of complex numbers, n^{th} roots of unity, De Moivre's theorem for rational indices and its applications. Exponential, logarithmic, trigonometric and hyperbolic functions of complex variable.
•Theory of equations: Relation between roots and coefficients, transformation of equation, Descartes rule of signs, Application of Sturm's theorem, cubic equation (solution by Cardan's method) and biquadratic equation (solution by Ferrari's method).
•Inequalities: The inequality involving $AM \geq GM \geq HM$, Cauchy-Schwartz inequality.

Group B
[Marks: 25] [20 classes]

•Relation: equivalence relation, equivalence classes & partition, partial order relation, poset, linear order relation.
•Mapping: composition of mappings, relation between composition of mappings and various set theoretic operations. Meaning and properties of $f^{-1}(B)$, for any mapping $f : X \to Y$ and $B \subseteq Y$.
•Well-ordering property of positive integers, Principles of Mathematical induction, equivalence of Wellordering property and Principles of Mathematical induction (statement only), division algorithm, divisibility and Euclidean algorithm. Prime numbers and their properties, Euclid's theorem. Congruence relation between integers. Fundamental Theorem of Arithmetic. Chinese remainder theorem. Arithmetic functions, some arithmetic functions such as ϕ, τ, σ and their properties.

Group C
[Marks:25] [20 classes]

•Systems of linear equations, homogeneous and non-homogeneous systems. Existence and Uniqueness of solution. The matrix equation $Ax = b$, row reduction and echelon forms, uniqueness of reduced echelon form. Rank of a matrix and characterization of invertible matrices, Pivot positions, basic and free variables, parametric description of the solution set. Existence and uniqueness theorem.

•Vectors in R^n , algebraic and geometric properties of the vectors. Vector form of a linear system and the column picture. Existence of solutions and linear combination of vectors. Geometry of linear combination and subsets spanned by some vectors. Uniqueness of solution and linear independence of vectors. Algebraic and geometric characterizations of linearly independent subsets.

References

[1] Titu Andreescu and DorinAndrica, Complex Numbers from A to Z, 2nd Ed., Springer Nature, 2014.

[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.

[4] Gilbert Strang; Introduction to Linear Algebra (5th Edition); Wellesley-Cambridge Press, 2019.

[5] Anton Howard and Chris Rorres; Elementary Linear Algebra with Supplemental Applications (11th Edition); Wiley, 2014.

[6] K. Hoffman, R. Kunze, Linear algebra, Prentice Hall India Learning Pvt. Ltd., 2015.

[7] W.S. Burnside and A.W. Panton, Theory of equations, Dublin University Press Series, S. Chand and Company Pvt. Ltd., 1986.

MATH-H-SEC1-1-Th

C Language with Mathematical Applications

Full marks: 100
(Theory: 75 and Tutorial: 25)
(60 classes)

Overview of architecture of computer, compiler, assembler, machine language, high level language, object oriented language, programming language, higher level language

• Constants, Variables and Data type of C-Program: Character set. Constants and variables data types, expression, assignment statements, declaration.

• Operation and Expressions: Arithmetic operators, relational operators, logical operators.

• Decision Making and Branching: decision making with if statement, if-else statement, Nesting if statement, switch statement, break and continue statement.

• Control Statements: While statement, do-while statement, for statement.

•Arrays: One-dimension, two-dimension and multidimensional arrays, declaration of arrays, initialization of one and multi-dimensional arrays.

• User-defined Functions: Definition of functions, Scope of variables, return values and their types, function declaration, function call by value, Nesting of functions, passing of arrays to functions, Recurrence of function.

• Introduction to Library functions: stdio.h, math.h, string.hstdlib.h, time.h etc.

Sample problems:

1. Display first 15 natural numbers.
2. Compute the sum of first 10 natural numbers.
3. Read 10 numbers from keyboard and find their average.
4. Find the sum of first 15 even natural numbers.
5. Write a program to find factorial of a number using recursion.
6. Write a program to make a pyramid pattern with numbers increased by 1.

7. From the terminal read three values, namely, length, width, height. Print a message whether the box is a cube or rectangle or semi-rectangle.
8. Find the AM, GM, HM of a given set of numbers.
9. Write a program to print multiplication table.
10. Write a program that generates a data file containing the list of customers and their contact numbers.
11. Find the maximum and minimum element of a given array.
12. Sort the elements of an array in ascending order
13. Write a program to read in an array of names and to sort them in alphabetical order.
14. Write a program for addition of two matrices.
15. Find the transpose of a given matrix.
16. Find the product of two matrices.
17. Write a program to check whether two given strings are an anagram.
18. Write a program to check Armstrong and Perfect numbers.
19. Write a program to check whether a number is a prime number or not.
20. Prepare a code for summing a Series.
21. Compute approximate value of pi .
22. Compute the area under a given curve.
23. Solve a quadratic equation.
24. Write a program to solve a system of two linear equations in two unknowns.
25. Write a program to find the shortest distance between two straight lines (parallel or intersecting or skew) in space.
26. Prepare an investment report by calculating compound interest.

Note: A practical note book is to be prepared with the internal assignments and to be submitted for the partial fulfilment of the course.

References

[1] B. W. Kernighan and D. M. Ritchi : The C-Programming Language, 2nd Edi.(ANSI Refresher), Prentice Hall, 1977.
[2] E. Balagurnsamy : Programming in ANSI C, Tata McGraw Hill, 2004.
[3] Y. Kanetkar : Let Us C ; BPB Publication, 1999.
[4] C. Xavier : C-Language and Numerical Methods, New Age International, 2007.
[5] V. Rajaraman : Computer Oriented Numerical Methods, Prentice Hall of India, 1980

MATH-H-SEC 2.1-2-Th
Python Programming and Introduction to Latex

Full marks: 100
(Theory: 75 and Tutorial: 25)

Group A: Python Programming
[Marks: 50][40 classes]

Python Programming Language, features, Installing Python. Running Code in the Interactive Shell, IDLE. Input, Processing and Output, Editing, Saving, and Running a Script, Debugging: Syntax Errors, Runtime Errors, Semantic Errors.

Data types and expressions: Variables and the Assignment Statement, Program Comments and Doc strings. Data Types-Numeric integers and Floating-point numbers. Boolean string. Mathematical operators, PEMDAS.Arithmetic expressions, Mixed-Mode Arithmetic and type Conversion, type( ). Input( ), print( ), program comments. id( ), int( ), str( ), float( ).

Loops and selection statements: Definite Iteration: for Loop, Executing statements a given number of times, Specifying steps using range( ) , Loops that count down, Boolean and Comparison operators and Expressions, Conditional and alternative statements- Chained and Nested Conditionals: if, if-else, if-elseif-else, nested if, nested if-else. Compound Boolean Expressions, Conditional Iteration: while Loop –with True condition, break Statement. Random Numbers. Loop Logic, errors and testing.

Strings, Lists, Tuple, Dictionary: Accessing characters, indexing, slicing, replacing.Concatenation (+), Repetition (*).Searching a substring with the 'in' Operator, Traversing string using while and for. String methods- find, join, split, lower, upper. len( ).

Lists – Accessing and slicing, Basic Operations (Comparison, +),List membership and for loop.Replacing element (list is mutable). List methods- append, extend, insert, pop, sort. Max( ), min( ). Tuples. Dictionaries-Creating a Dictionary, Adding keys and replacing Values , dictionary - key( ), value( ), get( ), pop( ), Traversing a Dictionary. Math module: sin(), cos(),exp(), sqrt(), constants- pi, e.

Design with functions: Defining Simple Functions- Parameters and Arguments, the return Statement, tuple as return value. Boolean Functions. Defining a main function. Defining and tracing recursive functions.

Working with Numbers: Calculating the Factors of an Integer, Generating Multiplication Tables, converting units of measurement, Finding the roots of a quadratic equation

Algebra and Symbolic Math with SymPy: symbolic math using the SymPy library. Defining Symbols and Symbolic Operations, factorizing and expanding expressions, Substituting in Values, Converting strings to mathematical expressions. Solving equations, Solving quadratic equations, Solving for one variable in terms of others, Solving a system of linear equations.

Plotting using SymPy , Plotting expressions input by the user, Plotting multiple functions

Sample problems:

1. Convert number from decimal to binary system.
2. Convert number from decimal to octal system.
3. Convert from Hexadecimal to binary system.
4. Write a program to read one subject mark and print pass or fail. Use single returnvalues function with argument.
5. Find the median of a given set of numbers.
6. Write a Python function that takes two lists and returns True if they have at least one common member.
7. Write a program for Enhanced Multiplication Table Generator.
8. Write down Unit converter code.
9. Write down Fraction Calculator code.
10. Write down Factor Findercode.
11. Write down Graphical Equation Solver code.
12. Write down a code for solving Single-Variable Inequalities.
13. Prepare an investment report by calculating compound interest.
14. Write a python program to open and write the content to file and read it.
15. Write a python program to check whether a given year is leap year or not and also print all the months of the given year.

Group B: Introduction to Latex
[Marks: 25] [20 classes]

Introduction to LATEX: Preparing a basic LATEX file. Compiling LATEX file.

Document classes: Different type of document classes, e.g., article, report, book etc.

Page Layout: Titles, Abstract, Chapters, Sections, subsections, paragraph, verbatim, References, Equation references, citation.

List structures: Itemize, enumerate, description etc.

Representation of mathematical equations: Inline math, Equations, Fractions, Matrices, trigonometric, logarithmic, exponential functions, line, surface, volume integrals with and without limits, closed line integral, surface integrals, Scaling of Parentheses, brackets etc.

Customization of fonts: Bold fonts, emphasise, mathbf, mathcal etc. Changing sizes Large, Larger, Huge, tiny etc.

Writing tables: Creating tables with different alignments, placement of horizontal, vertical lines.

Figures: Changing and placing the figures, alignments

Packages: amsmath,amssymb, graphics, graphicx, Geometry, algorithms, color, Hyperref etc. Use of Different LATEX commands and environments, Changing the type style, symbols from other languages. special characters.

Sample Projects:

1. Write down aresearch article.
2.Write down a given mathematical derivation.
3. Writea book chapter.
4. Write a report on a practical done in laboratory with results, tables and graphs.
5. Present graphical analysis taking graphs plotted in gnuplot.

Note: A practical note book is to be prepared with the internal assignments and to be submitted for the partial fulfilment of the course.

References

[1] Kenneth A Lambert, Fundamentals of Python: First programs, 2nd edition – Cengage Learning India, 2019.
[2] Saha Amit, Doing Math with Python - No starch press, San Francisco, 2015.

[3] E. Balgurusamy, Problem solving and Python programming- Tata McGraw Hill, 2017.
[4] LATEX- A Document Preparation System, Leslie Lamport, Addison-Wesley, 1994.
[5] E. Krishnan, LATEXTutorials A PRIMER, Indian TEXusers group, 2003.
[6] GeorgeGratzer,Practical LATEX, Springer, 2014.

MATH-H-SEC 2.2-2-Th

Artificial Intelligence

Full marks: 100
(Theory: 75 and Tutorial: 25)
(60classes)

Course Description:
This course aims to introduce the fundamental concepts of artificial intelligence (AI) to individuals from all academic backgrounds. Participants will develop a broad understanding of AI technologies, their implications, and their potential applications in various fields. The course will emphasize practical examples and real-world case studies to facilitate comprehension and inspire innovative thinking.

Course Objectives:

- Understand the basics of artificial intelligence and its subfields.
- Explore real-world applications of AI across different industries.
- Gain insights into the ethical, social, and economic implications of AI.
- Develop an appreciation for the potential of AI to drive innovation and transformation.

Course Outcome:

- Define and explain the fundamental concepts and subfields of AI.
- Identify real-world applications of AI across various industries.
- Analyze the ethical, social, and economic implications of AI.
- Recognize the potential of AI to drive innovation and transformation in different domains.

Unit 1: Introduction to Artificial Intelligence

- Definition and scope of AI
- Historical overview and key milestones
- Differentiating AI from human intelligence

Unit 2: AI Subfields and Technologies

- Machine learning: Supervised, unsupervised, and reinforcement learning
- Deep learning and neural networks
- Natural language processing (NLP) and computer vision

Unit 3: Applications of AI

- AI in healthcare: Diagnosis, treatment, and medical imaging
- AI in finance: Fraud detection, algorithmic trading, and risk assessment
- AI in transportation: Autonomous vehicles and traffic optimization
- AI in customer service and chatbots
- AI in education: Personalized learning and intelligent tutoring systems

Unit 4: Ethical and Social Implications of AI

- Bias and fairness in AI systems
- Privacy and data protection concerns
- Impact of AI on employment and the workforce
- AI and social inequality

Unit 5: Other Important Issues

- Ethical guidelines and responsible AI practices
- AI and Innovation
- Emerging trends and future directions in AI
- AI and creativity: Generative models and artistic applications

MATH-H-SEC3-3-Th
Linear Programming and Rectangular Games

Full Marks: 100 (Theory : 75 marks and Tutorial: 25 marks)
(60classes)

• Definition of Linear Programming Problem (L.P.P.). Formation of L.P.P. from daily life involving inequations. Graphical solution of L.P.P. Basic solutions and

Basic Feasible Solution (B.F.S) with reference to L.P.P. Matrix formulation of L.P.P. Degenerate and Non-degenerate B.F.S.

• Hyperplane, Convex set, Cone, extreme points, convex hull and convex polyhedron. Supporting and Separating hyperplane. The collection of a feasible solutions of an L.P.P. constitutes a convex set. The extreme points of the convex set of feasible solutions correspond to its B.F.S. and conversely. The objective function has its optimal value at an extreme point of the convex polyhedron generated by the set of feasible solutions (the convex polyhedron may also be unbounded). In the absence of degeneracy, if the L.P.P. admits of an optimal solution then at least one B.F.S. must be optimal. Reduction of a F.S. to a B.F.S.

• Slack and surplus variables. Standard form of L.P.P. theory of simplex method. Feasibility and optimality conditions. Algorithm. Two phase method. Degeneracy in L.P.P. and its resolution.

• Duality theory: The dual of dual is the primal. Relation between the objective values of dual and the primal problems. Relation between their optimal values.

Post-optimal Analysis**:** Discrete changes in the cost vector, Discrete changes in the requirement vector, Discrete changes in the coefficient matrix, Addition of a variable, Addition of a constraint.

• Transportation and Assignment problems. Mathematical justification for optimality criterion. Hungarian method. Traveling Salesman problem.

• Concept of game problem. Rectangular games. Pure strategy and Mixed strategy. Saddle point and its existence. Optimal strategy and value of the game. Necessary and sufficient condition for a given strategy to be optimal in a game. Concept of Dominance. Fundamental Theorem of rectangular games. Algebraic method. Graphical method and Dominance method to solveRectangular games. Inter-relation between theory of games and L.P.P.

Note:1. Students will learn formulation of L.P.P. and obtaining optimal solution of L.P.P. using software package.

2. A practical note book is to be prepared with the internal assignments and to be submitted for the partial fulfilment of the course.

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.
[5] Churchman, Ackoff, Arnoff, Introduction to Operations Research, John Wiley and Sons Inc., 1957.
[6] Billy, E. Gillet, Introduction to Operations Research: A Computer Oriented Algorithmatic Approach, TMH Edition, 1979.
[7] Swarup K., Gupta P.K., Man Mohan, Operations Research, Sultan Chand and Sons, 2020.
[8] Chakraborty J. G. and Ghosh, P.R., Linear Programming and Game Theory, Moulik Library, 1979.

MATH-H-IDC1-1-Th

Mathematical Logic

Full marks: 75 (Theory: 50 and Tutorial: 25)
(45classes)

Introduction: propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions.

General Notions: Formal language, object and meta language, general definition of a Formal Theory/Formal Logic.

Propositional Logic: Formal theory for propositional calculus, derivation, proof, theorem, deduction theorem, conjunctive and disjunctive normal forms, semantics, truth tables, tautology, adequate set of connectives, applications to switching circuits, logical consequence, consistency, maximal consistency, Lindenbaum lemma, soundness and completeness theorems, algebraic semantics.

Modal PropositionalLogic: Introduction, modal operators, well formed formulas, axioms of systems K, T, B, S4, S5, Rules of inference, interpretation in Kripke frame, validity, connection of accessibility relation with the systems, Statements of soundness and completeness theorems.

Predicate Logic: First order language, symbolizing ordinary sentences into first order formulae, free and bound variables, interpretation and satisfiability, models, logical validity, formal theory for predicate calculus.

Fuzzy Logic: Many-valued logic, 3-valued logic of Lukasiewich, the truth tables of conjunction, disjunction, negation and implication, tautology and validity, Infinite valued logic, calculation of truth values of the logical connectives.

Applications (briefidea): Applicationsof Modal Logic in Artificial Intelligence, database theory, distributed system, cryptography. Applications of Fuzzy Logic in Artificial Intelligence, Soft computing, Decision theory, NLP, Pattern recognition.

References

[1] Elliott Mendelson; Introduction to mathematical logic; Chapman & Hall; London, 1997.
[2] Angelo Margaris; First order mathematical logic; Dover publications, Inc, New York ,1990.
[3] S.C.Kleene; Introduction to Metamathematics; Amsterdam; Elsevier, 1952.
[4] J.H.Gallier; Logic for computer science; John.Wiley& Sons, 1987.
[5] H.B.Enderton; A mathematical introduction to logic; Academic Press; New York 1972.
[6] Chakraborty, M., Lecture note: A journey through the logic wonderland, IIEST, Shibpur, 2016.

MATH-H-IDC2-2-Th
Financial Mathematics

Full marks: 75 (Theory: 50 and Tutorial: 25)
(45classes)

- Profit, Loss and discount, Dividend, Calculation of income tax, Tabulations, Bar graphs, Pie charts, Line graphs.

- Introduction to Financial Markets and Instruments: Money Market and Capital Market, Financial Instruments – Stock, Bonds, Derivatives; Concept of Value (intrinsic) vs. Price of Financial Instruments, Concept of Arbitrage.

- Time Value of Money: Interest (simple and compound, discrete and continuous), Annuities, net present value, internal rate of return (calculation by bisection and Newton-Raphson methods), Comparison of NPV and IRR.
- Bonds: Bond Valuation; Bond Prices and Yields; Duration, Convexity, Interest Rate Risk; Fixed vs. Floating Rate Bonds, Immunization.
- Portfolio Theory: Brief introduction to expectation, variance, covariance and correlation; Asset Return and Risk; Portfolio Risk (Variance) and Return– Historical and Ex-Ante; Diversification and Risk Reduction; Feasible and Optimal Portfolio – Efficient Frontier; Markowitz model (review of Lagrange multipliers for 1 and 2 constraints).

References

[1] David G. Luenberger; Investment Science; Oxford University Press, Delhi, 1998.

[2] John C. Hull; Options, Futures and Other Derivatives, 6th Ed.; Prentice-Hall India, Indian reprint, 2006.

[3] Sheldon Ross; An Elementary Introduction to Mathematical Finance, 2nd Ed, Cambridge University Press, USA, 2003.

[4] Chandra P., Investment Analysis and Portfolio Management; McGraw Hill Education, 5th Ed., 2017.

[5] Ales Cerny: Mathematical Techniques in Finance: Tools for incomplete markets, PrincetonUniversity Press, 2009.

[6]S.R. Pliska, Introduction to Mathematical Finance: Discrete time model, 1st Ed., Wiley, 1997.

[7] Karatzas and S. Shreve, Method of Mathematical Finance, Springer, New York, 2016.

MATH-H-IDC3-3-Th

Bio - Mathematics

Full marks: 75 (Theory: 50 and Tutorial: 25)
(45 classes)

Mathematical biology and the modelling process: What is a model? Essential features of a modelling approach, Identification of variables, parameters, constants for a model; type of models (linear-nonlinear and continuous – discrete).

Simple single-species continuous population growth models:
Malthus model (1798): deduction (basic assumptions), analytic solution, doubling time; behavior of population size as $t \to \infty$, Stability analysis of the steady states of the Malthus model; limitations.

Logistic model (Verhulst 1838): motivation (Gause's 1934 Experiments) and formulation (basic assumptions), analytic solution, behavior of population size as $t \to \infty$ for different initial population size, carrying capacity. Effects of harvesting in a single species population: Constant-yield harvesting, constant-effort harvesting.

One dimensional models, fixed points, stability analysis of fixed points, phase diagrams.
Non-dimensionalization and re-parametrization in a model: Necessity and applications.

Bifurcation: Saddle-node, transcritical and pitchfork bifurcations in one-dimensional case.

Insect outbreak model (Morris, 1963): The spruce budworm model – deduction (basic assumptions), analysis of steady states, presence of saddle-node bifurcation; real life applications.

Interacting populations: Predator-prey model (basic assumptions) and Lotka (1925)-Volterra (1926) model (basic assumptions) – deduction, Steady states.

Chemical Reaction Kinetics; Law of mass action; Enzymatic reaction;
Enzyme Kinetics; Elimination of variables – model reduction; Michaelis-Menten kinetics (proposed in 1913). Formulation of model (basic assumptions) and steady states.

Gene regulation networks: Introduction, basic assumptions, two dimensional model; Constitutive gene expression; Gene transcription regulation by activators; Gene transcription regulation by repressors; Regulation of gene transcription: auto-activation and auto-inhibition.

Epidemic models: Basic terminologies.
SI model (assumptions), Kermack-McKendrick SIR model 1927 (basic assumptions) assuming total population as constant, Formulation of the models. Concept of basic reproduction number.

Discrete single-species models: Linear models, growth models, decay models, discrete Logistic models.

Overview of nonlinear difference equations: Steady states and linear stability analysis, Graphical solution of difference equations – cobwebbing.

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.
[6] F. Brauer and C. Castillo-Chavez, Mathematical Models in Population Biology and Epidemiology, Springer, 2012.
[7] S. H. Strogatz, Nonlinear Dynamics and Chaos, Perseus Books, 1994.
[8] N.F. Britton, Essential Mathematical Biology, Springer-Verlag London, 2003.
[9] R F Morris, The Memoirs of the Entomological Society of Canada, Cambridge.org, 1963.

SYLLABUS
FOR
THREE -YEAR (SIX-SEMESTER) B.SC. COURSE
UNDER THE UNIVERSITY OF CALCUTTA

Odd Semester: July to December

Even Semester: January to June

Syllabus for the 3 Year B.Sc. course in Mathematics effective from the academic year **2023-2024.**

COURSE STRUCTURE-MDC

	CC1	CC2	Minor	IDC	AEC	SEC	CVAC	Summer Internship	Total Credit
Semester	8x4= 32	8x4= 32	6x4= 24	3x3=9	4x2= 8	3x4=12	4x2=8	1x3= 3	128
1	1x4= 4 3TH+ 1P/TU	1x4= 4 3TH+ 1P/TU		1x3=3 2TH +1P/TU	1x2= 2 2TH +0P/TU	1x4= 4	2x2=4		21
2	1x4= 4 3TH+ 1P/TU	1x4= 4 3TH+ 1P/TU		1x3=3 2TH +1P/TU	1x2= 2 2TH +0P/TU	1x4= 4	2x2=4		21
3	1x4= 4 (3TH+ 1P/TU)	1x4= 4 3TH+ 1P/TU	1x4= 4 3TH+1P/TU	1x3=3 2TH +1P/TU	1x2= 2 2TH +0P/TU	1x4= 4			21
4	2x4=8 4x(3TH+ 1P/TU)	2x4= 8 2x(3TH+ 1P/TU	1x4= 4 (3TH+1P/TU)		1x2= 2 2TH +0P/TU				22
5	2x4= 8 2x(3TH+ 1P/TU)	1x4= 4 3TH+ 1P/TU	2x4= 8 2x(3TH+ 1P/TU						20
6	1x4= 4 (3TH+ 1P/TU)	2x4= 8 2x(3TH+ 1P/TU)	2x4= 8 2x(3TH+ 1P/TU)						20
Credits	8x4= 32	8x4= 32	6x4= 24	3x3= 9	4x2= 8	3x4= 12	4x2= 8		125+3 =128
Marks	8x100= 800	8x100= 800	6x100= 600	3x75= 225	4x50= 200	3x100= 300	4x50= 200		Total Marks =3200

Marks= 25 marks per credit.

Total credit=125+3 (for summer internship) = 128
Summer Internship: As mentioned in clause no. 8 (G)

Note: Tutorial marks will be awarded based on internal assessment – by evaluation of internal assignments for SEC papers and by internal examination for Core, Minor, IDC papers.

Modules Offered by Mathematics Department

NAMES OF CORE COURSES(Each carries 4 credits or 100 marks)

SEMESTER	COURSE CODE	COURSE NAME
I	MATH-MD-CC1-1-Th	Calculus, Geometry & Vector Analysis
II	MATH-MD-CC2-2-Th	Basic Algebra
III	MATH-MD-CC3-3-Th	Ordinary Differential Equations& Group Theory
IV	MATH-MD-CC4-4-Th MATH-MD-CC5-4-Th	Mechanics Statistics & Numerical Analysis
V	MATH-MD-CC6-5-Th MATH-MD-CC7-5-Th	Real Analysis Partial Differential Equations & Multivariate Calculus
VI	MATH-MD-CC8-6-Th	Advanced Algebra& Riemann Integration

NAMES OF SEC PAPERS (Each carries 4 credits or 100 marks)

SEMESTER	COURSE CODE	COURSE NAME
I	MATH-MD-SEC 1-1-Th	C Language with Mathematical Applications
II	MATH-MD-SEC 2-2-Th (Any one out of twocourses on right column)	SEC 2.1 : Python Programming and Introduction to Latex SEC 2.2 : Artificial Intelligence
III	MATH-MD-SEC3-3-Th	Linear Programming & Rectangular Games

NAMES OF IDC PAPERS (Each carries 3 credits or 75 marks)

SEMESTER	COURSE CODE	COURSE NAME
I	MATH-MD-IDC1-1-Th	Mathematical Logic
II	MATH-MD- IDC2-2-Th	Financial Mathematics
III	MATH-MD-IDC3-3-Th	Bio - Mathematics

SYLLABUS IN DETAIL

MATH-MD-CC1-1-Th
Calculus, Geometry & Vector Analysis

Full Marks: 100 (Theory: 75 and Tutorial: 25)

Group A: Calculus
[Marks:20] [16 classes]

• Differentiability of a function at a point and in an interval. Meaning of sign of derivative. Differentiating hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to functions of type e^{ax+b}sin x, e^{ax+b}cos x, $(ax + b)^n$ sin x, $(ax + b)^n$ cos x. Indeterminate forms. L'Hospital's rule (statement and example).
• Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin^n x\, dx$, $\int \cos^n x\, dx$, $\int \tan^n x\, dx$, $\int \sec^n x\, dx$, $\int (log\, x)^n dx$, $\int \sin^n x \sin^m x\, dx$, $\int \sin^n x \cos^m x\, dx$. Parametric equations, parametrizing a curve, arc length of a curve, arc length of parametric curves, area under a curve, area and volume of surface of revolution.

Group B: Geometry
[Marks:35] [28 classes]

• Rotation of axes and second degree equations, classification of conics using the discriminant, reduction to canonical form, tangent and normal, polar equations of conics.
• Spheres. Cylindrical surfaces. Central conicoids, paraboloids, plane sections of conicoids, generating lines, identification of quadric surfaces like cone, cylinder, ellipsoid, hyperboloid, classification of quadrics.

Group C: Vector Analysis
[Marks: 20] [16 classes]
• Triple product, vector equations, applications to geometry and mechanics — concurrent forces in a plane, theory of couples, system of parallel forces. Introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions of one variable.

References:

[1] G.B. Thomas and R.L. Finney, Calculus, 14th Ed., Pearson Education, Delhi, 2018.
[2] M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley

(India) P. Ltd. (Pearson Education), Delhi, 2022.
[3] H. Anton, I. Bivens and S. Davis, Calculus, 10th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2015.
[4] R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer- Verlag, New York, Inc., 1998.
[5] T. Apostol, Calculus, Volumes I and II, Wileyand Sons, 1969
[6] R. R. Goldberg, Methods of Real Analysis, Oxford & IBH Publishing, 2020.
[7] Marsden, J., and Tromba, Vector Calculus, W. H. Freeman & Co., 6th edition, 2011.
[8] M.R. Speigel, Schaum's outline of Vector AnalysisTata McGraw Hill Ed., 2011.
[9] S. L. Loney, Co-ordinate Geometry, 6th Edition, Arihant Publications, 2016.
[10] Robert J. T. Bell, Co-ordinate Geometry of Three Dimensions, Macmillan and Co., Ltd., London, 2018.

MATH-MD-CC2-2-TH
Basic Algebra

Full Marks: 100 (Theory: 75 and Tutorial:25)

Group A
[Marks:25[] [20 classes]

• Polar representation of complex numbers, n^{th} roots of unity, De Moivre's theorem for rational indices and its applications. Exponential, logarithmic, trigonometric and hyperbolic functions of complex variable.
•Theory of equations: Relation between roots and coefficients, transformation of equation, Descartes rule of signs, Application of Sturm's theorem, cubic equation (solution by Cardan's method) and biquadratic equation (solution by Ferrari's method).
•Inequalities: The inequality involving $AM \geq GM \geq HM$, Cauchy-Schwartz inequality.

Group B
[Marks: 25] [20 classes]

•Relation: equivalence relation, equivalence classes & partition, partial order relation, poset, linear order relation.
•Mapping: composition of mappings, relation between composition of mappings and various set theoretic operations. Meaning and properties of $f^{-1}(B)$, for any mapping $f : X \to Y$ and $B \subseteq Y$.
•Well-ordering property of positive integers, Principles of Mathematical induction, equivalence of Wellordering property and Principles of Mathematical induction (statement only), division algorithm, divisibility and Euclidean algorithm. Prime numbers and their properties, Euclid's theorem. Congruence relation between integers. Fundamental Theorem of Arithmetic. Chinese remainder theorem. Arithmetic functions, some arithmetic functions such as ϕ, τ, σ and their properties.

Group C
[Marks:25] [20 classes]

•Systems of linear equations, homogeneous and non-homogeneous systems. Existence and Uniqueness of solution. The matrix equation $Ax = b$, row reduction and echelon forms, uniqueness of reduced echelon form. Rank of a matrix and characterization of invertible matrices, Pivot positions, basic and free variables, parametric description of the solution set. Existence and uniqueness theorem.

•Vectors in R^n , algebraic and geometric properties of the vectors. Vector form of a linear system and the column picture. Existence of solutions and linear combination of vectors. Geometry of linear combination and subsets spanned by some vectors. Uniqueness of solution and linear independence of vectors. Algebraic and geometric characterizations of linearly independent subsets.

References

[1] Titu Andreescu and DorinAndrica, Complex Numbers from A to Z, 2nd Ed., Springer Nature, 2014.

[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.

[4] Gilbert Strang; Introduction to Linear Algebra (5th Edition); Wellesley-Cambridge Press, 2019.

[5] Anton Howard and Chris Rorres; Elementary Linear Algebra with Supplemental Applications (11th Edition); Wiley, 2014.

[6] K. Hoffman, R. Kunze, Linear algebra, Prentice Hall India Learning Pvt. Ltd., 2015.

[7] W.S. Burnside and A.W. Panton, Theory of equations, Dublin University Press Series, S. Chand and Company Pvt. Ltd., 1986.

MATH-MD-SEC1-1-Th

C Language with Mathematical Applications

Full marks: 100
(Theory: 75 and Tutorial: 25)
(60 classes)

Overview of architecture of computer, compiler, assembler, machine language, high level language, object oriented language, programming language, higher level language

• Constants, Variables and Data type of C-Program: Character set. Constants and variables data types, expression, assignment statements, declaration.

• Operation and Expressions: Arithmetic operators, relational operators, logical operators.

• Decision Making and Branching: decision making with if statement, if-else statement, Nesting if statement, switch statement, break and continue statement.

• Control Statements: While statement, do-while statement, for statement.

•Arrays: One-dimension, two-dimension and multidimensional arrays, declaration of arrays, initialization of one and multi-dimensional arrays.

• User-defined Functions: Definition of functions, Scope of variables, return values and their types, function declaration, function call by value, Nesting of functions, passing of arrays to functions, Recurrence of function.

• Introduction to Library functions: stdio.h, math.h, string.hstdlib.h, time.h etc.

Sample problems:

1. Display first 15 natural numbers.
2. Compute the sum of first 10 natural numbers.
3. Read 10 numbers from keyboard and find their average.
4. Find the sum of first 15 even natural numbers.
5. Write a program to find factorial of a number using recursion.
6. Write a program to make a pyramid pattern with numbers increased by 1.

7. From the terminal read three values, namely, length, width, height. Print a message whether the box is a cube or rectangle or semi-rectangle.
8. Find the AM, GM, HM of a given set of numbers.
9. Write a program to print multiplication table.
10. Write a program that generates a data file containing the list of customers and their contact numbers.
11. Find the maximum and minimum element of a given array.
12. Sort the elements of an array in ascending order
13. Write a program to read in an array of names and to sort them in alphabetical order.
14. Write a program for addition of two matrices.
15. Find the transpose of a given matrix.
16. Find the product of two matrices.
17. Write a program to check whether two given strings are an anagram.
18. Write a program to check Armstrong and Perfect numbers.
19. Write a program to check whether a number is a prime number or not.
20. Prepare a code for summing a Series.
21. Compute approximate value of pi .
22. Compute the area under a given curve.
23. Solve a quadratic equation.
24. Write a program to solve a system of two linear equations in two unknowns.
25. Write a program to find the shortest distance between two straight lines (parallel or intersecting or skew) in space.
26. Prepare an investment report by calculating compound interest.

Note: A practical note book is to be prepared with the internal assignments and to be submitted for the partial fulfilment of the course.

References

[1] B. W. Kernighan and D. M. Ritchi : The C-Programming Language, 2nd Edi.(ANSI Refresher), Prentice Hall, 1977.
[2] E. Balagurnsamy : Programming in ANSI C, Tata McGraw Hill, 2004.
[3] Y. Kanetkar : Let Us C ; BPB Publication, 1999.
[4] C. Xavier : C-Language and Numerical Methods, New Age International, 2007.
[5] V. Rajaraman : Computer Oriented Numerical Methods, Prentice Hall of India, 1980

MATH-MD-SEC 2.1-2-Th
Python Programming and Introduction to Latex

Full marks: 100
(Theory: 75 and Tutorial: 25)

Group A: Python Programming

[Marks: 50][40 classes]

Python Programming Language, features, Installing Python. Running Code in the Interactive Shell, IDLE. Input, Processing and Output, Editing, Saving, and Running a Script, Debugging: Syntax Errors, Runtime Errors, Semantic Errors.

Data types and expressions: Variables and the Assignment Statement, Program Comments and Doc strings. Data Types-Numeric integers and Floating-point numbers. Boolean string. Mathematical operators, PEMDAS.Arithmetic expressions, Mixed-Mode Arithmetic and type Conversion, type( ). Input( ), print( ), program comments. id( ), int( ), str( ), float( ).

Loops and selection statements: Definite Iteration: for Loop, Executing statements a given number of times, Specifying steps using range( ) , Loops that count down, Boolean and Comparison operators and Expressions, Conditional and alternative statements- Chained and Nested Conditionals: if, if-else, if-elseif-else, nested if, nested if-else. Compound Boolean Expressions, Conditional Iteration: while Loop –with True condition, break Statement. Random Numbers. Loop Logic, errors and testing.

Strings, Lists, Tuple, Dictionary: Accessing characters, indexing, slicing, replacing.Concatenation (+), Repetition (*).Searching a substring with the 'in' Operator, Traversing string using while and for. String methods- find, join, split, lower, upper. len( ).

Lists – Accessing and slicing, Basic Operations (Comparison, +),List membership and for loop.Replacing element (list is mutable). List methods- append, extend, insert, pop, sort. Max( ), min( ). Tuples. Dictionaries-Creating a Dictionary, Adding keys and replacing Values , dictionary - key( ), value( ), get( ), pop( ), Traversing a Dictionary. Math module: sin(), cos(),exp(), sqrt(), constants- pi, e.

Design with functions: Defining Simple Functions- Parameters and Arguments, the return Statement, tuple as return value. Boolean Functions. Defining a main function. Defining and tracing recursive functions.

Working with Numbers: Calculating the Factors of an Integer, Generating Multiplication Tables, converting units of measurement, Finding the roots of a quadratic equation

Algebra and Symbolic Math with SymPy: symbolic math using the SymPy library. Defining Symbols and Symbolic Operations, factorizing and expanding expressions, Substituting in Values, Converting strings to mathematical expressions. Solving equations, Solving quadratic equations, Solving for one variable in terms of others, Solving a system of linear equations.

Plotting using SymPy , Plotting expressions input by the user, Plotting multiple functions

Sample problems:

1. Convert number from decimal to binary system.
2. Convert number from decimal to octal system.
3. Convert from Hexadecimal to binary system.
4. Write a program to read one subject mark and print pass or fail. Use single returnvalues function with argument.
5. Find the median of a given set of numbers.
6. Write a Python function that takes two lists and returns True if they have at least one common member.
7. Write a program for Enhanced Multiplication Table Generator.
8. Write down Unit converter code.
9. Write down Fraction Calculator code.
10. Write down Factor Findercode.
11. Write down Graphical Equation Solver code.
12. Write down a code for solving Single-Variable Inequalities.
13. Prepare an investment report by calculating compound interest.
14. Write a python program to open and write the content to file and read it.
15. Write a python program to check whether a given year is leap year or not and also print all the months of the given year.

Group B: Introduction to Latex
[Marks: 25] [20 classes]

Introduction to LATEX: Preparing a basic LATEX file. Compiling LATEX file.

Document classes: Different type of document classes, e.g., article, report, book etc.

Page Layout: Titles, Abstract, Chapters, Sections, subsections, paragraph, verbatim, References, Equation references, citation.

List structures: Itemize, enumerate, description etc.

Representation of mathematical equations: Inline math, Equations, Fractions, Matrices, trigonometric, logarithmic, exponential functions, line, surface, volume integrals with and without limits, closed line integral, surface integrals, Scaling of Parentheses, brackets etc.

Customization of fonts: Bold fonts, emphasise, mathbf, mathcal etc. Changing sizes Large, Larger, Huge, tiny etc.

Writing tables: Creating tables with different alignments, placement of horizontal, vertical lines.

Figures: Changing and placing the figures, alignments

Packages: amsmath,amssymb, graphics, graphicx, Geometry, algorithms, color, Hyperref etc. Use of Different LATEX commands and environments, Changing the type style, symbols from other languages. special characters.

Sample Projects:

1. Write down aresearch article.
2.Write down a given mathematical derivation.
3. Writea book chapter.
4. Write a report on a practical done in laboratory with results, tables and graphs.
5. Present graphical analysis taking graphs plotted in gnuplot.

Note: A practical note book is to be prepared with the internal assignments and to be submitted for the partial fulfilment of the course.

References

[1] Kenneth A Lambert, Fundamentals of Python: First programs, 2nd edition – Cengage Learning India, 2019.
[2] Saha Amit, Doing Math with Python - No starch press, San Francisco, 2015.

[3] E. Balgurusamy, Problem solving and Python programming- Tata McGraw Hill, 2017.
[4] LATEX- A Document Preparation System, Leslie Lamport, Addison-Wesley, 1994.
[5] E. Krishnan, LATEXTutorials A PRIMER, Indian TEXusers group, 2003.
[6] GeorgeGratzer,Practical LATEX, Springer, 2014.

MATH-MD-SEC 2.2-2-Th

Artificial Intelligence

Full marks: 100
(Theory: 75 and Tutorial: 25)
(60classes)

Course Description:
This course aims to introduce the fundamental concepts of artificial intelligence (AI) to individuals from all academic backgrounds. Participants will develop a broad understanding of AI technologies, their implications, and their potential applications in various fields. The course will emphasize practical examples and real-world case studies to facilitate comprehension and inspire innovative thinking.

Course Objectives:

- Understand the basics of artificial intelligence and its subfields.
- Explore real-world applications of AI across different industries.
- Gain insights into the ethical, social, and economic implications of AI.
- Develop an appreciation for the potential of AI to drive innovation and transformation.

Course Outcome:

- Define and explain the fundamental concepts and subfields of AI.
- Identify real-world applications of AI across various industries.
- Analyze the ethical, social, and economic implications of AI.
- Recognize the potential of AI to drive innovation and transformation in different domains.

Unit 1: Introduction to Artificial Intelligence

- Definition and scope of AI
- Historical overview and key milestones
- Differentiating AI from human intelligence

Unit 2: AI Subfields and Technologies

- Machine learning: Supervised, unsupervised, and reinforcement learning
- Deep learning and neural networks
- Natural language processing (NLP) and computer vision

Unit 3: Applications of AI

- AI in healthcare: Diagnosis, treatment, and medical imaging
- AI in finance: Fraud detection, algorithmic trading, and risk assessment
- AI in transportation: Autonomous vehicles and traffic optimization
- AI in customer service and chatbots
- AI in education: Personalized learning and intelligent tutoring systems

Unit 4: Ethical and Social Implications of AI

- Bias and fairness in AI systems
- Privacy and data protection concerns
- Impact of AI on employment and the workforce
- AI and social inequality

Unit 5: Other Important Issues

- Ethical guidelines and responsible AI practices
- AI and Innovation
- Emerging trends and future directions in AI
- AI and creativity: Generative models and artistic applications

MATH-MD-SEC3-3-Th
Linear Programming and Rectangular Games

Full Marks: 100 (Theory : 75 marks and Tutorial: 25 marks)
(60classes)

• Definition of Linear Programming Problem (L.P.P.). Formation of L.P.P. from daily life involving inequations. Graphical solution of L.P.P. Basic solutions and

Basic Feasible Solution (B.F.S) with reference to L.P.P. Matrix formulation of L.P.P. Degenerate and Non-degenerate B.F.S.

• Hyperplane, Convex set, Cone, extreme points, convex hull and convex polyhedron. Supporting and Separating hyperplane. The collection of a feasible solutions of an L.P.P. constitutes a convex set. The extreme points of the convex set of feasible solutions correspond to its B.F.S. and conversely. The objective function has its optimal value at an extreme point of the convex polyhedron generated by the set of feasible solutions (the convex polyhedron may also be unbounded). In the absence of degeneracy, if the L.P.P. admits of an optimal solution then at least one B.F.S. must be optimal. Reduction of a F.S. to a B.F.S.

• Slack and surplus variables. Standard form of L.P.P. theory of simplex method. Feasibility and optimality conditions. Algorithm. Two phase method. Degeneracy in L.P.P. and its resolution.

• Duality theory: The dual of dual is the primal. Relation between the objective values of dual and the primal problems. Relation between their optimal values.

Post-optimal Analysis**:** Discrete changes in the cost vector, Discrete changes in the requirement vector, Discrete changes in the coefficient matrix, Addition of a variable, Addition of a constraint.

• Transportation and Assignment problems. Mathematical justification for optimality criterion. Hungarian method. Traveling Salesman problem.

• Concept of game problem. Rectangular games. Pure strategy and Mixed strategy. Saddle point and its existence. Optimal strategy and value of the game. Necessary and sufficient condition for a given strategy to be optimal in a game. Concept of Dominance. Fundamental Theorem of rectangular games. Algebraic method. Graphical method and Dominance method to solveRectangular games. Inter-relation between theory of games and L.P.P.

Note:1. Students will learn formulation of L.P.P. and obtaining optimal solution of L.P.P. using software package.

2. A practical note book is to be prepared with the internal assignments and to be submitted for the partial fulfilment of the course.

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.
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MATH-MD-IDC1-1-Th

Mathematical Logic

Full marks: 75 (Theory: 50 and Tutorial: 25)
(45classes)

Introduction: propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions.

General Notions: Formal language, object and meta language, general definition of a Formal Theory/Formal Logic.

Propositional Logic: Formal theory for propositional calculus, derivation, proof, theorem, deduction theorem, conjunctive and disjunctive normal forms, semantics, truth tables, tautology, adequate set of connectives, applications to switching circuits, logical consequence, consistency, maximal consistency, Lindenbaum lemma, soundness and completeness theorems, algebraic semantics.

Modal PropositionalLogic: Introduction, modal operators, well formed formulas, axioms of systems K, T, B, S4, S5, Rules of inference, interpretation in Kripke frame, validity, connection of accessibility relation with the systems, Statements of soundness and completeness theorems.

Predicate Logic: First order language, symbolizing ordinary sentences into first order formulae, free and bound variables, interpretation and satisfiability, models, logical validity, formal theory for predicate calculus.

Fuzzy Logic: Many-valued logic, 3-valued logic of Lukasiewich, the truth tables of conjunction, disjunction, negation and implication, tautology and validity, Infinite valued logic, calculation of truth values of the logical connectives.

Applications (briefidea): Applicationsof Modal Logic in Artificial Intelligence, database theory, distributed system, cryptography. Applications of Fuzzy Logic in Artificial Intelligence, Soft computing, Decision theory, NLP, Pattern recognition.

References

[1] Elliott Mendelson; Introduction to mathematical logic; Chapman & Hall; London, 1997.

[2] Angelo Margaris; First order mathematical logic; Dover publications, Inc, New York ,1990.

[3] S.C.Kleene; Introduction to Metamathematics; Amsterdam; Elsevier, 1952.

[4] J.H.Gallier; Logic for computer science; John.Wiley& Sons, 1987.

[5] H.B.Enderton; A mathematical introduction to logic; Academic Press; New York 1972.

[6] Chakraborty, M., Lecture note: A journey through the logic wonderland, IIEST, Shibpur, 2016.

MATH-MD-IDC2-2-Th
Financial Mathematics

Full marks: 75 (Theory: 50 and Tutorial: 25)

(45classes)

- Profit, Loss and discount, Dividend, Calculation of income tax, Tabulations, Bar graphs, Pie charts, Line graphs.

- Introduction to Financial Markets and Instruments: Money Market and Capital Market, Financial Instruments – Stock, Bonds, Derivatives; Concept of Value (intrinsic) vs. Price of Financial Instruments, Concept of Arbitrage.

- Time Value of Money: Interest (simple and compound, discrete and continuous), Annuities, net present value, internal rate of return (calculation by bisection and Newton-Raphson methods), Comparison of NPV and IRR.
- Bonds: Bond Valuation; Bond Prices and Yields; Duration, Convexity, Interest Rate Risk; Fixed vs. Floating Rate Bonds, Immunization.
- Portfolio Theory: Brief introduction to expectation, variance, covariance and correlation; Asset Return and Risk; Portfolio Risk (Variance) and Return– Historical and Ex-Ante; Diversification and Risk Reduction; Feasible and Optimal Portfolio – Efficient Frontier; Markowitz model (review of Lagrange multipliers for 1 and 2 constraints).

References

[1] David G. Luenberger; Investment Science; Oxford University Press, Delhi, 1998.

[2] John C. Hull; Options, Futures and Other Derivatives, 6th Ed.; Prentice-Hall India, Indian reprint, 2006.

[3] Sheldon Ross; An Elementary Introduction to Mathematical Finance, 2nd Ed, Cambridge University Press, USA, 2003.

[4] Chandra P., Investment Analysis and Portfolio Management; McGraw Hill Education, 5th Ed., 2017.

[5] Ales Cerny: Mathematical Techniques in Finance: Tools for incomplete markets, PrincetonUniversity Press, 2009.

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[7] Karatzas and S. Shreve, Method of Mathematical Finance, Springer, New York, 2016.

MATH-MD-IDC3-3-Th

Bio - Mathematics

Full marks: 75 (Theory: 50 and Tutorial: 25)
(45 classes)

Mathematical biology and the modelling process: What is a model? Essential features of a modelling approach, Identification of variables, parameters, constants for a model; type of models (linear-nonlinear and continuous – discrete).

Simple single-species continuous population growth models:
Malthus model (1798): deduction (basic assumptions), analytic solution, doubling time; behavior of population size as $t \to \infty$, Stability analysis of the steady states of the Malthus model; limitations.

Logistic model (Verhulst 1838): motivation (Gause's 1934 Experiments) and formulation (basic assumptions), analytic solution, behavior of population size as $t \to \infty$ for different initial population size, carrying capacity. Effects of harvesting in a single species population: Constant-yield harvesting, constant-effort harvesting.

One dimensional models, fixed points, stability analysis of fixed points, phase diagrams.
Non-dimensionalization and re-parametrization in a model: Necessity and applications.

Bifurcation: Saddle-node, transcritical and pitchfork bifurcations in one-dimensional case.

Insect outbreak model (Morris, 1963): The spruce budworm model – deduction (basic assumptions), analysis of steady states, presence of saddle-node bifurcation; real life applications.

Interacting populations: Predator-prey model (basic assumptions) and Lotka (1925)-Volterra (1926) model (basic assumptions) – deduction, Steady states.

Chemical Reaction Kinetics; Law of mass action; Enzymatic reaction;
Enzyme Kinetics; Elimination of variables – model reduction; Michaelis-Menten kinetics (proposed in 1913). Formulation of model (basic assumptions) and steady states.

Gene regulation networks: Introduction, basic assumptions, two dimensional model; Constitutive gene expression; Gene transcription regulation by activators; Gene transcription regulation by repressors; Regulation of gene transcription: auto-activation and auto-inhibition.

Epidemic models: Basic terminologies.
SI model (assumptions), Kermack-McKendrick SIR model 1927 (basic assumptions) assuming total population as constant, Formulation of the models. Concept of basic reproduction number.

Discrete single-species models: Linear models, growth models, decay models, discrete Logistic models.

Overview of nonlinear difference equations: Steady states and linear stability analysis, Graphical solution of difference equations – cobwebbing.

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.
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UNIVERSITY OF CALCUTTA

Notification No. CSR/51/2024

It is notified for information of all concerned that in terms of the provisions of Section 54 of the Calcutta University Act, 1979, (as amended), and, in the exercise of her powers under 9(6) of the said Act, the Vice-Chancellor has, by an order dated 26.07.2024 approved the syllabus for semester -3,4,5 of Mathematics (4-year Honours & Honours with Research) courses of studies under CCF and amendments in the syllabus of mathematics-3-year MDC, (as published under CSR/24/2023, dt. 10.08.2023).

The above shall take for Mathematics (4-year Honours & Honours with Research and 3-year MDC) courses of studies under CCF, which was introduced from the academic session 2023-2024.

01/8/2024

Prof.(Dr.) Debasis Das

Registrar

SENATE HOUSE

Kolkata-700073

01.08.2024

UNIVERSITY OF CALCUTTA

SYLLABUS
FOR
FOUR -YEAR (EIGHT-SEMESTER) HONOURS AND HONOURS WITH RESEARCH COURSE WITH MATHEMATICS MAJOR
UNDER CURRICULUM AND CREDIT FRAMEWORK

Syllabus in Detail for Semesters 3, 4 and 5

MATH-H-CC 3-3-TH
Real Analysis

Full Marks: 100 (Theory: 75 and Tutorial:25)

Group A
[Marks: 30][24 classes]

• Intuitive idea of real numbers. Mathematical operations and usual order of real numbers revisited with their properties (closure, commutative, associative, identity, inverse, distributive). Idea of countable sets, uncountable sets and uncountability of $\mathbb{R}$. Concept of bounded and unbounded sets in $\mathbb{R}$. L.U.B. (supremum), G.L.B. (infimum) of a set and their properties. L.U.B. axiom or order completeness axiom. Archimedean property of $\mathbb{R}$. Density of rational (and Irrational) numbers in $\mathbb{R}$.
• Intervals. Neighbourhood of a point. Interior point. Open set. Union, intersection of open sets. Limit point and isolated point of a set. Bolzano-Weierstrass theorem for sets. Existence of limit point of every uncountable set as a consequence of Bolzano-Weierstrass theorem. Derived set. Closed set (defined as Complement of open set). Union and intersection of closed sets as a consequence. No nonempty proper subset of $\mathbb{R}$ is both open and closed. Expressing an open set of $\mathbb{R}$ as countable union of disjoint open intervals (statement only). Dense set in $\mathbb{R}$ as a set having non-empty intersection with every open interval. $\mathbb{Q}$ and $\mathbb{R}\backslash\mathbb{Q}$ are dense in $\mathbb{R}$.

Group B
[Marks: 35][28 classes]

• Real sequence. Bounded sequence. Convergence and non-convergence. Examples. Boundedness of convergent sequence. Uniqueness of limit. Algebra of limits.
• Relation between the limit point of a set and the limit of a convergent sequence of distinct elements. Monotone sequences and their convergence. Sandwich rule. Nested interval theorem. Limit of some important sequences : $\left\{n^{\frac{1}{n}}\right\}_n$, $\{x^n\}_n$, $\left\{x^{1/n}\right\}_n$, $\{x_n\}_n$ with $\frac{x_{n+1}}{x_n} \to l$ and $|l| < 1$, $\left\{\left(1+\frac{1}{n}\right)^n\right\}_n$, $\left\{1+\frac{1}{1!}+\frac{1}{2!}+\cdots+\frac{1}{n!}\right\}_n$, $\{a^{x_n}\}_n$ $(a > 0)$. Cauchy's first and second limit theorems.
• Subsequence. Subsequential limits, lim sup as the L.U.B. and lim inf as the G.L.B of a set containing all the subsequential limits. Alternative definition of lim sup and lim inf of a sequence using inequality or as $lim\,sup\,x_n$ =

$\inf_n sup\{x_n, x_{n+1}, \ldots,\}$ and $lim\ inf\ x_n = \sup_n inf\{x_n, x_{n+1}, \ldots,\}$ [Equivalence between these definitions is assumed]. A bounded sequence $\{x_n\}_n$ is convergent if and only if $lim\ sup\ x_n = lim\ inf\ x_n$. Every sequence has a monotone subsequence. Bolzano-Weierstrass theorem for sequence. Cauchy sequence. Cauchy's general principle of Convergence.

Group C
[Marks: 10][8 classes]

• Infinite series, convergence and non-convergence of infinite series, Cauchy criterion, tests for convergence; comparison test, limit comparison test, ratio test, Cauchy's nth root test, Kummer's test (statement and problems), Raabe's test (statement and problems), Gauss test (statement and problems). Alternating series, Leibniz test. Absolute and conditional convergence, Riemann's rearrangement theorem (statement and problems).

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] G. G. Bilodeau, P. R. Thie, G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones & Bartlett, 2010.
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MATH-H-CC 4-3-TH
Ordinary Differential Equations – I
and Group Theory - I

Full Marks: 100 (Theory: 75 and Tutorial: 25)

Group A: Ordinary Differential Equations – I

[Marks: 45][36 classes]

- Formation of differential equations, order and degree of a differential equation, First order and first degree differential equations; Homogeneous and exact differential equations, conditions for an equation of the first order to be exact, Integrating factors, Rules for finding integrating factors, Linear equations and Bernoulli equations.

- First order higher degree differential equations solvable for *x*, *y* and *p*, Clairaut's forms. Singular solutions, Equations of tac-locus, nodal locus, cuspidal locus.

- Higher order linear and nonlinear equations, Concept of Wronskian and its properties, Complementary functions, Particular integrals, linear homogeneous and non-homogeneous equations with constant coefficients, Method of undetermined coefficients, Method of variation of parameters. Simultaneous linear differential equations.

- Higher order linear equations with variable coefficients reducible to linear equations with constant coefficients (Euler's equation), Condition for exactness of higher order linear equations, Integrating factors, Equations of the form $\frac{d^n y}{dx^n} = f(y)$ $(n \geq 2)$.

Group-B: Group Theory – I

[Marks: 30][24 classes]

- Definition of a group, examples of groups including permutation groups, dihedral groups and quaternion groups (through matrices), elementary properties of groups, examples of commutative and non-commutative groups. Subgroups and examples of subgroups, necessary and sufficient

condition for a nonempty subset of a group to be a subgroup, Normalizer, centralizer, center of a group, product of subgroups.

- Order of an element of a group, order of a group, cyclic group, properties of cyclic groups, classification of subgroups of cyclic groups, Permutation, cycle notation for permutations, properties of permutation, even and odd permutations, Alternating group, properties of cosets, Lagrange's theorem and consequences including Fermat's little theorem.

References

[1] S. Ahamad and A. Ambrosetti, A Textbook on Ordinary Differential Equations, Springer Verlag, 2015.

[2] W. E. Boyce and R.C. DiPrima, Elementary Differential Equations and BoundaryValue Problems, John Wiley & Sons, 2009.

[3] E. A. Coddington, An Introduction to Ordinary Differential Equations, Dover Publications, 1989.

[4] D. A. Murray, Introductory course in Differential Equations, Orient and Longman, 1967.

[5] H. T. H. Piaggio, An Elementary Treatise on Differential Equations and Their Applications, C. B. S. Publisher & Distributors, Delhi,1985.

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[16] J. J. Rotman, An Introduction to the Theory of Groups, 4th Ed., Springer Verlag, 1995.

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MATH-H-CC 5-4-TH
Theory of Real Functions

Full Marks: 100 (Theory: 75 and Tutorial: 25)

Group A : Limit and Continuity of Functions

[Marks: 45][36 classes]

• Limits of functions ($\epsilon - \delta$ approach), sequential criterion for limits. Cauchy's criterion of existence of limit (statement only). Limit theorems, one sided limits. Infinite limits and limits at infinity. Important limits like $\frac{\sin x}{x}$, $\frac{\log(1+x)}{x}$, $\frac{a^x-1}{x}$

(a > 0) as x → 0.

• Continuity of a function on an interval and at an isolated point. Sequential criteria for continuity. Concept of oscillation of a function at a point. A function is continuous at x if and only if its oscillation at x is zero. Familiarity with the figures of some well known functions: y = x^a (a = 2, 3, 1/2 , −1), |x|, [x], sin x, cos x, tan x, log x, e^x . Algebra of continuous functions as a consequence of algebra of limits. Continuity of composite functions. Examples of continuous functions. Continuity of a function at a point does not necessarily imply the continuity in some neighbourhood of that point.

• Bounded functions. Neighbourhood properties of continuous functions regarding boundedness and maintenance of same sign. Continuous function on a closed interval [a, b] is bounded and attains its bounds therein. Bolzano's theorem. Intermediate value theorem.

• Discontinuity of functions, type of discontinuity. Step functions. Piecewise continuity. Monotone functions. Monotone functions can have only jump discontinuity. Monotone functions can have at most countably many points of discontinuity. Monotone bijective function from an interval to an interval is continuous and its inverse is also continuous.

• Uniform continuity. Functions continuous on a closed and bounded interval is uniformly continuous. A necessary and sufficient condition under which a continuous function on a bounded open interval I will be uniformly continuous

on I. A sufficient condition under which a continuous function on an unbounded open interval I will be uniformly continuous on I (statement only). Lipschitz condition and uniform continuity.

Group B: Differentiability of Functions

[Marks: 30][24 classes]

• Darboux theorem, Rolle's theorem, Mean value theorems of Lagrange and Cauchy — as an application of Rolle's theorem. Taylor's theorem on closed and bounded interval with Lagrange's and Cauchy's form of remainder. Expansion of e^x, log(1+x), $(1+x)^m$, sin x, cos x with their range of validity (assuming relevant theorems). Application of Taylor's theorem to inequalities. Point of local extremum (maximum, minimum) of a function in an interval. Sufficient condition for the existence of a local maximum/minimum of a function at a point (statement only). Application of the principle of maximum/minimum in geometrical problems.

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MATH-H-CC 6-4-TH
Mechanics-I

Full Marks: 100 (Theory: 75 and Tutorial: 25)

Statics-I:

• Idea about Physical Independence Principle of Forces, Principle of transmissibility of a force, Principle of action and reaction and Principle of parallelogram law of forces, Composition and resolution of forces, Concurrent Forces in a plane, Composition and resolution of forces, Equilibrium of three forces acting at a point, Lami's theorem, Moment of a force about a point and an axis, Varignon's theorem, Resultant forces and resultant couple, Coplanar forces: Its reduction and conditions of equilibrium. [8 classes]

Particle Dynamics-I:

• Law of gravitation, Concept of inertial frame, Newton's laws of motion, Concept of equation of motion of a particle, Rectilinear motion in a given force field, Simple harmonic motion, damped and forced oscillations, Concept of resonance, motion of elastic strings, Rectilinear motion under uniform gravity, Rectilinear motion in a resisting medium where resistance is proportional to velocity. [18 classes]

• Work, power, energy, Conservative forces, Potential energy, Existence of potential energy function, Conservative field and Principle of conservation of energy. [6 classes]

• Impulse of a force, Impulsive force, Principle of conservation of linear momentum, Collision of elastic bodies: Coefficient of restitution, Newton's law of collision, Direct and oblique impact of a smooth sphere with a fixed plane, Direct and oblique impact of two smooth spheres. [8 classes]

• Motion of a particle in a plane (2D Cartesian): Angular velocity and angular acceleration, Expressions for components of velocity and acceleration, Tangential

and normal components of velocity and acceleration, Motion of a projectile in a resisting medium under gravity. Motion of a particle in a plane (2D Polar): Expressions for components of velocity and acceleration, Central forces and central orbits, Motion under inverse square law, Times of describing the arcs of central orbits for a particle moving under inverse square law, Kepler's laws on planetary motion, Motion of artificial satellites, Tangential and normal components of velocity and acceleration, Constrained motion of a particle on smooth curve. [20 classes]

References

[1] D. Chernilevski, E. Lavrova and V. Romanov, Mechanics for Engineers, MIR Publishers, 1984.

[2] F. Chorlton, Textbook of Dynamics, CBS Publishers, 2002 (2nd edition).

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MATH-H-CC 7-4-TH
Multivariate Calculus – I and Partial Differential Equations – I

Full Marks: 100 (Theory: 75 and Tutorial: 25)

Group A: Multivariate Calculus – I

[Marks: 60] [50 classes]

- Concept of neighbourhood of a point in $\mathbb{R}^n$ (n > 1), interior point, limit point, open sets and closed sets in $\mathbb{R}^n$ (n > 1).
- Functions from $\mathbb{R}^n$ (n > 1) to $\mathbb{R}$, limit and continuity of functions of two or more variables. Partial derivatives, related mean value theorem, sufficient condition for continuity. Differentiability, sufficient condition for differentiability.
- Directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes.
- Partial derivatives of higher order, sufficient condition for equality of mixed order partial derivatives (Schwarz's and Young's theorems), differentials of higher orders, total differential for function of functions, Chain rule for one and two independent parameters.
- Euler's theorem on homogeneous functions of two and three variables, change of variables – simple problems. Taylor's theorem of two variables.
- Implicit functions, statement of the existence theorem, derivative of implicit functions – simple problems. Jacobians – elementary properties (statements only) and simple problems.
- Extrema of functions of two variables, constrained optimization problems, method of Lagrangian multipliers for two variables.
- Multiple integral: Concept of upper sum, lower sum, upper integral, lower integral and double integral (no rigorous treatment is needed). Statement of existence theorem for continuous functions.
- Iterated or repeated integral, Statement of Fubini's theorem. Change of order of integration. Areas of plane regions.
- Triple integral. Cylindrical and spherical coordinates.
- Change of variables in double integrals and triple integrals. Transformation of double and triple integrals (problems only).
- Determination of volume and surface area by multiple integrals (problems only).
- Differentiation under the integral sign, Leibniz's rule (problems only).

Group B: Partial Differential Equations - I

[Marks: 15][10 classes]

- Definition, order and degree of PDE, classification of PDE (linear, quasilinear, semilinear and nonlinear), derivation of partial differential equations (by elimination of arbitrary constants / functions). Examples of PDEs that are central to the study of different problems in science and technology (e.g. Heat equation, Wave equation, Laplace equation, KDV equation).

- First order equations: Solution of quasilinear equations, Lagrange's method of solution. Cauchy problem for quasilinear PDE, The method of characteristics, method of characteristics for linear, semilinear equations; Solution via method of characteristics; Local existence and uniqueness theorem (statement and examples).

- Nonlinear first order partial differential equations, Charpit's general method of solution.

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MATH-H-CC 8-4-TH
Group Theory – II and Ring Theory – I

Full Marks: 100 (Theory: 75 and Tutorial: 25)

Group A : Group Theory- II
[Marks: 40] [32 classes]

• Normal subgroup and its properties. Quotient group. Group homomorphisms, properties of homomorphisms, correspondence theorem and one-one correspondence between the set of all normal subgroups of a group and the set of all congruences on that group, Cayley's theorem, properties of isomorphisms. First, Second and Third isomorphism theorems.

• Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinite cyclic groups, applications of factor groups to automorphism groups.

• External direct product and its properties, the group of units modulo n as an external direct product, internal direct product, converse of Lagrange's theorem for finite abelian group, Cauchy's theorem for finite abelian group.

Group B: Ring Theory- I
[Marks:35] [28 classes]

• Definition and examples of rings, properties of rings, subrings, necessary and sufficient condition for a nonempty subset of a ring to be a subring, integral domains and fields, subfield, necessary and sufficient condition for a nonempty subset of a field to be a subfield, characteristic of a ring. Ideal, ideal generated by a subset of a ring, factor rings, operations on ideals, prime and maximal ideals. Ring homomorphisms, properties of ring homomorphisms. First, Second and Third isomorphism theorems, Correspondence theorem, congruence on rings, one-one correspondence between the set of ideals and the set of all congruences on a ring.

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[1] D. S. Malik, J. M. Mordeson and M. K. Sen; Fundamentals of Abstract Algebra; McGraw-Hill, 1997.
[2] T. W. Hungerford; Algebra; Springer, 1980.
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MATH-H-CC 9-5-TH
Probability and Statistics

Full Marks: 100 (Theory: 75 and Tutorial: 25)

Group – A: Probability
[Marks: 45][35 classes]

• Random experiment, equally likely outcomes, Sample space, Events, σ-field, Probability as a set function, Probability axioms, Probability space;
Conditional probability, The multiplication rule, The law of total probability and Bayes' theorem; Independence of events and trials; Joint probability, Bernoulli trial and binomial law, Poisson approximation of binomial law;

• Real random variables (discrete and continuous), distribution function of a random variable, Properties of distribution function, Probability mass / density functions and properties;
Discrete distributions: Binomial, Poisson;
Continuous distributions: Uniform, Normal, Exponential;
Transformation of a random variable;
Mathematical expectation, Mean, Variance, Moments, Quantiles, Skewness, Kurtosis, Median, Mode;
Moment generating function, Characteristic function;

• Multivariate random variables, Joint distribution of discrete and continuous random variables and their properties, Joint probability mass / density functions, Marginal and Conditional distributions, Independent random variables;
Conditional expectations, Expectation of function of two random variables, Moments, Covariance, Correlation coefficient, linear regression for two variables, regression curves;
Bivariate normal distribution;
Distribution of the sums of independent discrete / continuous random variables, Product of two random variables;
Chi-square, t and F-distributions;

• Chebyshev's inequality, Convergence in Probability,
Statement of weak law of large numbers and strong law of large numbers;
Statement of Central limit theorem;
Statement of De Moivre Laplace limit theorem, Normal approximation of the binomial distribution;
Statement of Uniqueness theorem of Characteristic functions.

Group – B: Statistics
[Marks: 30][25 classes]

• Populations and Samples, Random Sample Sampling and Sampling Distributions,
Distribution of the sample, Simple random sampling with and without replacement, Sample Statistic,
Sample characteristics - Sample moments, Sample variance,
Sampling from the normal distributions;

• Estimation of parameters: Point estimation, Interval Estimation, Mean-squared error,
Properties of good estimators - unbiasedness, consistency, sufficiency,
Minimum-Variance Unbiased Estimator (MVUE), Unbiased estimators for expectation and variance;

• Method of Maximum likelihood: The maximum likelihood principle, Likelihood function and Loglikelihood function, Maximum likelihood estimators for discrete and continuous models, Properties of maximum likelihood estimators;

• Bivariate frequency Distribution: Bivariate data, Correlation and covariance, Linear Regression, principle of least squares and fitting of polynomials and exponential curves.

• Confidence intervals: General principle; Confidence intervals for the mean of Normal population-for known variance and unknown variance; Confidence interval for variance of Normal population;

• Statistical hypothesis: Simple and composite hypotheses, null hypotheses, alternative hypotheses, one sided and two-sided hypotheses, The critical region and test statistic, type I error and type II error, level of significance, Power function of a test, most powerful test, Neyman-Pearson lemma (Statement only), Likelihood-ratio tests;
Tests on the Mean of a Normal Distribution, Variance Known; Tests on the Mean of a Normal Distribution, Variance unknown; Tests on a Population Proportion, Chi-square test for goodness of fit.

References

[1] F. M. Dekking C. Kraaikamp, H. P. Lopuhaa, L. E. Meester, A Modern Introduction to Probability and Statistics-Understanding Why and How,

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MATH-H-CC 10-5-TH
Ring Theory - II and Linear Algebra - I

Full Marks: 100 (Theory: 75 and Tutorial: 25)

Group – A: Ring Theory - II
[Marks: 40][32 classes]

• Principal ideal domain, principal ideal ring, prime element, irreducible element, greatest common divisor (gcd), least common multiple (lcm), expression of gcd, examples of a ring R and a pair of elements a, b ∈ R such that gcd(a, b) does not exist, Euclidean domain, relation between Euclidean domain and principal ideal domain.
• Polynomial rings, division algorithm and consequences, factorization domain, unique factorization domain, irreducible and prime elements in a unique factorization domain, relation between principal ideal domain, unique factorization domain, factorization domain and integral domain, polynomial ring over unique factorization domain, Eisenstein criterion and unique factorization in Z[x].

• Ring embedding and quotient field, regular rings and their examples, properties of regular ring, ideals in regular rings.

Group –B: Linear Algebra - I
[Marks: 35][28 classes]

• Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces. Subspaces of $\mathbb{R}^n$. Dimension of subspaces of $\mathbb{R}^n$. Geometric significance of subspace up to $\mathbb{R}^3$. Four fundamental subspaces associated with a matrix. The dimension of the solution space of Ax = 0 and the rank of A. Full rank factorization, rank inequalities, Sylvester's inequality.

• Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, change of coordinate matrix. Algebra of linear transformations. Isomorphisms. Isomorphism theorems, invertibility and isomorphisms. Eigen values, eigen vectors and characteristic equation of a matrix (over C). Cayley-Hamilton theorem and its use in finding the inverse of a matrix.

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MATH-H-CC 11-5-TH
Riemann Integration and Series of Functions

Full Marks: 100 (Theory: 75 and Tutorial: 25)

Group – A: Riemann Integration
[Marks: 50][40 classes]

Riemann integration[32 classes]

• Partition of a closed and bounded interval and refinement of a partition. Upper Darboux sum U(P, f) and lower Darboux sum L(P, f) and associated results. Upper integral and lower integral. Darboux's theorem. Darboux's definition of integration over a closed and bounded interval. Riemann's definition of integrability. Equivalence with Darboux's definition of integrability (statement only). Necessary and sufficient condition for Riemann integrability.

• Concept of negligible set (or zero set) defined as a set covered by countable number of open intervals sum of whose lengths is arbitrary small. Examples of negligible sets: any subset of a negligible set, finite set, countable union of negligible sets. A bounded function on closed and bounded interval is Riemann integrable if and only if the set of points of discontinuity is negligible (Statement only). Example of Riemann integrable functions.

• Integrability of sum, scalar multiple, product, quotient, modulus of Riemann integrable functions. Properties of Riemann integrable functions arising from the above results.

• Function defined by definite integral $\int_a^x f(t)dt$ and its properties. Antiderivative (primitive or indefinite integral).

• Fundamental theorem of Integral Calculus. First Mean Value theorem of integral calculus. Weierstrass's & Bonnet's form of second mean value theorems (statement only).

Improper integral [8 classes]

• Range of integration, finite or infinite. Necessary and sufficient condition for convergence of improper integral in both cases. Cauchy's principal value of improper integral.

• Tests of convergence: Comparison and μ-test. Absolute and non-absolute convergence and inter-relations. Statement of Abel's and Dirichlet's test for convergence of the integral of product of two functions.

• Convergence and working knowledge of Beta and Gamma function and their interrelation (statement only) $\Gamma(n)\Gamma(1-n) = \frac{\pi}{\sin n\pi}$, $0 < n < 1$, to be assumed in computation of the integrals $\int_0^{\pi/2} sin^n x\, dx$, $\int_0^{\pi/2} \cos nx\ dx$, $\int_0^{\pi/2} tan^n x\, dx$, when they exist (using Beta and Gamma function).

Group B: Series of Functions
[Marks: 25][20 classes]

• Sequence of functions defined on a set, Pointwise and uniform convergence. Cauchy criterion of uniform convergence. Weirstrass's M-test. Boundedness, continuity, integrability and differentiability of the limit function of a sequence of functions in case of uniform convergence.

• Series of functions defined on a set, Pointwise and uniform convergence. Cauchy criterion of uniform convergence. Weierstrass's M-test. Passage to the limit term by term. Boundedness, continuity, integrability, differentiability of a series of functions in case of uniform convergence. Dini's theorem.

• Power series: Fundamental theorem of power series. Cauchy-Hadamard theorem. Determination of radius of convergence. Uniform and absolute convergence of power series. Properties of sum function. Differentiation and integration of power series. Abel's limit theorems. Uniqueness of power series having sum function.

• Fourier series: Trigonometric series. Statement of sufficient condition for a trigonometric series to be a Fourier series. Fourier coefficients for periodic functions defined on $[-\pi, \pi]$. Statement of Dirichlet's condition of convergence. Statement of Fourier's theorem on sum of Fourier series.

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[1] R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
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MATH-H-CC 12-5-TH
Mechanics-II

Full Marks: 100 (Theory: 75 and Tutorial: 25)

Statics-II:

• **Friction:** Laws of static friction, Limiting friction, Angle of friction and Cone of friction. Positions of equilibrium of a particle constrained to rest on a (i) rough plane curve and (ii) rough surface. [4 classes]

• **Virtual work:** Degrees of Freedom, Constraints, Virtual Displacement, Virtual Work, Workless Constraints, Forces which do not appear in the equation of virtual work, Forces which appear in the equation of virtual work, Principle of virtual work for any system of coplanar forces acting on a rigid body and deduction of conditions of equilibrium from the Principle of virtual work. [6 classes]

• **Stable and unstable equilibrium:** Field of forces, Conservative field, Potential energy of a system, Concepts of Stable, Unstable and Neutral equilibrium, Energy test of stability for a system having one degree of freedom, Stability when gravity is the only external force, Condition of stability of equilibrium of two heavy bodies resting one upon another, the bodies being rough enough to prevent sliding, [6 classes]

• **Arbitrary force system in three dimensions:** Axis of a couple, Resultant of any number of couples acting on a rigid body, Reduction of a system of forces acting on a rigid body, Equilibrium equations, Reduction to wrench intensity and pitch of a wrench, Poinsot's central axis, Equation of the central axis of a given system of forces, Invariants of a given system of forces. [6 classes]

Dynamics of a Particle-II:

• Stability of nearly circular orbits, Disturbed orbits, Motion of a particle on rough curve, Expressions for components of velocity and acceleration referred to a set

of rotating axes, Motion of a particle of varying mass including problems of mass addition (Rain-drop Problem) and mass reduction (Rocket Problem). [8 classes]

• **Dynamics of a system of particles:** General theorems (Emphasis should be given on theoretical discussion only in this part): Configuration of a mechanical system and its degrees of freedom, External forces, Internal forces and two assumptions connected with these forces, Mass of a system, Centre of mass of a system and its motion, Linear momentum of a system and principle of conservation of linear momentum, Angular momentum of a system about a point and an axis, Angular momentum principle about the centre of mass, Conservation of angular momentum about a point and an axis, Kinetic energy(K.E.) of a system, The energy principle and Conservation of energy. [4 classes]

Dynamics of rigid body:

• Vector angular velocity and its existence, particle velocities in a rigid body.

[2 classes]

• Moments and Products of Inertia, Moment of inertia of a body about any line through the origin of a coordinate frame, Radius of gyration, Equimomental systems, Principal axis and Momental ellipsoid, theorems of parallel and perpendicular axes (statements only). [4 classes]

• **General motion:** Deduction of the equations: $M\frac{d\vec{V}}{dx} = \vec{F}$, $\frac{d\overrightarrow{L_G}}{dx} = \overrightarrow{K_G}$ from linear and angular momentum principle, Deductions of equations of motions from D'Alembert's Principle, Independence of the motion of centre of inertia and the motion relative to the centre of inertia, Angular momentum of a rigid body and the kinetic energy of a rigid body rotating about a fixed axis, Motion of a rigid body about a fixed axis, Compound pendulum, Interchangeability of the point of suspension and centre of oscillation. [10 classes]

• **Motion of a rigid body in two dimensions:** Equations of motion of a rigid body in two dimensions in the form $M\frac{dV_x}{dx} = F_x$, $M\frac{dV_y}{dx} = F_y$, $I\frac{d\omega}{dx} = K_G$.

Expressions for K.E. and angular momentum about the origin, Condition of pure rolling and sliding. [6 classes]

• **Motion under impulsive forces:** Equation of motion for impulsive forces for two dimensions, Statements of the conservation of linear and angular momentum. Problems of impulse applied to a free rod and a rod constrained to rotate about a fixed axis. [4 classes]

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[1] D. Chernilevski, E. Lavrova and V. Romanov, Mechanics for Engineers, MIR Publishers, 1984.

[2] F. Chorlton, Textbook of Dynamics, CBS Publishers, 2002 (2nd Edition).

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UNIVERSITY OF CALCUTTA

AMENDMENT
IN
THE SYLLABUS
FOR
THREE -YEAR (SIX-SEMESTER) B.SC. COURSE
UNDER THE UNIVERSITY OF CALCUTTA

SEC Module Offered by Mathematics Department

NAMES OF SEC PAPER (Paper carries 4 credits or 100 marks)

SEMESTER	COURSE CODE	COURSE NAME	SYLLABUS
I	MATH-MD-SEC 1-1-Th	C Language with Mathematical Applications	Same as MATH-H-SEC 1-1-Th
II	MATH-MD-SEC 2-2-Th		
III	MATH-MD-SEC 3-3-Th		