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).

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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 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.

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[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.

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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

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[10] S. Timoshenko and D. H. Young, Engineering Mechanics, McGraw-Hill, 2017 (5th edition).

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.

References

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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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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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[1] D. S. Dummit and R. M. Foote; Abstract Algebra, 3rd Edition; Wiley, 2003.
[2] S. H. Friedberg, A. J. Insel and L. E. Spence and; Linear Algebra; Prentice Hall of India, 4th Edition, 2015.
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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.

References

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[3] B. S. Thomson, A. M. Bruckner and J. 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, 1969.
[6] R. Courant and F. John, Introduction to Calculus and Analysis, (Volumes I & II), Springer- Verlag, New York, Inc., 1998.

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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]

References

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[3] R. D. Gregory, Classical mechanics, Cambridge University Press, 2006.

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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		