

# University of Calcutta

Syllabus for three-year B.Sc. in Mathematics  
(General)

*Under*

**CBCS System**



**2018**

# 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
<i>Minimum number of classes required : 60</i>	
*1 Credit for Tutorial	
**15 Mark is reserved for Tutorial ***20 Mark is reserved for Internal Assessment & Attendance of 10 mark each	

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## 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 Descartes'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 on 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.

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## 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 : $65+15^{**}+20^{***}=100$
<i>Minimum number of classes required : 60</i>	
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### 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  $\epsilon$ . 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'Alembert'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 form 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 eigen-value 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] 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 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] to show it is an equivalence relation, to prove the following :  $a \equiv b \pmod{m}$  implies
  - (i)  $(a + c) \equiv (b + c) \pmod{m}$
  - (ii)  $ac \equiv bc \pmod{m}$
  - (iii)  $a^n \equiv b^n \pmod{m}$ , for any polynomial  $f(x)$  with integral coefficients  $f(a) \equiv f(b) \pmod{m}$  etc.Linear Congruence, to show how to solve these congruences, Chinese remainder theorem] Statement and proof and some applications. System of linear congruences, when solution exists] 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  $n = (a_k a_{k-1} \dots a_1 b)$  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] 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.

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## 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
<i>Minimum number of classes required : 60</i>	
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### 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)  $\mu$ -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 -  $\Delta$ ,  $\nabla$  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. in 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 point 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.

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## 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 : $65+15^{**}+20^{***}=100$
<i>Minimum number of classes required : 60</i>	
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### 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,  $2 \times 2$  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.

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