1 Foundation Courses

1.1 Bridge Mathematics, FN 102/MM 102

Name of the Academic Program: Foundation course for any program across the university other than for those offered by School of Mathematics and Statistics

Course Code: FN 102/MM 102

Title of the Course: Bridge Mathematics

L-T-P per week: 3-0-0

Credits: 3

Prerequisite Course/Knowledge (if any):
10th Standard Mathematics

Course Learning Outcomes (CLO's) (5 to 8)
After completion of this course successfully, the students will be able to

CLO-1: Prove the binomial theorem and apply it to find the expansions of any $(x + y)^n$ and also, solve the related problems

CLO-2: Find the various sequences and series and solve the problems related to them.

CLO-3: Explain the principle of counting and apply it to find the number of permutations and combinations in different cases.

CLO-4: Explain various trigonometric ratios and find them for different angles, including sum of the angles, multiple and submultiple angles, etc. Also, they can solve the problems using the transformations.

CLO-5: Find the limit and derivative of a function at a point, the definite and indefinite integral of a function.

CLO-6: Find the points of min/max of a function.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs) and Program Specific Outcomes (PSOs)

	PLOs						PSOs	
	1	2	3	4	5	6	1	2
CLO1	1	1	1	1	1	1	1	1
CLO2	2	1	1	2	2	1	2	1
CLO3	2	1	1	2	2	1	2	1
CLO4	1	1	1	1	1	1	2	1
CLO5	1	1	1	1	1	1	2	1
CLO6	2	1	1	1	1	1	2	2

Syllabus:

- **Unit I:** Algebra: Binomial theorem, General term, middle term, problems based on these concepts, sequences and series (Progressions). Fundamental principle of counting. Factorial n. Permutations and combinations, Derivation of formulae and their connections, simple applications, combinations with repetitions, arrangements within groups, formation of groups.
- **Unit II:** Trigonometry: Introduction to trigonometric ratios, proof of $\sin(A+B)$, $\cos(A+B)$, $\tan(A+B)$ formulae, multiple and sub multiple angles, $\sin(2A)$, $\cos(2A)$, $\tan(2A)$ etc., transformations - sum into product and product into sum formulae, inverse trigonometric functions, sine rule and cosine rule.
- **Unit III:** Calculus: Limits, standard formulae and problems, differentiation, first principle, uv rule, u/v rule, methods of differentiation, application of derivatives, integration - product rule and substitution method.

References / Reading Material :

1. NCERT class XI and XII text books.
2. Any State Board Mathematics text books of class XI and XII.

2 Core and Elective Courses

2.1 Math-I (Linear Algebra), MM 103

Name of the Academic Program: I.M.Sc. in Mathematics

Course Code: MM 103

Title of the Course: Math-I(Linear Algebra)

L-T-P per week: 3-0-0

Credits: 3

Prerequisite Course/Knowledge (if any): Nil

Course Learning Outcomes (CLO's) (5 to 8)
After completion of this course successfully, the students will be able to

CLO-1: Explain basics of matrices including definitions.

CLO-2: Solve numerical problems based on basics of matrices

CLO-3: Solve systems of linear equations using row reduced echelon matrices.

CLO-4: Define complex numbers, polar coordinates and triangle inequality

CLO-5: Apply principles of 2 dimensional geometry to solve simple problems

CLO-6: Apply principles of 3 dimensional geometry to solve simple problems

Mapping of CLOs with PLOs and PSOs.

	PLO						PSO	
	1	2	3	4	5	6	1	2
CLO1	3						1	1
CLO2	3						2	2
CLO3	3						2	2
CLO4	3						1	1
CLO5	3						3	3

Syllabus:

- **Unit I:** Basic concepts of matrices, multiplication of matrices by scalars, addition and multiplication of matrices, transpose, trace and determinant of a matrix, rank and inverse of a matrix, special matrices such as Hermitian, Unitary matrices.
- **Unit II:** System of linear equations, solution by Cramer's rule, row reduced Echelon matrices, existence and general properties of solutions, eigenvalues, eigenvectors, diagonalisation of matrices, functions of matrices and Cayley- Hamilton theorem.
- **Unit III:** Algebra of complex numbers, polar form, Argand diagram, triangle inequality. Addition of vectors, dot product, cross product and their geometric interpretation, triple product, area and volume in terms of vector products.
- **Unit IV:** Coordinate system, distance formula, section formula, area of triangle, straight lines, angle between two lines, concurrent lines, distance between two lines, conic sections.
- **Unit V:** Cartesian coordinates in 3-D, distance between points, direction cosines, direction ratios and their properties, equation of a plane using given data, equation of a straight line in different forms, image of a point with respect to a plane, distance between a point and a plane along a straight line, equation of a circle, sphere.

References / Reading Material :

1. Linear Algebra, Kenneth Hoffman and Ray Kunze, Pearson, 1971.
2. Linear Algebra : A geometric approach, S. Kumaresan, Prentice Hall of India, 2004.
3. Calculus and Analytic Geometry, George Thomas and Ross Finney, Addition Wesley, 1965.

Course Plan

S.No.	Sessions	Topics	Course Learning Outcomes
1.	10	Units-I, II	Students are able to find the rank of the given matrix. They can compute the inverse of the square matrices (of small sizes) of full rank. They can solve a system of linear equations. They can find the eigenvalues, eigenvectors of given square matrix. Moreover students can diagonalize the given diagonalizable matrix of small size. Students can discuss the solvability of a given system of linear equations. They are able to solve the system whenever it admits a solution.
3.	10	Unit-III	Students are able to apply the properties of the cross product and dot products to solve problems.
4.	12	Unit-IV	The students are able to apply the formulae that they learn to solve problems in the 2-D co-ordinate geometry.
5.	13	Unit-V	Students are able to apply the formulae that they learn to solve problems in the 3-D co-ordinate geometry.

2.2 Math-II (Multivariable Calculus), MM 152

Name of the Academic Program: I.M.Sc. in Mathematics

Course Code: MM 152

Title of the Course: Math-II (Multi variable Calculus)

L-T-P per week: 3-0-0

Credits: 3

Prerequisite Course/Knowledge (if any):

Students should know how to calculate the derivative and the integration of real-valued continuous functions over subsets of real-line.

Course Learning Outcomes (CLO's) (5 to 8)
After completion of this course successfully, the students will be able to

CLO-1: Calculate integration of functions by substitution, by partial fractions and by parts.

CLO-2: Apply basic properties of definite integrals to calculate definite integrals.

CLO-3: Define spherical and cylindrical co-ordinate systems.

CLO-4: Calculate the double integral over a rectangle and a region.

CLO-5: Calculate triple integrals, applying change of order of integration.

CLO-6: Define change of variables and Jacobian.

CLO-7: Parameterize curves and surfaces to find line integrals and surface integrals respectively.

CLO-8: Apply Green's theorem to find line integrals, Stokes' theorem to find surface integrals and Gauss' theorem to find volume integral.

Mapping of CLOs with PLOs and PSOs.

	PLO						PSO	
	1	2	3	4	5	6	1	2
CLO1	1		1	1		1	1	
CLO2	1							
CLO3	1					1		
CLO4	1	1		1				
CLO5	2	1		1	1		1	
CLO6	1		1					
CLO7	2	1	1	1	1	1	1	
CLO8	2	1	2	1	2	1	1	

Syllabus:

- **Unit I: (Integration):** To resolve a proper fraction $P(x)/Q(x)$ into its simplest set of partial fractions. Integration of functions by substitution, by partial fractions, by parts etc. Definite integrals, basic properties of definite integrals and evaluation of definite integrals.
- **Unit II**:**(Double and triple integrals):** Brief introduction to co-ordinate systems - spherical and cylindrical systems. Double integral over a rectangle, double integral over a region, change of order of integration. Triple integral.
- **Unit III**:**(Differential operators):** Change of variables and Jacobian. Vector fields, gradient, divergence, curl, vector calculus identities.
- **Unit IV**:**(Line integrals):** parametric curves, line integrals, path dependence, fundamental theorems of line integrals, conservative fields.
- **Unit V**:**(Theorems of Green, Gauss and Stokes):** Application of Greens theorem in 2-D, parametric surfaces, surface of revolution, surface integrals, applications of Stokes theorem and Gauss divergence theorem, Green's identities.

References / Reading Material :

1. Apostol, Tom M., *Calculus. Vol. II: Multi-variable Calculus and Linear Algebra, with Applications to Differential Equations and Probability*, second edition, Blaisdell Publishing Co. Ginn and Co., Waltham, Mass.-Toronto, Ont.-London, **1969**.

2. Grewal, B. S., *Higher Engineering Mathematics*, Khanna Publications, **2001**.

3. Thomas George and Finney Ross, *Calculus and Analytic Geometry,*Addition Wesley, **1995**.

Course Plan

S.No.	Sessions	Topics	Course Learning Outcomes
1.	10	Unit-I	Students are able to compute the definite and indefinite integrals using various techniques discussed in the course.
2.	20	Units-II,III	Students are able to compute multiple integrals.
3.	20	Units-IV, V	Students are able to compute line, surface and volume integrals.

2.3 Math-IIIA (Ordinary Differential Equations), MM 202

Name of the Academic Program: I.M.Sc. in Mathematics

Course Code: MM 202

Title of the Course: Math-IIIA (Ordinary Differential Equations)

L-T-P per week: 3-0-0

Credits: 3

Prerequisite Course/Knowledge (if any): Calculus

Course Learning Outcomes (CLO's) (5 to 8)
After completion of this course successfully, the students will be able to

CLO-1: Explain the genesis of ordinary differential equations.

CLO-2: Apply various techniques of getting exact solutions of solvable first order differential equations and linear differential equations of higher order.

CLO-3: Apply Picard's method of obtaining successive approximations of solutions of first order differential equations, passing through a given point in the plane and Power series method for higher order linear equations, especially in cases when there is no method available to solve such equations.

CLO-4: Explain the concept of a general solution of a linear differential equation of an arbitrary order and apply a few methods to obtain the general solution of such equations.

CLO-5: Explain the Laplace transforms and Fourier series and their applications.

Mapping of CLOs with PLOs and PSOs.

	PLO						PSO	
	1	2	3	4	5	6	1	2
CLO1	2						3	3
CLO2		3					3	3
CLO3		3					3	3
CLO4				3		2	3	3
CLO5	3						3	3

Syllabus:

- **Unit I:** First order differential equations : Order and degree of a differential equation, first order equations: variables separable method, homogeneous equations of degree zero, non-homogeneous equations, exact equations, integrating factor, linear equations, Bernoulli's equation.
- **Unit II:** First order higher degree equations : solvable for x, y and p. Clairaut's form and singular solutions. Picard's method of successive approximations and the statement of Picard's theorem for the existence and uniqueness of the solutions of the first order differential equations.
- **Unit III:** Higher order homogeneous linear equations with constant coefficients, second order homogeneous linear equation with variable coefficients, variation of parameters, 2×2 autonomous system of equations, power series solution, meaning of existence and uniqueness of a solution and some counter examples.
- **Unit IV:** Laplace Transform : Definition, L.T. of some elementary functions, effect of L.T. on translation, scaling, convolution. Inverse Laplace transform, applications of L.T. to ODE.
- **Unit V:** Fourier series : Fourier series of a periodic function, half range Fourier series.
- **Unit VI:** Sets, relations and functions : Sets, relations, equivalence, partial ordered relations, mathematical induction, elements of mathematical logic.

References / Reading Material :

1. Advanced Engineering Mathematics, Erwin Kreyszig, Wiley and Sons, 2011.
2. Differential equations with applications and historical notes, George F. Simmons, McGraw Hill Inc, 1972.
3. Elementary Differential Equations, William E. Boyce (Author), Richard C. DiPrima, Wiley and Sons,2012.
4. Elementary Differential Equations, William E. Boyce (Author), Richard C. DiPrima, Wiley and Sons,2012.
5. Daniel A. Murray (2003). Introductory Course in Differential Equations, Orient.

Course Plan

S.No.	Sessions	Topics	Course Learning Outcomes
1.	5	Unit-I	Students are able to solve first order ODEs using various methods discussed in the course.
2.	5	Unit-II	Students are able to find solutions of first order nonlinear ODEs with special structure. They can compute Picard sequences of approximations corresponding to the initial value problems.
3.	10	Unit-III	Students are able to solve second order linear ODEs and system of ODEs with constant coefficients using various methods discussed in the course.
4.	10	Unit-IV	Students are able to compute the Laplace transforms and the inverse Laplace transforms of functions.
5.	5	Unit-V	Students are able to express functions as a trigonometric series.
6.	5	Unit-VI	Students are able to solve problems involving different types of relations and use the principle of mathematical induction to prove mathematical statements.

2.4 Math-IIIB (Introductory Probability and Statistics), MM 203

Course Code: (MM 203): IMSc in Mathematical Sciences

Title of the Course: Math-IIIB (Introductory Probability and Statistics)

L-T-P per week: 3-0-0

Credits: 3

Course Overview: This course introduces the notion of Uncertainty and Randomness, Probability & Random variables and Basic Data Analysis. Students in this course will learn several univariate discrete and continuous random variables and its properties. This course also introduces the ideas of Statistical Inference and its importance in real world applications.

Pre-requisite Course/Knowledge (if any): Basic Mathematics at High School Level

Course Learning Outcomes (CLO's)
After completion of this course successfully, the students will be able to

CLO-1: Identify uncertainty in Nature, other phenomena and processes.

CLO-2: Recognize different random variables in Nature and other phenomena and identify parameters.

CLO-3: Write the sample space for any random experiment.

CLO-4: Determine probabilities of events and probability distributions of random variables.

CLO-5: Determine moments of widely known distributions.

CLO-6: Determine what all data can tell about the data and when anything 'more' can be said, based on the data.

CLO-7 Identify the concept of statistical inference: parameter, statistic, estimator, estimate and pivotal quantity.

Syllabus

Unit I: Random experiments, sample spaces, events, probability measure on events definition, properties, examples. Conditional probability-definition, properties, examples, Bayes theorem, independent events.

Unit II: Definition of random variables, standard discrete and continuous random variables -viz. Bernoulli, Binomial, Geometric, Poisson, Exponential, Gamma, Normal. Expectation, variance, other properties.

Unit III: Definition of bivariate random variables, joint distributions, covariance and correlation between two random variables, independence, distributions of sums.

Unit IV: Data collection methods, types of data, graphical summaries of data, numerical summaries of univariate data, bivariate summaries, measures of association.

Unit V: Introduction to statistical inference, population parameters, variable(s) of interest, statistic, estimators as random variables.

References / Reading Material :

1. Ross, S., A First Course in Probability, sixth edition, Pearson Education, 2007.
2. Ramachandran, K.M. and Tsokos, C.P., Mathematical Statistics with Applications, Academic Press, 2009.
3. Daniels, W.W., Biostatistics: a foundation for analysis in the health sciences, 9th edition, John Wiley & Sons, 2008.
4. Moore, D.S., The Basic Practice of Statistics, W.H. Freeman, 2003.

2.5 Math-IVA (Analysis), MM 253

Name of the Academic Program: I.M.Sc. in Mathematics

Course Code: MM 253

Title of the Course: Math-IVA (Analysis)

L-T-P per week: 4-0-0

Credits: 4

Prerequisite Course/Knowledge (if any):

First year Maths courses at CIS

Course Learning Outcomes (CLO's) (5 to 8)
After completion of this course successfully, the students will be able to

CLO-1: Explain basics of sequences,various types of them and learn epsilon-delta language and prove some basic theorems

CLO-2: Explain the concept of continuous functions with examples and some basic theorems.

CLO-3: Explain differentiability of a function at a point, several examples and basic theorems

CLO-4: Explain integrable functions with examples and some theorems and statement of fundamental theorem of calculus

CLO-5: Apply sequences and integration to study infinite series rigorously

Mapping of CLOs with PLOs and PSOs.

	PLO						PSO	
	1	2	3	4	5	6	1	2
CLO1	3	3		3	3	3	2	2
CLO2	3	3		3	3	3	2	2
CLO3	3	3		3	3	3	3	3
CLO4	3	3		3	3	3	3	3
CLO5	3	3		3	3	3	3	3

Syllabus:

- **Unit I:** Rational numbers, real numbers, sequences, subsequences, monotonicity, boundedness, convergence, limit of a sequence, Cauchy criterion, Bolzano- Weierstrass theorem.
- **Unit II:** Limit of a function, Continuity - both sequential and epsilon-delta definitions, examples of continuous functions, intermediate value theorem.
- **Unit III:** Differentiation, chain rule, mean value theorems and applications, Taylor's theorem, L'Hospital's rule, maxima-minima problems.
- Unit-IV: Integration, Riemann's original definition, statement of fundamental theorem of calculus.
- **Unit V:** Rigorous definition of convergence of infinite series, application of integration to summability of series.

References / Reading Material :

1. R.G. Bartle and D.R. Sherbert, Introduction to Real Analysis, Wiley and Sons, 2011.
2. Ajit Kumar and S. Kumaresan, A Basic Course in Real Analysis, Chapman and Hal, 2014.
3. Richard R. Goldberg, Methods of Real Analysis, Wiley and Sons, 1976.
4. Tom M. Apostol, Mathematical Analysis, Pearson, 1974.

Course Plan

S.No.	Sessions	Topics	Course Learning Outcomes
1.	5	Unit-I	Students will study sequences and apply them to solve problems.
2.	10	Unit-II	Students will study continuous functions and apply them to solve problems.
3.	10	Unit-III	Students will study differentiable functions and apply them to solve problems
4.	5	Unit-IV	Students will study integrable functions and apply them to solve problems.
5.	10	Unit-V	Students will study series and solve problems

2.6 Math-IVB (Algebra), MM 254

Name of the Academic Program: I.M.Sc. in Mathematics

Course Code: MM 254

Title of the Course: Math- IVB (Algebra)

L-T-P per week: 4-0-0

Credits: 4

Prerequisite Course/Knowledge (if any):

First year Maths courses at CIS

Course Learning Outcomes (CLO's) (5 to 8)
After completion of this course successfully, the students will be able to

CLO-1: Explain the most important concept- relations in all detail, revisit induction and explain a bit of mathematical logic

CLO-2: Explain the concept of a group with several examples , thereby getting into basic concepts of abstract Maths,

CLO-3: Discuss what kind of maps are useful in the study of groups, the important concept of isomorphism between groups and explain proofs of basic theorems in groups.

CLO-4: Define vector space and explain the important concept of a basis via spanning sets and linearly independent sets.

CLO-5: Explain linear transformations between vector spaces, in particular all about finite dimensional vector spaces, connection between matrices and linear maps and solve the related problems

Mapping of CLOs with PLOs and PSOs.

	PLO						PSO	
	1	2	3	4	5	6	1	2
CLO1	3	3	3		3	3	1	1
CLO2	3	3	3		3	3	2	2
CLO3	3	3	3		3	3	2	2
CLO4	3	3	3		3	3	1	1
CLO5	3	3	3		3	3	2	2

Syllabus:

- **Unit I:** Sets, Relations, equivalence relations, partial order, mathematical induction, elements of mathematical logic.
- **Unit II:** Groups, examples, subgroups, order of an element in a group, cyclic groups, normal subgroups, permutation groups, quotient groups.
- **Unit III:** Group homomorphisms, isomorphisms, fundamental theorem of group homomorphisms and applications.
- **Unit IV:** Vector space, examples, subspaces, spanning set, linear dependence, linear independence, basis, dimension, sum of two subspaces.
- **Unit V:** Linear transformations, isomorphism, finite dimensional vector spaces are isomorphic to $\mathbb{R}^n$, rank- nullity theorem, dimension of quotient spaces, matrix of a linear transformation with examples.

References / Reading Material :

1. Contemporary Algebra, Joseph Gallian, Cengage 2012.
2. Topics in Algebra, I.N.Herstein, Wiley and Sons, 1975.
3. Linear Algebra, Kenneth Hoffman and Ray Kunze, Pearson, 1971.
4. Linear Algebra : A geometric approach, S. Kumaresan, Prentice hall of India, 2004.

Course Plan

S.No.	Sessions	Topics	Course Learning Outcomes
1.	5	Unit-1	Students will learn logic and relations and apply them to solve problems.
2	10	Unit-2	Students will learn basics of groups and apply them to solve problems.
3	10	Unit-3	Students will study maps between groups and apply them to solve problems.
4	10	Unit-4	Students will study basics of Linear algebra and apply them to solve problems.
5	5	Unit-5	Students will study basics of linear maps and apply them to solve problems.