B.Sc.(H) Mathematics

2019-20

SCHEME OF B.Sc. (HONS) MATHS 2019-22

Sem	Course 1	Course 2	Course 3	Course 4	Course 5	Course 6	GP	Cont hrs	Credits
I	MAL 101 Calculus and Geometry 3-1-0(4)	MAL 103 Intro to Probability 3-1-0(4)	MAL 105 Algebra I 3-1-0(4)	CLL 101 Effective Comm.-I 1-0-2 (2)	CHL100 EVS 3-0-0 (3)	Foreign Language Elective (1-2-0)3	MAR 100 (1)	21	21
II	MAL 102 Analysis I 3-1-0(4)	MAL 104 Differential Equations I 3-1-0(4)	MAL 108 Algebra II 3-1-0(4)	SML 150 Leadership 2-1-0(3)	CLL 102 Effective Comm.-II 1-0-2 (2)	CLL 120 Human Values (2-0-0)2	MAR 110 (1)	20	20
III	MAL 201 Analysis II 3-1-0(4)	MAL 203 Differential Equations II 3-1-0(4)	MAL 205 Algebra III (3-1-0) 4	MAL 207 Operations Research (3-1-0) 4	Open Elective I 3 (3)		MAR 200 (1)	19	20
IV	SML300 Entrepreneurship 2-1-0 (3)	MAL 206 Mathematical Statistics 3-1-0(4)	MAL 308 Linear Algebra (3-1-0) 4	Prog.Elective II 3-0-2 (4) *(Image Processing./ DBMS. / Data Visual.Tech.)*	Prog. Elective I 3-0-2 (4) *(Lin. Prog/ Math. Modelling/ Data Struc.Algos*	Open Elective II 3 (3)	MAR 210 (1)	24	23
V	MAL 321 Mathematical Methods 3-1-0(4)	MAL 310 Numerical Analysis 2-1-2 (4)	MAL301 Data Analysis (3-0-2) 4	Prog.Elective III (MOOC) 3-0-2 (4) *(Mechanics/ Statis. Modeling./ Number theory)*	Open Elective III 3 (3)		MAR 300 (1)	22	20
VI	MAL 311 Intro. to Complex Analysis 3-1-0(4)	MAL 313 Integral & Vector Calculus 3-1-0(4)	Prog. Elective IV (MOOC) 3-0-2 (4) *(Financial Maths/ Metric Space./ Predictive Analytics*	Open Elective IV 3 (3)	**Project (0-0-6)3**	Creativity and innovation outcome **(1)** MAL 320	MAR 310 (1)	16	20
	Total							122	124

The Overall credits structure of BSc (Hons) Mathematics

Credits Structure	
Category	Credits
Program Core (PC)	68
Program Electives (PE)	16
Open Electives (OE)	12
Ability Enhancement Courses (AEC)	18
General Proficiency	6
Project based learning	4
TOTAL	**124**

A.   Program Core (PC)

SN	Code	Course Name	L-T-P	Credits
1	MAL 101	Calculus and Geometry	3-1-0	4
2	MAL 103	Introduction to Probability	3-1-0	4
3	MAL 105	Algebra I	3-1-0	4
4	MAL 102	Analysis I	3-1-0	4
5	MAL 104	Differential Equations I	3-1-0	4
6	MAL 108	Algebra II	3-1-0	4
7	MAL 201	Analysis II	3-1-0	4
8	MAL 203	Differential Equations II	3-1-0	4
9	MAL 205	Algebra III	3-1-0	4
10	MAL 206	Mathematical Statistics	3-1-0	4
11	MAL 208	Linear Algebra	3-1-0	4
12	MAL 321	Mathematical Methods	3-1-0	4
13	MAL 310	Numerical Analysis	3-0-2	4
14	MAL 301	Data Analysis	3-0-2	4
15	MAL 311	Intro. Complex Analysis	3-1-0	4
16	MAL 313	Integral and Vector Calculus	3-1-0	4
17	MAL 207	Operations Research	3-1-0	4
		Total Credits		**68**

B.   Program Electives (PE)

PE-I			
MAL303	Linear Programming and Its Applications	3-0-2	4
MAL317	Mathematical Modeling	3-0-2	4
CSL 209	Data Structures and Algorithms	3-0-2	4
PE-II			
MAL318	Image processing	3-0-2	4
CSL214	DBMS	3-0-2	4
MAL 340	Data Visualization Techniques	3-0-2	4
PE-III			
MAL 302	Mechanics	3-0-2	4
MAL 308	Number Theory	3-0-2	4
MAL 200	Statistical Modeling	3-0-2	4
PE-IV			
MAL 319	Metric Spaces	3-0-2	4
MAL 315	Financial Mathematics	3-0-2	4
MAL320	Predictive Analytics	3-0-2	4

C. Ability Enhancement Courses (AEC) L-T-P C

CLL101	Effective Communication – I	1-0-2	2
CLL102	Effective Communication – II	1-0-2	2
CLL120	Human Values	2-0-0	2
SML 300	Entrepreneurship	2-1-0	3
SML 250	Leadership	2-1-0	3
ASL 140	Environmental Sciences	3-0-0	3
	Foreign Language Elective	2-0-2	3
	Total Credits		18

D. Project

MAD 300	Project	0-0-6	**3**
MAL320	Creativity and innovation outcome		**1**

Outline of Choice based credit system (CBCS):

1. **Program Core:** A course, which should compulsorily be studied by a student as a core requirement is termed as a program core course.
2. **Program Elective:** Elective courses may be offered by the main discipline/subject of study is referred to as Program Elective. The University may also offer Program related elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).
3. **Generic (or Open) Elective:** An elective course generally chosen from an unrelated discipline/subject, with an intension to seek exposure is called a Generic (or Open) Elective.

4. **Ability Enhancement Courses (AEC):** These are the courses based upon the content that leads to knowledge enhancement. They are (i) Environmental Studies, (ii) English/Communication courses.

5. **Project/Dissertation:** The Project work/ Dissertation based on application of Mathematics knowledge in exploring/solving/analyzing a real world problem.

Short Syllabus for BSc (H) MATHEMATICS Courses (w. e. f. 2019-20)

MAL 101 Calculus and Geometry (3-1-0 = 4 Credits)

Differential Calculus: Successive differentiation and Leibnitz theorem, limit, continuity, properties of continuous functions, differentiability, chain rule of differentiation, mean value theorems, Taylor's and Maclaurin's theorems, application of differential calculus in curve sketching, Integral Calculus: Reduction formulae, 3-D geometry.

CO 1 To determine limit and continuity of the function.

CO 2 To estimate remainders of Taylro

CO 3 To sketch curves.

MAL 103 Introduction to Probability (3-1-0 = 4 Credits)

Random experiment, elementary properties of probability, Random Variables: Concept, cumulative distribution function, discrete random variable: Bernoulli random variable, binomial random variable, geometric random variable, Poisson random variable. Continuous random variable: Uniform random variable, exponential random variable, gamma random variable, normal random variable, Chebychev's inequality, conditional probability and conditional expectations.

The lab classes will be devoted to introduction to software for data analysis using spread sheets and other visualization tools.

CO 1 Students will able to understand the uses of different measures of central tendencies and dispersion.

CO 2 Students will able to understand the concept and applications of probability methods in modern science.

CO 3 Students will able to understand and apply the concept of Random Variable and Distribution Functions.

CO 4 Students will able to apply the knowledge the various probability distributions in practical applications.

MAL105 Algebra I (3-1-0 = 4 Credits)

Matrix algebra: Introduction, inverse of a matrix, rank of a matrix, application of matrices to the system of linear equations. De Moiver's theorem and its applications, complex roots of unity, fundamental theorem of algebra, Descarte's rule of signs, relation between roots and coefficients for any polynomial equation. Algebra: Definition of a group with examples and simple properties.

CO 1 1. Students will be able to solve system of equations using matrix theory. 2. After studying eigen values and eigen vectors, students will present solutions to problems in other fields of Science and Technolofy effectively. 3.Learn basics of matrix theory which is a prerequisite for many advanced level courses.

CO 2 Students will be able to 1. Analyse quantitative data verbally, graphically and numerically. 2 Integrate technology into mathematical process.

CO 3 Students will be able to 1. Demonstrate knowledge of basic concepts such as sets , relations and functions . 2. As the advanced theory of Groups will be studied in Algebra II course, this course only prepares the background of group theory for the students.

MAL 102 Analysis I (3-1-0 = 4 Credits)

The algebraic and order properties of R, supremum and infimum, open sets, closed sets, limit points of a set, isolated points, closure, complements, nested intervals, Cantor intersection theorem, uncountability of R, Sequences and Infinite series, Limits of functions, continuous functions, sequential criterion for continuity, discontinuity criterion, Dirichlet's nowhere continuous function, combinations of continuous functions and compositions of continuous functions, Bolzano's intermediate value theorem, Uniform continuity, differentiation, derivative, combinations of differentiable functions, derivative of inverse functions. Interior extremum theorem, Caratheodory theorem, Darboux's theorem, Rolle's theorem, Cauchy's mean value theorem, Taylor's theorem with Lagrange and Cauchy form of remainders, binomial series theorem.

CO 1 Students will be able to describe the real line as a complete ordered field and to determine the basic topological properties of subsets of the real numbers

CO 2 To understand the concept of sequences and series of real numbers and their convergence.

CO 3 To understand the concept of limit and continuity for functions and to explain discontinuity criterion, combinations and compositions of continuous functions

CO 4 To apply the knowledge of continuity to various important theorems. To understand the idea of uniform continuity and various theorems based on differentiability of functions.

MAL 104 Differential Equations I (3-1-0 = 4 Credits)

Ordinary differential equations of first order, Exact differential Equation, First order higher degree equations solvable for x, y, p, Singular solution and envelopes, Linear differential equations with constant and variable coefficients, Cauchy-Euler equations, Method of variation of parameters, Series solutions of differential equations, Bessel and Legendre equations, Picard's iterative method, Problem of existence and uniqueness.

CO 1 Students should be able to form differential equations for different mathematical and physical situations.

CO 2 Categorize the variety of differential equations and solve them using appropriate method.

CO 3 Ability to solve Cauchy–Eulers equations

CO 4 To understand orthogonal trajectories and singular solutions

CO 5 Towards the end of the unit, students should be able to: Form differential equations for different mathematical and physical situations and their existence

CO 6 Obtain power series solution of differential equation near ordinary and singular point.

CO 7 Able to solve Bessel's and Legendre's equations, understand their different recurrence formulae

.MAL 108 Algebra II (3-1-0 = 4 Credits)

Subgroup, cyclic groups, Permutations, product of two subgroups, external direct product of finite number of groups, normal subgroups, factor groups, commutatorsubgroup.Homomorphisms, Cayley's theorem, Isomorphisms, Isomorphism theorems I, II and III, Automorphisms.

CO 1 Students will write precise and accurate mathematical definitions of objects in ring theory.

CO 2 Students will understand the relevance of prime ideals, maximal ideals and principal ideals.

CO 3 Students will understand polynomial rings and their use to construct field extensions.

MAL 201 Analysis II (3-1-0 = 4 Credits)

Taylor series, Maclaurin series, expansions of exponential, logarithmic and trigonometric functions, Riemann integral, Riemann sum, Riemann integrability for continuous functions, monotonic functions and functions with finite number of discontinuities, the fundamental theorem of Calculus. Series of functions, Weierstrass M- test, pointwise and uniform convergence of sequence of functions, uniform norm, uniform

convergence and continuity, Improper integrals, convergence of improper integrals, Abel's and Dirichlet's tests for improper integrals.

CO 1 To appreciate and understand the concept of Taylor series and Maclaurin series

CO 2 To explain the series expansion

CO 3 To apply and understand the concept of Riemann integral

CO 4 To explain the concept of uniform convergence

CO 5 To understand and apply improper integral

MAL 203 Differential Equations II(3-1-0 = 4 Credits)

Linear partial differential equations of first order, Non-linear partial differential equations of first order, Charpit's method, Linear partial differential equations of second and higher order, Monge's method, Solution of one and two dimensional heat and wave equations using method of separation of variables.

CO1. Possible usefulness of this course after its completion i.e. how this course will be practically useful to him once it is completed

MAL 205 Algebra III (3-1-0 = 4 Credits)

Rings, Integral Domains and Fields.Prime and maximal ideals.Fields of quotients of an integral domain.Principal ideal domains. Polynomial Rings, Division algorithm. Euclidean Rings, The ring Z[i].

CO 1 Students will write precise and accurate mathematical definitions of objects in ring theory.

CO 2 Students will understand the relevance of prime ideals, maximal ideals and principal ideals.

CO 3 Students will understand polynomial rings and their use to construct field extensions.

MAL 206 Mathematical Statistics (3-1-0 = 4 Credits)

Sampling Distributions, Introduction to Statistics with examples of its use, Graphical representation of data, Basic distributions, properties, fitting, and their uses, Distribution theory for transformations of random vectors, Sampling distributions based on normal populations- t, chi-square and F distributions. Moment generating function, Estimation, Sampling Distribution and Hypothesis testing.

CO 1 To Graphically represent data

CO 2 To Summarize data in terms of measures of central tendency, variation and basic frequency distribution.

 CO 3 To know basics of combinatorial probability and fit various discrete and continuous distribution to provided frequency data

CO 4 To determine the measure of linear association between two variables and predict one from another

CO5 To derive sampling distributions of discrete (Binomial and Poisson) and Continuous (Normal)

CO6 To estimate population characteristics from sample statistic and test the significance of sample statistics

MAL 208 Linear Algebra (3-1-0 = 4 Credits)

Vector spaces, Finite dimensional vector spaces, Linear transformations and their matrix representations. Algebra of linear transformations (LT), Change of basis, Eigenvalues and eigenvectors of LT. Cayley Hamilton theorem. Inner product spaces, Bessel's inequality, Gram- Schmidt orthogonalization process, Linear operators on Inner product spaces.

CO 1 To learn about matrix operations and apply them for solving system of linear equations.

CO 2 To learn about vector spaces, sub spaces, basis and dimensions.

 CO 3 To learn concepts of Linear transformations , their representations and the sub spaces associated with them.

CO 4 To understand inner product spaces, their properties, projections and method of approximation.

CO 5 To learn more about special types of linear transformations through eigen values and eigen spaces and diagonalization.

MAL 321 Mathematical Methods (3-1-0 = 4 Credits)

Integral Transforms: Laplace Transformation, Fourier series expansion. Fourier integral and Fourier transforms. Calculus of Variations: Functionals, Deduction of Euler's equations for functionals of first order and higher order for fixed boundaries. Shortest distance between two non- intersecting curves.Isoperimetricproblems.Jacobi and Legendre conditions (applications only).

CO 1 To appreciate and understand the concept of integral transforms.

CO 2 To explain usefulness of Fourier series and applications to mathematical problems.

CO 3 To apply the knowledge of Fourier integral and Fourier transforms.

CO 4 To understand the idea of Calculus of variations and its importance and application to Mathematical problems.

MAL 310 Numerical Analysis (3-1-0 = 4 Credits)

Numerical solutions of algebraic and transcendental equations, Interpolation, Numerical differentiation, Numerical Quadrature, System of linear equations, Numerical solution to ordinary differential equations of first order.

CO 1 Students should be able to understand numerical solutions of non-linear/ transcendental equations.

CO 2 Students should be able to apply various algorithms to solve system of linear equations.

CO 3 Students should be able to approximate mathematical functions and find intermediate values using interpolation techniques.

CO 4 Students should be able to apply numerical techniques for differentiating and integrating the nonanalytical functions

CO 5 Students should be able to apply numerical techniques to solve various differential equations of engineering importance

MAL 301 Data Analysis (3-1-0 = 4 Credits)

Data types and sources, visualizing and exploring data, organizational Interfaces, precondition for data analysis, comparison among several samples, linear combinations &multiple comparisons of means, linear regression: a model for the mean, multiple regression and inferential tools.

CO 1 Students should be able to understand introduction and basics of statistics, sources and types of.

CO 2 Students should be able to visualize data through charts and graphs and learn how to explore data.

CO 3 Students should be able to understand how to apply organizational Interfaces.

CO 4 Students should understand to perform data preconditioning.

CO 5 Students should be able to perform linear combinations and multiple comparisons of means.

CO 6 Students should be able to apply linear correlation, independent and dependent variables and the types of correlation.

MAL 311 Introduction to Complex Analysis (3-1-0 = 4 Credits)

Power series, Analytic functions, Power series representation, Cauchy-Riemann equations, Complex line integrals, Zeros of Analytic functions, Cauchy's theorem, Cauchy's integral formula, Laurent series, Calculus of residues and evaluation of integrals using contour integration.

CO 1 Establish one-one correspondence between the points on a sphere and the points on a plane.

CO 2 Form analytic function from Harmonic function, define and classify the type of singularities and generate Taylor and Laurent series from Complex-valued function.

CO 3 Able to solve Complex integration and important results based on it and the knowledge to obtain zeros of analytic function.

CO 4 Capable to evaluate the Residue of Complex-valued function at a Finite Point and the Point Infinity and significance on the residue of complex functions.

CO 5 Understand Meromorphic and Entire Functions and the Important applications based on it.

CO 6 Able to transform the complex points in z-plane onto the points in w-plane and understand the basic of Measure theory.

MAL 313 Integral and Vector calculus (3-1-0 = 4 Credits)

Functions of Two Variables: Limit, Continuity, Differentiability, Partial differentiation, Change of variables, Taylor's theorem. Maxima and minima. Beta and Gamma functions, Multiple integrals. Vector Calculus: Gradient, Divergence and Curl. Green's, Stokes and Gauss Theorems with applications.

CO 1	Students will be able to utilize the derivative in applied contexts, including function approximation, to find maximum, minimum, or otherwise "optimal" input values for equations important in science and engineering.
CO 2	Students will be able to change the order of integration and find the area enclosed by plane curves. Triple integral, change of variables, volume of solids.
CO 3	Students will be able to conceptualize the geometrical and physical significance of gradient of scalar point function, divergence and curl of the vector point functions. Apply the Gauss divergence theorem, Green's theorem and Stokes theorem to convert the multiple integrals into simpler forms.

MAL 207 Operation Research (3-1-0=4 Credits)

Linear Programming Models, Integer Programming, Dynamic Programming, Game Theory, Job Sequencing, Network Analysis, Goal Programming.

CO 1 Students will be able to understand and analyze managerial problems in industry so that they are able to use resources effectively.

CO 2 They will be able to frame mathematical models for analysis of real problems in operations research for quantitative analysis of managerial problems in industry.

CO 3 They will be able to solve linear programming models for various realistic situations using variety of techniques. CO 4 Students will be in a state to understand the concept of various goals of an industry and their process to get optimal solution.

Programme Elective I

MAL 303 Linear Programming and its Applications (3-1-0 = 4 Credits)

Linear Programming problem, Convex sets and their properties, Simplex method, Big-M method, Duality theory, Dual simplex method, Sensitivity Analysis, Transportation, Assignment problems.

CO 1 Students will be able to understand and analyze managerial problems in industry so that they are able to use resources effectively.

CO 2 They will be able to frame mathematical models for analysis of real problems in operations research for quantitative analysis of managerial problems in industry.

CO 3 They will be able to solve linear programming models for various realistic situations using variety of techniques. CO 4 Students will be in a state to understand the concept of various goals of an industry and their process to get optimal solution.

MAL 317 Mathematical Modeling (3-1-0 = 4 Credits)

Modelling process and classification. Model formulation based on differential Equations: Growth and decay models, Prey Predator models, Traffic flow models, applications in Ecology and environment sciences.

CO 1	To simplify the real world problem or approximate it by another problem which is quite close to the original problem that can be translated and solved mathematically..
CO 2	To formulate the problem in Problem Language.
CO 3	To think about the entire physical, chemical, biological, social, economic laws that may be relevant to the situation.
CO 4	To modify either the idealization assumptions or form another structure for the mathematical model when its comparison is not good with the existing problem.

Programme Elective II

MAL 318 Image Processing(3-0-2 = 4 Credits)

Digital image basics, Terminology, Mathematical preliminaries: Neighbour of Pixels, connectivity, Relations, equivalenceand Transitive Closure; distance Measures, Arithmatic/Logic Opoerations, Fourier Transformation, Discrete Cosine and sine Transform. Image Enhancement; Spatial domain Method, Frequency Domain Method, Contrast Enhancement- Linear and non- Linear stretching, Histogram Procesing; Smoothing- Image Averaging, Mean Filter, Lowpass Filtering; Image sharpening. High pass Filtering, High –boost Filtering, Derivative filtering, Homomorphic Filtering.

CO 1 Students should be able to understand introduction and basics of Digital Image processing.

CO 2 Students should be able to visualize digital image and understand RGB to Gray image.

CO 3 Students should be able to understand how to apply organizational Interfaces.

CO 4 Students should understand to perform image matrix .

CO 5 Students should be able to perform linear and non linear stretching

MAL 340 Data Visualization Techniques (3-1-0 = 4 Credits)

Purposes of visualization, Statistical graphics, visualization for Exploratory Data Analysis, Interacting with graphics, and large dataset applications Understand Analytics output and their interpretation, Understand various types of charts, tables and graphs, dashboards, comparison charts and their usage, Identify data sets required for reports, Tools for graphs and charts, Tools for conducting basic statistics (for example, SPSS, SAS), analytics (for example, SAS JMP KNIME), and visualization (for example, Tableau) would be employed to demonstrate application of concepts covered in the module.

CO 1	Identifying contrast between traditional and modern Database Systems, thereby recognizing their applications.
CO 2	Developing conceptual database design for any real time project by defining the relationship, constraints etc. on entities.
CO 3	Applying appropriate design techniques to design a good database that meets the user requirement.
CO 4	Creating a database and devising queries for extracting information from the database using Relational Algebra and SQL.
CO 5	Applying the concepts of DBMS for developing a backend for a non-trivial project using NoSQL.
CO 6	Ability to improvise data fetching time by applying indexing concepts.
CO 7	Understanding the concepts of end-to-end transaction processing in a database.

Programme Elective III

MAL200 Statistical Modeling (3-1-0 = 4 Credits)

Introduction to Data Mining, Modeling Techniques, Rule Induction and Automating Models, Comparing & Combining Models, Introduction to Big Data.

CO 1	To simplify the real world problem or approximate it by another problem which is quite close to the original problem that can be translated and solved mathematically..
CO 2	To formulate the problem in Problem Language.
CO 3	To think about the entire physical, chemical, biological, social, economic laws that may be relevant to the situation.
CO 4	To modify either the idealization assumptions or form another structure for the mathematical model when its comparison is not good with the existing problem.

MAL 308 Number Theory (3-1-0 = 4 Credits)

Primes and factorization, Division algorithm, Congruence and modular arithmetic, Chinese remainder theorem, Euler phi function, Primitive roots of unity, Quadratic law of reciprocity, application, Arithmetical functions, Mobius inversion formula, The Diophantine equations $x^2 + y^2 = z^2$, $x^4 + y^4 = z^4$, Farey sequences.

CO 1 To understand basic structure and properties of integers. Prove results involving divisibility and greatest common divisors and use the theory of numbers to solve linear Diophantine equations.

CO 2 Understand the theory of modular arithmetic and Congruences, solve the systems of linear congruences and apply Euler-Fermat's Theorem to prove relations involving prime numbers and apply the Wilson's theorem.

CO 3 Finding the divisors and relatively prime integers by applying number theortic functions, Apply elementary number theory to cryptography. To study composite numbers having Primitive roots.

CO 4 To study quadratic Congruences and find the integral solution of some nonlinear Diophantine equations. Develop a deeper conceptual understanding of the theoretical basis of number theory.

Programme Elective IV

MAL 315 Financial Mathematics (3-1-0 = 4 Credits)

Financial Management.Time value of Money-Interest rate and discount rate. Present value and future value-discrete case as well as continuous compounding case. Annuities and its kinds.Meaning of return.Taylor series and Bond Valuation.Calculation of Duration and Convexity of bonds.Financial Derivatives-Futures. Forward. Swaps and Options. Call and put Option. Call and Put Parity Theorem. Pricing of contigent claims through Arbitrage and Arbitrage Theorem.

CO 1 Students should be able to understand the basic concepts of interest and their role in finance. Also, they should be able to calculate present and future values of a bond.

CO 2 Students should be able to find the internal rate of return for a given cash flow, price of a plain vanilla bond and price-yield curve.

CO 3 Students should be able to find the risk characteristics of a portfolio through financial derivatives like forwards and futures and then modify the risk associated to the portfolio.

CO 4 Students should be able to do the extensive analysis of options pricing and the use of options in hedging and speculation.

CO 5 Students should be able to examine the exact relationship of the options's price with various factors using Black Scholes model.

MAL 319 Metric Spaces (3-1-0 = 4 Credits)

Set Theory, metric spaces, neighborhood, limit points, interior points, open and closed set, closure and interior, boundary points. Subspace of a metric space. Connectedness, completeness, Cantor's intersection theorem.Densesubsets.Separable metric spaces. Continuous functions. Uniform continuity, Isometry and homeomorphism.Equivalent metrics.

CO1.Understand and appreciate the concept of a **metric space** and be able to recognize standard examples.

CO2. Be familiar with the fundamental notions of continuity, convergence and compactness.

CO3.Be able to utilise **metric space** arguments to obtain a variety of results.

MAL320 Predictive Analytics(3-1-0 = 4 Credits)

Simple linear regression: Coefficient of determination, Significance tests, Residual analysis, Confidence and Prediction intervals, Multiple linear regression: Coefficient of multiple coefficient of determination, Interpretation of regression coefficients, Categorical variables, Heteroscedasticity, Multicollinearity, Outliers, Auto-regression and Transformation of variables

Logistic and Multinomial Regression: Logistic function, Estimation of probability using logistic regression, Deviance, Wald Test, HosmerLemeshow Test, Forecasting: Moving average, Exponential smoothing, Trend, Cyclical and seasonality components, ARIMA (autoregressive integrated moving average), Application of predictive analytics in retail, direct marketing, health care, financial services, insurance, supply chain, etc.

CO 1 Students should be able to understand introduction and basics of linear Regression.

CO 2 Students should be able to visualize Data and multiple Linear regression.

CO 3 Students should be able to understand how to Regression.

CO 4 Students should understand to perform Forecasting.

CO 5 Students should be able to Predict analytics in real life examples.

Ability Enhancement Courses

CLL101 Effective Communication- I (2-2 = 3 Credits)

Vocabulary-1, Word building and enriching vocabulary Essentials of Grammar-1 Errors pertaining to Nouns, Pronouns, Verbs, Adverbs and Adjectives Writing Skills-1 Business Correspondence, Reading Skills-1 Theme detection, Literal comprehension Speaking Skills-1: Introducing oneself mini presentation, collaborative task, Listening Skills-1: Listening specific information, theme detection, gap filling.

CO 1 Demonstrate the use of basic and advanced writing techniques using enriched vocabulary and grammar in various forms of writing.

CO 2 Exhibit excellence in writing effectively.

CO 3 Communicate effectively by overcoming the different barriers to communication.

CO 4 Apply generic conventions and formats to memoranda, notices and business correspondence.

CO 5 Display confidence in conversational skills.

CLL102 Effective Communication- II (2-2 = 3 Credits)

Vocabulary-2 Technical vocabulary, foreign expressions.Essentials of Grammar-2 Errors pertaining to Articles, Prepositions, Non-finites and conjunctions.Writing Skills-2 Resume Writing, Reports and Proposals. Reading Skills-2 Analytical reading, Reading for cohesion and proof reading Speaking Skills-2 Group Discussion, Role playing activities, Public speaking, Simulated conversation, Facing Interview, Presentation skills, Business etiquette. Listening Skills-2 Listening short pieces for gist and analytical comprehension.

CO 1.Communicate effectively in social and professional situations and convey the intended message with clarity and conciseness.

CO 2.Compose concrete and correct formal correspondence texts viz. namely formal letters, business reports and proposals.

CO3.Effective participation using language &interpersonal skills during group discussions, debates,oral presentations and social conversations and make informed, ethical opinions on relevant global issues.

CO 4. Enhanced acquisition of vocabulary & correct language structures for effective expression.

 CO 5. Ability to think logically and critically: use this skill in written & spoken expression.

SML 300 Entrepreneurship (2-1-0 = 3 Credits)

This course aims to provide students with an understanding of the nature of enterprise and entrepreneurship and introduces the role of the entrepreneur, innovation and technology in the entrepreneurial process. It is not about small business or life style businesses but instead the development of growth oriented businesses -w h e t h e r f o r - p r o f it o r n o t - f o r - p r o f it. Entrepreneurship is both a way of thinking and of

doing. It involves "building something from nothing" and successful entrepreneurs know how to manage and mitigate uncertainty and risk. The course content is relevant to those individuals thinking about starting a business or who are already in business - large or small, those who are interested in commercializing their own innovations or of others, and those who advise entrepreneurs or engage in policy making in the

entrepreneurship area. The course provides step by step process of writing a business plan for the operation of a successful small business. The content of the course will include all aspects of start-up of a small business, sales, finance, personnel, marketing, budgets, insurances, customer target and possibly a different alternative to business either start up or purchase of small business.

CO 1 Ability to select a business idea and conduct preliminary analysis of it.

CO 2 Able to make a business plan out of a business idea.

CO 3 Ability to conduct all analysis involved before starting a business.

CO 4 Get direction as to how to start a new enterprise & write a business plan. Role of multiple institutions

CO 5 Being socially responsible while doing business.

SML 150 Leadership (2-1-0= 3 Credits)

This course places self-awareness at the core of effective leadership. The students will be exposed

to personality assessments including the Enneagram, Strengths Finder and Multiple Intelligences Test to gain a deep understanding of their strengths and values. Topics include:Exploring, Identifying and Articulating Core Personal Values (Value Cards); Stages of Moral Development (Kohlberg's Experiment); Principled Leadership (Instilling Values in Others); Understanding Differences in Personality

(Enneagram Test); Multiple Intelligences Test (Howard Gardner); Trust Equations; and Attributes

of Leadership. The students will identify their intentions as leaders, learn strategies to improve

per sonal res i l ience and gain a deeper understanding of their leadership style. Interactive exercises, designed to allow students to experience leadership while studying it, help build a renewed sense of self as leader. The focus of the course is to move the individual from responding to the situation to being responsible for it. The students will learn to build their own motivation, confidence, skills, and commitment.

CO 1 Identifying personal strengths, weaknesses, leadership styles

CO 2 Understanding the value of people leadership CO 3 Learning to manage and lead people effectively

CO 4 Understanding how to align oneself and others towards a common goal

ASL140 Environmental Studies (3-1-0 = 4 Credits)

The Multidisciplinary nature of environmental studies, Natural Resources, Ecosystem, Biodiversity and its conservations, Environmental Pollution, Social issues and the Environment, Human population and the Environment, Field Work.

CO 1 Application of knowledge gained to generate awareness for environmental protection so as to sensitize the student community towards environmental management and becoming Green Citizens and to apply the knowledge gained in sustaining various resources by using green technologies.

CO 2 To apply the concepts learnt in maintaining balance in natural ecosystems and it covers all aspects of life and contributes in constructive decision-making keeping environment in view.

CO 3 Development of understanding of pollution and to develop an understanding of Environmental management to enable them in becoming green engineers and green managers. To become green citizens and contribute in the sustainable development of the society, country and the world.

CO 4 To apply the concepts learnt in earning resources for their organizations by using green technologies.

CO 5 It encapsulates sound theoretical base of all the environmental aspects coupled with practical and projects.

CLL 120 Human Values and Professional Ethics 2 Credits (2-0-0)
Human values – Morals, Indian views on Education, Understanding harmony in self, family, society and the existence; Self-exploration, Introduction to ethics, Ethical and Servant Leadership, Corporate Social Responsibility, Corporate governance – need and importance.

CO 1 Demonstrate an ability to empathize/concern for societal issues.

CO 2 Combine technical competence with the right approach to life, profession, and society.

CO 3 Ability to handle professional and personal dilemmas effectively i.e. the right course of action in a given situation.

CO 4 Applying professional values, ethics and attitude to complex work assignments and making decisions

Foreign Language Electives

CLL 220 German I   3 credits (1-2-0)

Greetings, Self-introduction, Learning alphabets, start a conversation, numbers from 0 to 1000, order in a restaurant and pay the bill, asking questions ,verbs in present tense, articles in nominative, use of dictionary, articles in accusative, verbs in accusative, negation, nouns: singular and plural, listen to umlauts and speak, speak about cities and tourist features, about countries and languages spoken there, to indicate the geographical location, the past tense of the verbs, accent in questions and statements, time data- clock time/ week days, To fix up appointments, to excuse oneself on being late, prepositions related to time.

CO 1 Understands and use familiar, everyday expressions and simple sentences.

CO 2 Introduce themselves and others and able to ask/answer simple questions. For example, where they live/add…

CO 3 Communicate in a simple manner, about their family, talk about their likes and dislikes, invite someone and write a simple e-mail.

CO 1 Understand and use familiar, everyday expressions and simple sentences.

CO 2 Introduce themselves and others as well as ask others simple questions, for instance, where they live, whom they know, what they own etc.

CO 3 Communicate in a simple manner, about their family, express likes and dislikes, order food in a restaurant, answer the phone, invite someone and write a simple e-mail.

CLL 200 FRENCH I   3 credits (1-2-0)

Introduce oneself and a friend/colleague or any other person,hobbies, leisure activities and daily routines, ask directions, to ask and to give personal information, give instructions , ask and tell time, understand a short and simple written passage, to organize ,to accept or to refuse an outing/an invitation, leaving a message on the answering machine, place an order and pay in a restaurant, to speak about a near future plan and able to read a programme.

CO 1 Understands and use familiar, everyday expressions and simple sentences.

CO 2 Introduce themselves and others and able to ask/answer simple questions. For example, where they live/add…

CO 3 Communicate in a simple manner, about their family, talk about their likes and dislikes, invite someone and write a simple e-mail.

CLL270 SPANISH I   3 credits (1-2-0)

Personal information, exchange greetings, understanding conjugations, using the

verbs "to have", "to be", learn numbers 1-100, nationalities, professions, express intentions/interests, explain reasons for actions, use of Present Indicative, use of prepositions, description of places and countries, talk about climate, use of superlatives, expressing agreement, doubt, future and past tenses, gender and number of adjectives, identification of objects, expression of needs, asking prices/products, give and ask for information about someone, knowledge about the company, number of employees, ability to talk about the post or job of someone in a company, read a technical drawing with dictionary, Irregular verbs .

CO 1 Present him/herself, talk about his daily activities, ask for and give information, give advice, tell the time.

CO 2 Understand short articles on the internet, understand online discussions, organize meetings, leave messages, order a meal in a restaurant, read a small advertisement Read simple texts and answer questions on them

CO 3 Make a curriculum vitae and write application letters, write and understand sms Have monologues and dialogues about the immediate environment