SANSKARAM UNIVERSITY
JHAJJAR

Scheme of Examination and Syllabus for

B.Sc. Mathematics Hons.

Under Multiple Entry-Exit, Internships and CBCS-LOCF in accordance to NEP 2020

w.e.f. 2024-25

Programme Structure, B.Sc. Mathematics Hons., 2024

Semester	Discipline Specific Core Courses (4) #	Discipline SpecificElective (DSE) (4) #/ Generic Elective(GE) (4) #	Ability Enhancement Course (AEC) (2)#	Skill Enhancement Course(SEC) (2) #/ Internship/Apprenticeship/Project/Community Outreach (IAPC) (2)*	Value Addition Course (VAC) (2)#	Total Credits earn
I	Calculus Algebra Logic, sets and Special Functions	Choose one GE from the pool of GE Courses of sem I	Choose one AEC from pool of courses	Choose one SEC from a pool of SEC of seme I	Choose one VAC from a pool of courses	22
II	Real Analysis-1 Differential Equations Group Theory-1	Choose one GE from the pool of GE Courses of sem II	Choose one AEC from pool of courses	Choose one SEC from a pool of SEC of seme II	Choose one VAC from a pool of courses	22
Students on exit shall be awarded Undergraduate Certificate in Mathematics after securing the requisite 44 credits in Semesters I - II						
III	DSC-7 DSC-8 DSC-9	Choose one DSE from the pool of DSE Courses of sem III Or Choose one GE from the pool of GE Courses of sem III	Choose one AEC from pool of courses	Choose one SEC from a pool of SECs given for sem III OR Internship/Apprenticeship/Project/Community Outreach (IAPC) (2)*	Choose one VAC from a pool of courses	22
IV	DSC-10 DSC-11 DSC-12	Choose one DSE from the pool of DSE Courses of sem IV Or Choose one GE from the pool of GE Courses of sem IV	Choose one AEC from pool of courses	Choose one SEC from a pool of SECs given for sem IV OR Internship/Apprenticeship/Project/Community Outreach (IAPC) (2)*	Choose one VAC from a pool of courses	22
Students on exit shall be awarded Undergraduate Diploma in Mathematics after securing the requisite 88 credits after completion of Semesters I - IV						
V	DSC-13 DSC-14 DSC-15	Choose one DSE from the pool of DSE Courses of sem V and Choose one GE from the pool of GE Courses of sem V		Choose one SEC from a pool of SECs given for sem V OR Internship/Apprenticeship/Project/Community Outreach (IAPC) (2)*		22
VI	DSC-16 DSC-17 DSC-18	Choose one DSE from the pool of DSE Courses of sem VI and Choose one GE from the pool of GE Courses of sem VI		Choose one SEC from a pool of SECs given for sem VI OR Internship/Apprenticeship/Project/Community Outreach (IAPC) (2)*		22
Students on exit shall be awarded Bachelor of Mathematics (Hons.) after securing the requisite 132 credits on completion of Semesters I - VI						
VII	DSC-19	Choose from a pool of DSE and GE courses given for semester VII in the combinations given below: • Choose three DSE courses		Dissertation on Major (4+2) OR Dissertation on Minor (4+2) OR Academic project/ Entrepreneurship (4+2)		22

		OR • Choose two DSE and one GE courses OR Choose one DSE and two GE courses ***				
VIII	DSC-20	Choose from a pool of DSE and GE courses given for semester VIII in the combinations given below: • Choose three DSE courses OR • Choose two DSE and one GE courses OR Choose one DSE and two GE *** courses		Dissertation on Major (4+2) OR Dissertation on Minor (4+2) OR Academic project/ Entrepreneurship (4+2)		22

After securing the requisite 176 credits on completion of Semester VIII, students on exit shall be awarded

- ***Bachelor of Mathematics (Hons. with Research /* Internship/Apprenticeship/Project/Community Outreach*)***

Or

Bachelor of Mathematics (Hons.) with Research in Mathematics (Major) and Discipline-2 (Minor)

Value inside parenthesis signifies credit of that course.
* There shall be choice in Semester III and IV to either choose a DSE (from a pool of Mathematics DSE courses) or a GE (from a pool of GE courses other than mathematics).
** 'Research Methodology' shall be offered as one of the DSE courses in VI and VII. If a student wishes to pursue four years Honours Degree with research, he/she shall compulsorily opt for a Research Methodology course in either VI Semester or VII Semester.
***The following choices will be available in VII and VIII semesters:
(i) to choose three DSEs of 4 credits each OR
(ii) to choose two DSEs and one GE of 4 credits each OR
(iii) to choose one DSE and two GEs of 4 credits each.

List of Discipline Specific Core (DSC) Courses

A student will study three Discipline Specific Core Courses each in Semesters I to VI and onecore course each in semesters VII and VIII. The semester wise distribution of DSC courses over eight semesters as listed in Table.

Semester	Discipline Specific Core (DSC) Course	Course Code	Nomenclature	Credits			
				L	T	P	Total
I	DSC-1	020801001	Calculus	3	1	0	4
	DSC-2	020801002	Algebra	3	1	0	4
	DSC-3	020801003	Logic, Sets and Special Functions	3	1	0	4
II	DSC-4	020802004	Real Analysis-1	3	1	0	4
	DSC-5	020802005	Differential Equations	3	1	0	4
	DSC-6	020802006	Group Theory-1	3	1	0	4
III	DSC-7	020803007	Real Analysis-2	3	1	0	4
	DSC-8	020803008	PDE and Systems of ODE	3	1	0	4
	DSC-9	020803009	Mathematical Transforms	3	1	0	4
IV	DSC-10	020804010	Numerical Methods	3	0	1	4
	DSC-11	020804011	Riemann Integration and Series of Functions	3	1	0	4
	DSC-12	020804012	Ring Theory	3	1	0	4
V	DSC-13	020805013	Multivariate Calculus	3	1	0	4
	DSC-14	020805014	Group Theory-II	3	1	0	4
	DSC-15	020805015	Analytical Geometry	3	1	0	4
VI	DSC-16	020806016	Metric Spaces	3	1	0	4
	DSC-17	020806017	Linear Algebra	3	1	0	4
	DSC-18	020806018	Linear Programming	3	1	0	4
VII	DSC-19	020807019	Topology	3	1	0	4
VIII	DSC-20	020808020	Functional Analysis	3	1	0	4

List of Discipline Specific Elective (DSE) Courses

The Discipline Specific Electives (DSEs) are a pool of credit courses of Mathematics from which a student will choose to study based on his/ her interest. A student of B.Sc. hons. Mathematics gets an option of choosing one DSE of Mathematics in each of the semesters III to VI, while the student has an option of choosing a maximum of three DSEcourses of Mathematics in semesters VII and VIII. The semester wise distribution of DSE courses over six semesters is listed in Table. In addition to the above proposed courses, students may select courses from the Swayam.org as MOOCs courses in semester VII & VIII up to the permissible limit.

Semester	Discipline Specific Elective (DSE) Course	Course Code	Nomenclature	Credits		
				L	P	Total
III	DSE 1		Bio Mathematics	3	1	0
	DSE 2		Theory of Equations	3	1	0
IV	DSE 3		Differential Geometry	3	1	0
	DSE 4		Combinatorial Mathematics	3	1	0
V	DSE 5		Probability and Statistics	3	1	0
	DSE 6		Finite Element Methods	3	1	0
	DSE 7		Mechanics	3	1	0
VI	DSE 8		Graph Theory	3	1	0
	DSE 9		Mathematical Finance	3	1	0
	DSE 10		Cryptography and Network Security	3	1	0
VII	DSE 11		Finite Field	3	1	0
	DSE 12		Ordinary Differential Equation (ODE)	3	1	0
	DSE 14		Advanced Numerical Analysis	3	1	0
	DSE 15		Mathematical Modelling	3	1	0
VIII	DSE 16		Complex Analysis	3	1	0
	DSE 17		Partial Differential Equation (PDE)	3	1	0

	DSE 18		Measure & Integration	3	1	0
	DSE 19		Advanced Linear Programming	3	1	0
	DSE 20		Number Theory	3	1	0

List of Generic Elective (GE) Courses

Generic Elective courses provide multidisciplinary or interdisciplinary education to students.Various GE courses offered by the Mathematics Department are listed below in Table**.** In addition to the proposed courses, students may select courses from the Swayam.org as MOOCs courses in semester VII & VIII up to the permissible limit.

Semester	Discipline Specific Core (DSC) Course	Course Code	Nomenclature	Credits		
				L	P	Total
I	GE-1		Applied Calculus	3	1	0
	GE-2		Programming in C++	3	0	1
II	GE-3		Econometrics	3	1	0
	GE-4		Information Security	3	1	0
III	GE-5		Applications of Algebra	3	1	0
	GE-6		Bio Mathematics	3	1	0
	GE-7		Theory of Equations	3	1	0
IV	GE-8		Numerical Methods	3	1	0
	GE-9		Differential Geometry	3	1	0
	GE-10		Combinatorial Mathematics	3	1	0
V	GE-11		Probability and Statistics	3	1	0
	GE-12		Finite Element Methods	3	1	0
	GE-13		Mechanics	3	1	0
VI	GE-14		Graph Theory	3	1	0
	GE-15		Mathematical Finance	3	1	0
	GE-16		Cryptography and Network Security	3	1	0
VII	GE-17		Finite Field	3	1	0
	GE-18		Ordinary Differential Equation (ODE)	3	1	0
	GE-19		Advanced Numerical Analysis	3	1	0

	GE-20		Mathematical Modelling	3	1	0
VIII	GE-21		Complex Analysis	3	1	0
	GE-22		Partial Differential Equation (PDE)	3	1	0
	GE-23		Measure & Integration	3	1	0
	GE-24		Advanced Linear Programming	3	1	0
	GE-25		Number Theory	3	1	0

List of Skill Enhancement (SEC) Courses

To enhance the skills required for advanced studies, research and employability of studentsvarious Skill Enhancement Courses will be offered to students as listed in Table. In addition to the proposed courses, students may select courses from the Swayam.org as MOOCs courses upto the permissible limit.

Semester	Skill Enhancement Course (SEC)	Course Code	Nomenclature		Credits		
				L	T	P	Total
I	SEC 1		Latex for scientific typesetting	0	0	2	2
	SEC 2		Operating System: Linux	0	0	2	2
II	SEC 3		Introduction to Programming with MATLAB	0	0	2	2
	SEC 4		Introduction to Python	0	0	2	2
III	SEC 5		Programming with Mathematica	0	0	2	2
IV	SEC 7		Computer Graphics	1	0	1	2
	SEC 8		Financial Accounting	2	0	0	2
V	SEC 9		Internship				2
	SEC 10		Apprenticeship				2
	SEC 11		Project				2
	SEC 12		Community Outreach				2
	SEC 13		Internship				2

VI	SEC 14		Apprenticeship				2
	SEC 15		Project				2
	SEC 16		Community Outreach				2
VII	SEC 17		Dissertation				6
	SEC 18		Academic Project				6
VIII	SEC 19		Dissertation				6
	SEC 20		Academic Project				6

Discipline Specific Core Course

DSC-1

Calculus

Course Prerequisites: Fundamentals of Differentiation and Integration, Limit, Partial fractions, Binomial theorem, Plane geometry, conics, Basic vector algebra

Course outcomes:

a) To introduce fundamentals of the calculus in order to enhance application skill of students and prepare them to pursue higher analytical mathematics.
b) By the completion of the course the students will be able to analysis the relationships between quantities such as rates of changes, area, volume, properties of curves) and their mathematical equivalents.
c) The course will be able to equip the students with the tools of calculus to measure various quantities such as curvature, torsion, point motion in space etc.
d) One of the main objective of the course is to further deepen the fundamentals of analytical mathematics.

Course Contents:

Hyperbolic functions, higher order derivatives, Leibniz rule and its applications to problems of type $e^{ax+b}\sin x$, $e^{ax+b}\cos x$, $(ax+b)^n\sin x$, $(ax+b)^n\cos x$, concavity and inflection points, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L'Hospital's rule, applications in business, economics and life sciences.

Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin nx\,dx$, $\int \cos nx\,dx$, $\int \tan nx\,dx$, $\int \sec nx\,dx$, $\int (\log x)n\,dx$, $\int sinn\ x\ sinm\ x\,dx$, volumes by slicing, disks and washers methods, volumes by cylindrical shells, parametric equations, parameterizing a curve, arc length, arc length of parametric curves, area of surface of revolution. Techniques of sketching conics, reflection properties of conics, rotation of axes and second degree equations, classification into conics using the discriminant, polar equations of conics.

Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions, tangent and normal components of acceleration, modeling ballistics and planetary motion, Kepler's second law.

Books Recommended

1. G.B. Thomas and R.L. Finney, *Calculus,* 9th Ed., Pearson Education, Delhi, 2005.
2. M.J. Strauss, G.L. Bradley and K. J. Smith, *Calculus,* 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.
3. H. Anton, I. Bivens and S. Davis, *Calculus,* 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.
4. R. Courant and F. John, *Introduction to Calculus and Analysis* (Volumes I & II), Springer-Verlag, New York, Inc., 1989.
5. Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

DSC-2

Algebra

Course Prerequisites: An understanding of numbers, matrices, ratios, proportions, the order of operations, equality, algebraic equations and functions.

Course outcomes:

This course will enable the students to:

a) Employ De Moivre's theorem in a number of applications to solve numerical problems.
b) Learn about equivalent classes and cardinality of a set.
c) Use modular arithmetic and basic properties of congruences.
d) Recognize consistent and inconsistent systems of linear equations by the row echelon form of the augmented matrix.
e) Find eigenvalues and corresponding eigenvectors for a square matrix.

Course Contents:

Polar representation of complex numbers, n^{th} roots of unity, De Moivre's theorem for rational indices and its applications.

Equivalence relations, Functions, Composition of functions, Invertible functions, One to one Correspondence and cardinality of a set, Well-ordering property of positive integers, Division algorithm, Divisibility and Euclidean algorithm, Congruence relation between integers, Principles of Mathematical Induction, statement of Fundamental Theorem of Arithmetic.

Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation Ax=b, solution sets of linear systems, applications of linear systems, linear independence.

Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices. Subspaces of R^n, dimension of subspaces of R^n and rank of a matrix, Eigen values, Eigen Vectors and Characteristic Equation of a matrix.

Books Recommended

1. Titu Andreescu and Dorin Andrica, *Complex Numbers from A to* Z, Birkhauser, 2006.
2. Edgar G. Goodaire and Michael M. Parmenter, *Discrete Mathematics with Graph Theory,* 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005**.**
3. David C. Lay, *Linear Algebra and its Applications,* 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
4. Johnson, L., Riess, D. and Arnold, J., *Introduction to Linear Algebra*, 5^{th} Ed., Pearson India, 2019.
5. Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

DSC-3
Logic, Sets and Special Functions

Course Prerequisites: Knowledge of basic concepts of set theory and calculus.

Course Outcomes:

At the end of the course the students will be able to:

a) know the solution of second order differential equations with variable coefficients.
b) find the solution of Legendre's differential equations and know about its properties.
c) determine the solution of Bessel's differential equation.
d) find the solution of Chebyshev differential equations and its properties.
e) Construct proofs of basic set-theoretic identities involving unions, intersections, and cartesian products
f) Formulate the negation, converse, and contrapositive of a quantified implication, both linguistically and in symbolic form.
g) Demonstrate an understanding of the concept of a "counterexample" and be able to provide appropriate instances.
h) Demonstrate an understanding of the Principle of Mathematical Induction.
i) Understand the concepts of propositions, truth table, predicates and quantifiers, relation ,partition etc.

Course Contents:

Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators. Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.

Sets, subsets, Set operations and the laws of set theory and Venn diagrams. Examples of finite and infinite sets. Finite sets and counting principle. Empty set, properties of empty set. Standard set operations. Classes of sets. Power set of a set.

Difference and Symmetric difference of two sets. Set identities, Generalized union and intersections. Relation: Product set, Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation, Partial ordering relations, nary relations.

Legendre polynomials, Series expansion, Orthogonality and Normalization, A second solution, Rodriquez's formula, Generating function, Recursion relations.
Bessel functions, Series solution of Bessel's equation, Orthogonality of Bessel functions, Orthogonal series of Bessel functions, Generating function, Recursion relations.

Laguerre polynomials, Generating functions, Recurrence relations and differential equations. Orthogonality and expansion of a functions in Laguerre polynomials.

Books Recommended:

1. N. N. Lebedev, *Special Functions and Their Applications*, Dover, 1973.
2. 2. R.P. Grimaldi, *Discrete Mathematics and Combinatorial Mathematics,* Pearson Education, 1998.
3. P.R. Halmos, *Naive Set Theory*, Springer, 1974.

4. *E. Kamke*, Theory of Sets, *Dover Publishers, 1950.*
5. *Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.*

DSC-4

Real Analysis-1

Course Prerequisites: Knowledge of Calculus at high school level and number system.

Course Outcomes:

This course will enable the students to:

a) Understand many properties of the real line $\mathbb{R}$, including completeness and Archimedean properties.
b) Learn to define sequences in terms of functions from $\mathbb{N}$ to a subset of $\mathbb{R}$.
c) Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.
d) Apply the ratio, root, alternating series and limit comparison tests for convergence and absolute convergence of an infinite series of real numbers.

Course Contents:

Review of Algebraic and Order Properties of *R*, ε-nneighborhood of a point in *R*, Idea of countable sets, uncountable sets and uncountability of *R*. Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets, Suprema and Infima, The Completeness Property of *R*, The Archimedean Property, Density of Rational (and Irrational) numbers in *R*, Intervals. Limit points of a set, Isolated points, Illustrations of Bolzano-Weierstrass theorem for sets.

Sequences, Bounded sequence, Convergent sequence, Limit of a sequence. Limit Theorems, Monotone Sequences, Monotone Convergence Theorem. Subsequences, Divergence Criteria, Monotone Subsequence Theorem (statement only), Bolzano Weierstrass Theorem for Sequences. Cauchy sequence, Cauchy's Convergence Criterion.

Infinite series, convergence and divergence of infinite series, Cauchy Criterion, Tests for convergence: Comparison test, Limit Comparison test, Ratio Test, Cauchy's n^{th} root test, Integral test, Alternating series, Leibniz test, Absolute and Conditional convergence.

Books Recommended

1. R.G. Bartle and D. R. Sherbert, *Introduction to Real Analysis,* 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
2. Gerald G. Bilodeau , Paul R. Thie, G.E. Keough, *An Introduction to Analysis,* 2nd Ed., Jones & Bartlett, 2010.
3. Brian S. Thomson, Andrew. M. Bruckner and Judith B. Bruckner, *Elementary Real Analysis,* Prentice Hall, 2001.
4. S.K. Berberian, *A First Course in Real Analysis,* Springer Verlag, New York, 1994.
5. S.C. Malik and S. Arora, *Mathematical Analysis*, New Age International Private Limited, 2017.
6. Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

DSC-6

Differential Equations

Course Prerequisites: Knowledge of calculus at high school level.

Course Outcomes:

The course will enable the students to:

a) Learn basics of differential equations and mathematical modeling.
b) Formulate differential equations for various mathematical models.
c) Solve first order non-linear differential equations and linear differential equations of higher order using various techniques.
d) Apply these techniques to solve and analyze various mathematical models.

Course Contents:

Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations.

Introduction to compartmental model, exponential decay model, lake pollution model (case study of Lake Burley Griffin), drug assimilation into the blood (case of a single cold pill, case of a course of cold pills), exponential growth of population, limited growth of population, limited growth with harvesting.

General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters.

Books Recommended

1. Belinda Barnes and Glenn R. Fulford, *Mathematical Modeling with Case Studies, A Differential Equation Approach using Maple and Matlab*, 2nd Ed., Taylor and Francis group, London and New York, 2009.
2. C.H. Edwards and D.E. Penny, *Differential Equations and Boundary Value problems Computing and Modeling*, Pearson Education India, 2005.
3. S.L. Ross, *Differential Equations*, 3rd Ed., John Wiley and Sons, India, 2004.
4. Martha L Abell, James P Braselton, *Differential Equations with MATHEMATICA*, 3rd Ed., Elsevier Academic Press, 2004.
5. Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

Generic Elective(GE)

GE-1
Applied Calculus

Course Prerequisites: Basic calculus.

Course Outcomes:

At the end of the course, students should be able to:

- Identify functions as linear, exponential, or periodic, compute the change and average rate of change forgiven functions,
- Interpret the concept of derivative as the rate of change, and approximate the derivative at a single point,
- Perform analysis and computation of limits by analytic, graphical and numerical methods, and use limits to investigate continuity of functions.
- Use techniques of differentiation, including the product, quotient, and chain rules to derive derivativesfor polynomials, powers, exponentials, periodic functions and their compositions.
- Interpret definite integrals as areas, and evaluate them by numerical approximations and by the Fundamental Theorem of Calculus. Derive indefinite integrals by using power rule, exponential rule, logarithm rule, and rules for periodic functions.
- Use first and second derivatives to determine max/min values and locations for given functions, and to apply them to investigate the behaviors of logistic and surge functions.
- Understand the concepts of vector triple product, introduction to vector functions, space curves , tensor, tangent plane, normal and envelope analysis, helices, etc.

Course Contents:

Higher order derivatives, Leibniz rule, Curvature, Concavity and inflection points, Cartesian, Spherical, Cylindrical coordinate systems, asymptotes, curve tracing in Cartesian and polar coordinates coordinates. Maxima and Minima. L'Hospital's rule, Mean value theorems, Taylor's formula and their applications in Science, Engineering, business and economics.

Area and volumes by slicing, disks and washers methods, volumes by cylindrical shells, parametric equations, arc length, arc length of parametric curves, area of surface of revolution. Applications in science, engineering and real life.

Vector triple product, introduction to vector functions, vector-valued functions, differentiation and integration of vector functions, tangent and normal components of acceleration, modeling ballistics and planetary motion, Kepler's second law. Gradient, divergence and curl and use in fluid mechanics.

Space curve, Tangent, normal and osculating planes, Length of a curve, Seret-Frenet formulas, Curvature, circle of curvature, torsion. Curve by its intrinsic equations, Helices. Surfaces, Parametric equations of a surface. Tangent plane, Normal and Envelope. Applications.

Books Recommended

1. N. Piskunov, *Differential and Integral Calculus*, Mir Publisher Moscow, CBS Publishers & Distributors India.
2. Deborah Hughes et al., *Applied Calculus,* 5th Edition, Wiley.

3. Shanti Narayan, P. K. Mittal, *Differential Calculus,* S. Chand.
4. J. Stewart, *Calculus: Early Transcendentals,* Nelson Publication Canada.
5. Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

GE-2

Programming in C++

Course Prerequisites: Logics and sets.

Course Outcomes:

After completion of this course, student will be able to:

a) Identify importance of object oriented programming and difference between structured
b) oriented and object oriented programming features.
c) make use of objects and classes for developing programs.
d) use various object oriented concepts to solve different problems.

Course Contents:

OOP Paradigm: Comparison of Programming paradigms, Characteristics of Object-Oriented Programming Languages, Object-based programming languages C++: Brief History of C++,Structure of a C++ program, Difference between C and C++ - cin, cout, new, delete operators, ANSI/ISO Standard C++, Comments, Working with Variables and const Qualifiers. Enumeration, Arrays and Pointer.

Implementing oops concepts in C++ Objects, Classes, Encapsulation, Data Abstraction, Inheritance, Polymorphism, Dynamic Binding, Message Passing, Default Parameter Value,Using Reference variables with Functions.

Abstract data types, Class Component, Object & Class, Constructors Default and Copy Constructor, Assignment operator deep and shallow coping, Access modifiers - private, publicand protected. Implementing Class Functions within Class declaration or outside the Class declaration. instantiation of objects, Scope resolution operator, Working with Friend Functions, Using Static Class members. Understanding Compile Time Polymorphism function overloading Rules of Operator Overloading (Unary and Binary) as member function/friend function, Implementation of operator overloading of Arithmetic Operators, Overloading Output/Input,Prefix/ Postfix Increment and decrement Operators, Overloading comparison operators, Assignment, subscript and function call Operator , concepts of namespaces.

Practicals to be performed in computer lab.

Books Recommended

1. A. R. Venugopal, Rajkumar, and T. Ravishanker, *Mastering C++*, TMH, 1997.
2. S. B. Lippman and J. Lajoie, *C+ + Primer*,3rd Ed., Addison Wesley, 2000.
3. Bruce Eckel, *Thinking in C++*, 2nd Ed., President, Mindview Inc., Prentice Hall.
4. D. Parasons, *Object Oriented Programming with C++*, BPB Publication.
5. Bjarne Stroustrup , *The C++ Programming Language*, 3rd Ed., Addison Welsley.
6. Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

GE-3
Econometrics

Course Prerequisites: The course requires basic knowledge of elementary calculus(secondary level).

Course Outcomes:

At the end of the course the students will be able to:

a) Apply basic statistical concepts like normal distribution, chi square, t, and F distributions, and test- Hypotheses to the data based problems.
b) Apply Simple linear and multilinear regression models with the application of statistical tools for estimating economic relationships, testing economic hypotheses and forecasting.

Course Contents:

Statistical Concepts Normal distribution; chi-square, t and F-distributions; estimation of parameters; properties of estimators; testing of hypotheses: defining statistical hypotheses; distributions of test statistics; testing hypotheses related to population parameters; Type I and Type II errors; power of a test; tests for comparing parameters from two samples.

Simple Linear Regression Model: Two Variable Case Estimation of model by method of ordinary least squares; properties of estimators; goodness of fit; tests of hypotheses; scaling and units of measurement; confidence intervals; Gauss-Markov theorem; forecasting.

Multiple Linear Regression Model Estimation of parameters; properties of OLS estimators; goodness of fit - R2 and adjusted R2 ; partial regression coefficients; testing hypotheses - individual and joint; functional forms of regression models; qualitative (dummy) independent variables.

Violations of Classical Assumptions: Consequences, Detection and Remedies Multicollinearity; heteroscedasticity; serial correlation.

Specification Analysis Omission of a relevant variable; inclusion of irrelevant variable; tests of specification errors.

Books Recommended

1. Jay L. Devore, *Probability and Statistics for Engineers,* Cengage Learning, 2010.
2. John E. Freund, *Mathematical Statistics,* Prentice Hall, 1992.
3. Richard J. Larsen and Morris L. Marx, *An Introduction to Mathematical Statistics and its Applications,*Prentice Hall, 2011.
4. D. N. Gujarati and D.C. Porter, *Essentials of Econometrics,* McGraw Hill, 4th Ed., International Edition, 2009.
5. Christopher Dougherty, *Introduction to Econometrics,* Oxford University Press, 3rd Ed., Indian edition, 2007.
6. Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

GE-4
Information Security

Course Prerequisites:

Course Outcomes:

After the completion of the course, the students will be able to:

a) develop basic understanding of security, cryptography, system attacks and defences against them,
b) Cryptography tools usage
c) understand the methods and techniques for information security,
d) have knowledge of data security and secure system development.

Course Contents:

Overview of Security: Protection versus security; aspects of security-data integrity, data availability, privacy; security problems, user authentication, Orange Book.

Security Threats: Program threats, worms, viruses, Trojan horse, trap door, stack and buffer over flow; system threats- intruders; communication threats- tapping and piracy.

Cryptography: Substitution, transposition ciphers, symmetric-key algorithms-Data Encryption Standard, advanced encryption standards, public key encryption - RSA; Diffie- Hellman key exchange, ECC cryptography, Message Authentication- MAC, hash functions.

Digital signatures: Symmetric key signatures, public key signatures, message digests, public key infrastructures.

Security Mechanisms: Intrusion detection, auditing and logging, tripwire, system-call monitoring.

Books Recommended

1. W. Stallings, *Cryptography and Network Security Principles and Practices,*4th Ed., Prentice-Hall of India, 2006.
2. *C. Pfleeger and S.L. Pfleeger,* Security in Computing,*3rd Ed., Prentice-Hall of India, 2007.*
3. D. Gollmann, *Computer Security*, John Wiley and Sons, NY, 2002.
4. J. Piwprzyk, T. Hardjono and J. Seberry, *Fundamentals of Computer Security,*Springer- Verlag Berlin, 2003.
5. J.M. Kizza, *Computer Network Security*, Springer, 2007.
6. M. Merkow and J. Breithaupt, *Information Security: Principles and Practices,*Pearson Education, 2006.
7. Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

Skill Enhancement Course (SEC)

SEC-1
Latex for scientific typesetting

Prerequisites: There are no prerequisites for this course, except knowledge of editing text. The course can be taken by any learner who wants to create documents using LaTeX.

Course Outcome:

a) Handle different types of documents
b) Organize documents into different sections, subsections, etc.
c) Formatting pages (margins, header, footer, orientation)
d) Formatting text
e) Write complex mathematical formulae
f) Include tables and images
g) Cross-referencing, bibliography, and Indexing
h) Read error messages as and when required
i) Create presentations using Beamer

Course Contents:

This topic introduces the learner to LaTeX, its installation, and different IDEs. The learner creates the first document using LaTeX, organizes content into sections using article and book class of LaTeX, different paper sizes, examines packages, formats the page by setting margins, customizing header and footer, changing the page orientation, dividing the document into multiple columns. The topic ends with reading different types of error messages.

This topic concentrates on formatting text (styles, size, alignment), adding colors to text and entire page, and adding bullets and numbered items. It concludes by explaining the process of writing complex mathematics. Creating basic tables, adding simple and dashed borders, merging rows and columns, and handling situations where a table exceeds the size of a page. The sessions then continue to add an image, explore different properties like rotate, scale, etc..

In this topic, the learner learns to add cross-referencing (refer to sections, table, images), add bibliography (references), and create back index. Introduction to creating slides, adding frames, dividing the slide into multiple columns, adding different blocks, etc.

Book Recommended:

1. Stefan Kottwitz: *LaTeX Beginner's Guide: Create visually appealing texts, articles, and books for business and science using LaTeX*, 2nd Edition , Packt Publishing, 2021.
2. Firuza Karmali Aibara *: A short introduction to LaTeX: A book for beginners*, Createspace Independent Publishing Platform, 2019.
3. Dilip Datta*: LaTeX in 24 Hours: A Practical Guide for Scientific Writing* , 1st ed., Springer, 2017.
4. Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

SEC-2
Operating System: Linux

Course Prerequisites: Good knowledge of C, Computer Organization and Architecture, x86 Assembly level programming.

Course Outcomes:

On completion of this course, students will be able to understand

a) the objectives and functions of modern operating systems,
b) the basic commands of Linux operating system and can write shell scripts,
c) to create file systems and directories and operate them,
d) to create processes background and fore ground etc.,by fork() system calls,
e) to create shared memory segements, pipes ,message queues and can exercise interprocess communication.

Course Contents:

Linux - The Operating System: Linux history, Linux features, Linux distributions, Linux's relationship to Unix, Overview of Linux architecture, Installation, Start up scripts, system processes (an overview), Linux Security, The Ext2 and Ext3 File systems: General Characteristics of, The Ext3 File system, file permissions. User Management: Types of users, the powers of Root, managing users (adding and deleting): using the command line and GUI tools.

Resource Management in Linux: file and directory management, system calls for files Process Management, Signals, IPC: Pipes, FIFOs, System V IPC, Message Queues, system calls for processes, Memory Management, library and system calls for memory.

Books Recommended

1. Arnold Robbins, *Linux Programming by Examples The Fundamentals*, 2nd Ed., Pearson Education, 2008.
2. Cox K, *Red Hat Linux Administrator's Guide*, PHI, 2009.
3. R. Stevens, *UNIX Network Programming*, 3rd Ed., PHI, 2008.
4. Sumitabha Das, *Unix Concepts and Applications*, 4th Ed., TMH, 2009.
5. Ellen Siever, Stephen Figgins, Robert Love, Arnold Robbins, *Linux in a Nutshell*, 6th Ed., O'Reilly Media, 2009.
6. Neil Matthew, Richard Stones, Alan Cox, *Beginning Linux Programming*, 3rd Ed., 2004.
7. Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

SEC-3

Introduction to Programming with MATLAB

Course Prerequisites: None.

Course Outcome:

After the completion of the course, the students will be able to:

a) Understand the basics functions of MATLAB.

b) Plot the 2D, 3D figures.

c) Use basic commands of MATLAB.

d) Solve various differential equations using MATLAB.

Course Content:

Introduction to MATLAB: vector and matrix generation, subscripting and the colon notation, matrix and array operations and their manipulations, introduction to some inbuilt functions related to array operations. m-files: scripts and functions, editing, saving m-files, and interaction between them.

Introduction to builtin functions: related to matrix inversion, eigenvalues, eigenvectors, condition number; for data representation: bar charts, histograms, pie chart, stem plots etc; for solving various type of differential equations; for specialized plotting.

Relational and logical operators: flow control using various statements and loops including If-End statement, If-Else-End statement, nested If-Else-End statement, For-End and While-End loops with Break commands.

Two & three-dimensional graphics: basic plots, change in axes and annotation in a figure, multiple plots in a figure, saving and printing figures, mesh plots, surface plots and their variants e.g., contour plots, sphere, and animations.

Symbolic Math and working with polynomials. Some applications: Numerical solution of ODE using solver, Numerical differentiation and integrations etc.

Books Recommended:

1. Amos Gilat, *MATLAB: An Introduction with Applications*, 4th edition, Wiley; Fourth edition, 2012.
2. Stephen J. Chapman, *MATLAB Programming for Engineers*, Cengage learning; 4th edition, 2012.
3. Rudra Pratap ,*Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers,* Oxford, 2010.
4. V. Dukkipati, Rao, *Matlab: An Introduction With Applications,* New Age International Private Limited; 1st edition, 2009.
5. Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

SEC-4
Introduction to Python

Course Prerequisites: None.

Course Outcomes:

After the completion of the course, the students will be able to:

a) To understand why Python is a useful scripting language for developers.
b) To learn how to design and program Python applications.
c) To learn how to use lists, tuples, and dictionaries in Python programs.
d) To learn how to use indexing and slicing to access data in Python programs.
e) To learn how to write loops and decision statements in Python.
f) To learn how to use python to solve mathematical problems.

Course Content:

Introduction to Python Programming, Installation of Python, Application of Python, Writing Python Code, Running Python Programs, Variables, Basic Input-Output Operations, Operators.

Number, String, List, tuple, set, dictionary, Arrays and Vectors, Conditional Statements (if, if-else, if-elif-else), Loops (For loop, while loop).
Writing and Calling Functions, Function Inputs and Outputs, Local and Global Scope of variable, lamda function , Types of Errors.

Library for Mathematics (sympy and numpy), problems on Algebraic expression, ordinary and partial derivatives, integral, limit, Ordinary Differential Equations, Algebra of Matrices, Plotting of functions.

Books Recommended:

1. Harsh Bhasin, *Python For Beginners*. New Age International; 1st Edition,2018.
2. Tim Hall and J-P Stacey, *Python 3 for Absolute Beginners*. Apress, 2009.
3. Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.