M.Sc. (Industrial Mathematics with Computer Applications)
Programme Structure

PG II:

Semester	Paper Code	Paper Title	Credits
III	MTS -601	Design and Analysis of Algorithms	4
	MTS -602	Digital Image Processing	4
	MTS -603 OR	Financial Mathematics	4
	MTS -604 OR	Dynamical Systems	
	MTS -605 OR	Data Mining	
	MTS -606	Computational Intelligence	
	MTS -610	Research Project	4
	MTS -620	Practical Lab V (Data structures using C++)	2
	MTS -621	Practical Lab VI (Core Java)	2
	MNC - 02	Mandatory Non-credit Course (Cyber Security -2)	2
	MNC - 03	Mandatory Non-credit Course (Skill Development -2)	2
	Students can choose any one course from MTS603 to MTS606 **Total Semester Credits**		**20**
IV	MTS -651	Cryptography	4
	MTS -652	Applied Geometry for Computer Graphics using CAD	
	MTS -653	Optimization Techniques	
	MTS -654	Statistical Machine Learning	
	MTS -660	Research Project	6
	MTS -671 OR	Emerging Technologies: Introduction to Blockchain Technology	2
	MTS -672 OR	Emerging Technologies: Cloud Computing	
	MTS -673	Emerging Technologies: Edge Computing	
	MTS -674	OJT / Industrial Training	8
	Total Semester Credits		**20**

Students can choose any one course from MTS651 to MTS655 **Total PG-II Credits**	**40**

Title of the Course and Course Code	**Design and Analysis of Algorithms** **MTS-601**	**Number of Credits: 04**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Describe basic concepts in algorithms	
CO2	Illustrate the concepts of recurrences, hash tables to run complex functions	
CO3	Solve problems based on Polynomial and Non polynomial time approaches	
CO4	Analyze concepts of dynamic programming, greedy and graph theoretic algorithms	
CO5	Evaluate and compare performance of various algorithms	
CO6	Develop algorithm based on design techniques to compute asymptotic complexities	

Unit No	Title of the Unit and Contents
I	**Growth Functions** Asymptotic Notations
II	**Recurrences** The Substitution Method, Recursion Tree Method, Master theorem
III	**Sorting of Ordered Statistics** Heap Sort, Quick Sort, Sorting in Linear Time, Median and Ordered Statistics
IV	**Dynamic Programming** Matrix Chain Multiplication, Longest Common subsequence, Optimal Binary Trees
V	**Greedy Algorithm** Activity Selection problem, Elements of Greedy Strategy, Huffman Codes
VI	**String Matching** The Naïve String-Matching Algorithm, The Rabin Karp Algorithm, String Matching with finite automata, The Knuth-Morris-Pratt algorithm
VII	**Hash Tables** Direct Address Tables, Hash Tables, Hash Functions, Open Addressing, Perfect Hashing
VIII	**NP completeness** Informal concepts of Deterministic and Non deterministic, P , NP and NP Completeness, Statement of Cooks Theorem, Discussion on Vertex cover problem, Discussion on Travelling Salesman Problem

Learning Resources

1) Introduction to Algorithms, H Coremen, Rivest, Stein and Leiserson

2) Fundamentals of Algorithms, Horowiitz, Sahani and Rajasekeran

3) Mathematics for Analysis of Algorithms, Donald Knuth and H.Green

4) Algorithm Design, Eva Tardos , Jon Klienberg

5) An Introduction to Analysis of Algorithms, Micheal Soltys

6) The Algorithm Design Manual, Steven Skiena

Title of the Course and Course Code	**Digital Image Processing MTS-602**	**Number of Credits: 04**
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	State basic concepts related to mathematics behind digital image processing, different causes for image degradation.	
CO2	Discuss different feature extraction and segmentation techniques.	
CO3	Apply different techniques employed for the enhancement of images, various techniques of image enhancement and compression. Demonstrate and execute morphological image processing on various image formats.	
CO4	Explain the need for image compression and apply.	
CO5	Compare spatial transforms and intensity transforms, different techniques used in feature extraction in images.	
CO6	Reconstruct the images using various reconstruction models.	

Unit No	Title of the Unit and Contents
I	**Introduction** What is Digital Image Processing, Examples of Fields that use Digital Image Processing**,** Imaging in various electromagnetic bands**,** Fundamental steps in Digital Image Processing, Components of an Image Processing System
II	**Digital Image Processing Fundamentals** Elements of Visual Perception, Light and the Electromagnetic Spectrum, Image sensing and Acquisition, Image Sampling and Quantization, Some Basic Relationships between Pixels, An Introduction to the Mathematical Tools Used in Digital Image Processing
III	**Intensity and Spatial Filtering** Some Basic Intensity Transformation Functions ,Histogram Processing ,Histogram Equalization and Normalization, Histogram Matching (Specification), Local Histogram Processing Fundamentals of Spatial Filtering, Sharpening Spatial Filters Combining Spatial Enhancement Methods.
IV	**Filtering in Frequency Domain** Background and Preliminary Concepts, Sampling and the Fourier Transform of Sampled Functions, The Discrete Fourier Transform (DFT) of One variable, The Basics of Filtering in the Frequency Domain, Image Smoothing using Frequency Domain Filters, Image Sharpening Using Frequency Domain Filters
V	**Image Restoration and Reconstruction** A Model of the Image Degradation / Restoration Process, Noise Model, Restoration in the Presence of Noise Only-Spatial Filtering, Periodic Noise Reduction by Frequency Domain Filtering, Band reject Filters: Band pass Filters, Notch Filters, Estimating the Degradation Function, Geometric Mean Filter

VI	**Morphological Image Processing** Preliminaries, Erosion and Dilation, Opening and Closing , The Hit-or-Miss Transformation, Basic Morphological Algorithms, Boundary Extraction, Hole Filling Extraction of Connected Components, Convex Hull, Thinning and Thickening, Skeletons, Pruning, Morphological Reconstruction
VII	**Image Segmentation** Fundamentals, Point, Line, and Edge Detection, Edge Models, Basic Edge Detection Edge Linking and Boundary Detection, Thresholding: Foundation, Basic Global Thresholding, Optimum Global Thresholding, Thresholding using Otsu's Method Region-Based Segmentation
VIII	**Representation and Description** Representation: Boundary (Border) Following algorithms ,Polygonal Approximations Using Minimum-Perimeter Polygons, Other Polygonal Approximation Approaches, Some Simple Descriptors, Shape Numbers, Fourier Descriptors, Regional Descriptors, Some Simple Descriptors, Topological Descriptors, Textural descriptors
	Note: Lectures are assigned to implementation Laboratory Course on MATLAB / Open CV

Learning Resources

1) Gonzalez, R. C. and Woods, R. E. [2002 / 2008], Digital Image Processing, 3rd ed., Prentice Hall
2) Sonka, M., Hlavac, V., Boyle, R. [1999]. Image Processing, Analysis and Machine Vision (2nd edition), PWS Publishing, or (3rd edition) Thompson Engineering, 2007
3) Gonzalez, R. C., Woods, R. E., and Eddins, S. L. [2009]. Digital Image Processing Using MATLAB, 2nd edition, Gatesmark Publishing, Knoxville, TN.
4) Anil K. Jain [2001], Fundamentals of digital image processing (2nd edition), Prentice-Hall, NJ.
5) Willian K. Pratt [2001], Digital Image Processing (3rd Edition), John Wiley & Sons, NY.
6) Burger, Willhelm and Burge, Mark J. [2008]. Digital Image Processing
7) Kropatsch, Digital Image Analysis (With CD-ROM), Springer, ISBN: 978038795066

Title of the Course and Course Code	**Financial Mathematics MTS-603**	**Number of Credits: 04**
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Retrieve basic concepts in Mathematical Finance	
CO2	Interpret properties of Brownian and Geometric Brownian motion	
CO3	Implement Arbitrage theorem to value investments	
CO4	Analyze investments using Expected utility	
CO5	Formulate the theory of Black Scholes to value options in continuous time	
CO6	Choose the appropriate hedging strategy to value against options	

Unit No	Title of the Unit and Contents
I	**Brownian Motion and Geometric Brownian Motion** Brownian Motion, Brownian Motion as Limit of Simpler Models, Geometric Brownian Motion, The Maximum Variable, The Cameron Martin Theorem
II	**Interest Rates and Present Value Analysis** Interest Rates, Present Value Analysis, Rate of Return, continuously varying Interest Rates
III	**Pricing Contracts vs Arbitrage** An example of Options Pricing, Other Examples of Pricing via Arbitrage, The Arbitrage Theorem, The Multi-period Binomial Model, Proof of Arbitrage theorem
IV	**Black Scholes Formula** Black Scholes Formula, Properties of Black Scholes Option Cost, The Delta Hedging Arbitrage Strategy, Some Derivations, European Put Options
V	**Additional Results and Options** Call Options on Dividend Paying Securities, Pricing American Put Options, Adding Jumps to Geometric Brownian Motion, Estimating Volatility Parameter
VI	**Valuing by Expected Utility** Limitations of Arbitrage Pricing, Valuing Investments by Expected Utility, The Portfolio Selection problem, Value at Risk and Conditional Value at risk, The Capital Assets Pricing Model, Rates of Return: Single Period and Geometric Brownian Motion

Learning Resources

1) Sheldon M Ross, An Elementary Introduction to Mathematical Finance, Third Edition, Cambridge University Press.

2) D.G. Luenberger, Investment Science, Oxford University Press

3) Marek Capinski, An introduction to Financial Engineering, Springer Publications.

4) Amber Habib, Calculus of Finance, Universities Press

5) John Hull, Sanskaran Basu, Options, Futures & Derivatives, Pearson Edition

Title of the Course and Course Code	**Dynamical Systems MTS-604**	**Number of Credits : 04**

Course Outcomes (COs) On completion of the course, the students will be able to:	
CO1	Retrieve basic concepts in Differential Equations and Systems
CO2	Interpret properties of solutions to planar systems
CO3	Apply the concept of limit cycles and bifurcations to have a detailed study of planar autonomous systems
CO4	Analyze the interacting Species model within the survival ecosystem
CO5	Formulate the theory of Hamiltonian systems, Lyapanov Functions and determine its stability
CO6	Review the theory of three-dimensional autonomous systems and Chaos

Unit No	Title of the Unit and Contents
I	**Differential Equations** Simple Differential Equations, Applications to Chemical Kinematics, Applications to Electrical Circuits, Existence and Uniqueness Theorem
II	**Planar Systems** Canonical Forms, Eigen values defining Stable and Unstable Manifolds, Phase Plane Portraits, Linearization and Hartman's Theorem, Constructing Phase Plane Diagram
III	**Interacting Species** Competing Species, Predator Prey Models, Other Characteristics Affecting Interacting Species
IV	**Limit Cycles** Existence and Uniqueness of Limit Cycles in a Plane, Non-Existence of Limit Cycles,
V	**Hamiltonian Cycles, Lyapunov Functions and Stability** Hamiltonian Systems in the plane, Lyapanov Systems and Stability
VI	**Bifurcation Theory** Bifurcations of Non-Linear Systems, Normal Forms, Multistability and Bistability
VII	**Three Dimensional Autonomous Systems and Chaos** Linear System and Canonical Forms, Non-Linear Systems and Stability, The Rossler System and Choas, The Lorentz Equations

Learning Resources

1) Stephen Lynch, Dynamical Systems with Applications using Python, Birkhauser Publications

2) Morris Hirsch, Stephen Smale, Differential Equations, Dynamical Systems and introduction to Choas, Academic Press

3) James .D. Miess, Differential Dynamical Systems, Society for Industrial and Applied Mathematics (SIAM)

4) Lawrence Perko, Differential Equations and Dynamical Systems, Springer Texts in Applied Mathematics

5) Kathleen Alligood, Tim Sauer, James Yorke, CHAOS An introduction to Dynamical Systems, Springer

Title of the Course and Course Code	**Data Mining** **MTS-605**	**Number of Credits : 04**

Course Outcomes (COs) **On completion of the course, the students will be able to:**	
CO1	Define Data Mining and its functionalities, Data Warehouses and terminologies used for Attribute Oriented Analysis
CO2	Compare Memory Based Reasoning and Collaborative Filtering in Nearest Neighbors approach
CO3	Use techniques of Association rules to do Market Basket Analysis in Transactional data
CO4	Analyze various techniques for automatic cluster detection
CO5	Reframe concepts in Survival Analysis to apply for customer retention.
CO6	Develop concepts in Data Warehouse, OLAP for efficient data storage

Unit No	Title of the Unit and Contents
I	**Introduction to Data Mining:** What is data Mining, Tasks performed in data mining, Why data Mining, How data mining is used today with various Examples
II	**Decision trees** What is a decision tree, How a tree is grown, Tests for choosing the best split, Pruning, Further refinements of a decision tree model, Alternative representations of decision trees, Case study with decision trees
III	**Nearest Neighbour Approaches:** Memory Based Reasoning and Collaborative Filtering Memory based reasoning, Challenges with MBR, Measuring distance, The Combination Function: Asking the Neighbours for answers, Collaborative Filtering: A Nearest Neighbour approach to making recommendations Case Study with Nearest Neighbours
IV	**Market Basket Analysis and Association Rules** Defining Market Basket Analysis, Association Rules, Building Association Rules, Apriori Algorithm, FP Growth Algorithm, Case study with Market Basket Analysis
V	**Link Analysis** Basic Graph Theory, Directed Graphs, Revision of Travelling Salesman problem, Detecting Cycles in a Graph, A familiar application to Link Analysis, The Kleinberg Algorithm , Case study with Link Analysis
VI	**Automatic Cluster detection** Concept of K Means Clustering, Concept of Similarity and distance, Data Preparation for Clustering, Other approaches of Clustering, Agglomerative clustering Algorithm, Divisive Clustering Algorithm, Evaluating Clusters, Case Study with Clustering
VII	**Hazard Function and Survival Analysis** Problem of Customer Retention, Hazards, Hazard Functions, Censoring, From Hazard to Survival, Proportional Hazards, Cox Proportional Hazards, Limitations of Proportional Hazard Models, Case Study with Survival Analysis

Learning Resources

1) Data Mining Techniques, Micheal Berry and Gordon Linoff, Wiley Publications

2) Data Mining Concepts and Techniques, Jiawei Han and Micheline Kamber, Elsevier Publications

3) Data Warehousing, Data Mining & OLAP, Alex Berson and Stephen Smith, Tata McGraw-Hill Edition

4) Data Mining Models and Methods, Daniel Lacrose, Wiley Interscience

5) Data Mining Techniques, Arun Pujari, Universities Press

6) Insight in to Data Mining Theory and Practice, Easter Economy Edition, Prentice Hall India

Title of the Course and Course Code	**Computational Intelligence MTS-606**	**Number ofCredits :4**
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Describe key concepts associated with computational intelligence and hard computing.	
CO2	Illustrate various concepts associated with Genetic algorithms and compare Generic Algorithm vs. Traditional Algorithms	
CO3	Apply the concept of Artificial neural network to find linear separability and solve various problems.	
CO4	Explain and Compute Mathematical properties of Fuzzy Logic, Classical Sets and Fuzzy Sets and solve examples to justify the properties.	
CO5	Review the concept of Swarm Computing and Ant colony optimization, formulate the concept of Associative Memory Network and Neuro FuzzyModeling to discuss real life problems.	
CO6	Design and analyze the concept of Supervised learning and unsupervised learning to solve real life problems.	

Unit No.	Title of Unit and Contents
I	**Introduction to computational intelligence and Soft computing** What is soft computing? Differences between soft computing and hardcomputing, Soft Computing constituents, Methods in soft computing, Applications of Soft Computing

II	**Introduction to Fuzzy Logic, Classical Sets and Fuzzy Sets** Operations on classical and fuzzy sets Properties of Classical and fuzzy Sets Classical Relations and Fuzzy RelationsTolerance and Equivalence Relations Membership Functions Features of the Membership FunctionsFuzzification Methods of Membership Value Assignments Defuzzification Lambda-Curs for Fuzzy Sets (Alpha-Cuts)Lambda- Cuts for Fuzzy Relations Defuzzification Methods Fuzzy Arithmetic and Fuzzy MeasuresExtension Principle Fuzzy MeasuresFuzzy Integrals Introduction to Fuzzy Rule Base and Approximate Reasoning Introduction to Fuzzy Decision Making Introduction to Fuzzy Logic Control Systems

III	**Genetic Algorithms (GA)** What are Genetic Algorithms? Why Generic Algorithms?Biological Background Traditional Optimization and Search TechniquesGenetic Algorithm and Search Space Generic Algorithm vs. Traditional Algorithms Simple GA, General Genetic Algorithm, Operators in Generic Algorithm
IV	**Artificial Neural Network:** Fundamental Concept Evolution of Neural Networks Basic Models of Artificial Neural NetworkImportant Terminologies of ANN McCulloch-Pits Neuron Linear SeparabilityHebb Network
V	**Supervised Learning Network** Introduction Perceptron Nonworks Adaptive Linear Neuron (Adaline) Multiple Adaptive Linear Neurons Back-Propagation Network
VI	**Unsupervised Learning Networks** Introduction Fixed Weight Competitive Nets Kohonen Self- Organizing Feature MapsLearning Vector Quantization Counter propagation Networks Adaptive Resonance Theory Network
VII	**Introduction to Neuro Fuzzy Modeling, Swarm Computing and Ant colony optimization**

Learning Resources:

1. Timothy J. Ross, Fuzzy Logic: With Engineering Applications Wiley India, ThirdEdition ISBN: 978-81-265-3126-4
2. Kumar Satish, Neural Networks: A Classroom Approach,1/e TMH, ISBN:9780070482920

3. David E. Goldberg, Genetic Algorithms in search, Optimization & MachineLearning by, Pearson Education, ISBN: 81-7808-130-X
4. James A. Freeman and David M. Skapura, Neural Networks Algorithms, Applications, and Programming Techniques, Edition: Pearson Edn., 2003.V. Kecman,Learning and Soft Computing, MIT Press, 2001.
5. J. S. R. Jang, C. T. Sun, and E. Mizutani, "Neuro-Fuzzy and Soft Computing",PHI, 2004, Pearson Education.
6. S. N. Sivanandam, S. N. Deepa, Principles of Soft Computing (With CD)Wiley India, ISBN: 9788126527410
7. S. Rajasekaran and G. A. Vijayalaksmi Pai, Neural Network, Fuzzy Logic andGenetic Algorithms - Synthesis and Applications", (2005), Prentice Hall
8. Konar A., “Computational Intelligence: Principles, Techniques and Applications”, Springer Verlag, 2005
9. Engelbrecht, A.P, “Fundamentals of Computational Swarm Intelligence”, John Wiley & Sons, 2006.

Title of the Course and Course Code	**Research Project MTS-610**	**Number of Credits :4**
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	**Understanding Research Fundamentals**: Gain a comprehensive understanding of the basic principles of research, including its purpose, significance, and different methodologies.	
CO2	**Literature Review Skills:** Develop the ability to conduct a thorough literature review by identifying and critically analyzing existing research in the chosen field of study. Learn to summarize, synthesize, and organize relevant literature to build a conceptual framework for the research.	
CO3	**Research Problem Identification:** Acquire skills in recognizing gaps, controversies, or unresolved issues within the existing literature. Learn to formulate clear and concise research questions or hypotheses based on the identified gaps or problems.	
CO4	**Proposal Writing Skills:** Develop effective proposal writing skills, including clear articulation of the research problem, objectives, and significance. Learn to structure and format a research proposal following academic standards and guidelines.	
CO5	**Research Proposal Presentation:** Gain experience in presenting and defending the research proposal through oral presentations, addressing questions and concerns raised by the audience.	
CO6	**Time Management and Planning:** Learn effective time management and planning skills to successfully complete the literature survey and research proposal within specified timelines.	

Title of the Course and Course Code	**Practical Lab V** **Data Structures using C++** **MTS-620**	**Number of Credits: 02**

Course Outcomes (COs) **On completion of the course, the students will be able to:**	
CO1	Identify fundamental data structures.
CO2	Illustrate fundamental data structures, their uses, strengths, and weaknesses.
CO3	Compute the time complexity of various data structures algorithms.
CO4	Explain the memory representations of several data structures.
CO5	Determine appropriate data structures as per the specified problem definitions.
CO6	Identify fundamental data structures.

Unit No	Title of the Unit and Contents
I	**Introduction to C++** Overview, Basic Syntax – input/output, variables , constant ***(Comparative discussion),*** literal ,operators, loops, Storage Classes, functions, Arrays, Strings , Pointers, References
II	**Object Oriented Concepts** Object, Class, Encapsulation, Abstraction, Inheritance, Polymorphism, Types of Languages (Object Oriented, Procedure Oriented, Scripting)
III	**Introduction to Data Structures and Algorithms** Data, Data Types. Abstract Data Types, Data Structure and its types, Asymptotic Analysis of Algorithms
IV	**Array** Concept, Arrays as ADT, 1-D and Multidimensional Arrays, Advantages and Disadvantages **Application** (Sorting, Searching, Polynomial handling)
V	**Stack** Concept, Stack as ADT, Operations (Push and Pop), Stack Representation (Sequential), Advantages and Disadvantages **Applications** (Infix to Postfix conversion of Expression, Postfix Expression Evaluation & Recursion)
VI	Queue Concept, Queue as ADT, Operations (Insert, Delete and Traversal), Queue Representation (Sequential), Types of Queue (Priority Queue, Circular Queue, Dequeue), Advantages and Disadvantages **Applications** (CPU scheduling Algorithm: FCFS, SJF (Preemptive), Priority)
VII	**Linked List** Concept, Linked List as ADT, Types (Singly, Doubly and Circular), Operations (Insert, Delete and Traversal), Linked List Representation (Sequential, Linked), Advantages and Disadvantages **Applications** (Contiguous File Allocation as well as Linked File Allocation using Sequential Linked List, Linked Representation (Stack, Queue), Disk Scheduling Algorithm using Doubly Linked List- SCAN)

VIII	**Tree** Concept, Terminologies, Types of Trees (Binary and Binary Search Tree), Binary Search Tree Representation (Sequential and Linked), Operations on BST (Insert, Delete and Traversal (In-order, Pre-order and Post-order)) Application (Heap Sort, AVL tree)
IX	**Graphs** Concept, Terminologies, Graph Representation (Sequential and Linked), Traversals (DFS and BFS) Applications (Shortest path algorithm: Dijkstra's algorithm)

Learning Resources:

1. Sahni Horowitz, Fundamentals of Computer Algorithms

2. Langsam / Augenstein / Tenenbaum, Data Structures Using C and C++
3. Jean-Paul Tremblay &Paul G. Sorenson, An Introduction to Data Structures with Applications, Tata McGraw Hill.
4. Alfred V. Aho, John E. Hopcroft and Jeffry D. Ullman, "Data Structures & Algorithms"
5. Yashavant Kanetkar, Data Structure Through C++

Title of the Course and Course Code	**Practical Lab VI** **Core Java** **MTS-621**	**Number of Credits: 02**

Course Outcomes (COs) **On completion of the course, the students will be able to:**	
CO1	Identify Java language components and their working in applications.
CO2	Discuss the concepts of OOPs and Java 8 features.
CO3	Implement object-oriented design with Java, file handling operations in Java.
CO4	Analyze Java APIs for program development.
CO5	Test and validate Java applications using exception handling mechanism.
CO6	Write applications using JDBC and Threads.

Unit No	Title of the Unit and Contents
I	**Introduction to the Java Technology** The Java Platform, API, JVM, Java Compiler, Byte Code, Java Editions, Difference between JDK, JRE & JVM
III	**Basics of Java** Introduction to Java, Writing & Compiling Java Programs- The main Method, Command Line Arguments, Primitive Data Types, Variables, and Assignment, Javadoc Comments, Naming Convention, Expressions, Data Conversion, Boolean Data Type and Expressions { if, switch } Statements,{for,while,do}Statements, for-each loop, Methods, Parameter Passing, Returning Values, Overloading Methods, Scope of Variables, Varargs
IV	**Arrays** Defining and Initializing Arrays, new Operator, Using Arrays, Passing Arrays to Methods, Returning Arrays from Methods, Command-Line Arguments, Dimensional Arrays
V	**Objects and Classes** Defining Class, Creating Object, Packages (Concept of package, package and import keywords, Use of predefined packages), Access Modifiers(public, private, protected, default), Object, Members and Class Members (static), Arrays of Objects, this Keyword, Wrapper Classes, Types of Classes (Inner Class, Anonymous Class), Static block , Scanner Class
VI	**String Handling** What is a String? Immutable Strings, Substring, Methods of String Class, toString() Method, String Buffer Class, String Builder Class, String Buffer vs String Builder
VII	**Inheritance and Polymorphism** Inheritance (IS-A), Aggregation/Composition (HAS-A), Superclass and Subclass – extends Keyword, super Keyword, Overriding Members, Protected Data Members-Object Class and its toString() Method, Final Classes, Methods and Variables, instance of Operator, Dynamic Binding, Casting Objects
VIII	**Abstract Classes & Interfaces** Concept of Interfaces, Implementing Interfaces, when to use which? Programming to Interface Concept
IX	**Exception handling** Exception Handling: What and why? try and catch Block, Multiple catch Block, Nested try, finally Block, throw Keyword, Exception Propagation, throws Keyword, Checked & Unchecked Exceptions, Custom Exceptions

X	**File Handling** File Output Stream & File Input Stream, Buffered Output Stream & Buffered Input Stream, File Writer & File Reader, Using Scanner Class to Read from File, Print Writer, Stream Tokenizer, Object Input Stream & Object Output Stream, Serialization & Deserialization, transient Keyword
XI	**Multithreading** Multithreading: What and why? Life Cycle of a Thread, Creating Thread (Extending Thread Class/ Implementing Runnable Interface), Thread Priority, what is a Daemon Thread? Thread synchronization, Inter-Thread Communication Methods (wait () &notify ())
XII	**Introduction to Collection Framework** Collection Framework, ArrayList Class, LinkedList Class, HashSet Class, TreeSet Class, Hash table Class, HashMap Class, TreeMap Class, Comparable and Comparator Interfaces
XIII	**JDBC** JDBC Driver (Type4), Connectivity with MySQL, Driver Manager, Connection interface, Statement interface, Result Set interface, Prepared Statement, Result Set Meta Data, Database Meta Data
XIV	**JAVA 8 Features** Lambda expression, Functional Interfaces, Method References, Default Method in interface, Streams API (filter,map,collect), DateTime API
XV	**JAVA 11 Features** New Utility methods in String class - isBlank(), repeat(), lines(), strip(),stripLeading(),stripTrailing() Reading/Writing strings to files – readString() & writeString()
XVI	**JAVA 17 Features** Pattern matching for switch, Sealed classes

Learning Resources:

1. Java: How to Program, Deitel & Deitel, PrenticeHall
2. Core Java 2: Volume I – Fundamentals, Cay S. Horstmann and Gary Cornell; Prentice-Hall 2002. ISBN 0130471771
3. Core Java 2: Volume II – Advanced Features, Cay S. Horstmann and Gary Cornell; Prentice Hall 2001. ISBN0130927384
4. Java: The Complete Reference, Herbert Schildt. Fifth Edition Important URLs: http://java.sun.com/reference/docs/

Title of the Course and Course Code	**Cryptography MTS-651**	**Number of Credits: 04**

Course Outcomes (COs) On completion of the course, the students will be able to:	
CO1	Describe key notions and principles related to basic Cryptography.
CO2	Discuss the notion of classical cryptography, basic principles, theory of public key.
CO3	Implement basic symmetric key algorithms and public key algorithms using programming language.
CO4	Explain different cryptographic algorithms.
CO5	Justify different cryptographic algorithms to obtain security and to encrypt, decrypt data, different types of attacks on data.
CO6	Integrate basic algorithms on elliptic curves and its use in cryptography.

Unit No	Title of the Unit and Contents
I	**Basic number theoretic concepts** Congruence, Chinese Remainder Theorem, Primitive Roots**,** Quadratic reciprocity Finite fields**,** Arithmetic functions, Primality Testing and factorization algorithms**,** Pseudo-primes, Fermat's pseudo-primes, Prime Numbers**,** Testing for Primality, Continued fractions, Hash Functions
II	**Classical Cryptosystems** Cryptography in Modern world, Substitution cipher, Ceaser cipher as a special case of substitution cipher, Mono alphabetic ciphers Transposition Cipher, Polyalphabetic substitution ciphers, Vigenère Cipher, Introduction to poly-graphic substitution ciphers cryptanalysis of substitution cipher
III	**Symmetric Key Cryptography** Introduction and overview, Stream Cipher, Block ciphers, one-time Pad, Modes of operation electronic codebook, Digital signature, Data Encryption Standard, Advanced Encryption Standard, IDEA (International Data Encryption Algorithm), Various attacks on data encryption algorithms
IV	**Public Key Cryptography** Introduction and Overview, The RSA algorithm, Generation of keys, Diffie Hellman Key Agreement protocol, EI Gamal Encryption Algorithms, Discrete Logarithm, Attacks against RSA, Discrete Logarithm Problem
V	**Elliptic Curve Cryptography** Introduction and Overview, Elliptic Curves over Real Numbers, Elliptic curves over finite fields, Elliptic curve cryptography, Diffie Hellman key exchange over Elliptic curves.
VI	**Hashing** Motivation and applications, cryptographically secure hashing, Message authentication codes (MAC), Hash Algorithm - MD5, Hash Algorithms – SHA, Examples of Hashing

	using programming language.
VII	**Introduction to Quantum Cryptography** Over view of quantum cryptography and its applications.

Learning Resources:

1) D. R. Stinson: CRYPTOGRAPHY, Theory and practice, CRC Press, 1995
2) Neil Koblitz: A course in Number theory and Cryptography, 2nd Edition, Springer
3) Robert Edward Lewand: Cryptological Mathematics (Mathematical Association of America).
4) Jeffrey Hoffstein, Jill Pipher, Joseph H. Silverman: An introduction to Mathematical Cryptography, Springer
5) Adam J. Elbirt: (CRC press): Understanding and Applying cryptography and Data security.
6) Bruice Schneier: Applied Cryptography (Wiley India Edition)
7) Atul Kahate: Cryptography and Network security (Tata McGraw Hill)
8) Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder. Bitcoin and cryptocurrency technologies: a comprehensive introduction. Princeton University Press, 2016. (Free download available)
9) Joseph Bonneau et al, SoK: Research perspectives and challenges for Bitcoin and cryptocurrency, IEEE Symposium on security and Privacy, 2015 (article available for free download) { curtain raiser kind of generic article, written by seasoned experts and pioneers}.

Title of the Course and Course Code	**Applied Geometry for Computer Graphics using CAD MTS-652**	**Number of Credits : 04**

Course Outcomes (COs) On completion of the course, the students will be able to:	
CO1	Outline the basic principles and theory of homogeneous coordinates and transformations in plane and space, different types of projections on an object.
CO2	Explain the knowledge of basic concepts and principles related to transformations in plane.
CO3	Implement knowledge of basic concepts and principles related to transformations in plane, viewing pipeline, different types of projections on an object, standard 2D and 3D transformation algorithms.
CO4	Explain points on standard curves, Bezier curve.
CO5	Evaluate points on standard curves, Bezier curve and on B-Spline using computations.
CO6	Create different projections and transformations based on basic 2D and 3D transformations.

Unit No	Title of the Unit and Contents
I	**Transformations in a Plane** Translations, Scaling about the Origin, Reflections, Rotation about the Origin, Shears, Concatenation of Transformations, Applications, Instancing, Applications in Robotics
II	**Homogeneous Coordinates and Transformations of the Plane** Homogeneous Coordinates, Points at Infinity Visualization of the Projective Plane, Line Model of the Projective Plane, Spherical Model of the Projective Plane, Transformations in Homogeneous Coordinates, Translations, Scaling about the Origin Rotation about the Origin, Concatenation of Transformations, Inverse Transformations, Rotation about an Arbitrary Point, Reflection in an Arbitrary Line, Applications in Instancing, Device Coordinate Transformation
III	**Homogeneous Coordinates and Transformations of Space** Homogeneous Coordinates, Transformations of Space, Translations, Scaling and Reflections, Rotations about the Coordinate Axes, Rotation about an Arbitrary Line, Reflection in an Arbitrary Plane, Applications in Computer-aided Design, Orientation of a Rigid Body
IV	**Projections and the Viewing Pipeline:** Introduction, Projections of the Plane, Projections of Three-dimensional Space, The View plane Coordinate Mapping, The Viewing Pipeline, Classification of Projections, Classification of Parallel Projections, Classification of Perspective Projections.
V	**Curves** Introduction, Curve Rendering, Parametric Curves (Circle, Ellipse, Parabola, Hyperbola, Arc length and Reparameterization, The general conic equations, Application: Numerical Controlled Machining and Offsets
VI	**Bezier Curves** Introduction, Linear Bezier Curves, Quadratic Bezier Curves, Cubic Bezier Curves

VII	**B-splines** Integral B-spline Curves, Properties of the B-spline Curve, B-spline Types, Applications in Font Design, Applications in Morphing or Soft Object Animation Note

Learning Resources

1) Duncan Marsh, Applied Geometry for Computer Graphics and CAD, 2nd Edition, Springer.
2) D.F. Rogers, J. Alan Adams, Computer Graphics, 2nd Edition, McGraw-Hill Publishing Company.
3) David Lay, Linear Algebra Mathematical Elements of Computer Graphics

Title of the Course and Course Code	Optimization Techniques MTS-653	Number of Credits :4
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Identify and state basic concepts in Linear, Non-linear programming and Game theory.	
CO2	Interpret the Game as a Linear Programming problem and discuss methods to solve them.	
CO3	Apply methods to solve Integer programming problems and examine the Solutions	
CO4	Analyze the primal-dual relationship of a Linear programming problem and compute the dual.	
CO5	Determine local solutions to develop techniques and solve non-linear programming problems.	
CO6	Formulate and solve a Linear Programming problem using Simplex method.	

Unit No	Title of the Unit and Contents
I	**Introduction to Linear Programming** Prototype Example, The Linear Programming Model, Assumptions ofLinear Programming, Additional Examples, Case Studies
II	**Solving Linear Programming Problem: Simplex Method** The Essence of Simplex Method, Setting up the Simplex Method, Algebra of Simplex method, Simplex Method in Tabular Form, Tie Breaking in Simplex Method, Adapting to Other forms, Post Optimality Analysis, Conclusions, Case Studies
III	**Duality and Sensitivity Analysis** The Essence of Duality Theory, Economic Interpretation of Duality, Primal Dual Relationships, Adapting to Other Primal Forms, The Roleof Duality in Sensitivity Analysis, The Essence of Sensitivity Analysis, Applying Sensitivity Analysis, Conclusions, Case Studies
IV	**Integer Programming** Prototype Example, Some BIP Applications, Innovative use of Binary Variables in Model Formulation, Some Formulation Examples, Some Perspectives of solving Integer Programming Problems, The Branch and Bound Technique and its applications to Integer Programming, A Branch and Bound Technique for Mixed Integer Programming, Other Developments in solving BIP Problems, Conclusions, Case Studies
V	**Non-Linear Programming** Sample Applications, Graphical Illustration of Non Linear Programming Problems, Types of Non Linear Programming Problems, One Variable unconstrained Optimization, Multivariable unconstrained Optimization, The Karush Kuhn Tucker conditions for constrained Optimization, Quadratic Programming, Separable Programming, Convex Programming, Non Convex Programming, Conclusions, Case StudiesProcess,
VI	**Game Theory** The Formulation of Two Person Zero Sum Games, Solving Simple Games-Prototype Example, Games with Mixed Strategies, Graphical Solution Procedure, Solving by Linear Programming, Extensions , Conclusion

References:

1. Frederick Hiller & Gerald Lieberman, Introduction to Operational Research, McGrawHill
2. Mykel J Kochenderfer and Tim Wheeler, Algorithms for Optimization, MIT Press
3. S.D. Sharma, Operations Research, Kedarnath Ram Nath
4. Prem Kumar Gupta, D.S. Hira, Operations Research

Title of the Course and Course Code	**Statistical Machine Learning MTS-654**	**Number of Credits : 04**

Course Outcomes (COs) On completion of the course, the students will be able to:	
CO1	Retrieve basic concepts in Statistical Machine Learning
CO2	Discuss various Resampling Methods
CO3	Apply the concept of Linear Regression to build sustainable predictive models
CO4	Analyze the various classification problems using different methods
CO5	Formulate the theory for various tree based methods
CO6	Review the theory of Unsupervised Learning

Unit No	**Title of the Unit and Contents**
I	**Statistical Learning** What is Statistical Learning, Accessing Model Accuracy
II	**Linear Regression** Simple Linear Regression, Multiple Linear Regression, Other Considerations in Regression Model, The Marketing Plan, Comparison of Linear Regression with K Nearest Neighbours, Lab Regression
III	**Classification** An Overview of Classification, Logistic Regression, Linear Discriminant Analysis, A Comparison of Classification methods, Lab: Logistic Regression, LDA, QDA and KNN
IV	**Resampling Methods** Cross Validation, The Bootstrap, Lab: Cross Validation and the Bootstrap
V	**Tree Based Methods** The Basics of Decision trees, Bagging, Boosting, Random Forests, Lab: Decision Trees
VI	**Unsupervised Learning** The Challenge of Unsupervised Learning, Principal Component Analysis, Clustering Methods, Lab 1: Principal Component Analysis, Lab 2: Clustering

Learning Resources:

1) Gareth James, Daneila Witten, Trevor Hastie, Robert Tibshirani: An Introduction to Statistical Learning, Springer Publications

2) Christopher Bishop, Pattern Recognition and Machine Learning, Springer Publications

3) Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer

4) Alan Agresti, Christine Franklin, Statistics The Art and Science of Learning from Data, Pearson Edition

Title of the Course and Course Code	**Research Project MTS-660**	**Number of Credits :4**
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	**Critical Thinking:** Encourage critical thinking skills by requiring students to evaluate and synthesize existing literature, identify research gaps, and propose innovative solutions or perspectives principles of research, including its purpose, significance, and different methodologies.	
CO2	**Hypothesis Formulation:** Help students formulate clear and testable hypotheses or research questions, guiding them through the process of defining the scope and objectives of their research	
CO3	**Research Design:** Familiarize students with various research designs and methodologies, enabling them to choose the most appropriate approach for their specific research question	
CO4	**Data Collection and Analysis:** Train students in the methods of collecting and analysing data, whether through qualitative or quantitative approaches, and help them develop skills in using relevant tools and techniques	
CO5	**Ethical Considerations:** Instil a strong understanding of research ethics, ensuring that students conduct their research in a responsible and ethical manner, respecting the rights and well-being of participants.	
CO6	**Communication, Time management and problem-solving Skills:** Improve students' ability to communicate their research effectively, both in written and oral forms. This includes preparing research proposals, reports, and presenting findings to diverse audiences Develop effective time management skills, helping students create realistic timelines, set milestones, and manage their project efficiently. Problem-solving: Cultivate problem-solving skills by challenging students to overcome obstacles and adapt their research methods when faced with unexpected issues. .	

Title of the Course and Course Code	**Emerging Technologies: Introduction to Block chain Technology MTS-671**	**Number of Credits : 02**

Course Outcomes (COs) On completion of the course, the students will be able to:	
CO1	Understand of basic concepts of Blockchain.
CO2	Learn the technology used for blockchain.
CO3	Familiarize the primitives of the distributed computing and cryptography related to blockchain.
CO4	Illustrate the concepts of Bitcoin and their usage.
CO5	To understand the Ethereum and smart contracts in block chain technology
CO6	Understand use of smart contract in real world applications.

Unit No	**Title of the Unit and Contents**
I	**Introduction**: Need for Distributed Record Keeping, Modeling faults and adversaries, Byzantine Generals problem, Consensus algorithms and their scalability problems, Nakamoto's concept with Blockchain based cryptocurrency, Technologies Borrowed in Blockchain – hash pointers, consensus, byzantine fault-tolerant distributed computing, digital cash etc.
II	**Basic Distributed Computing & Crypto primitives**: Atomic Broadcast, Consensus, Byzantine Models of fault tolerance, Hash functions, Puzzle friendly Hash, Collison resistant hash, digital signatures, public key crypto, verifiable random functions, Zero-knowledge systems
III	**Bitcoin basics:** Bitcoin blockchain, Challenges and solutions, proof of work, Proof of stake, alternatives to Bitcoin consensus, Bitcoin scripting language and their use
IV	**Ethereum basics**: Ethereum and Smart Contracts, The Turing Completeness of Smart Contract Languages and verification challenges, using smart contracts to enforce legal contracts, comparing Bitcoin scripting vs. Ethereum Smart Contracts, writing smart contracts using Solidity & JavaScript

V	**Privacy, Security issues in Blockchain**: Pseudo-anonymity vs. anonymity, Zcash and Zk-SNARKS for anonymity preservation, attacks on Blockchains: Sybil attacks, selfish mining, 51% attacks advent of algorand; Sharding based consensus algorithms to prevent these attacks
VI	**Case Studies:** Block chain in Financial Service, Supply Chain Management and Government Services

Learning Resources :

1. Narayanan, Bonneau, Felten, Miller and Goldfeder, "Bitcoin and Cryptocurrency Technologies – A Comprehensive Introduction", Princeton University Press.

2. Josh Thompson, 'Blockchain: The Blockchain for Beginnings, Guild to Blockchain Technology and Blockchain Programming', Create Space Independent Publishing Platform, 2017.

3. Imran Bashir, "Mastering Blockchain: Distributed ledger technology, decentralization, and smart contracts explained", Packt Publishing.

4. Merunas Grincalaitis, "Mastering Ethereum: Implement Advanced Blockchain Applications Using Ethereum-supported Tools, Services, and Protocols", Packt Publishing.

5. Prof. Sandip Chakraborty, Dr. Praveen Jayachandran, "Blockchain Architecture Design and Use Cases" [MOOC], NPTEL: https://nptel.ac.in/courses/106/105/106105184/

6. BLOCKCHAIN BASICS, Daniel Drescher, Apress Publication, 2017.

7. Blockchain, Melanie Swan, O'reilly Publication, 2015.

Title of the Course and Course Code	**Emerging Technologies: Cloud Computing MTS-672**	**Number of Credits: 02**

Course Outcomes (COs) On completion of the course, the students will be able to:	
CO1	Understanding the Overview of Cloud Computing
CO2	Learn the technology used for Cloud Computing Models
CO3	Familiarize the primitives of service models
CO4	Illustrate the concepts of Virtualization and Cloud Service Providers
CO5	To understand concept of Data centre in cloud computing
CO6	Understand use of services from the aspect of cloud service models and data centres.

Unit No	***Title of the Unit and Contents***
I	Introduction to Cloud Computing: Overview, Characteristics, Architecture, how it works? Advantages/Disadvantages, Risks of Cloud Computing, Applications
II	Cloud Computing Deployment Models: Cloud Computing Deployment Models Types of Cloud (Public Cloud, Private Cloud, Hybrid Cloud, Community Cloud, Multi-Cloud)
III	Cloud Computing Service Models: Software as a service (SaaS), Platform as a service (PaaS), Infrastructure as a service (IaaS), Difference between IaaS, PaaS, and SaaS
IV	Virtualization: What is Virtualization, what is Virtual Machine, what is Container, Data Virtualization, Hardware Virtualization, Software Virtualization, Server Virtualization, Storage Virtualization, OS Virtualization, Windows Virtualization, Demo (any one)
V	Cloud Service Providers: Cloud Service Provider Companies, Amazon Web Services (AWS), Microsoft Azure, Google Cloud (In brief)
VI	Data Centre in Cloud Computing: ui What is a Data Centre? How do Data Centres work? Why are data centres important? Main components of data centre, Data Centre vs. Cloud

Learning Resources :

1. Cloud Computing: Principles and Paradigms, Editors: Rajkumar Buyya, James Broberg, Andrzej M. Goscinski, Wiley,2011
2. Enterprise Cloud Computing - Technology, Architecture, Applications, Gautam Shroff, Cambridge University Press, 2010
3. Cloud Computing Bible, Barrie Sosinsky, Wiley-India, 2010
4. Cloud Security: A Comprehensive Guide to Secure Cloud Computing, Ronald L. Krutz, Russell Dean Vines, Wiley- India,2010

Title of the Course and Course Code	**Emerging Technologies: Edge Computing MTS-673**	**Number of Credits: 02**

Course Outcomes (COs) On completion of the course, the students will be able to:	
CO1	Understanding the basics of cloud computing and Edge Computing
CO2	Learn the Architecture in Edge Computing
CO3	Familiarize the primitives of User applications in Edge Computing
CO4	Illustrate the concepts of Distributed Systems in Edge Computing
CO5	To understand edge data centres, services, and edge Containers.
CO6	Understand use of Data Integration Platform and Use cases

Unit No	**Title of the Unit and Contents**
I	Background of Edge Computing - Introduction to Cloud and its limitations to support low latency and RTT. From Cloud to Edge computing: Waves of innovation
II	Overview of Edge Computing, Architectures in Edge Computing
III	Supporting User Applications - Edge Computing to support User Applications (5G-Slicing, self-driving cars and more)
IV	Distributed Systems in Edge Computing: Concepts of distributed systems in edge computing such as time ordering and clock synchronization, distributed snapshot, etc.
V	Edge Data Centers and Services: Introduction to Edge Data Center, Lightweight Edge Clouds and its services provided by different service providers.
VI	Edge Containers: Introduction to docker container and Kubernetes in edge computing. Design of edge storage systems like key-value stores
VII	Data Integration Platforms: Introduction to MQTT and Kafka for end-to-end edge pipeline. Edge analytics topologies for M2M and WSN network (MQTT)
VIII	Use cases based on Machine Learning for edge sensor data in predictive maintenance, image classifier and self-driving cars.

Books and references

1. “Fog and Edge Computing: Principles and Paradigms”, Rajkumar Buyya (Editor), Satish Narayana Srirama (Editor), Wiley, 2019
2. Cloud Computing: Principles and Paradigms”, Editors: Rajkumar Buyya, James Broberg,Andrzej M. Goscinski, Wiley, 2011
3. “Cloud and Distributed Computing: Algorithms and Systems”, Rajiv Misra, Yashwant Patel, Wiley 2020.

Title of the Course and Course Code	**Industrial Training MTS-674**	**Number of Credits :8**
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Describe and develop the various skills, attitude, and knowledge to understand the professionalism in the IT industry.	
CO2	Discuss and explain the working culture of the Industry in view to maintain quality standards.	
CO3	Implement the confidence, presentation skills and logical thinking, communication skills in developing the system.	
CO4	Differentiate between the academics and professional work culture in timely delivery of projects.	
CO5	Compare and contrast the professional development of the programs and project.	
CO6	Combine the techniques to enhance oneself as a thorough software professional.	

The structure for the Industrial Training Project (ITP) will be as follows

A student can complete Industrial Training Project (ITP) in any I.T. industry / academic institute / with a research project of a teacher / an expert funded by any funding agency for a minimum period of three months.
There will be a teacher coordinator mentoring a group of 10 students throughout the Semester. The teacher coordinator is expected to perform the following tasks

- Maintain a weekly status/progress report of the student. The student will report to the assigned student coordinator once a week either offline/ online mode regarding the progress of his/her work at the Industry/Academic Institute.
- Maintain contact with the Industry/Academic regarding the internship offered to the student.
- Help the student in solving difficulties
- Organize presentations and discussions as required
- Guide the student in preparing the Final Project Documentation
- Maintain a track record for each student through the semester
- Conduct an Internal Assessment for each student consisting of 50 Marks

The work load for the teacher coordinator is proposed as four hours per week.

The workload for a teacher coordinator who is guiding 3 students doing their ITP in Fergusson College (Autonomous) Pune (no mentor from industry) is proposed as four hours per week.

Guidelines for submitting the Final Project report

The student must include the project completion certificate issued by the respective industry/research institute/educational institute in the report. A student will submit two hard bound copies and one softcopy (pdf format): Student Copy, Department copy, Controller of Examinations copy of the work carried out during ITP (pdf format to be emailed by the respective emails).

2. Scheme of Assessment

- **Continuous Internal Assessment**

Evaluation for internal 50 Marks to be done by the Internal Teacher Coordinator

Description	Marks
Weekly reporting (Minimum 12) (Online or Offline Mode as needed	25 Marks
Final Project report documentation	15 Marks
Presentation Demo	10 Marks

End Semester Assessment :

Evaluation for external 50 Marks will be done by a panel of three consisting of One Industrial Expert, One Academic Expert (External from other college) and One Internal Examiner. Each examiner is expected to assess each student for 50 marks independently and average of the three scores is to be considered as the final ESE score (out of 50).

Description	**Marks**
Knowledge and Execution of the System	15
Final Project Report	15
Presentation	10
Viva Voce	10

The Internal Examiner will submit the total of 100 marks to the Examination Section
The final grade (to be printed on the mark list) is to be calculated based on UGC 10-point scale.

Marks	Grade	Grade Point
90-100	O : Outstanding	10
80-89	A+ : Excellent	9
70-79	A : Very Good	8
65-69	B+ : Good	7
60-64	B: Above Average	6
55-59	C+ : Average	5
50-54	C: Below Average	4
45-49	D: Satisfactory	3
40-44	E: Pass	2
0-39	Fail	0
	Absent	0

Note: - A student who has obtained Grade F will have to carry out this project once again for a complete semester (minimum three months).