PROGRAM STRUCTURE FOR THIRD YEAR

UNIVERSITY OF MUMBAI (With Effect from 2022-2023)

**Semester VI**

| **Course**  **Code** | **Course Name** | **Teaching Scheme**  **(Contact Hours)** | | | | | **Credits Assigned** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Theory** | | **Pract.**  **Tut.** | | | **Theory** | | **Pract.** | | | **Total** | |
| CSC601 | Data Analytics and  Visualization | 3 | | -- | | | 3 | | -- | | | 3 | |
| CSC602 | Cryptography and System Security | 3 | | -- | | | 3 | |  | | | 3 | |
| CSC603 | Software Engineering and Project Management | 3 | | -- | | | 3 | | -- | | | 3 | |
| CSC604 | Machine Learning | 3 | | -- | | | 3 | | -- | | | 3 | |
| CSDLO6  01X | Department Level Optional Course -2 | 3 | | -- | | | 3 | | -- | | | 3 | |
| CSL601 | Data Analytics and  Visualization Lab | -- | | 2 | | | -- | | 1 | | | 1 | |
| CSL602 | Cryptography & System Security Lab | -- | | 2 | | | -- | | 1 | | | 1 | |
| CSL603 | Software Engineering and Project Management Lab | -- | | 2 | | | -- | | 1 | | | 1 | |
| CSL604 | Machine Learning Lab | -- | | 2 | | | -- | | 1 | | | 1 | |
| CSL605 | Skill base Lab Course: Cloud Computing | -- | | 4 | | | -- | | 2 | | | 2 | |
| CSM601 | Mini Project Lab: 2B | -- | | 4$ | | | -- | | 2 | | | 2 | |
| **Total** | | **15** | | **16** | | | **15** | | **08** | | | **23** | |
| **Course**  **Code** | **Course Name** | **Examination Scheme** | | | | | | | | | | | |
| **Theory** | | | | | | | | **Term**  **Work** | **Pract.**  **&oral** | | **Total** |
| **Internal Assessment** | | | | **End**  **Sem**  **Exam** | | **Exam.**  **Duration (in Hrs)** | |  |  | |  |
| **Test**  **1** | **Test**  **2** | | **Avg** |  | |  | |  |  | |  |
| CSC601 | Data Analytics and  Visualization | 20 | 20 | | 20 | 80 | | 3 | | -- | -- | | 100 |
| CSC602 | Cryptography and System Security | 20 | 20 | | 20 | 80 | | 3 | | -- | -- | | 100 |
| CSC603 | Software Engineering and Project Management | 20 | 20 | | 20 | 80 | | 3 | | -- | -- | | 100 |
| CSC604 | Machine Learning | 20 | 20 | | 20 | 80 | | 3 | | -- | -- | | 100 |
| CSDLO6  01X | Department Level Optional Course -2 | 20 | 20 | | 20 | 80 | | 3 | | -- | -- | | 100 |
| CSL601 | Data Analytics and  Visualization Lab | -- | -- | | -- | -- | | -- | | 25 | 25 | | 50 |
| CSL602 | Cryptography & System Security Lab | -- | -- | | -- | -- | | -- | | 25 | -- | | 25 |
| CSL603 | Software Engineering and Project Management Lab | -- | -- | | -- | -- | | -- | | 25 | - | | 25 |
| CSL604 | Machine Learning Lab |  |  | |  |  | |  | | 25 | 25 | | 50 |
| CSL605 | Skill base Lab Course: Cloud Computing | -- | -- | | -- | -- | | -- | | 50 | 25 | | 75 |
| CSM601 | Mini Project Lab: 2B | -- | -- | | -- | -- | | -- | | 25 | 25 | | 50 |
| **Total** | | **--** | **--** | | **100** | **400** | | -- | | **175** | **100** | | **775** |

PROGRAM STRUCTURE FOR THIRD YEAR

UNIVERSITY OF MUMBAI (With Effect from 2022-2023)

**DEPARTMENT OPTIONAL COURSES**

| **Department Optional**  **Courses** | **Semester** | **Code & Subject** |
| --- | --- | --- |
| Department  Optional  Course -1 | V | CSDLO5011 : Statistics for Artificial Intelligence & Data Science CSDLO5012: Advanced Algorithms  CSDLO5013: Internet of Things |
| Department  Optional  Course -2 | VI | CSDLO6011 :High Performance Computing  CSDLO6012: Distributed Computing  CSDLO6013: Image & Video processing |

| **Course Code** | **Course Name** | **Credit** |
| --- | --- | --- |
| **CSC601** | Data Analytics and Visualization | **03** |

| Module |  | Detailed Content | Hours |
| --- | --- | --- | --- |
| 1 |  | Introduction to the Science of Statistics. | 5 |
|  | 1.1 | Fundamental Elements of Statistics, Qualitative and Quantitative Data Summaries, Normal distribution ∙ Sampling, The Central Limit Theorem. |  |
| 2 |  | Confidence Intervals and Hypothesis Tests. | 6 |
|  | 2.1 | Statistical Inference, Stating Hypotheses, Test Statistics and p-Values, Evaluating Hypotheses. |  |
| 2.2 | Significance Tests and Confidence Intervals, Inference about aPopulation Mean, Two-Sample Problems. |
| 3 |  | Understanding the association between two continuous or quantitative factors. | 5 |
|  |  | 3.1 Simple Linear Regression, F-test, and t-test for Simple Linear Regression. |  |
|  | 3.2 Multiple linear regression, F-test, and t-test for Multiple Linear Regression. |
| 4 |  | Analysis of Variance (ANOVA) and Analysis for Proportions. | 12 |
|  | 4.1 | One-Way and Two-Way Analysis of Variance and Covariance, F-test for ANOVA, Type I and Type II Errors. |  |
| 4.2 | Analysis for proportions: One-Sample Tests for Proportions, Significance Tests for a Proportion, Confidence Intervals for a Proportion, Two-Sample Tests for Proportions, Confidence Intervals for |

|  |  | Differences in Proportions, Significance Tests for Differences in Proportions. |  |
| --- | --- | --- | --- |
| **5** |  | **Time Series Analysis** | 6 |
|  | 5.1 | Operation on Time Series Analysis, Testing a Time Series for Autocorrelation, Plotting the Partial Autocorrelation Function, Fitting an ARIMA Model, Running Diagnostics on an ARIMA Model |  |
| **6** |  | **Data Visualization** | 5 |
|  | 6.1 | Bar graphs, Line graphs, Histogram, Box plots, Scatter plots, and Choropleth (map) plots, Radial Bar plots |  |
| 6.2 | Time series plots, Creating Dashboard using any tool. |
|  |  | **Total** | 39 |

| **Course Code** | **Course Name** | **Credit** |
| --- | --- | --- |
| **CSC602** | Cryptography and System Security | **03** |

| **Module** |  | **Detailed Content** | **Hours** |
| --- | --- | --- | --- |
| **1** |  | **Introduction & Number Theory** |  |
|  | 1.1 | Services, Mechanisms and attacks-the OSI security architecture-Network security model-Classical Encryption techniques (Symmetric cipher model, mono-alphabetic and poly-alphabetic substitution techniques: Vignere cipher, Playfair cipher, Hill cipher, transposition techniques: keyed and keyless transposition ciphers, steganography). | 7 |
| **2** |  | **Block Ciphers & Public Key Cryptography** | 7 |
|  | 2.1 | Data Encryption Standard-Block cipher principles-block cipher modes of operationAdvanced Encryption Standard (AES)-Triple DES-Blowfish-RC5 algorithm. Public key cryptography: Principles of public key cryptosystems The RSA algorithm, The knapsack algorithm, and the El-Gamal Algorithm. Key management – Diffie Hellman Key exchange |  |

| **3** |  | **Cryptographic Hashes, Message Digests and Digital Certificates** | 7 |
| --- | --- | --- | --- |
|  | 3.1 | Authentication requirement – Authentication function, Types of Authentication, MAC – Hash function – Security of hash function and MAC –MD5 – SHA – HMAC – CMAC, Digital Certificate: X.509, PKI |  |
| **4** |  | **Digital signature schemes and authentication Protocols** | 6 |
|  | 4.1 | Digital signature and authentication protocols: Needham SchroederAuthentication protocol, Digital Signature Schemes – RSA, EI Gamal and Schorr, DSS. |  |
| **5** |  | **System Security** | 6 |
|  |  | Operating System Security: Memory and Address Protection, File Protection Mechanism, User Authentication. Linux and Windows: Vulnerabilities, File System Security  Database Security: Database Security Requirements, Reliability and Integrity, Sensitive Data, Inference Attacks, Multilevel Database Security |  |
| **6** |  | **Web security** | **6** |
|  | 6.1 | Web Security Considerations, User Authentication and Session Management, Cookies, SSL, HTTPS, SSH, Web Browser Attacks, WebBugs, Clickjacking, CrossSite Request Forgery, Session Hijacking and Management, Phishing Technique, DNS Attack, Secure Electronic Transaction, Email Attacks, Firewalls, Penetration Testing |  |

| **Course Code** | **Course Name** | **Credit** |
| --- | --- | --- |
| **CSC603** | Software Engineering and Project Management | **03** |

| Module |  | Detailed Content | Hours |
| --- | --- | --- | --- |
| 1 |  | Introduction to Software Engineering |  |
|  |  | Nature of Software, Software Engineering, Software Process, Capability Maturity Model (CMM) Generic Process Model, Prescriptive Process Models: The Waterfall Model, V-model, Incremental Process Models, Evolutionary Process Models, Concurrent Models, Agile process, Agility Principles, Extreme Programming (XP), Scrum, Kanban model | 08 |
| 2 |  | Requirements Analysis and Cost Estimation | 06 |
|  | 2.1 | Software Requirements: Functional & non-functional – user-system requirement engineering process – feasibility studies – elicitation – validation & management – software prototyping – S/W documentation – Analysis and modelling Requirement Elicitation, Software requirement specification (SRS)  3Ps (people, product and process) Process and Project metrics Software Project Estimation: LOC, FP, Empirical Estimation Models - COCOMO II Model |  |
| 3 |  | Design Engineering | 07 |

|  | 3.1 | Design Process & quality, Design Concepts, The design Model, Pattern-basedSoftware Design. 4.2 Architectural Design: Design Decisions, Views, Patterns, Application Architectures, Modeling Component level Design: component, Designing class-based components, conducting component-level design, User Interface Design: The golden rules, Interface Design steps & Analysis, Design Evaluation |  |
| --- | --- | --- | --- |
| 4 | 4.1 | Software Risk, Configuration Management | 05 |
|  | Risk Identification, Risk Assessment, Risk Projection, RMMM Software Configuration Management, SCM repositories, SCM process Software Quality Assurance Task and Plan, Metrics, Software Reliability, Formal Technical Review (FTR), Walkthrough. |  |
| 5 |  | Software Testing and Maintenance | 05 |
|  | 5.1 | Testing: Software Quality, Testing: Strategic Approach, Strategic Issues Testing: Strategies for Conventional Software, Object-oriented software, Web AppsValidating Testing- System Testing- Art of Debugging. Maintenance: Software Maintenance-Software Supportability Reengineering- Business Process Reengineering- Software Reengineering Reverse Engineering- Restructuring- Forward Engineering. |  |
| 6 |  | IT Project Management and Project Scheduling | 08 |
|  | 6.1 | Introduction, 4 P‘s, W5HH Principle, Need for Project Management, Project Life cycle and ITPM, Project Feasibility, RFP, PMBOK Knowledge areas, Business Case, Project Planning, Project Charter and Project Scope. |  |
|  | 6.2 | Project Scheduling: Defining a Task Set for the Software Project, Timeline chartsWBS, Developing the Project Schedule, Network Diagrams (AON, AOA), CPM and PERT, Gantt Chart, Tracking the Schedule, Earned Value Analysis |  |

| **Course Code** | **Course Name** | **Credit** |
| --- | --- | --- |
| **CSC604** | Machine Learning | **03** |

| **Module** |  | **Detailed Content** | **Hours** |
| --- | --- | --- | --- |
| **1** |  | **Introduction to Machine Learning** | 6 |
|  | 1.1 | Introduction to Machine Learning, Issues in Machine Learning, Application of Machine Learning, Steps of developing a Machine Learning Application. |  |
|  | Supervised and Unsupervised Learning: Concepts of Classification, Clustering and prediction, Training, Testing and validation dataset, cross-validation, overfitting and underfitting of model |
|  | Performance Measures: Measuring Quality of model- Confusion Matrix, Accuracy, Recall, Precision, Specificity, F1 Score, RMSE |
| **2** |  | **Mathematical Foundation for ML** | 5 |
|  | 2.1 | System of Linear equations, Norms, Inner products, Length of Vector, Distance between vectors, Orthogonal vectors |  |
| 2.2 | Symmetric Positive Definite Matrices, Determinant, Trace, Eigenvalues and vectors, Orthogonal Projections, Diagonalization, SVD and its applications |
| **3** |  | **Linear Models** | 7 |
|  | 3.1 | The least-squares method, Multivariate Linear Regression, Regularized Regression, Using Least-Squares Regression for classification |  |
| 3.2 | Support Vector Machines |
| **4** |  | **Clustering** | 4 |
|  | 4.1 | Hebbian Learning rule |  |

|  | 4.2 | Expectation -Maximization algorithm for clustering |  |
| --- | --- | --- | --- |
| **5** |  | **Classification models** | 10 |
|  | 5.1 | Introduction, Fundamental concept, Evolution of Neural Networks, Biological Neuron, Artificial Neural Networks, NN architecture, McCulloch-Pitts Model. Designing a simple network, Non-separable patterns, Perceptron model with Bias. Activation functions, Binary, Bipolar, continuous, Ramp. Limitations of Perceptron. |  |
| 5.2 | Perceptron Learning Rule. Delta Learning Rule (LMS-Widrow Hoff), Multi-layer perceptron network. Adjusting weights of hidden layers. Error backpropagation algorithm. |
|  | 5.3 | Logistic regression |  |
| **6** |  | **Dimensionality Reduction** | 07 |
|  | 6.1 | Curse of Dimensionality. |  |
| 6.2 | Feature Selection and Feature Extraction |
| 6.3 | Dimensionality Reduction Techniques, Principal Component Analysis. |

| Course Code | Course Name | Credit |
| --- | --- | --- |
| CSDLO6011 | High PerformanceComputing | 03 |

**DETAILED SYLLABUS:**

| **Sr.**  **No.** | **Module** | **Detailed**  **Content** | **Hours** |
| --- | --- | --- | --- |
| 0 | Prerequisite | Computer Organization, C Programming, Data  structures andAlgorithm Analysis. | **02** |
| I | Introduction | **Introduction to Parallel Computing:** Motivating Parallelism, Scope of Parallel Computing, Levels of parallelism (instruction,transaction, task, thread, memory, function), Models (SIMD,  MIMD, SIMT, SPMD, Dataflow Models, Demand drivenComputation).  **Self-learning Topics:** Parallel Architectures:  Interconnectionnetwork, Processor Array,  Multiprocessor. | **05** |

| II | Parallel  Programming  Platforms | **Parallel Programming Platforms:** Implicit  Parallelism:Dichotomy of Parallel Computing  Platforms, Physical  Organization of Parallel Platforms, Communication Costs inParallel Machines.  **Self-learning Topics:** Trends in Microprocessor & Architectures,Limitations of Memory System Performance. | **04** |
| --- | --- | --- | --- |
| III | Parallel  Algorithm  And  Concurrency | **Principles of Parallel Algorithm Design:**  Preliminaries,Decomposition Techniques,  Characteristics of Tasks andInteractions, Mapping Techniques for Load Balancing,  Basic Communication operations: Broadcast and ReductionCommunication types.  **Self-learning Topics: Parallel Algorithm Models** | **09** |
| IV | Performance  Measures for  HPC | **Performance Measures :** Speedup, execution time, efficiency,cost, scalability, Effect of granularity on performance, Scalability of Parallel Systems, Amdahl‘s Law, Gustavson‘s Law.  **Self-learning Topics:** Performance Bottlenecks. | **05** |
| V | Programming  Paradigms for HPC | **Programming Using the Message-Passing**  **Paradigm :** Principles of Message Passing  Programming, The BuildingBlocks: Send and Receive Operations, MPI: the Message Passing Interface, Topology and Embedding.  **Parallel Algorithms and Applications :** | **09** |
|  |  | One-Dimensional Matrix-Vector Multiplication, Graph Algorithms, Sample Sort, Two-Dimensional  MatrixVectorMultiplication.  **Self-learning Topics:** Introduction to OpenMP. |  |
| VI | General  Purpose  Graphics  Processing  Unit(GPGPU)  Architecture  and  Programming | OpenCL Device Architectures, Introduction to OpenCL Programming.  **Self-learning Topics:** Introduction to CUDA  architecture, and Introduction to CUDA Programming. | **05** |

| **Course Code** | **Course Name** | **Credit** |
| --- | --- | --- |
| **CSDLO6012** | Distributed Computing | **03** |

| **Module** |  | **Detailed Content** | **Hours** |
| --- | --- | --- | --- |
| **1** |  | **Introduction to Distributed Systems** |  |
|  | 1.1 | Characterization of Distributed Systems: Issues, Goals, and Types of distributed systems, Distributed System Models, Hardware Concepts, and Software Concepts. | 06 |
|  | 1.2 | Middleware: Models of Middleware, Services offered by middleware, Client Server model. |  |
| **2** |  | **Communication** | 06 |
|  | 2.1 | Layered Protocols, Interprocess communication (IPC): MPI, Remote Procedure Call (RPC), Remote Object Invocation, Remote Method Invocation (RMI**)** |  |
|  | 2.2 | Message Oriented Communication, Stream Oriented Communication, Group Communication |  |
| **3** |  | **Synchronization** | 09 |
|  | 3.1 | Clock Synchronization, Physical Clock, Logical Clocks, Election Algorithms, Mutual Exclusion, Distributed Mutual Exclusion-Classification of Mutual Exclusion Algorithm, Requirements of Mutual Exclusion Algorithms, and Performance measure. |  |
|  | 3.2 | Non-Token-based Algorithms: Lamport Algorithm, Ricart–Agrawala's Algorithm, Maekawa‘s Algorithm |  |

|  | 3.3 | Token-Based Algorithms: Suzuki-Kasami‘s Broadcast Algorithms, Singhal‘s Heuristic Algorithm, Raymond‘s Tree.based Algorithm, Comparative Performance Analysis. |  |
| --- | --- | --- | --- |
| **4** |  | **Resource and Process Management** | 06 |
|  | 4.1 | Desirable Features of a global Scheduling algorithm, Task assignment approach, Load balancing approach, load sharing approach |  |
|  | 4.2 | Introduction to process management, process migration, Threads, Virtualization, Clients, Servers, Code Migration |  |
| **5** |  | **Consistency, Replication and Fault Tolerance** | 06 |
|  | 5.1 | Introduction to replication and consistency, Data-Centric and Client-Centric Consistency Models, Replica Management |  |
|  | 5.2 | Fault Tolerance: Introduction, Process resilience, Reliable client-server and group communication, Recovery |  |
| **6** |  | **Distributed File Systems and Name Services** | 06 |
|  | 6.1 | Introduction and features of DFS, File models, File Accessing models, File-Caching Schemes, File Replication, Case Study: Distributed File Systems (DSF), Network File System (NFS), Andrew File System (AFS), HDFS |  |

**\* Suggestion: Laboratory work based on the above syllabus can be incorporated as a mini project in CSM601: Mini-Project.**

## Image and Video Processing

| **Module** |  | **Content** | **Hrs** |
| --- | --- | --- | --- |
| **1** |  | **Digital Image Fundamentals** | **04** |
|  | 1.1 | Introduction to Digital Image, Digital Image Processing System, Sampling and Quantization, |  |
|  | 1.2 | Representation of Digital Image, Connectivity, Image File Formats: BMP, TIFF, and JPEG. |  |
| **2** |  | **Image Enhancement in Spatial Domain** | **08** |
|  | 2.1 | Introduction to Image Enhancement: Gray Level Transformations, Zero Memory Point Operations, |  |
|  | 2.2 | Histogram Processing,. |  |
|  | 2.3 | Neighbourhood Processing, Spatial Filtering, Smoothing and Sharpening Filters |  |
| **3** |  | **Image Segmentation** | **06** |
|  | 3.1 | Segmentation based on Discontinuities (point, Line, Edge) |  |
|  | 3.2 | Image Edge detection using Robert, Sobel, Previtt masks, Image Edge detection using Laplacian Mask. |  |

|  | 3.3 | Region-Oriented Segmentation: Region growing by pixel Aggregation, Split and Merge |  |
| --- | --- | --- | --- |
| **4** |  | **Image Transforms** | **09** |
|  | 4.1 | Introduction to Unitary Transforms |  |
|  | 4.2 | Discrete Fourier Transform(DFT), Inverse DFT, Properties of DFT, Fast Fourier Transform(FFT), |  |
|  | 4.3 | Discrete Hadamard Transform(DHT), Inverse DHT, Fast Hadamard Transform(FHT), Discrete Cosine Transform(DCT), Inverse DCT |  |
| **5** |  | **Image Compression** | **08** |
|  | 5.1 | Introduction, Redundancy, Fidelity Criteria |  |
|  | 5.2 | Lossless Compression Techniques: Run length Coding, Arithmetic Coding, Huffman Coding |  |
|  | 5.3 | Lossy Compression Techniques: Improved Gray Scale Quantization, Vector Quantization |  |
| 6 |  | **Digital Video Processing** | **04** |
|  | 6.1 | Introduction to Digital Video Processing, Sampled Video |  |
|  | 6.2 | Composite and Component Video, Digital video formats and applications |  |
|  |  | **Total** | **39** |