UNIVERSITY OF CALCUTTA

Notification No. CSR/ 107 /18

It is notified for information of all concerned that the Syndicate in its meeting held on 06.12.2018 (vide Item No.16) approved the revised syllabi of

a. M.Sc. in Computer and Information Science under Choice Based Credit System (CBCS), and,

b. B.Tech. in Computer Science and Engineering ,

under this University as laid down in the accompanying pamphlet.

The above shall be effective from the academic session 2018-2019.

SENATE HOUSE
KOLKATA-700073
The 13th December, 2018

(Dr. Soumitra Sarkar)
Registrar (Officiating)

UNIVERSITY OF CALCUTTA
Faculty of Engineering & Technology

Syllabus for 4-year B. Tech. course Semester VII & VIII
Curriculum for B Tech Computer Science and Engineering (4 years)

B. Tech. Semester-III					
Paper	**Course Title**	**L+T+P**	**Credit**	**Full Marks**	**Pre-requisite**
CSML301	Discrete Mathematics	**3+1+0**	4	100	
CSCL302	Data Structure	3+1+0	4	100	CS 106
CSCL303	Digital Logic	3+1+0	4	100	
CSCL304	Microprocessor and microcontroller	3+0+0	3	100	
CSHL305	Environment and society	2+0+0	2	100	
CSCP306	Data Structure Lab	0+0+3	2	100	
CSCP307	Digital logic and Microprocessor Lab	0+2+3	4	100	
CSCP308	Computer Programming Lab-I (C & Python)	0+0+3	2	100	
	Total Hours	14+5+9	25	800	
B. Tech. Semester-IV					
Paper	Course Title	L+T+P	Credit	Full Marks	Pre-requisite
CSML401	Probability and Stochastic Process	3+1+0	4	100	
CSCL402	Computer Organization	3+0+0	3	100	CSCL 303
CSCL403	Design & Analysis of Algorithms	3+1+0	4	100	CSML301 ,CSCL 302
CSCL404	Operating Systems	3+1+0	4	100	CSCL 402
CSHL405	Social issues and Professional Practice	2+0+0	2	100	
CSCP406	Computer Organization Lab	0+0+3	2	100	
CSCP407	Operating Systems Lab	0+0+3	2	100	
CSCP408	Computer Programming Lab-II (OOP)	0+2+3	4	100	
	Total Hours	14+5+9	25	800	
B. Tech. Semester-V					
Paper	Course Title	L+T+P	Credit	Full Marks	Pre-requisite
CSCL501	Computer Networks	3+1+0	4	100	
CSC502	Database Management System	3+1+0	4	100	
CSCL503	Software Engineering	3+1+0	4	100	
CSCL504	Computer Architecture	3+0+0	3	100	CSCL 402
CSCL505	Optimization Techniques	3+1+0	4	100	MA204, CSML 401
CSCP506	Computer Networks Lab	0+0+3	2	100	
CSCP507	DBMS Lab	0+0+3	2	100	
CSCP508	Software Engineering Lab	0+0+3	2	100	
	Total Hours	15+4+9	25	800	
B. Tech. Semester-VI					
Paper	Course Title	L+T+P	Credit	Full Marks	Pre-requisite
CSCL601	Formal Languages and Automata theory	3+1+0	4	100	
CSCL602	Computer Graphics	3+1+0	4	100	MA 204
CSCL603	Distributed system	3+0+0	3	100	
CSCL604	Internet Technology	3+0+0	3	100	
CSHL605	Innovation and Entrepreneurship development	2+2+0	4	100	
CSCP606	Computer Graphics Lab	0+0+6	4	100	
CSCP607	Internet Technology Lab	0+0+3	2	100	
CSCP608	Mini Programming Project(Lab)	0+0+3	2	100	
	Total	14+4+12	26	800	
B. Tech. Semester-VII					
Paper	**Course Title**	L+T+P	**Credit**	**Full Marks**	
CSEL7X1	Elective I	3+0+0	3	100	

CSEL7X2	Elective II	3+0+0	3	100	
CSEL7X3	Elective III	3+0+0	3	100	
CSCP704	Term Paper	0+0+6	4	100	
CSCP705	Project	0+0+6	4	100	
CSEP7X6	Elective I (LAB)	0+0+3	2	100	
CSEP7X7	Elective II (LAB)	0+0+3	2	100	
CSEP7X8	Elective III(LAB)	0+0+3	2	100	
	Total	9+0+21	**23**	**800**	
B. Tech. Semester-VIII					
Paper	**Course Title**	**L+T+P**	**Credit**	**Full Marks**	
CSL8X1	Elective IV	3+1+0	4	100	
CSL8X2	Elective V	3+1+0	4	100	
CSL8X3	Elective VI	3+1+0	4	100	
CSP804	Project	0+0+18	12	400	
CSP805	General Viva		2	100	
	Total	9+3+18	**26**	**800**	

List of Electives for Semester VII and VIII

Course Code	Courses
	Elective-I
CSEL711	Internet of Things
CSEL712	Compiler Design
CSEL713	VLSI Technology
	Elective-II
CSEL 721	Algorithmic Graph Theory
CSEL 722	Linear and Abstract Algebra
CSEL 723	Modeling and Simulation
	Elective-III
CSEL 731	Principles of Artificial Intelligence
CSEL 732	Introduction to Data Mining
CSEL 733	Introduction to Computational Biology
	Elective-IV
CSEL 841	Cloud Computing
CSEL 842	Information Retrieval
CSEL 843	Wireless Sensor Network
	Elective-V
CSEL 851	Digital signal Processing
CSEL 852	Parallel Algorithms
CSEL 853	Information Security
	Elective-VI
CSEL 861	Introduction Machine Learning
CSEL 862	Image Processing
CSEL 863	Introduction to Data Science

Paper No. - CSEL711 **Paper Name - INTERNET OF THINGS (Elective-I)**		**Full Marks: 100**
Module	**Topics**	**Hours**
Module-1: **Fundamental of IoT-**	Fundamental of IoT- Evolution of Internet of Things-Enabling Technologies-IoT Architectures: oneM2M, IoT World forum (IoTWF) and Alternative IoT models- Simplified IoT Architecture and Core IoT Functional Stack-Fog, Edge and Cloud in IoT-Functional blocks of an IoT ecosystem-Sensors, Actuators, Smart Objects and Connecting Smart Objects	8
Module-2: **IoT Protocols- IoT Access Technologies**	IoT Protocols- IoT Access Technologies: Physical and MAC layers, topology and Security of IEEE 802.15.4, 802.15.4g, 802.15.4e, 1901.2a, 802.11ah and LoRaWAN- Network Layer: IP versions, Constrained Nodes and Constrained Networks-Optimizing IP for IoT: From 6LoWPAN to 6Lo, routing over Low Power and Lossy Networks- application Transport Methods: Supervisory Control and Data Acquisition – Application Layer Protocols: CoAP and MQTT.	8
Module-3: **Design and Development-**	Design and Development- Design Methodology- Embedded computing logic-Microcontroller, System on Chips- IoT system building blocks- Arduino- Board details, IDE programming – Raspberry Pi- Interfaces and Raspberry Pi with Python Programming.	8
Module-4: **Data analytics and Supporting Services**	Data analytics and Supporting Services- Structured Vs Unstructured Data and Data in Motion Vs Data in Rest-Role of Machine Learning-No SQL Databases- Hadoop Ecosystem-Apache Kafka, Apache Spark- Edge Streaming Analytics and Network Analytics – Xively Cloud for IoT, Python Web Application Framework – Django –AWS for IoT – System Management with NETCONF-YANG.	8
Module-5: **Case Studies/ Industrial Applications**	Cisco IoT system – IBM Watson IoT platform- Manufacturing Converged Plantwide Ethernet Model (CPwE) – Power Utility Industry- Grid Blocks Reference Model – Smart and Connected Cities: Layered architecture, Smart Lighting, Smart Parking Architecture and Smart Traffic Control.	8

Text Books:

David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, "IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things", Cisco Press 2017

References:

1. Arshdeep Bahga, Vijay Madisetti, "Internet of Things- A Hands-on Approach", Universities Press, 2015
2. Olivier Hersent, David Boswarthick, Omar Elloumi, "The Internet of things- Key applications and Protocols", Wiley, 2012 (for unit 2)
3. Jan Ho "iller, Vlasios Tsiatsis, Catherine Mulligan, Stamatis, Karnouskos, Stefan Avesand, David Boyle, "From Machine-to-Machine to the Internet of Things- Introduction to a New Age of Intelligence", Elsevier, 2014.
4. Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), "Architecting the Internet of things", Springer, 2011.
5. Michael Margolis, Arduino Cookbook, "Recipies to Begin, Expand and Enhance Your Projects", 2nd Edition, O'Reilly Media, 2011.

   https://www.arduino.cc/

   https://www.ibm.com/smarterplanet/us/en/?ca=v_smarterplanet..

Paper Code – CSEL712 **Paper Name – Compiler Design (Elective-I)**		**Full Marks 100**
Module	**Topics**	**Lecture Hours**
Module-1: **Introduction to Compiling**	Introduction, Analysis-synthesis model, Phases of the compiler.	2
	Lexical Analysis: Role of lexical analyser, Tokens, Patterns, Lexemes, Input buffering, Specifications of a token, Recognition of tokens, Finite automata, regular expression to an NFA conversion, From a regular expression to NFA, From a regular expression to DFA, Design of a lexical analyser generator (Lex).	5
Module-2: **Syntax Analysis**	The role of a parser, Context free grammars, Writing a grammar, Top down Parsing, Non-recursive Predictive parsing (LL), Bottom up parsing, Handles, Viable prefixes, Operator precedence parsing, LR parsers (SLR, LALR), Parser generators (YACC). Error Recovery strategies for different parsing techniques.	8
	Syntax directed translation: Syntax directed definitions, Construction of syntax trees, Bottom-up evaluation of S attributed definitions, L-attributed definitions, and Bottom-up evaluation of inherited attributes.	5
Module-3: **Type checking**	Type checking: Type systems, Specification of a simple type checker, Equivalence of type expressions, Type conversions	3
	Run time environments: Source language issues (Activation trees, Control stack, scope of declaration, Binding of names), Storage organization (Subdivision of run-time memory, Activation records), Storage allocation strategies, Parameter passing (call by value, call by reference, copy restore, call by name), Symbol tables, dynamic storage allocation techniques.	4
Module-4: **Intermediate code generation**	Intermediate code generation: Intermediate languages, Graphical representation, Three-address code, Implementation of three address statements (Quadruples, Triples, Indirect triples).	4
Module-5: **Run Time Environment and Code Generation**	Storage Organization, Stack allocation Space, Access to Non local Data on the Stack, Heep Management- Issues in the design of code generator, a simple code generator, Register allocation & assignment.	4
Module-6: **Code optimization**	Code optimization: Introduction, Basic blocks & flow graphs, Transformation of basic blocks, Dag representation of basic blocks, the principle sources of optimization, Loops in flow graph, Peephole optimization.	5

Text Books:

1. Alfred V. Aho, Ravi Sethi, Jeffrey D. Ullman, Compilers: Principles, Techniques and Tools, Addison-Wesley.
2. Michael L. Scott, Programming Language Pragmatics, Elsevier.
3. Andrew W. Appel, Modern Compiler Implementation in C/Java, Cambridge University Press.
4. Keith D. Cooper and Linda Torczon, Engineering a Compiler, Elsevier.
5. Allen I. Holob, Compiler Design in C, Prentice-Hall.
6. Steven S. Muchnik, Advanced Compiler Design and Implementation, Elsevier.
7. Randy Allen and Ken Kennedy, Optimizing Compilers for Modern Architectures, Elsevier.

Paper Code – CSEL713 Paper Name: VLSI Technology (Elective-I)		Full Marks: 100
Module	**Topics**	**Hours**
Module-1: **Overview of VLSI Technology:**	**Overview of VLSI Technology:** Hierarchical Design of VLSI, Behavioural Description, RTL, Logic Circuit, Gate Circuits, Device, Process, Circuit Topology, Wafer Preparation.	5
Module-2: **Integrated Circuit Manufacturing**	**Integrated Circuit Manufacturing:** Layout Design Rules, Circuit Characterization and Performance Estimation, Delay Estimation, Transistor Sizing, Power Disruption, Interconnect, Design Margin, Reliability, Scaling.	5
Module-3: **Type checking**	**nMOS and CMOS Technology:** IC Design Techniques, MOS Transistors, CMOS Processing Technology, Design of nMOS and CMOS Inverter, NAND, and NOR Gates, Stick Diagrams, Colour and Monochrome Codes in Stick Diagrams and Mask Layouts, Pull-up to Pull-down Ratio for nMOS Inverter, Correspondence of Design Parameters with Specifications, Mask Layout Designs for nMOS and CMOS NAND and NOR Gates.	7
Module-4: **Design Methodologies:**	**Design Methodologies:** Custom and Semi-Custom Designs, Standard Cell, Gate Array, FPGA, PLDs.	4
Module-5: **CAD VLSI Tools**	**CAD VLSI Tools:** Simulators for Logic, Timing, Circuit, Device and Process Optimization, Layout Design, Assignment, Partitioning, Floor-Planning, Placement, Routing, Compaction, and Verification Algorithms.	8
Module-6: **Hardware Description Languages for VLSI design**	**Hardware Description Languages for VLSI design:** VHDL and Verilog, Programming and Subsystem Design Concepts, Design of Multiplexer, Parity Generator, Adder, Subtractor, Multiplier, ALU, Datapaths and Control Unit Design.	4
Module-7: **Trends and Issues in High Performance VLSI Design**	**Trends and Issues in High Performance VLSI Design:** Interconnect as Key Limiting Factor, Wire Modeling, Clock Distribution of High Speed System, Power Distribution, Crosstalk and Power Distribution Noise, High Speed Circuit Design Techniques, Low Power Design Issues, High Density and High Speed Memory Design, ASIC Design.	7

Text Books:

1. Principles of CMOS VLSI Design. N. Weste and K. Eshraghian. Addison Wesley; 2nd edition (December 20, 2000).
2. Basic VLSI Design. D. A. Pucknell and K. Eshraghian. Pearson College Div., Subsequent edition (January 1, 1995).
3. An Introduction to VLSI Physical Design. M. Sarrafzadeh and C. K. Wong. McGraw-Hill College (February 21, 1996).
4. Algorithms for VLSI Physical Design Automation. N. A. Sherwani. Springer; 3rd edition (November 30, 1998).
5. Multi-Layer Channel Routing: Complexity and Algorithms. R. K. Pal. Narosa, 1st edition (28 September 2000).

Paper Code – CSEL722 Paper Name: Linear and Abstract Algebra (Elective-II)		Full Marks: 100
Module	**Topics**	**Hours**
Module-1: **Introducing graphs and Algorithmic complexity**	**Introducing graphs and Algorithmic complexity:** P, NP, NP-Completeness and NP-Hardness, Approximation algorithms.	6
Module-2: **Spanning trees and Connected components**	**Spanning trees and Connected components:** Algorithms for minimum spanning tree and minimum spanning forest. Strongly connected and Biconnected components.	6
Module-3: **Planar graphs and Graph isomorphism**	**Planar graphs and Graph isomorphism:** Importance of the problem, Planarity testing algorithm, Isomorphism complete problems, Polynomial time algorithm for planar graph problems, Group theoretic method.	6
Module-4: **Network and Flows**	**Network and Flows:** Basic concepts, Max-flow-min-cut theorem, Ford and Fulkerson augmenting path method, Integral flow theorem, Maximum capacity augmentation, Edmond-Karp method, Preflow-push method (Goldberg and Tarjan) and its analysis, Better time bounds for simple networks. Minimum cost flow: Minimum cost augmentation and its analysis.	6
Module-5: **Matching**	**Matching:** Basic concepts, Bipartite matching for unweighted and weighted graphs, Edmond's blossom shrinking algorithm and its analysis.	6
Module-6: **Graph Coloring**	Vertex colouring, Edge colouring, NP-completeness proof, Countability and chromatic polynomials, Greedy colouring algorithms.	4
Module-7: **Notion of Perfect graphs**	**Notion of Perfect graphs:** Definition and concept of perfect graphs, Perfect graph Algorithms, Algorithms for graph theoretic invariants for chordal graphs, interval graphs, and comparability graphs.	6

Text Books:

1. Introduction to Algorithms. Cormen, Thomas H., Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein. The MIT Press, 3rd edition (July 31, 2009).
2. Graph Theory with Applications. J. A. Bondy and U. S. R. Murthy. Elsevier Science Ltd/North-Holland (June 1, 1976).
3. Graph Algorithms. S. Even. Computer Science Press; 1st edition (June 1, 1979).
4. Data Structures and Algorithms 2: Graph Algorithms and NP-Completeness. K. Mehlhorn. Springer, Softcover reprint of the original 1st edition: 1984 edition (December 25, 2011).
5. Computers and Intractability: A Guide to the Theory of NP-Completeness. M. R. Garey and D. S. Johnson. W. H. Freeman; 1st edition (January 15, 1979).
6. Algorithmic Graph Theory and Perfect Graphs. M. C. Golumbic. North Holland; 2nd edition (February 18, 2004).
7. Algorithmic Graph Theory. J. A. McHugh. Prentice Hall (August 1, 1989).
8. Introduction to Algorithms: A Creative Approach. U. Manber. Addison-Wesley; 1st edition (January 11, 1989)
9. Combinatorial Optimization: Algorithms and Complexity. C. H. Papadimitriou and K. Steiglitz. Dover Publications; Unabridged edition (January 29, 1998).
10. Pearls in Graph Theory: A Comprehensive Introduction. N. Hartsfield and G. Ringel. Dover Publications (December 29, 2003).

Paper Code – CSEL723 **Paper Name – MODELLING AND SIMULATION (Elective-II)**		**Full Marks 100**
Module	**Topics**	**Lecture Hours**
Module-1: Introduction	Concept of model and model building, model classification and representation, Use of simulation as a tool, steps in simulation study.	6
Module-2: Continuous-time and Discrete-time systems	Laplace transform, transfer functions, state-space models, order of systems, z-transform, feedback systems, stability, observability, and controllability. Statistical Models in Simulation: Common discrete and continuous distributions, Poisson process, and empirical distributions.	6
Module-3: Random Numbers:	Properties of random numbers, generation of pseudo random numbers, techniques of random number generation, tests for randomness, random variate generation using inverse transformation, direct transformation, convolution method, acceptance-rejection.	6
Module-4: Design and Analysis of simulation experiments	Data collection, identifying distributions with data, parameter estimation, goodness of fit tests, selecting input models without data, multivariate an time series input models, verification and validation of models, static and dynamic simulation output analysis, steady-state simulation, terminating simulation, confidence interval estimation, Output analysis for steady state simulation, variance reduction techniques.	8
Module-5: Queuing Models	Characteristics of queuing systems, notation, transient and steady-state behavior, performance, network of queues.	8
Module-6: Large Scale systems	Model reduction, hierarchical control, decentralized control, structural properties of large scale systems.	6

Text Books:

1. Narsingh Deo, System Simulation with Digital Computer, Prentice Hall of India, 1999.
2. Averill Law, Simulation Modeling and Analysis (3rd Ed.), Tata McGraw-Hill, 2007.
3 G. Gordan, System Simulation (2nd Ed.), Pearson Education, 2007.
4. A.F. Seila, V. Ceric and P. Tadikamalla, Applied Simulation Modeling (International Student Edition), Thomson Learning, 2004.
5. Jerry Banks, Handbook of Simulation: Principles, Methodology, Advances, Applications, and Practice, Wiley Inter Science, 1998.
6. J. Banks, J.S. Carson, B.L. Nelson, Discrete Event System Simulation (4th Ed.), Prentice-Hall of India, 2004.
7. N.A. Kheir, Systems Modeling and Computer Simulation, Marcel Dekker, 1988.
8. B.P. Zeigler, T.G. Kim, and H. Praehofer, Theory of Modeling and Simulation (2nd Ed.), Academic Press, 2000

Paper Code – CSEL731 **Paper Name: Principle of Artificial Intelligence (Elective-III)**		**Full Marks: 100**
Module	**Topics**	**Hours**
Module-1: **Introduction**	**Introduction** [2L]: Overview of Artificial intelligence- Problems of AI, AI technique, Tic - Tac - Toe problem	4
Module-2: **Intelligent Agents**	**Intelligent Agents** [2L]: Agents & environment, nature of environment, structure of agents, goal based agents, utility based agents, learning agents.	2
Module-3: **Problem Solving**	**Problem Solving** [2L]: Problems, Problem Space & search: Defining the problem as state space search, production system, problem characteristics, issues in the design of search programs.	2
Module-4: **Search techniques**	**Search techniques** [5L]: Solving problems by searching :problem solving agents, searching for solutions; uniform search strategies: breadth first search, depth first search, depth limited search, bidirectional search, comparing uniform search strategies.	3
Module-5: **Heuristic search strategies**	**Heuristic search strategies** [5L]: Greedy best-first search, A* search, memory bounded heuristic search: local search algorithms & optimization problems: Hill climbing search, simulated annealing search, local beam search, genetic algorithms; constraint satisfaction problems, local search for constraint satisfaction problems.	5
Module-:6 **Adversarial search**	**Adversarial search** [3L]: Games, optimal decisions & strategies in games, the minimax search procedure, alpha-beta pruning, additional refinements, iterative deepening.	3
Module-7 **Knowledge & reasoning**	**Knowledge & reasoning** [3L]: Knowledge representation issues, representation & mapping, approaches to knowledge representation, issues in knowledge representation	3
Module-8: **Predicate logic**	**Predicate logic [3L]:** Representing simple fact in logic, representing instant & ISA relationship, computable functions & predicates, resolution, natural deduction	3
Module-9: **Representing knowledge using rules**	**Representing knowledge using rules** [3L]: Procedural verses declarative knowledge, logic programming, forward verses backward reasoning, matching, control knowledge.	3
Module-10: **Probabilistic reasoning**	**Probabilistic reasoning** [4L]: Representing knowledge in an uncertain domain, the semantics of Bayesian networks, Dempster-Shafer theory, Fuzzy sets & fuzzy logics.	4
Module-11: **Soft Computing Approaches & learning**	**Soft Computing Approaches & learning** [8L]: Overview, Rough set, Forms of learning, inductive learning, learning decision trees, explanation based learning, learning using relevance, information, neural net learning & genetic learning.	8
Module-12: **Expert Systems**	**Expert Systems [2L]:** Representing and using domain knowledge, expert system shells, knowledge acquisition.	2

Text Books:

1. Artificial Intelligence, Ritch & Knight, TMH
2. Artificial Intelligence A Modern Approach, Stuart Russel Peter Norvig Pearson
3. Introduction to Artificial Intelligence & Expert Systems, Patterson, PHI
4. Poole, Computational Intelligence, OUP
5. Logic & Prolog Programming, Saroj Kaushik, New Age International
6. Expert Systems, Giarranto, VIKAS
7. Artificial Intelligence, Russel, Pearson

Paper Code – CSEL732 **Paper Name: Introduction to Data Mining (Elective-III)**		**Full Marks: 100**
Module	**Topics**	**Hours**
Module-1: **Introduction**	Motivation, Definition, Data Mining Functionalities: Summarization, Association, Classification, Clustering, Outlier Analysis, Challenges in DM like Scalability, Missing data handling etc, DM in KDD process	4
Module-2: **Introduction to Data warehousing**	Introduction, DW architecture, Dimensional Modelling, OLAP operations, ROLAP: Snowflake & Star Schema, Data Pre-processing like Aggregation, Sampling, Dimensionality Reduction etc.	6
Module-3: **Association Rules**	Concepts and Definitions like Support, Frequent Set etc, Association Rule, Support-Confidence Measure, Discovering Association rules, Apriori Algorithm, FP tree Growth Algorithm, Interestingness measure for evaluation of rules,	6
Module-4: **Classification**	Classification problem, Classification techniques through supervised learning, **Decision tree**: Concept, Tree Construction (Top-down approach), Best Split & Entropy, Decision Tree extension, Pruning, **Bayes Classifier:** Class conditional probability, Posterior Probability, Multivariate Bayes, Naïve Bayesian Classification, Conditional independence, **Support Vector Machine**: Linear Discriminant, Hyperplane, Support vector, **K nearest neighbour Classifier**	14
Module-5: **Cluster analysis and deviation detection**	**Clustering :** Cluster Analysis Problem, Partitioning, Classical approach: K-means & K-medoids, Density based methods: DBSCAN, Hierarchical Clustering approach: Agglomerative clustering, Outlier analysis	6
Module-:6 Applicatons	**Applications of Data Mining:** Discussion on use cases like Financial data Analysis, Biological data Analysis etc.	4

Text Books:

1. Han, J., Kamber, M., & Pei, J. , Data mining: Concepts and techniques (3rd ed.). Morgan Kaufmann, 2011.
2. A. K. Pujari: Data Mining Techniques, Fourth Edition, Universities Press,
3. D. J. Hand, H. Mannila and P. Smyth: Principles of Data Mining, MIT Press
4. M. Berry and G. Linoff: Mastering Data Mining, John Wiley & Sons

Paper Code – CSEL733 **Paper Name: Introduction to Computational Biology (Elective-III)**		**Full Marks: 100**
Module	**Topics**	**Hours**
Module-1: **Introduction to Molecular Biology**	**Introduction to Molecular Biology** Concepts of Cell, tissue, types of cell, components of cell, organelle. Functions of different organelles. Concepts of DNA: Basic Structure of DNA; Double Helix structure; Watson and crick model. Exons and Introns and Gene Concept. Concepts of RNA : Basic structure, Difference between RNA and DNA. Types of RNA. Concept of Protein: Basic components and structure. Introduction to Central Dogma: Transcription and Translation, Introduction to Metabolic Pathways.	7
Module-2: **Sequence & Expression Databases**	**Sequence & Expression Databases** Introduction to Bioinformatics. Recent challenges in Bioinformatics. Protein Sequence Databases, DNA sequence databases. sequence database search programs like BLAST and FASTA. NCBI different modules: GenBank; GEO, OMIM, Taxonomy browser, PubMed, EMBL, OMICS data.	7
Module-3: **DNA sequence analysis**	**DNA sequence analysis** DNA Mapping and Assembly: Size of Human DNA, Copying DNA: Polymerase Chain Reaction (PCR), Hybridization and Microarrays, Cutting DNA into Fragments, Sequencing Short DNA Molecules, Mapping Long DNA Molecules. DeBruijn Graph. Sequence Alignment: Introduction, local and global alignment, pair wise and multiple alignment, Dynamic Programming Concept. Alignment algorithms: Needleman and Wunsch algorithm, Smith-Waterman.	9
Module-4: **Probabilistic models used in Computational Biology**	**Probabilistic models used in Computational Biology** Probabilistic Models; Hidden Markov Model: Concepts, Architecture, Transition matrix, estimation matrix. Application of HMM in Bioinformatics : Gene finding, profile searches, multiple sequence alignment and regulatory site identification. Feature Selection: ID3, CART, Naïve Bayesian Classifier, Bayesian networks Model: Architecture, Principle ,Application in Bioinformatics.	8
Module-5: **Biological Data Classification and Clustering**	**Biological Data Classification and Clustering** Assigning protein function and predicting splice sites: Decision Tree Gene Expression Clustering. K Means, Fuzzy C-means Algorithm, Artificial Neural Network: Back propagation, Auto encoder, Recurrent Neural Network, Boltzmann Machine, RBM, Convolution Neural Network	9

Text Books:

1. Alberts et.al. Molecular Biology of the Cell
2. Vavid W. Mount: Bioinformatics:Sequenc and Genome analysis
3. Arther M. Lesk: Introduction to Bioinformatics, Oxford
4. Rastogi et.al.: Bioinformatics-Methods and applications-genomics, Proteomics and Drug Discovery, Prentice Hall.
5. Dan Gasfield: Algorithms on Strings, Trees and Sequences, Computer Science and Computational Biology, Cambridge University Press
6. M. S. Waterman: Introduction to Computational Biology: Maps, Sequences and Genomes, 1995.
7. Gibas, Jambeck: Developing Bio-informatics Computer Skills, SPD

Paper Code – CSEL841 **Paper Name: Cloud Computing (Elective-IV)**		**Full Marks: 100**
Module	**Topics**	**Hours**
Module-1: **Introduction to Cloud Computing**	**Introduction to Cloud Computing [5L]:** Cloud computing at a glance – The vision of cloud computing, Definition of cloud computing, The cloud computing reference model, Characteristics and benefits of cloud computing. Evolution of cloud computing – parallel computing, distributed computing, cluster computing, grid computing, virtualization, Web 2.0, Client/Server computing, P2P computing, service-oriented computing and utility-oriented computing. Business driver for adopting cloud computing. Cloud Service Models – IaaS, PaaS, SaaS, XaaS. Cloud Deployment Models – Private, Public, Hybrid, Community, Cloud Federation.	5
Module-2: **Virtualization Technologies**	**Virtualization Technologies [10L]:** Introduction to virtualization. Characteristics of virtualized environment – Security, Managed execution, Portability. Types of Virtualization – Bare Metal and Hosted. Hardware level virtualization – Machine(x86) reference model, Hypervisor, Hardware assisted virtualization, Full virtualization, Paravirtualization. Operating system level virtualization. Other types of virtualization – storage virtualization, Network virtualization, Desktop virtualization. VM Migration techniques. Pros and cons of virtualization. Case studies – Xen, VMware and Microsoft Hyper-V.	10
Module-3: **Cloud Services and Platforms**	**Cloud Services and Platforms [10L]:** Compute service – Amazon EC2, Google Compute Engine, Windows Azure VM. Storage Services – Amazon S3, Google Cloud Storage, Windows Azure Storage. Database Services – Amazon RDS, Amazon SimpleDB and DynamoDB, Google Coud SQL, Google Cloud Datastore, Windows Azure SQL Database and Table Service. Application Services – Amazon SQS, Amazon SNS, Email service. Content Delivery Services – Amazon CludFrnt, Windows Azure Content Delivery Network. Analytics Services – Amazon EMR, Google BigQuery, Windows Azure HDInsight. Deployment and Management Services – Amazon Elastic Beanstalk, Amazon CloudFormation. Open Source Cloud Platform – CloudStack, Eucalyptus, OpenStack.	10
Module-4: **Management of Cloud Resources**	**Management of Cloud Resources [15L]:** Lifecycle management of cloud applications. Monitoring cloud resources – Zabix, Amazon CloudWatch. Feedback control based on dynamic thresholds, Bag-of-Task (BoT) scheduling problems, VM Placement problems, Resource bundling, combinatorial auctions, fair queuing, borrowed virtual time, Cloud scheduling subject to deadlines, Cost and Energy efficient Scheduling algorithms, Scheduling in Federated environment. Identity and Access management for Cloud Resources – Amazon Identity and Access Management Services, Windows Azure Active Directory.	15

Text Books:

1. Mastering Cloud Computing - Foundations and Applications Programming by Christian Vecchiola, Rajkumar Buyya, and S. Thamarai Selvi, Elsevier, 2013
2. Cloud Computing – A Hands-on Approach by Arshdeep Bahga and Vijay Madasetti, Universities Press, 2014

Reference Books:

1. Cloud Computing Bible by Barrie Sosinsky, Wiley-India, 2010
2. Cloud Computing: Principles and Paradigms by Rajkumar Buyya, James Broberg, Andrzej M. Goscinski, Wile, 2014
3. Cloud Computing: Principles, Systems and Applications, Editors: Nikos Antonopoulos, Lee Gillam, Springer, 2012
4. Cloud Security: A Comprehensive Guide to Secure Cloud Computing by Ronald L. Krutz, Russell Dean Vines, Wiley-India, 2010

Paper No.- CSEL842 Paper Name- INFORMATION RETRIEVAL (Elective-IV)		Full Marks: 100
Module	**Topics**	**Hours**
Module-1: Introduction to Information Retrieval	The nature of unstructured and semi-structured text. Inverted index and Boolean queries.	2
Module-2: Text Indexing, Storage and Compression	Text encoding: tokenization, stemming, stop words, phrases, index optimization. Index compression: lexicon compression and postings, lists compression. Gap encoding, gamma codes, Zipf's Law. Index construction. Postings size estimation, merge sort, dynamic indexing, positional indexes, n-gram indexes, real-world issues.	6
Module-: Retrieval Models	Boolean, vector space, TFIDF, Okapi, probabilistic, language modeling, latent semantic indexing. Vector space scoring. The cosine measure. Efficiency considerations. Document length normalization. Relevance feedback and query expansion. Rocchio.	6
Module-4: Performance Evaluation	Evaluating search engines. User happiness, precision, recall, F-measure. Creating test collections: kappa measure, interjudge agreement.	4
Modulle-5: Text Categorization and Filtering	Introduction to text classification. Naive Bayes models. Spam filtering. Vector space classification using hyperplanes; centroids; k Nearest Neighbors. Support vector machine classifiers. Kernel functions. Boosting.	6
Module-6: Text Clustering	Clustering versus classification. Partitioning methods. k-means clustering. Mixture of Gaussians model. Hierarchical agglomerative clustering. Clustering terms using documents.	6
Module-7: Advanced Topics	Summarization, Topic detection and tracking, Personalization, Question answering, Cross language information retrieval.	6
Module-8 Web Information Retrieval	Hypertext, web crawling, search engines, ranking, link analysis, PageRank, HITS, XML and Semantic web.	4

Text Books:

1. Manning, Raghavan and Schutze, Introduction to Information Retrieval, Cambridge University Press.
2. Baeza-Yates and Ribeiro-Neto, Modern Information Retrieval, Addison-Wesley.
3. Soumen Charabarti, Mining the Web, Morgan-Kaufmann.

Refernces:

1. Survey by Ed Greengrass available in the Internet.

Paper Code – CSEL843 **Paper Name: Wireless Sensor Network (Elective-IV)**		**Full Marks: 100**
Module	**Topics**	**Hours**
Module-1: **Introduction**	**Introduction:** commercially available sensor nodes - Imote, IRIS, Mica Mote, EYES nodes, BTnodes, TelosB, Sunspot, node – architecture, sensing and communication range, design issues, energy consumption, clustering of sensors, applications, sensor deployment, scheduling and coverage issues	8
Module-2: **Medium Access Control Protocols**	**Medium Access Control Protocols:** Fundamentals of MAC protocols - Low duty cycle protocols and wakeup concepts - Contention-based protocols - Schedule-based protocols - SMAC - BMAC - Traffic-adaptive medium access protocol (TRAMA) - The IEEE 802.15.4 MAC protocol	10
Module-3: **Routing And Data Gathering Protocols**	**Routing And Data Gathering Protocols:** Routing Challenges and Design Issues in Wireless Sensor Networks, Flooding and gossiping – Data centric Routing – SPIN – Directed Diffusion – Energy aware routing - Gradient-based routing - Rumour Routing – COUGAR – ACQUIRE – Hierarchical Routing - LEACH, PEGASIS – Location Based Routing – GF, GAF, GEAR, GPSR – Real Time routing Protocols – TEEN, APTEEN, SPEED, RAP - Data aggregation - data aggregation operations - Aggregate Queries in Sensor Networks - Aggregation Techniques – TAG, Tiny DB, Energy efficient routing	15
Module-4: **Embedded Operating Systems**	**Embedded Operating Systems:** Operating Systems for Wireless Sensor Networks – Introduction - Operating System Design Issues - Examples of Operating Systems – TinyOS – Mate – MagnetOS – MANTIS - OSPM - EYES OS – SenOS – EMERALDS – PicOS – Introduction to Tiny OS – NesC – Interfaces and Modules- Configurations and Wiring - Generic Components -Programming in Tiny OS using NesC, Emulator TOSSIM	7

Text Books:

1.Kazem Sohraby, Daniel Minoli and Taieb Znati, " Wireless Sensor Networks Technology, Protocols, and Applications", John Wiley & Sons, 2007.

2.Holger Karl and Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks", John Wiley & Sons, Ltd, 2005.

3.K. Akkaya and M. Younis, "A survey of routing protocols in wireless sensor networks", Elsevier Ad Hoc Network Journal, Vol. 3, no. 3, pp. 325--349

4.Philip Levis, " TinyOS Programming"

5. Holger Karl & Andreas Willig, " Protocols And Architectures for Wireless Sensor Networks" , John Wiley, 2005.

6. Feng Zhao & Leonidas J. Guibas, "Wireless Sensor Networks- An Information Processing Approach", Elsevier, 2007.

7. Kazem Sohraby, Daniel Minoli, & Taieb Znati, "Wireless Sensor Networks - Technology, Protocols, And Applications", John Wiley, 2007.

8. Anna Hac, "Wireless Sensor Network Designs", John Wiley, 2003.

Paper Code – CSEL851 **Paper Name: Digital Signal Processing (Elective-V)**		**Full Marks: 100**
Module	**Topics**	**Hours**
Module-1: **Introduction**	Signals: Analog & Digital Signals, Classification and Characterization, Typical Signal Processing Applications. Why DSP .	2
Module-2: **Discrete Time Signals (in Time domain & Transform Domain):**	Discrete Time Signals and System, Sequence and its representation, Sampling Process, Random Signals, Correlation of Signals, Analysis & Modeling of Random Signals Fourier Transform, Transfer Function, Discrete Fourier, Transform & Discrete Time Fourier Transform and their relationship, Z-Transform. Inverse Z- Transform and its Applications, Discrete Cosine Transform, Frequency Response. Simple Digital and Analog Filters, Complementary Transform Functions.	8
Module-3: **Digital Signal Processing and Continuous Time Signals:**	Sampling of Continuous signals. Sampling Theorem, Power Spectral Density, Design and Analysis of Analog High pass and Band pass Filters, A/D, D/A Circuits.	6
Module-4: **Sample/ Hold Circuits Digital Filter Structure and Design:**	Block Diagram Representation, Equivalent Structure, Realization of Basic Structures, Computational Complexity	6
Module-5: **Different Filter Design :**	IR Filter, Truncation, Windowing, FIR Filter Impulse invariance. Bilinear Transformation	8
Moddulee-6: **DSP Algorithms and Application:**	Basic Concepts and issues. Structure Simulation, Number Representation, Arithmetic Operations. Overflow, Function Approximation, Engineering Applications Speech, Music, RADR, Two Dimensional Digital signal Processing in Picture Processing and Pattern Recognition.	10

Text Book:

1. **Quinn, M. J.** (2004). Parallel Programming in C with MPI and OpenMP. – New York, NY: McGraw-Hill.
2. **Grama, A., Gupta, A., Kumar V.** (2003, 2nd edn.). Introduction to Parallel Computing. – Harlow, England: Addison-Wesley.
3. **Pacheco, P.** (1996). Parallel Programming with MPI. - Morgan Kaufmann.
4. **Chandra, R., Dagum, L., Kohr, D., Maydan, D., McDonald, J., and Melon, R.** (2000). Parallel Programming in OpenMP. Morgan Kaufmann Publishers.
5. **Culler, D., Singh, J.P., Gupta, A.** (1998) Parallel Computer Architecture: A Hardware/Software Approach. - Morgan Kaufmann.
6. **Tanenbaum, A.** (2001). Modern Operating System. 2nd edn. – Prentice Hall

Paper Code – CSEL852 **Paper Name: Parallel Algorithms (Elective-V)**		**Full Marks: 100**
Module	**Topics**	**Hours**
Module-1: **Introduction to Parallel Programming**	Needs for parallel computations. Challenges of parallel programming	2
Module-2: **Overview of Parallel System Architectures**	Overview of some parallel systems. Multiprocessors and multicomputers. Network topologies. Computer system classification. Clusters	4
Module-3: Modeling and Analysis of Parallel Computations	Efficiency characteristics of parallel computation: speedup, efficiency, scalability. Modeling the computations in the form of the "operation-operand" graph. Model analysis: determining the parallel method execution time, estimating the maximum possible parallelization, computational load balancing. The Amdahl's and Gustavson-Barsis's laws. Aggregating the computation model.	4
Module-4: **Communication Complexity Analysis of Parallel Algorithms**	Network topology characteristics. Routing algorithms and data communication methods. Main communication operations. Logical (virtual) representation of network topology. Estimating the data communication time for clusters.	4
Module-5: **Parallel Programming with MPI**	Overview of the MPI standard. Point-to-point communication operations. Synchronous and asynchronous modes of data transmission. Collective operations. Derived data types. Process management. Logical topologies. Case studies: matrix computations; solving partial differential equations.	6
Module-6: **Parallel Programming with OpenMP**	Overview of the OpenMP standard. Parallel regions. Computational load distributing among the threads. Shared and private data. Synchronization. OpenMP environment. Comparative consideration of various approaches to parallel programming for distributed and shared memory systems.	4
Module-7: **Principles of Parallel Algorithm Design**	Parallel program modeling. Development stages: computation partitioning, analyzing the information dependencies, scaling and distributing computations among the processors. Case study: solving the gravitational problem of *N* bodies	4
Moddulee-8: **Parallel algorithms for solving time consuming problems**	Matrix computa Matrix-vector multiplication Matrix multiplication Solving the linear equation systems Sorting Solving the partial differential equations	8
Module-9: **Modeling the parallel program executing**	Representation of the parallel program as a system of processes carried out in parallel. Mutual exclusion in using the shared resources. Semaphores and monitors. Modeling the program state in the form of the "process-resource" graph. Model analysis: the detection and exclusion of deadlocks. Petri networks. Case studies: the "producer-consumer" problem, the "dining philosophers" problem etc.	4

Text Book:

1. **Quinn, M. J.** (2004). Parallel Programming in C with MPI and OpenMP. – New York, NY: McGraw-Hill.
2. **Grama, A., Gupta, A., Kumar V.** (2003, 2nd edn.). Introduction to Parallel Computing. – Harlow, England: Addison-Wesley.
3. **Pacheco, P.** (1996). Parallel Programming with MPI. - Morgan Kaufmann.
4. **Chandra, R., Dagum, L., Kohr, D., Maydan, D., McDonald, J., and Melon, R.** (2000). Parallel Programming in OpenMP. Morgan Kaufmann Publishers.
5. **Culler, D., Singh, J.P., Gupta, A.** (1998) Parallel Computer Architecture: A Hardware/Software Approach. - Morgan Kaufmann.
6. **Tanenbaum, A.** (2001). Modern Operating System. 2nd edn. – Prentice Hall

Paper Code – CSEL853 **Paper Name: Information Security (Elective-V)**		**Full Marks: 100**
Module	**Topics**	**Hours**
Module-1: **Cryptography Basics**	**Cryptography basics:** Possible attacks, Cipher text generation, Block & Stream Cipher, Stream Cipher generation, Algorithmic Mode, Secret Key & Public Key Encryption, Secret Key Encryption: Algorithms DES, AES with necessary Mathematical Basis, Public Key Encryption: RSA, El-gamal, Eliptic Curve algorithms with necessary mathematical analysis, Digital Signature creation techniques, Message Integrity through Hash function, Authentication techniques.	25
Module-2: **Network Security**	**Network Security:** Security layers in Network Protocol Stack, IP Sec, Secure Socket Layer, Security protocols used in Application layer like PGP, SHTTP etc., Network Defence tools – Firewalls, Intrusion Detection, Filtering, Security in Mobile Platforms: Threats in mobile applications, analyzer for mobile apps to discover security vulnerabilities.	15

Text Books:

1. Cryptography and Network Security, Sixth Edition, Wiliam Stallings, Pearson
2. Cryptography and Network Security, Special Indian Edition, B.A. Forouzan,TMH publishing Company Limited
3. Cryptography and Network Security, Atul Kahate, Tata McGraw Hill Publication
4. Applied Cryptography: Protocols, Algorithms, and Source Code in C, 2nd Edition, Bruce Schneier, Willy Publication

Paper No.- CSEL861 **Paper Name- Introduction to Machine Learning (Elective-VI)**		**Full Marks: 100**
Module	**Topics**	**Hours**
Module-1: **Introductory Topics**	A brief introduction to machine learning, Supervised Learning, Unsupervised Learning, Reinforcement Learning, Probability Basics, Linear Algebra, Statistical Decision Theory - Regression, Classification, Bias-Variance	2
Module-2: **Linear Regression and Feature Selection**	Linear Regression, Multivariate Regression, Dimensionality Reduction-Subset Selection 1, Subset Selection 2, Shrinkage Methods, Principal Components Regression, Partial Least Squares	4
Module-: **Linear Classification**	Linear Classification, Logistic Regression, Linear Discriminant Analysis, Weka Tutorial	3
Module-4: **Support Vector Machines and Artificial Neural Networks**	Artificial Neural Network- Early Models, Backpropogation, Initialization, Training & Validation SVM- Perceptron Learning, SVM - Formulation, SVM - Interpretation & Analysis, SVMs for Linearly Non Separable Data SVM Kernels, SVM - Hinge Loss Formulation	5
Modulle-5: **Bayesian Learning and Decision Trees**	Maximum Likelihood Estimate, Priors & MAP Estimate Bayesian Parameter Estimation Decision Tree- Introduction, Regression Trees, Stopping Criteria & Pruning, Loss Functions for Classification, Categorical Attributes, Multiway Splits, Missing Values, Imputation & Surrogate Splits, Instability, Smoothness & Repeated Subtrees	4
Module-6: **Evaluation Measures**	Evaluation Measures, Bootstrapping & Cross Validation 2 Class Evaluation Measures, The ROC Curve, Minimum Description Length & Exploratory Analysis	4
Module-7: **Hypothesis Testing**	Introduction to Hypothesis Testing, Basic Concepts, Sampling Distributions & the Z Test, Student's t-test, The Two Sample & Paired Sample t-tests, Confidence Intervals	4
Module-8 **Ensemble Methods**	Bagging, Committee Machines & Stacking, Boosting, Gradient Boosting Random Forest	4
Module-9: **Clustering**	Partitional Clustering, Hierarchical Clustering, Threshold Graphs The BIRCH Algorithm, The CURE Algorithm, Density Based Clustering Gaussian Mixture Models, Expectation Maximization, Expectation Maximization Continued, Spectral Clustering	3
Module-10: **Graphical Models**	Naive Bayes, Bayesian Networks, Undirected Graphical Models - Introduction, Undirected Graphical Models - Potential Functions Hidden Markov Models, Variable Elimination, Belief Propagation	3
Module-11: **Learning Theory and Expectation Maximization**	Learning Theory, Frequent Itemset Mining, The Apriori Property	2
Module-12: **Introduction to Reinforcement Learning**	Introduction to Reinforcement Learning, RL Framework and TD Learning Solution Methods & Applications	2

Text Books:

1. T. Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning, 2e, 2008.
2. Christopher Bishop.Pattern Recognition and Machine Learning. 2e.

Paper Code – CSEL862 **Paper Name: Image Processing (Elective-VI)**		**Full Marks: 100**
Module	**Topics**	**Hours**
Module-1: **Introduction**	**Introduction [4L]:** Background, Digital Image Representation, Fundamental steps in Image Processing, Elements of Digital Image Processing - Image Acquisition, Storage, Processing, Communication, Display.	4
Module-2: **Digital Image Formation**	**Digital Image Formation [4L]:**A Simple Image Model, Geometric Model- Basic Transformation (Translation, Scaling, Rotation), Perspective Projection, Sampling & Quantization - Uniform & Non uniform.	4
Module-3: **Mathematical Preliminaries**	**Mathematical Preliminaries [9L]:** Neighbour of pixels, Connectivity, Relations, Equivalence & Transitive Closure; Distance Measures, Arithmetic/Logic Operations, Fourier Transformation, Properties of The Two Dimensional Fourier Transform, Discrete Fourier Transform, Discrete Cosine & Sine Transform.	9
Module-4: **Image Enhancement**	**Image Enhancement [8L]:** Spatial Domain Method, Frequency Domain Method, Contrast Enhancement -Linear & Nonlinear Stretching, Histogram Processing; Smoothing - Image Averaging, Mean Filter, Low-pass Filtering; Image Sharpening. High-pass Filtering, High-boost Filtering, Derivative Filtering, Homomorphic Filtering; Enhancement in the frequency domain - Low pass filtering, High pass filtering.	8
Module-5: **Image Restoration**	**Image Restoration [7L] :**Degradation Model, Discrete Formulation, Algebraic Approach to Restoration - Unconstrained & Constrained; Constrained Least Square Restoration, Geometric Transformation - Spatial Transformation, Gray Level Interpolation	7
Module-6: **Image Segmentation**	**Image Segmentation [7L]:** Point Detection, Line Detection, Edge detection, Combined detection, Edge Linking & Boundary Detection - Local Processing, Global Processing via The Hough Transform; Thresholding - Foundation, Simple Global Thresholding, Optimal Thresholding; Region Oriented Segmentation - Basic Formulation, Region Growing by Pixel Aggregation, Region Splitting & Merging	7
Text Books: Digital Image Processing; by Gonzalez, Woods, Eddins; Pearson Publication Fundamentals of Digital Image Processing ; by Anil K Jain; PHI Publication		

Paper Code – CSEL863 **Paper Name: Introduction to Data Science (Elective-VI)**		**Full Marks: 100**
Module	**Topics**	**Hours**
Module-1: Introduction	What is Data Science? ; Big Data and Data Science; Datafication; Current landscape of perspectives; - Skill sets needed	3
	Statistical Inference: Populations and samples; Statistical modeling, probability distributions; fitting a model; Introduction to R	3
	Exploratory Data Analysis and the Data Science Process; Basic tools (plots, graphs and summary statistics) of EDA; - Philosophy of EDA; The Data Science Process; Case Studies	2
Module-2: Three Basic Machine Learning Algorithms	Linear Regression; k-Nearest Neighbors (k-NN); k-means One More Machine Learning Algorithm and Usage in applications Motivating application: Filtering Spam Why Linear Regression and k-NN are poor choices for Filtering Spam Naive Bayes and why it works for Filtering Spam Data Wrangling: APIs and other tools for scrapping the Web	8
Module-3: Recommendation Systems: Building a User-Facing Data Product	Feature Generation and Feature Selection (Extracting Meaning From Data) Motivating application: user (customer) retention Feature Generation (brainstorming, role of domain expertise, and place for imagination) Feature Selection algorithms Filters; Wrappers; Decision Trees; Random Forests Algorithmic ingredients of a Recommendation Engine Dimensionality Reduction Singular Value Decomposition Principal Component Analysis Exercise: build your own recommendation system	8
Module-4: Mining Social-Network Graphs	Social networks as graphs Clustering of graphs Direct discovery of communities in graphs Partitioning of graphs Neighborhood properties in graphs	6
Module-5: Data Visualization	Basic principles; ideas and tools for data visualization Examples of inspiring (industry) projects Exercise: create your own visualization of a complex dataset	6
Module-6: Data Science and Ethical Issues	Discussions on privacy, security, ethics A look back at Data Science Next-generation data scientists	4

Text Book:

1. Cathy O'Neil and Rachel Schutt. Doing Data Science, Straight Talk From The Frontline. O'Reilly. 2014.

Additional references and books :

2. Jure Leskovek, Anand Rajaraman and Jefffey Ullman. Mining of Massive Datasets. v2.1, Cambridge University Press. 2014. (free online)
3. Kevin P. Murphy. Machine Learning: A Probabilistic Perspective. ISBN 0262018020. 2013.
4. Foster Provost and Tom Fawcett. Data Science for Business: What You Need to Know about Data Mining and Data-analytic Thinking. ISBN 1449361323. 2013.
5. Trevor Hastie, Robert Tibshirani and Jerome Friedman. Elements of Statistical Learning, Second Edition. ISBN 0387952845. 2009. (free online)
6. Avrim Blum, John Hopcroft and Ravindran Kannan. Foundations of Data Science.
7. Mohammed J. Zaki andWagner Miera Jr. Data Mining and Analysis: Fundamental Concepts and Algorithms. Cambridge University Press. 2014.
8. Jiawei Han, Micheline Kamber and Jian Pei. Data Mining: Concepts and Techniques, Third Edition. ISBN 0123814790. 2011

(Draft Copy)

UNIVERSITY OF CALCUTTA

(Document no) (Document no)

Bachelor of Technology (B. Tech.) in Computer Science and Engineering

Eighth Semester Examination, …….. (year)

The following is the statement of marks obtained by …….. (Name)

Roll No. : …….. , Registration No.: …….. at the aforesaid Examination, ……..(Year)

(held in …… (month and year of examination)) in **Computer Science and Engineering.**

Course No.	Details of Courses	Credit	Full Marks	Marks Obtained	Paper Total		Grade Point	Letter Grade
					Full Marks	Marks Secured		
Theoretical								
xxxxxx	Xxxxxxxxxxxxxxxx Mid Semester End Semester		30 70	….. …..	100	***	…….	……..
xxxxxx	xxxxxxxxxxxxxxxx Mid Semester End Semester		30 70	…. ….	100	***	…….	……..
xxxxxx	xxxxxxxxxxxxxxxx Mid Semester End Semester		30 70	…. ….	100	***	…….	……..
xxxxxx	xxxxxxxxxxxxxxxx Mid Semester End Semester		30 70	…. ….	100	***	…….	……..
	Theoretical Total							
Practical								
xxxxxx	xxxxxxxxxxxxxx Internal Assessment End Semester		60 40	60 40	…	100	***	……	……
	Practical Total							
	Total Marks of Eight Semester							

% of Marks	Grade		Grade Point(P)	Cumulative Statement		Semester	Total Marks	Grand Total	SGPA	Remarks
90-100	O		10	Cumulative Total Marks		8th	800	***		
80-89	A		9	Cumulative Grand Total		7th	800	***		
70-79	B		8	CGPA		6th	800	***		
60-69	C		7	Result		5th	800	***		
50-59	D		6	*XP-Back Credits in 7th Semester *XS-Back Credits in previous Semester(s). F-Not eligible for B.Tech Degree		4th	800	***		
Below 50	F		0			3rd	800	***		
						2nd	850	***		
						1st	850	***		

Candidates securing 66% or more in Cumulative Grand Total will be awarded 'First Class' and candidates securing 50% or more but less than 66% in Cumulative Grand Total will be awarded 'Second Class'.

Grade 'F' also implies failure to earn the corresponding credit. Grades higher than 'F' and Grade points≥6 indicate successful clearing of a unit that will earn the student the corresponding Grade Point (P) & the Credit (C) assigned to that unit.

A student who fails to earn the total credit of a semester in the semester examination will be allowed to continue in the next semester provided he/she earns at least 15 credit in the semester examination.

(Controller of Examinations)

UNIVERSITY OF CALCUTTA
Faculty of Engineering & Technology

A. Regulation for 4-year 8-semester B. Tech. course
(with effect from the academic year 2017 – 2018)

1. The Faculty of Engineering and Technology, University of Calcutta shall provide instructions leading towards the 4-year, 8-semester B. Tech. degree in different **Engineering/ Technology** courses as mentioned below:

    1. **Chemical Engineering**
    2. **Chemical Technology**
    3. **Computer Science and Engineering**
    4. **Electrical Engineering**
    5. **Electronics and Communication Engineering**
    6. **Information Technology**
    7. **Instrumentation Engineering**
    8. **Jute and Fibre Technology**
    9. **Optics and Optoelectronics Engineering**
    10. **Polymer Science and Technology**

    Each of the courses is of four (4) years duration comprised of eight (8) Semesters, each Semester being of six (6) months' duration.

2. **Eligibility for Admission**

    (a) Category-1: For admission into the FIRST YEAR of 4-Year B.Tech. course in any stream, the candidates must have passed Class XII Examinations in the system of 10+2 under West Bengal Council of Higher Secondary Education or equivalent with Physics, Chemistry, Mathematics securing an average of at least 60% marks (or equivalent grade) in these subjects and **cleared West Bengal JEE.** *The minimum requirement of marks will however not be applicable for admission to Jute and Fibre Technology only in session 2017-18. After the academic year 2017-18 the minimum criteria of admission will be same for all the engineering streams.*

    (b) Category-2: For admission of the B.Sc. (Hons.) qualified students into the SECOND YEAR of all B.Tech. courses **except the Jute and Fibre Technology course**, the candidates must have passed B.Sc. Honours with the subjects specified for different courses as given below. The selection will be strictly based on merit as adopted and invoked time to time by University of Calcutta.

Chemical Engineering: B.Sc. Honours in Chemistry **Chemical Technology**: B.Sc. Honoursin Chemistry

Computer Science and Engineering: B.Sc. Honours in Physics/ Computer Science/Mathematics/ Statistics

Electrical Engineering: B.Sc. Honours in Physics

Electronics and Communication Engineering: B.Sc. Honours in Physics/Electronics

Information Technology: B.Sc. Honours in Computer Science/Physics/Electronics

Instrumentation Engineering: B.Sc. Honours in Physics

Optics & Optoelectronics Engineering: B.Sc. Honours in Physics/Electronics

Polymer Science and Technology: B.Sc. Honours in Chemistry

The 'Category-2' students (except Jute & Fiber Tech. course)' must have to attend and pass 'Workshop' and 'Engineering Drawing' subjects additionally arranged during THIRD to EIGHTH Semester curriculum (preferable to complete by THIRD/FOURTH semester). However, no credit points will be awarded and will not be included for SGPA calculation. In the main mark sheet, mention will be made (at the bottom) that he/she has qualified 'Workshop/Drawing' with grade ----. The course of study for students admitted in the 2nd year will be of 6 Semesters (starting from third Semester) in three academic years.

(c) Category-3: Jute and Fibre Technology: For admission into the SECOND YEAR of B.Tech. course in Jute and Fibre Technology, the candidates should qualify JELET for lateral entry, and should have any one of the following degrees:
B.Sc. with Physics/Chemistry/Mathematics, B.Sc. in Textile and Clothing/ B.FAD OR Diploma in Mechanical Engineering/ Electrical Engineering/ Chemical Engineering/ Computer Engineering/Ceramic Engineering / Electronics/ Textile Technology/ Handloom Technology/ Apparel and Fashion Technology; Post B.Sc. 2-year PG Diploma in Jute Technology and Management.
The course of study for students admitted in the 2nd year will be of 6 Semesters (starting from third Semester) in three academic years.

(d) Any seat(s) remaining vacant at the end of Second Semester will be filled up by Category-2 candidates except for Jute and Fibre Technology (who might consider JELET qualified candidates) as per AICTE rules.

3. The award of the said B. Tech. Degrees will be conferred to students who are successful in all of the eight (8) / six (6) Semester examinations.

4. **Attendance:** A student **must attend 75%** of the theoretical and laboratory/ practical classes **and successfully complete sessional assessment** in order to appear at Semester examinations.

5 **Credit based Evaluation**

(a) The credit based examination system will be followed for all Semester examinations. Each course shall have a certain number of credits assigned to it depending upon the academic load of the course assessed on the basis of *weekly contact hours* of lecture, tutorial and laboratory classes, assignments or field study and/or self study
Generally, each course shall have an integer number of credits reflecting its weight. The number of credits of a course in a semester shall ordinarily be calculated as under

(i) Lecture (L)/Tutorial (T): One lecture hour per week shall normally be assigned one credit. One hour of tutorial per week shall be assigned one credit. For determining the credits of a theory course, lectures and tutorials shall be added.

(ii) Practical (P): Three laboratory hours per week shall be assigned two (2) credits. Courses other than Lectures/Tutorials shall be treated as practical courses.
The course credits for each course shall be given as L-T-P. For example, 3-1-0 will mean that it is a lecture based course and has 3 lectures, 1 tutorial, and no practical assigned to it. Similarly, a course with 0-0-3 means that it is a practical course with 3 hours of practical work. Credits will be assigned to seminar, dissertation, project etc. under the practical component.

The 4-year course in any field of study will have subjects covering minimum of 190 credits. The Semester wise credit points in various Departments may vary except the first two Semesters which are common to all disciplines (each Semester having a total of 28 credit points).

All examinations of 1st and 2nd semester for theoretical papers will be on 100 marks while the laboratory/practical papers will carry 50 marks. Credit points of theoretical and practical papers including project work, design, General Viva Voce, plant training, seminar presentation etc. offered by various Departments will be given in Course Structures separately. There will be two components of examinations of theoretical papers i) Sessional assessment 30% i.e. 30 marks ii) End Semester examination 70% i.e. 70 marks

(b) The Sessional assessment components of theory papers are

Serial No	Type of evaluation	Marks
01	Sessional Assessments through Class Test/ Assignments	20
02	Active participation in routine classes	05
03	Overall conduct, attendance, manners, skills etc.	05

(c) Evaluation in Laboratory/ practical papers (for 1st and 2nd Semester)

Serial No	Type of evaluation	Marks
01	Report and results	20
02	Viva	20
03	Overall conduct, attendance, discipline, manners, skills etc.	10

Eligibility of success/failure in a Semester Examination:

(i) A student admitted in 1st semester of B.Tech. course will get total 6 consecutive academic years from his year of admission to pass in all the 8 semesters. A student admitted in 3rd semester of B.Tech. course will get total 5 consecutive academic years from his year of admission to pass in all the 6 semesters.

(ii) A student has to secure at least 50% marks i.e. Grade-D in all subjects individually in order to ***pass the examination.***

(iii) If a student don't secure at least 50% marks or absent in the end semester examination of theory subject need to appear in that paper in the examination of next academic session(s). In the case of for theoretical paper the marks of Sessional assessment would be retained.

(iv) A student will be eligible to take admission to the next immediate higher semester if the number of non-appeared paper in Theoretical examination does not exceed two. A student must have to appear in all the papers of the practical examination of the semester concerned.

(v) A student can appear in current semester and along with that could appear supplementary examination of maximum of 2 previous semesters of the corresponding even or odd semester. (e.g. A students has failed in a paper in 1st semester will get 2 additional chances in 3rd and 5th Semester).

(vi) **Special supplementary examinations** will be arranged only for *Semester 7 and 8* just after the declaration of results of *7th and 8th Semester.* Students who

could not secure 50% marks in Special supplementary examination will have to appear in next academic session. (Provided maximum 6 years span for 4 Year B.Tech. and 5 Years span for 3 Years B.Tech. kept intact).

(vii) **Eligibility for a Degree:** A student needs to pass in all the theoretical and practical papers to qualify for B.Tech. Degree.

'Category 1' student has to pass all the theoretical and practical papers of 8-Semesters in maximum of 6 year periods from admission to obtain B.Tech. degree in corresponding course.

'Category 2' student has to pass all the theoretical and practical papers of 6-Semesters starting from 3rd Semester in maximum of 5 year periods to obtain B.Tech. degree in corresponding course.

6. **(a)** On the basis of total marks (TA+CT+ESE) secured in each paper, **Grade (G)** and **Grade Point (GP)** shall be awarded to a student.

The equivalence between grades, grade points and the percentage marks is given by:

Percentage (%) of marks	**Grade (G)**	**Grade Point (GP)**
≥ 90	Ex	10
≥ 80 and <90	A	9
≥ 70 and <80	B	8
≥ 60 and <70	C	7
≥ 50 and <60	D	6
< 50	F	0

(b) Each paper shall carry **Credit (C)** according to the number of hours allotted per week and as indicated in the following table

Paper/subject	No. of hours/week	Credit (C) assigned
Theoretical	1	1
Tutorial	1	1*
Practical	1	(2/3)*

*: For fractional credit, calculation is to be made by rounding off.

(c) The course structure and the credits assigned to each semester of each course are provided by individual Departments.

(d) The performance of a candidate in n^{th} Semester examination, who earns all the Credit of that semester, will be assessed by the **'Semester Grade Point Average' (SGPA), 'S_n' to be computed as:**

$$SGPA\ [S_n\ ] = \frac{\sum_{k}[C_k\ GP_k\ ]}{\sum_{K} C_k}$$

where 'k' denotes the number of papers in a particular semester and and $\sum C_k$ denotes the total credits of a particular semester and GP_k is the grade point of k^{th} paper.

(e) On completion of the B.Tech. course, the overall performance of a candidate will be assessed by the '**Cumulative Grade Point Average' (CGPA)** to be computed as:

$$CGPA = \frac{\sum_{n}[C_n\ S_n\ ]}{\sum C_n}$$

where, $C_n = \sum C_k$ and $\sum C_n$ denotes total credits of all the semesters

(f) Each theory and each practical paper will be assessed by internal examiner(s). Project, and General Viva Voce examinations will be assessed by a board consisting of at least two (2) internal examiners and at least one (1) external examiner

7. Candidates appearing in a semester examination shall join classes in the next semester immediately, wherever applicable, after completion of the examination.

8. At the end of each Semester examination, a Grade-Sheet showing the Semester performance (Semester Grade Sheet) indicated by **SGPA** will be issued to the students. However, SGPA will not be calculated for those candidates who fail to earn all the credits in that Semester.

The Semester Grade Sheet should have the following basic information: The merit list will be prepared on the basis of the total marks obtained.

9. **(a)** A consolidated Grade-Sheet, showing the overall performance in the B. Tech course indicated by **CGPA**, will be issued only to those successful students who have passed all the theoretical and practical papers of all of the 8 semesters (for Category -1 student) or 6 semesters (for Category -2 student).

The consolidated grade sheet shall consist of two components. The first component will have the information of the final Semester as follows:

Paper	Details of courses	Full Marks	Marks obtained	Credit obtained	Grade	Grade Point	SGPA	Remarks

The second component will have a **summary** of all the semesters having the following basic information:

Semester	Total credit	Credit obtained	SGPA	Full marks	Marks Obtained	Cumulative statement	
						Total credit	
						CGPA	
						Full marks (Total)	
						Marks obtained	
						Result	#

The hash (#) in the last row of last column will contain the information regarding the final achievement of the candidate in all the examinations. This box will contain only o ne (1) of the following three (3) information: '1st Class' / '2nd Class'.

(b) Candidates securing CGPA at least 7.5 in B. Tech. Examination shall be placed in the First Class and those securing 6.0 or more but less than 7.5 shall be placed in the 'Second Class'.

10. The Degree of **"Bachelor of Engineering/Technology"** under the seal of the University shall be awarded to a successful candidate mentioning the grade and class he/she has obtained. The format will be as follows

UNIVERSITY OF CALCUTTA
LOGO

It is hereby certified that after satisfying all the

conditions prescribed by the University

----------*(Name)* Was on the ---th day of ----(month), -----(year)
Duly admitted to the Degree of
Bachelor of ---------- Engineering/Technology
In the ---- Class

Vice Chancellor
Senate House

UNIVERSITY OF CALCUTTA
Faculty of Engineering & Technology

A. Regulation for 4-year 8-semester B. Tech. course
(with effect from the academic year 2015 – 2016)

01	The Faculty of Engineering and Technology, University of Calcutta shall provide instructions leading towards the 4-year, 8-semester B. Tech. degree in different **Engineering/ Technology** courses as mentioned below: 1. **Chemical Engineering** 2. **Chemical Technology** 3. **Computer Science and Engineering** 4. **Electrical Engineering** 5. **Electronics and Communication Engineering** 6. **Information Technology** 7. **Instrumentation Engineering** 8. **Jute and Fibre Technology** 9. **Optics and Optoelectronics Engineering** 10. **Polymer Science and Technology** Each of the courses is of four (4) years duration comprised of eight (8) Semesters, each Semester being of six (6) months' duration.	
02	**Eligibility for Admission**	
	(a)	Category-1: For admission into the FIRST YEAR of 4-Year B.Tech. course in any stream, the candidates must have passed Class XII Examinations in the system of 10+2 under West Bengal Council of Higher Secondary Education or equivalent with Physics, Chemistry, Mathematics securing an average of at least 60% marks (or equivalent grade) in these subjects and **cleared West Bengal JEE.** *The minimum requirement of marks will however not be applicable for admission to Jute and Fibre Technology.*

	(b)	Category-2: For admission of the B.Sc. (Hons.) qualified students into the SECOND YEAR of all B.Tech. courses **except the Jute and Fibre Technology course**, the candidates must have passed B.Sc. Honours with the subjects specified for different courses as given below. The selection will be strictly based on merit as adopted and invoked time to time by University of Calcutta. **Chemical Engineering**: BSc Honours in Chemistry **Chemical Technology**: BSc Honours in Chemistry **Computer Science and Engineering**: BSc Honours in Physics/ Computer Science/Mathematics/ Statistics **Electrical Engineering**: BSc Honours in Physics **Electronics and Communication Engineering:** BSc Honours in Physics/Electronics **Information Technology:** BSc Honours in Computer Science/Physics/Electronics **Instrumentation Engineering**: BSc Honours in Physics **Optics & Optoelectronics Engineering**: B.Sc. Honours in Physics/Electronics **Polymer Science and Technology**: BSc Honours in Chemistry The 'Category-2' students (except Jute & Fiber Tech. course)' must have to attend and pass 'Workshop' and 'Engineering Drawing' subjects additionally arranged in the THIRD/FOURTH Semester curriculum. However, no credit points will be awarded and will not be included for SGPA calculation. In the main mark sheet, mention will be made (at the bottom) that he/she has qualified 'Workshop/Drawing' with grade ----. The course of study for students admitted in the 2nd year will be of 6 Semesters (starting from third Semester) in three academic years. **<u>Special Note</u>: A certain percentage of seats in 4-year B.Tech. course will be set aside for entry of B.Sc. (Hons) qualified students in the second year. This percentage is 50% for the academic year 2015-16, and will be reduced in successive years as may be decided from time to time, but will never be below 20%. This provision, however, will not be applicable for admission to Jute and Fibre Technology.**
	(c)	Category-3: **Jute and Fibre Technology:** For admission into the SECOND YEAR of B.Tech. course in Jute and Fibre Technology, the candidates should qualify JELET for lateral entry, and should have any one of the following degrees: BSc with Physics/Chemistry/Mathematics, BSc in Textile and Clothing/ B.FAD OR Diploma in Mechanical Engineering/ Electrical Engineering/ Chemical Engineering/ Computer Engineering/Ceramic Engineering / Electronics/ Textile Technology/ Handloom Technology/ Apparel and Fashion Technology; Post BSc 2-year PG

		Diploma in Jute Technology and Management. The course of study for students admitted in the 2nd year will be of 6 Semesters (starting from third Semester) in three academic years.
	(d)	Any seat(s) remaining vacant at the end of Second Semester will be filled up by Category-2 candidates except for Jute and Fibre Technology (who might consider JELET qualified candidates).
03	The award of the said B. Tech. Degrees will be conferred to students who are successful in all of the eight (8) / six (6) Semester examinations.	
04	**Attendance:** A student must attend 75% of the theoretical and laboratory/ practical classes separately in order to appear at Semester examinations.	
05	**Credit based Evaluation**	
	(a)	The credit based examination system will be followed for all Semester examinations. Each course shall have a certain number of credits assigned to it depending upon the academic load of the course assessed on the basis of *weekly contact hours* of lecture, tutorial and laboratory classes, assignments or field study and/or self study. Generally, each course shall have an integer number of credits reflecting its weight. The number of credits of a course in a semester shall ordinarily be calculated as under: (i) Lecture (L)/Tutorial (T): One lecture hour per week shall normally be assigned one credit. One hour of tutorial per week shall be assigned one credit. For determining the credits of a theory course, lectures and tutorials shall be added. (ii) Practical (P): Three laboratory hours per week shall be assigned two (2) credits. Courses other than Lectures/Tutorials shall be treated as practical courses. The course credits for each course shall be given as L-T-P. For example, 3-1-0 will mean that it is a lecture based course and has 3 lectures, 1 tutorial, and no practical assigned to it. Similarly, a course with 0-0-3 means that it is a practical course with 3 hours of practical work. Credits will be assigned to seminar, dissertation, project etc. under the practical component. The 4-year course in any field of study will have subjects covering a total of 190 credits. The Semester wise credit points in various Departments may vary except the first two Semesters which are common to all disciplines (each Semester having a total of 28 credit points). All examinations on theoretical papers will be on 100 marks while the laboratory/practical papers will carry 50 marks. Credit points of theoretical and practical papers including project work, design, General Viva Voce, plant training, seminar presentation etc. offered by various Departments will be given in Course

Structures separately. There will be two components of examinations of theoretical papers: i) Sessional assessment 30% i.e. 30 marks ii) End Semester examination 70% i.e. 70 marks.

(b) The Sessional assessment components of theory papers are:

Serial No	Type of evaluation	Marks
01	Sessional Assessments through Class Test/ Assignments	20
02	Active participation in routine classes	05
03	Overall conduct, attendance, manners, skills etc.	05

(c) Evaluation in Laboratory/ practical papers:

Serial No	Type of evaluation	Marks
01	Report and results	20
02	Viva	20
03	Overall conduct, attendance, discipline, manners, skills etc.	10

(e) Eligibility of success/failure in a Semester Examination:

(i) A student has to secure at least 50% marks i.e. Grade-D in all subjects individually in order to ***pass the examination.***

(ii) If a student fails in some subjects having total credits more than 8, he/she will have to repeat the whole Semester and will not be allowed to continue his studies to the next Semester classes. The student will eventually face a year loss.

(iii) If a student fails in some subjects amounting 8 credits or less in a Semester but earns rest of the credits, he/she will be allowed to continue to the next Semester, ***provided that total of such backlog credits within the entire course period of eight semesters is 24 or less***. [Example: In the *first and second* Semesters, one has to earn at least 28 - 8= 20 credits; this may vary in other Semesters]

(iv) Supplementary examinations of all papers of present Semester will be arranged soon after the publication of results of regular examinations of the present Semester. If the candidate fails to clear the supplementary paper(s), he / she will get another chance to clear the same in the corresponding semester in the next academic session.

(v) **Special supplementary examinations** will be arranged only for *Semester 8* just after the declaration of results of 8^{th} *Semester.*

(vi) **Additional Semester Examination:** A student who does not appear in some or all the examinations in a Semester on medical grounds or for representing the University

in sports, cultural activities, NSS or any other reason considered valid under exceptional circumstances may apply for supplementary examinations to the Vice Chancellor through Head of the Department. These cases will be considered by the university authority and decision will be taken by the Syndicate.

(vii) 'Category 1' students will have to utilize all the allowed chances (to pass back papers) **within six years** (i.e. 12 consecutive Semesters) to acquire 190 credits in 8 Semesters. Similarly, 'Category 2' students including lateral entry students of Jute and Fibre Technology will have to utilize all the allowed chances (to pass back papers) within **five years** (i.e. 10 consecutive Semesters) to acquire 134 credits in 6 Semesters.

(viii) Eligibility for a Degree: The total credits for all the engineering courses are 190 for a 4-year course. Thus, a student ('Category 1') who could earn 190 credits in 8-Semester course would be eligible for a B.Tech. degree in above mentioned courses. 'Category 2' candidates, however will have to earn a total of 134 credits for the same B.Tech. Degree in 6 (six) Semesters starting from THIRD Semester.

(ix) A student failing in any subject should apply to the Secretary, UCSTA through respective Head of the Department for appearing at the supplementary examinations within 07 days of the publication of results.

06 (a) On the basis of total marks (TA+CT+ESE) secured in each paper, **Grade (G)** and **Grade Point (GP)** shall be awarded to a student.

The equivalence between grades, grade points and the percentage marks is given by:

Percentage (%) of marks	Grade (G)	Grade Point (GP)
≥ 90	Ex	10
89 – 80	A	9
79 - 70	B	8
69 - 60	C	7
59 - 50	D	6
< 50	F	0

(b) Each paper shall carry **Credit (C)** according to the number of hours allotted per week and as indicated in the following table:

Paper/subject	No. of hours/week	Credit (C) assigned
Theoretical	1	1
Tutorial	1	1*
Practical	1	(2/3)*

*: For fractional credit, calculation is to be made by rounding off.

(c) The course structure and the credits assigned to each semester of each course are provided by individual Departments.

	(d)	The performance of a candidate in n^{th} Semester examination, who earns all the credits of that semester, will be assessed by the **'Semester Grade Point Average' (SGPA), 'S_n'** to be computed as: $$SGPA[S_n] = \frac{\sum_k [C_k GP_k]}{\sum_k C_k}$$ where 'k' denotes the number of papers in a particular semester and $\sum_k C_k$ denotes the total credits of a particular semester and GP_k is the grade point of k^{th} paper.
	(e)	On completion of the B.Tech. course, the overall performance of a candidate will be assessed by the **'Cumulative Grade Point Average' (CGPA)** to be computed as: $$CGPA = \frac{\sum_n [C_n S_n]}{\sum_n C_n}$$ where, $C_n = \sum_k C_k$ and $\sum_n C_n$ denotes total credits of all the semesters i.e. 190 credits for category-1 and 134 credits for category-2 and 3.
	(f)	Each theory and each practical paper will be assessed by internal examiner(s). Design, Project, seminar and General Viva Voce examinations will be assessed by a board consisting of at least two (2) internal examiners and at least one (1) external examiner.
07		Candidates appearing in a semester examination shall join classes in the next semester immediately, wherever applicable, after completion of the examination.
08		If a candidate is unable to appear at any of the theory or practical examination(s), he/she will earn zero (0) credit in that paper(s).
09		The CU syndicate shall publish a list of successful candidates of the B. Tech. examination for each of the Semester examinations.
10		At the end of each Semester examination, a Grade-Sheet showing the Semester performance (Semester Grade Sheet) indicated by **SGPA** will be issued to the students. However, SGPA will not be calculated for those candidates who fail to earn all the credits in that Semester. The Semester Grade Sheet should have the following basic information: The merit list will be prepared on the basis of the total marks obtained.
11	(a)	A consolidated Grade-Sheet, showing the overall performance in the B. Tech course indicated by **CGPA**, will be issued only to those successful students who have earned 190 credits for Category-1 and 134 credits for category-2 and 3 in the B. Tech. courses. The consolidated grade sheet shall consist of two components. The first component will have the information of the final Semester as follows:

Paper	Details of courses	Full Marks	Marks obtained	Credit obtained	Grade	Grade Point	SGPA	Remarks

The second component will have a **summary** of all the semesters having the

following basic information:

Semester	Total credit	Credit obtained	SGPA	Full marks	Marks obtained	Cumulative statement	
						Total credit	
						CGPA	
						Full marks (Total)	
						Marks obtained	
						Result	#

The hash (#) in the last row of last column will contain the information regarding the final achievement of the candidate in all the examinations. This box will contain only one (1) of the following three (3) information: '1st Class' / '2nd Class' / 'Failed'.

(b) Candidates securing CGPA at least 7.5 in B. Tech. Examination shall be placed in the First Class and those securing 6.0 or more but less than 7.5 shall be placed in the 'Second Class'. Candidates securing CGPA less than 6.0 shall be declared 'Failed'.

12 The Degree of **"Bachelor of Engineering/Technology"** under the seal of the University shall be awarded to a successful candidate mentioning the grade and class he/she has obtained. The format will be as follows:

UNIVERSITY OF CALCUTTA
LOGO

It is hereby certified that after satisfying all the conditions prescribed by the University

----------*(Name)* Was on the ---th day of ----(month), -----(year)
Duly admitted to the Degree of
Bachelor of ---------- Engineering/Technology
In the ---- Class

Vice Chancellor
Senate House