Department of Computer Science and Engineering
University of Dhaka

**Syllabus for B.Sc. in Computer Science and Engineering**
**Session: 2019-20 and onward**

| **Semester I** | | | |
|---|---|---|---|
| **Course Code** | **Course Title** | **Prerequisites** | **Credit Hours** |
| **Theory Courses** | | | |
| CSE-1101 | Fundamentals of Computers and Computing | | 2.0 |
| CSE-1102 | Discrete Mathematics | | 3.0 |
| EEE-1103 | Electrical Circuits | | 3.0 |
| CHE -1104 | Chemistry | | 3.0 |
| MATH-1105 | Differential and Integral Calculus | | 3.0 |
| **Lab Courses** | | | |
| CSE-1111 | Fundamentals of Computers and Computing Lab | | 1.5 |
| EEE-1113 | Electrical Circuits Lab | | 1.5 |
| CHE -1114 | Chemistry Lab | | 1.5 |
| | **Total Credits in 1st Semester** | | **18.50** |

| **Semester II** | | | |
|---|---|---|---|
| **Course Code** | **Course Title** | **Prerequisites** | **Credit Hours** |
| **Theory Course** | | | |
| CSE-1201 | Fundamentals of Programming | CSE-1101, CSE-1102 | 3.0 |
| EEE-1202 | Digital Logic Design | | 3.0 |
| PHY-1203 | Physics | | 3.0 |
| MATH-1204 | Methods of Integration, Differential Equations, and Series | MATH-1105 | 3.0 |
| **Lab Course** | | | |
| CSE-1211 | Fundamentals of Programming Lab | CSE-1111 | 3.0 |
| EEE-1212 | Digital Logic Design Lab | | 1.5 |
| PHY-1213 | Physics Lab | | 1.5 |
| ENG-1215 | Developing English Language Skills Lab | | 1.5 |
| | **Total Credits in 2nd Semester** | | **19.50** |

| Semester III | | | |
|---|---|---|---|
| **Course Code** | **Course Title** | **Prerequisites** | **Credit Hours** |
| **Theory Courses** | | | |
| CSE-2101 | Data Structures and Algorithms | CSE-1201 | 3.0 |
| CSE-2102 | Object Oriented Programming | CSE-1201 | 3.0 |
| EEE-2103 | Electronic Devices and Circuits | EEE-1202 | 3.0 |
| GED-2104 | Bangladesh Studies | | 2.0 |
| MATH-2105 | Linear Algebra | MATH-1204 | 3.0 |
| **Lab Courses** | | | |
| CSE-2111 | Data Structures and Algorithms Lab | CSE-1211 | 1.5 |
| CSE-2112 | Object Oriented Programming Lab | CSE-1211 | 1.5 |
| EEE-2113 | Electronic Devices and Circuits Lab | EEE-1212 | 0.75 |
| | **Total Credits in 3rd Semester** | | **17.75** |

| Semester IV | | | |
|---|---|---|---|
| **Course Code** | **Course Title** | **Prerequisites** | **Credit Hours** |
| **Theory Courses** | | | |
| CSE-2201 | Database Management Systems - I | CSE-2101 | 3.0 |
| CSE-2202 | Design and Analysis of Algorithms - I | CSE-2101 | 3.0 |
| CSE-2203 | Data and Telecommunication | CSE-2101 | 3.0 |
| CSE-2204 | Computer Architecture and Organization | EEE-1202 | 3.0 |
| CSE-2205 | Introduction to Mechatronics | EEE-1103, EEE-1202 | 2.0 |
| **Lab Courses** | | | |
| CSE-2211 | Database Management Systems - I Lab | CSE-2111 | 1.5 |
| CSE-2212 | Design and Analysis of Algorithms - I Lab | CSE-2111 | 1.5 |
| CSE-2213 | Data and Telecommunication Lab | CSE-2111 | 0.75 |
| CSE-2216 | Application Development Lab | CSE-2101, CSE-2102, CSE-2111, CSE-2112 | 1.5 |
| | **Total Credits in 4$^{th}$ Semester** | | **19.25** |

| Semester V | | | |
|---|---|---|---|
| **Course Code** | **Course Title** | **Prerequisites** | **Credit Hours** |
| **Theory Courses** | | | |
| CSE-3101 | Computer Networking | CSE-2203 | 3.0 |
| CSE-3102 | Software Engineering | CSE-2101, CSE2102 | 3.0 |
| CSE-3103 | Microprocessor and Microcontroller | CSE-2204 | 3.0 |
| CSE-3104 | Database Management Systems - II | CSE-2201 | 3.0 |
| MATH-3105 | Multivariable Calculus and Geometry | MATH-2105 | 3.0 |
| **Lab Courses** | | | |
| CSE-3111 | Computer Networking Lab | CSE-2213 | 1.5 |
| CSE-3112 | Software Engineering Lab | CSE-2111, CSE-2112 | 0.75 |
| CSE-3113 | Microprocessor and Assembly Language Lab | | 1.5 |
| CSE-3116 | Microcontroller Lab | | 0.75 |
| | **Total Credits in 5th Semester** | | **19.50** |

| Semester VI | | | |
|---|---|---|---|
| **Course Code** | **Course Title** | **Prerequisites** | **Credit Hours** |
| **Theory Courses** | | | |
| CSE-3201 | Operating Systems | CSE-2202, CSE-2204 | 3.0 |
| CSE-3202 | Numerical Methods | CSE-2202 | 3.0 |
| CSE-3203 | Design and Analysis of Algorithms - II | CSE-2202 | 3.0 |
| CSE-3204 | Formal Language, Automata and Computability | CSE-1102 | 3.0 |
| STAT-3205 | Introduction to Probability and Statistics | | 3.0 |
| **Lab Courses** | | | |
| CSE-3211 | Operating Systems Lab | CSE-2212 | 1.5 |
| CSE-3212 | Numerical Methods Lab | CSE-2212 | 0.75 |
| CSE-3216 | Software Design Patterns Lab | CSE-3112 | 1.5 |
| ENG-3217 | Technical Writing and Presentation Lab | ENG-1215 | 0.75 |
| | **Total Credits in 6th Semester** | | **19.50** |

| Semester VII | | | |
|---|---|---|---|
| **Course Code** | **Course Title** | **Prerequisites** | **Credit Hours** |
| **Theory Course** | | | |
| CSE-4101 | Artificial Intelligence | CSE-2202 | 3.0 |
| CSE-4102 | Mathematical and Statistical Analysis for Engineers | MATH-2105<br>MATH-3105<br>STAT-3205 | 3.0 |
| CSE-4XXX | Any course from Option - A | | 3.0 |
| CSE-4XXX | Any course from Option - B | | 3.0 |
| **Lab Courses** | | | |
| CSE-4111 | Artificial Intelligence Lab | CSE-2212 | 1.5 |
| CSE-4XXX | Lab for the Option - A course | | 1.5 |
| CSE-4113 | Internet Programming Lab | CSE-2216 | 1.5 |
| CSE-4114 | Project | | 2.0 |
| | **Total Credits in 7th Semester** | | **18.50** |

| Semester VIII | | | |
|---|---|---|---|
| **Course Code** | **Course Title** | **Prerequisites** | **Credit Hours** |
| **Theory Courses** | | | |
| ECO-4201 | Economics | | 2.0 |
| CSE-4202 | Society and Technology | | 2.0 |
| CSE-4XXX | Any course from Option - A (excepting the course taken in semester VII) | | 3.0 |
| CSE-4XXX | Any course from Option - B (excepting the course taken in semester VII) | | 3.0 |
| **Lab Courses** | | | |
| CSE-4XXX | Lab for the Option - A course (excepting the course taken in semester VII) | | 1.5 |
| CSE-4214 | Project | CSE-4114 | 4.0 |
| | **Total Credits in 8th Semester** | | **15.50** |

**Summary of Eight Semesters**

| | |
|---|---|
| 1st Semester (1st Year 1st Semester) | 18.50 |
| 2nd Semester (1st Year 2nd Semester) | 19.50 |
| 3rd Semester (2nd Year 1st Semester) | 17.75 |
| 4th Semester (2nd Year 2nd Semester) | 19.25 |
| 5th Semester (3rd Year 1st Semester) | 19.50 |
| 6th Semester (3rd Year 2nd Semester) | 19.50 |
| 7th Semester (4th Year 1st Semester) | 18.50 |
| 8th Semester (4th Year 2nd Semester) | 15.50 |
| **Total Credits in Eight Semesters:** | **148.00** |

| Option - A | | |
|---|---|---|
| **Course Code** | **Course Title** | **Credit Hours** |
| **Theory Courses** | | |
| CSE-4121 | Robotics Science and Systems | 3.0 |
| CSE-4123 | Computational Methods in Bio-molecular Sequence & Structure Analysis | 3.0 |
| CSE-4125 | Introduction to Machine Learning | 3.0 |
| CSE-4127 | Information Retrieval | 3.0 |
| CSE-4131 | Introduction to VLSI Design | 3.0 |
| CSE-4133 | Algorithm Engineering | 3.0 |
| CSE-4135 | Software Requirements Specification and Analysis | 3.0 |
| CSE-4137 | Cryptography and Security | 3.0 |
| CSE-4139 | Computer Graphics | 3.0 |
| CSE-4221 | Robot Learning | 3.0 |
| CSE-4223 | Fundamentals of Genomics and Proteomics | 3.0 |
| CSE-4225 | Introduction to Data Mining and Warehousing | 3.0 |
| CSE-4227 | Cloud Computing | 3.0 |
| CSE-4229 | Introduction to Reversible Computing | 3.0 |
| CSE-4231 | Computational Geometry | 3.0 |
| CSE-4233 | Software Testing and Verification | 3.0 |
| CSE-4235 | Digital Forensic | 3.0 |
| CSE-4237 | Digital Image Processing | 3.0 |
| CSE-4239 | Parallel and Distributed Systems | 3.0 |
| **Corresponding Lab Courses for Option-A** | | |
| CSE-4151 | Robotics Science and Systems Lab | 1.5 |
| CSE-4153 | Computational Methods in Bio-molecular Sequence & Structure Analysis Lab | 1.5 |
| CSE-4155 | Introduction to Machine Learning Lab | 1.5 |
| CSE-4157 | Information Retrieval Lab | 1.5 |
| CSE-4161 | Introduction to VLSI Design Lab | 1.5 |
| CSE-4163 | Algorithm Engineering Lab | 1.5 |
| CSE-4165 | Software Requirements Specification and Analysis Lab | 1.5 |
| CSE-4167 | Cryptography and Security Lab | 1.5 |
| CSE-4169 | Computer Graphics Lab | 1.5 |
| CSE-4251 | Robot Learning Lab | 1.5 |
| CSE-4253 | Fundamentals of Genomics and Proteomics Lab | 1.5 |
| CSE-4255 | Introduction to Data Mining and Warehousing Lab | 1.5 |
| CSE-4257 | Cloud Computing Lab | 1.5 |
| CSE-4259 | Introduction to Reversible Computing Lab | 1.5 |
| CSE-4261 | Computational Geometry Lab | 1.5 |

| | | |
|---|---|---|
| CSE-4263 | Software Testing and Verification Lab | 1.5 |
| CSE-4265 | Digital Forensic Lab | 1.5 |
| CSE-4267 | Digital Image Processing Lab | 1.5 |
| CSE-4269 | Parallel and Distributed Systems Lab | 1.5 |

| **Option - B** | | |
|---|---|---|
| **Course Code** | **Course Title** | **Credit Hours** |
| **Theory Courses** | | |
| CSE-4122 | Mathematics for Robotics | 3.0 |
| CSE-4124 | Introduction to Bioinformatics | 3.0 |
| CSE-4126 | Introduction to Data Science | 3.0 |
| CSE-4128 | Wireless Networks | 3.0 |
| CSE-4130 | Introduction to Quantum Logic | 3.0 |
| CSE-4132 | Graph Theory | 3.0 |
| CSE-4134 | Software Project Management | 3.0 |
| CSE-4136 | Computer Security | 3.0 |
| CSE-4140 | Compiler Design | 3.0 |
| CSE-4222 | Human Robot Interaction | 3.0 |
| CSE-4224 | Mobile Robotics | 3.0 |
| CSE-4226 | Aerial Robotics | 3.0 |
| CSE-4228 | Application of Computational Biology | 3.0 |
| CSE-4230 | Human Computer Interaction | 3.0 |
| CSE-4232 | Internet of Things | 3.0 |
| CSE-4234 | Introduction to Multiple-Valued Logic | 3.0 |
| CSE-4236 | VLSI Layout Algorithms | 3.0 |
| CSE-4238 | Concepts of Concurrent Computation | 3.0 |
| CSE-4240 | Applied Cryptography | 3.0 |
| CSE-4242 | Computer Vision | 3.0 |
| CSE-4244 | Computer and Network Security | 3.0 |
| CSE-4246 | Natural Language Processing | 3.0 |

# Semester I (1st year 1st Semester)

**CSE-1101: Fundamentals of Computers and Computing [2.0 credits, 30 hours lecture]**
**(Pre-requisite Courses: None)**

**Introduction to Computers:** From a Key Press to Display, Hardware, Software, Operating System, Microprocessor, Memory Overview, File and File System. **Input-Output Devices. Application Software:** Basic Text Editor (gedit, Notepad), Document Processing, Spreadsheet, Presentation, Database, Mathematical Analysis, Simulation, Image and Video Editing, Games etc.**Network and Internet:**Networking Concept and Topologies, Network Addresses (MAC, IP and Port), Name vs. IP (role of DNS).**Browser Software:** Examples, URL, Security, Email, Email Address, Email - Client Software, Email Software in the Internet, Network Configuration and Basic Tools (ping, traceroute etc.). **Number System:**Concept of Bit, Electronic Representation of Bits.**Bit- Array:** Byte, Word, Double Word. Binary – to- Decimal Conversion, Binary Arithmetic, Bit- Shifting, Logic Representation (1-Bit, Bit- Array). Hexadecimal Arithmetic up to 32- Bit Array Representation. Conversion between Binary, Hexadecimal and Octal Numbers. **Representation of Characters by Bit- Array:** ASCII and UTF-8. **Character Arithmetic:** Case and Language Mapping and Changing.**Memory:** Introduction to Computer Memory.**System Modeling and Flow Chart.Introduction to Programming:**Program Structure, Variables, Constants, I/O, Conditional Statements (If- Else), More about Conditional Statements (Nested If).

**CSE-1102: Discrete Mathematics [3.0 credits, 45 hours lecture]**
**(Pre-requisite Courses: None)**

**Logics and Proofs:** Propositional Logic, Applications of Propositional Logic, Propositional Equivalences, Predicates and Quantifiers, Nested Quantifiers, Rules of Inference, Introduction to Proofs. **Set, Function, Sequence, Summation and Matrix:** Sets, Set Operations, Functions, Sequences and Summations, Zero – One Matrices, Boolean Product.**Number Theory:** Divisibility and Modular Arithmetic, Integer Representations and Algorithms, Primes and Greatest Common Divisors, Modular Exponentiation. **Induction:** Mathematical Induction. **Counting:** The Basics of Counting, the Pigeonhole Principle, Permutations and Combinations, Binomial Coefficients and Identities, Generalized Permutations and Combinations.**Recursion:** Applications of Recurrence Relations.

**Inclusion Exclusion:** Inclusion – Exclusion. **Relations:** Relations and Their Properties, Representing Relations. **Graphs:** Graphs and Graph Models, Graph Terminology and Special Types of Graph, Euler and Hamilton Paths. **Trees:** Introduction to Trees.

**EEE-1103: Electrical Circuits [3.0 credits, 45 hours lecture] (Pre-requisite Courses: None)**

**Resistor:** Properties, Types of Resistors, Ohm's Law, Power, Energy, Efficiency, etc. **Series DC Circuits:** Kirchhoff's Voltage Law, Voltage Divider Rule, Power Distribution, Voltage Regulation, Voltage Sources in Series, etc. **Parallel DC Circuits:** Conductance and Resistance, Kirchhoff's Current Law, Current Divider Rule, Open Circuit, Short Circuit, Voltage Sources in Parallel, etc. **DC Series - Parallel Network:** Reduce and Return Approach, Block Diagram Approach, Ladder Networks. **Methods of Analysis for DC Networks:** Current Source, Source Conversion, Current Sources in Series and Parallel, Branch- Current Analysis, Mesh Analysis, Nodal Analysis, Bridge Network and Y-Δ and Δ-Y Conversions. **Network Theorems (DC):** Superposition, Thevenin's, Norton's, Maximum Power Transfer, Millman's, Substitution, Reciprocity, etc. **Capacitor:** Electric Field, Capacitance, Dielectric Strength, Leakage Current, Types of Capacitors, Charging and Discharging Phase, Energy Stored by a Capacitor, Capacitors in Series and Parallel. **Inductor:** Magnetic Field, Inductance, Types of Inductors, Faraday's Law and Lenz's Law, Inductors in Series and Parallel. R-L, R-C and R-L-C Circuits with DC Input. **Introduction to Sinusoidal Alternating Waveforms:** Definitions, General Format for the Sinusoidal Voltage or Current, Phase Relations, Average and RMS Values etc. Ordinary and Frequency Response of Basic R, L and C Elements, Average Power and Power Factor, Rectangular and Polar Form, Phasors.

**CHE-1104: Chemistry [3.0 credits, 45 hours lecture] (Pre-requisite Courses: None)**

**Atomic Structure:** Bohr Atomic Model, Limitations of Bohr's Model, Atomic Spectra, Wave Nature of Electron, Heisenberg Uncertainty Principle, Schrodinger Equation, Quantum Numbers, Pauli's Exclusion Principle, Aufbau Principle, Hund's Rule, Electronic Configuration. **Periodic Table:** s, p, d and f- Block Elements, Periodic Law, Atomic Radii, Ionization Potential, Electronegativity, Electron Affinity, Diagonal Relationship, Metals, Metalloids, Nonmetals and Their Properties, Properties and Uses of Noble Gases. **Chemical Bonding:** Reason of Chemical Bonding, Ionic Bond, Covalent Bond, Coordinate Covalent Bond, Hydrogen Bond, Metallic Bond, Vander Waal's Force. **Oxidation Reduction:** Charge Concept, Electronic Concept, Oxidizing Agent, Reducing Agent, Oxidation Number, Balancing the Oxidation Reduction

Equation. **Acid Base:** Bronsted Concept, Lewis Concept, Ionization of Water, pH, Neutralization Curve, Indicators and Their Selection, Buffer, Henderson Equation. **State of Matter:** Gas Laws: Boyle's Law, Charles' Law, Avogadro's Law, Ideal Gas, Real Gas, Ideal Gas Equation and Its Limitation, Vander Waal's Equation, Kinetic Theory of Gases. **Phase Rule:** Definitions, Phase Rule of Water and Carbon Dioxide. **Thermodynamics:** First Law, Work Done for Expansion of Gases, Thermochemistry, Second Law, Carnot Cycle, Third Law. **Chemical Kinetics:** Rate Law, Rate Equation, Molecularity and Order of a Reaction, Derivation of Rate – Expression and Half- Life for First Order and Second Order Reactions, Pseudo First Order Reaction. **Chemical Equilibrium:** Dynamic Behavior of Chemical **E**quilibrium, Law of Mass Action, Equilibrium Constant, Le Chatelier Principle and Its Application. **Solution:** Different Solutions, Colligative Properties. **Electrochemistry:** Electrolysis, Electrolytes, Electrolytic Cell, Faraday's Law, Electrochemical Cells, Electrode Potential, Standard Electrode and Standard Electrode Potential, Nernst Equation and Its Application. **Biomolecules:** Carbohydrates, Proteins, Nucleic Acid, Polymers and Polymerization Processes.

**MATH-1105: Differential and Integral Calculus [3.0 credits, 45 hours lecture] (Pre-requisite Courses: None)**

**Functions:** Graphing Functions, Mathematical Models and Commonly used Functions (Linear, Polynomial, Power), Mathematical Models and Commonly Used Functions (Algebraic, Trigonometric, Exponential, and Logarithmic Functions), Transformations (Scaling, Reflection, Composition), Inverse of Functions, Growth of Functions. **Limits:**Concepts, One Sided Limits, Infinite limits, Limit Laws, Sandwich Theorem, Formal Definition of Limits and Continuity of Functions, Intermediate Value Theorem and Its Application, Limits at Infinity and the Horizontal Asymptotes. **Derivatives:**Derivatives and Rate of Change, Derivatives as Functions, Differentiability of Functions, Rules and Techniques of Differentiation. **Applications of Differentiation:**Rates of Change in Natural and Social Sciences, Exponential Growth and Decay, Linear Approximation and Differentials, Finding Minimum and Maximum Value of Functions and the first and Second Derivative Tests, Indeterminate Forms and L'Hospital's Rule, Curve Sketching. **Integrals:**Riemann Sum and Definite Integrals, Properties of Integrals, Fundamental Theorem of Calculus,Anti-Derivative and Indefinite Integral, Net Change Theorem, Substitution Rule.

**Application of Integration:**Finding Area between Curves, Volumes, Volumes by Cylindrical Shells, Average Value of a Function,Mean Value Theorem for Integrals.

**CSE-1111: Fundamentals of Computers and Computing Lab [1.5 Credits, 45 Hours Lab] (Pre-requisite Courses: None)**

Contents related to the coursework CSE-1101 (Fundamentals of Computers and Computing).

**EEE-1113: Electrical Circuits Lab [1.5 Credits, 45 Hours Lab] (Pre-requisite Courses: None)**

Contents related to the coursework EEE-1103 (Fundamentals of Electricals and Electronics).

**CHE-1114: Chemistry Lab [1.5 Credits, 45 Hours Lab] (Pre-requisite Courses: None)**

Contents related to the coursework CHE-1104 (Chemistry).

# Semester II (1st Year 2nd Semester)

**CSE-1201: Fundamentals of Programming[3.0 credits, 45 hours lecture] (Pre-requisite Courses: CSE-1101, CSE-1102)**

**Review of Basics:** Basic I/O, Data Type, Conditional Logic, Switch Case, Character, ASCII Value, Reading and Writing Character, Integer to Character Conversion. **Operators:** Arithmetic, Relational, Logical and Bitwise Operators, Operator Precedence and Associativity, Arithmetic Expression Evaluation, Short Cut Operator. **Functions–I:**Basic Functions, Void Functions with No Parameters. **Loops:** Looping Basic, Necessity of Loops, While Loop, Loop Condition, Body, Initialization, Increment, For Loops, Part of For Loops, Do While Loop, Entry Controlled Loops, Exit Controlled Loops, Example, Formulating Problems Using Loops. **Formatted I/O:**Specifying Width using Format Specifier in printf and scanf in Details. **Nested Loop:** Nesting of Two Loops, Example, Nesting of Independent Loops inside One, Example, Nesting of More Than Two Loops. **Functions – II:** Functions with Return Type and Trivial Parameters, Local and Global Variables, Call by Value, Library Functions/Header Files Concept. **Arrays:** Basics of Array, Necessity, Declaration, Accessing through Indices, Accessing using Loops, Initialization, Example, Two Dimensional Arrays, Declaration, Initialization, Accessing through Loops, Example, Multidimensional Arrays, Example. **Functions – III:** Passing Arrays in a Function as Parameter, Call by Reference, Recursion, Scope Visibility and Lifetime of Variable. **Strings:** Basics, Difference between String and Character Array, I/O, Basic Operations without using Library Functions, Array of Strings. **String Library:** Basic String Operations, Length, Compare, Concatenate, Substring, Reverse. **Structures:**Basics, Necessity, Declaration, Accessing, Initialization, Array of structures. **Pointers:** Basics, Uses, Pointer Operation, Call by Reference using Pointers, Pointer for 1D/2D/3D Array, Structure, Pointer Expression, Array of Pointers, Function Returning Pointers. **Dynamic Memory Allocation:** Basics, Uses, Malloc, Free, Calloc, Realloc. **File Operation:** Basics, Uses, File Opening, Closing, File I/O, Use of Redirect Operator to Write in File or Read from File. **Preprocessors and Macros.**

**EEE-1202: Digital Logic Design [3.0 credits, 45 hours lecture]**
**(Pre-requisite Courses: None)**

**Introduction:** Introductory Concepts, Binary, Octal and Hexadecimal Number System BCD, ASCH and EBCDIC Codes, **Combinatorial Logic:** Data Representation Logic Gates and Boolean Algebra, Combinational Circuits Design using NAND of NOR Gates Only. Introduction to Decision Diagram, Minimization of Switching Functions Algebraic Simplification, Karnaugh Map, VEKM, Quince McCluskey Method. **Sequential Logic:** NAND and NOR Latches. Clocked SR. JK D and T Flip - Flops. FF Timing Consideration. Master- Slave FF. **Complex Sequential logic:** Frequency Division and Counting Troubleshooting Case Studies. Asynchronous Ripple Up and Down Counters, Counters with Any MOD Numbers Asynchronous IC Counters, Propagation Delay. Parallel Up Down and Up/Down Counters. Presentable Counters. The 74193 Counter. Decoding a Counter. Cascading Counters. Shift Registers, IC Shift Digital Clock. **MSI Logic Circuits:** BCD – to - Decimal Decoders, BCD – to- 7 Segment Decoder/Drivers. Encoders. Multiplexer and Demultiplexer. **Integrated Circuits Logic Families:** TTL Logic Family Standard TTL Series Characteristics, Other TTL Series TTL Loading Rules, Digital MOSFET Circuits. **Memory Devices:** Semiconductor Memory Technologies ROM Architecture Timing and Type of ROM, EPROM, EEPROM, ROM Applications. RAM Architecture Static and Dynamic RAM, DRAM Structure Operation and Refreshing. Introduction to Sequential Circuits, Formal Representation of Sequential Circuits. **Arithmetic circuits:** The Half- Adder Full Adder. Parallel Adders.

**PHY-1203: Physics [3.0 credits, 45 hours lecture]**
**(Pre-requisite Courses: None)**

**Heat and Thermodynamics:** Introductory Concepts and Zeroth Law, Energy Considerations, Work and Heat, Units, Thermodynamic Process, Properties and Equilibrium, First Law of Thermodynamics and It's Applications, Reversible and Irreversible Processes, Second Law of Thermodynamics, Carnot Cycle, Efficiency of Heat Engines and Heat Pump, Carnot's Theorem, Absolute Scale of Temperature, Entropy. **Structure of Matter:** Crystalline & Non-Crystalline Solids, Single Crystal and Polycrystal Solids, Unit Cell, Crystal Systems, Co-ordinations Number, Crystal Planes and Directions, Packing Factor, Miller Indices, Bragg's Law, Defects in Solids, Point Defects, Line Defects, Bonds in Solids, Interatomic Distances, Introduction to Band Theory, Distinction between Metal, Semiconductor and Insulator. **Waves and Oscillations:** Differential Equation of a Simple Harmonic Oscillator, Total Energy and Average Energy, Combination of Simple Harmonic Oscillations, Issajous' Figures, Spring- Mass System, Damped Oscillation, Forced Oscillation, Resonance, Two- Body

Oscillations, Reduced Mass, Differential Equation of a Progressive Wave, Power and Intensity of Wave Motion, Stationary Wave, Group Velocity and Phase Velocity, Architectural Acoustics, Reverberation and Sabine's Formula. **Physical Optics:** Theories of Light, Interference of Light, Young's Double Slit Experiment, Displacements of Fringes and Its Uses, Fresnel Bi- Prism, Newton's Rings, Interferometers, Diffraction of Light, Fresnel and Fraunhoffer Diffraction, Resolving Power of Optical Instruments, Diffraction at Double Slit & N – Slits, Diffraction Grating, Polarization, Production and Analysis of Polarized Light.

**MATH-1204: Methods of Integration, Differential Equations and Series [3.0 credits, 45 hours lecture] (Pre-requisite Courses: MATH-1105)**

**Techniques of Integration:** Integration by Parts, Trigonometric Substitution, Partial Fractions, Computer Algebra Systems (e.g., Mathematica, Sage), Approximate Integration - Simpson's Rule, Improper Integrals. **Application of Integration:** Arc Length, Area of a Surface of Revolution. **Differential Equations:** Modeling with Differential Equations, Solving First Order Differential Equations, Direction Fields and Euler's Method, Methods for Separable Equations and Linear Equations. **Parametric Equations and Polar Coordinates:** Curves Defined by Parametric Equations, Calculus with Parametric Curves, Polar Coordinates, Area and Length in Polar Coordinates, Conic Sections in Polar Coordinates. **Sequence and Infinite Series:** Sequence and Convergence of Sequences, Infinite Series and Its Convergence, Convergence Tests, Alternating Series, Power Series and Its Convergence, Representing Functions as Power Series, Taylor and McClaurin Series, Applications of Taylor Polynomials, Approximating Functions by Polynomials.

**CSE-1211: Fundamentals of Programming Lab [3.0 Credits, 90 Hours Lab] (Pre-requisite Courses: CSE-1111)**

Contents related to the coursework CSE-1201 (Fundamentals of Programming).

**EEE-1212: Digital Logic Design Lab [1.5 Credits, 45 Hours Lab] (Pre-requisite Courses: None)**

Contents related to the coursework EEE-1202 (Digital Logic Design).

**PHY-1213: Physics Lab [1.5 Credits, 45 Hours Lab] (Pre-requisite Courses: None)**

Contents related to the coursework PHY-1203 (Physics).

**ENG-1215: Developing English Language Skills lab [1.5 Credits, 45 Hours Lab] (Pre-requisite Courses: None)**

Contents are based on Listening, Speaking, Reading and Writing tutorials to develop English language skills.

# Semester III (2nd Year 1st Semester)

**CSE-2101: Data Structures and Algorithms [3.0 credits, 45 hours lecture] (Pre-requisite Courses: CSE-1201)**

**Introduction:** Introduction to Data Structures, idea of abstract data type, preliminary idea of algorithm runtime complexity (Big Oh notation), preliminary idea of data structure space complexity. **LinkedList:** Singly/doubly/circular linked lists, basic operations on linked list (insertion, deletion and traverse), dynamic array and its application. **Stack and Queue:** Basic stack operations (push/pop/peek), stack-class implementation using Array and linked list, in-fix to post-fix expressions conversion and evaluation, balancing parentheses using stack, basic queue operations (enqueue, dequeue), circular queue/ dequeue, queue-class implementation using array and linked list, application- Josephous problem, palindrome checker using stack and queue. **Recursion:** Basic idea of recursion (3 laws-base case, call itself, move towards base case by state change), tracing output of a recursive function, applications- merge sort, permutation, combination. **Sorting:** Insertion sort, selection sort, bubble sort, merge sort, quick sort (randomized quick sort), distribution sort (counting sort, radix sort, bucket sort), lower bounds for sorting, external sort. **Binary Tree:** Binary tree representation using array and pointers, traversal of Binary Tree (in-order, pre-order and post-order). **Binary Search Tree:** BST representation, basic operations on BST (creation, insertion, deletion, querying and traversing), application- searching, sets. **Searching:** Linear search, binary Search, application of Binary Search- finding element in a sorted array, finding $n^{th}$ root of a real number, solving equations. **Heap:** Min-heap, max-heap, Fibonacci-heap, applications-priority queue, heap sort. **General Tree:** Implementation, application of general tree- file system.**Disjoint Set:** Union find, path compression. **Huffman Coding:** Implementation, application- Compression. **Graph:** Graph representation (adjacency matrix/adjacency list), basic operations on graph (node/edge insertion and deletion), traversing a graph: breadth-first search (BFS), depth-first search (DFS), graph-bicoloring. **Self-balancing Binary Search Tree:** AVL tree (rotation, insertion). **Set Operations:** Set representation using bitmask, set/clear bit, querying the status of a bit, toggling bit values, LSB, application of set operations. **String ADT:** The

concatenation of two strings, the extraction of substrings, searching a string for a matching substring, parsing.

**CSE-2102: Object Oriented Programming [3.0 credits, 45 hours lecture] (Pre-requisite Courses: CSE-1201)**

**Introduction:** Object oriented programming overview. **Object Oriented Concepts:** Modeling problems using object oriented concepts. Introduction to UML. Encapsulation, Inheritance and Polymorphism. Object Oriented vs. Procedural programming, Basics of Object Oriented Programming language. **Objects and Classes:** Attributes and functions, constructors and destructors, functions or methods, overloading methods, access control, special considerations in different languages. **I/O:** Stream and files. **Inheritance:** Inheriting classes, subclass, super class, access control, inheritance hierarchy, overriding, dynamic binding, abstract class, inner classes, special considerations in different languages, multiple inheritance, interface. **Exception and exception handling:** Exception handling fundamentals, exception types, chained exception, creating own exception subclasses. **Generics or Templates:** Special considerations in different languages. **Package/Namespace:** Understanding and implementing package/namespace. **Object-oriented Design Principles and examples:** Introduction to object-oriented design principles and examples, introduction to object-oriented design. **Case Study using Object Oriented Programming.**

**EEE-2103: Electronic Devices and Circuits [3.0 credits, 45 hours lecture] (Pre-requisite Courses: EEE-1202)**

**Introduction to Semiconductors:** Properties, bonds and types of semiconductors. **Semiconductor Diodes and Special Purpose Diodes:** The pn junction diode: formation, properties and V-I characteristics, Basic constructions, characteristics, operations and uses of special diodes: Light-emitting diode (LED), Zener diode etc. **Diode Application:** Half-wave and full-wave rectifiers – operation and efficiency, Ripple factor, Filter circuits – capacitor input filter, LC filter and Π-filter, Clipping and Clamping circuits, Voltage regulation and regulator circuits - Zener diode and transistor voltage regulator. **Bipolar Junction Transistors:** npn and pnp transistors, amplifying and switching actions of transistor, transistor characteristics in CB, CE & CC configurations, transistor load line and Operating point. **BJT Biasing:** Faithful amplification, inherent variation of transistor parameters and thermal runway, stabilization and stability factor, methods of BJT biasing, analysis and design of biasing circuits. **Single Stage Transistor Amplifier:** Single stage amplifier circuit,

phase reversal, dc and ac equivalent circuits, load line analysis, voltage gain and power gain, classification of amplifiers, amplifier equivalent circuits. **Field Effect Transistors:** Classification of FET, construction, operation and characteristics of JFET and MOSFET, transfer characteristics and Shockley's equation, DC biasing of JFET. **Power Electronics:** operations, characteristics and applications of industrial electronics devices: SCR (Silicon Controlled Rectifier), TRIAC, DIAC etc. **Feedback Techniques and Op-amps:** Concepts- negative and positive feedback, characteristics and gain with negative voltage and current feedback, **e**mitter follower, basic Op-amps-characteristics, inverting, non-inverting, integrators, differentiators, summing amplifiers. **Oscillators:** Theory of oscillation and characteristics of different oscillators. **Introduction to IC fabrication.**

**GED-2104: Bangladesh Studies [2.0 credits, 30 hours lecture] (Pre-requisite Courses: None)**

**Introduction to the course and its objectives. History and Society of Bengal under the British rule and Pakistan rule:** The impact of British and Pakistan rules on the economy and education of the people. Language Movement of 1952, Events Leading to the Mass Upsurge of 1969, War of Independence and the Emergence of Bangladesh in 1971. **Study of Geography and Resources of Bangladesh:** Location, Area, Boundary, Ecological Settings, River System, Climate, People and Resources of Bangladesh. **Social Structure of Bangladesh. Culture of Bangladesh:** Language, Literature, Art and Culture of Bangladesh. **Politics, Formation and role of major political parties in Bangladesh and Constitutional development of Bangladesh. Economy of Bangladesh. Achievements in different sectors** (economy, culture, sports etc.) of Bangladesh. **Socio-cultural problems and prospects of Bangladesh.**

**MATH-2105: Linear Algebra [3.0 credits, 45 hours lecture] (Pre-requisite Courses: MATH-1204)**

**Basics:** Matrices, Linear Equations and Gaussian Elimination, Inverse Matrices, LU Factorization. **Vector Spaces:** Solving system of linear equations and row space, column space, null space, and Rank. **Linear independence:** basis and dimension. **Orthogonal vectors:** Subspaces, inner products, projection onto subspaces, projection matrices and least squares, orthogonal basis and Gram-Schmidt orthogonalization. **Determinants and their properties**, Co-factors, Cramer's rule and other applications of determinants. **Eigenvalues and Eigenvectors:** Basics, application in diagonalization, computing powers of matrices, and solving difference equations. **Various Matrices:** Symmetric matrices, Hermitian matrices, Spectral theorem, positive definite matrices and minima. **Introduction to Linear Transformations:** change of basis, and Singular Value Decomposition. **Computation with Matrices:** using MATLAB/OCTAVE, norm of a matrix and condition number, Left and Right inverse and pseudoinverse, QR decomposition.

**CSE-2111: Data Structures and Algorithms Lab [1.5 Credits, 45 Hours Lab] (Pre-requisite Courses: CSE-1211)**

Contents related to the coursework CSE-2101 (Data Structures and Algorithms).

**CSE-2112: Object Oriented Programming Lab [1.5 Credits, 45 Hours Lab] (Pre-requisite Courses: CSE-1211)**

Contents related to the coursework CSE-2102 (Object Oriented Programming).

**EEE-2113: Electronics Devices and Circuits Lab [0.75 Credits, 22.5 Hours Lab] (Pre-requisite Courses: EEE-1212)**

Contents related to the coursework EEE-2103 (Electronics Devices and Circuits).

# Semester IV (2nd Year 2nd Semester)

**CSE-2201: Database Management Systems - I [3.0 credits, 45 hours lecture] (Pre-requisite Courses: CSE-2101)**

**Introduction:** General overview and purpose of Database Management Systems (DBMSs), advantages, applications, common features and overall structure of the database. **Data modeling (Relational model):** structure of relational model, key constraints, referential integrity constraints, general constraints, Relational algebra: fundamental, additional and extended operations, aggregate functions, outer joins and database modification using RA. ER model: entity and relationship sets, constraints – key, mapping cardinality and participation constraints, strong and weak entity sets, E-R diagram, class hierarchies, aggregation, conceptual database design with the ER model, converting ER to relational model. **Database application development (SQL):** data definition and data manipulation languages, integrity constraints, basic queries, nested and complex queries, modification of the database, Views: definition, update on views, cursors, Extending DBMS functionality: stored procedures, assertions and triggers, embedded and dynamic SQL, DBMS administration: DBA, users, privileges, security etc. **Relational database design:** Features of good relational design, functional dependency theory - basic concept, uses, closure of a set of FDs, closure of attribute sets, canonical cover, algorithms for FDs, decomposition using FDs & its desirable properties, Normalization: atomic domains and first normal form, BCNF and 3NF, multi-valued dependencies and fourth normal form, decomposition algorithms for different normal forms, database design process.

**CSE-2202: Design and Analysis of Algorithms - I [3.0 credits, 45 hours lecture] (Pre-requisite Courses: CSE-2101)**

**Introduction:** Introduction to Algorithms, role of algorithms in computing with respect to state of the art researches. **Complexity Analysis and Recurrence Relation:** Asymptotic notations, growth of a function, methods to solve recurrence relation- Substitution method, Recursion tree method, Master method. **Graph Traversal:** Review of Breadth first search (BFS), Depth first search (DFS), Topological Sort, Strongly Connected Components, Euler Path, Articulation Point, Bridge, Bi-connected Components. **Shortest Path Algorithms:** Dijkstra's Shortest Path Algorithm, Bellman –Ford algorithm and negative cycle detection, Floyd-Warshall all pair shortest path algorithm, shortest path in Directed Acyclic Graph.

**Divide & Conquer (DC):** Counting Inversion using merge sort, closest pair of points, finding Ak mod M using DC method, Finding median (in general k-th smallest element) in a set using DC in expected linear time. **Greedy Algorithms:** Elements and properties of Greedy algorithms, fractional knapsack, job scheduling with deadline minimum spanning tree: Prim's algorithm and Kruskal's algorithm. **Dynamic Programming:** Basic idea, properties and comparison with Divide & Conquer and Greedy Algorithms, general form of Dynamic Programming and Memorization, coin related problems, Longest Increasing subsequence (LIS), Longest Common Subsequence (LCS), 0/1 Knapsack, Matrix Chain Multiplication, Applications of Dynamic programming. **Network Flow:** Flow Networks, Max-Flow Min-cut theorem, Ford Fulkerson method and its limitation, Edmonds Karp algorithm, Maximum bipartite matching, minimum path cover, edge cover.

**CSE-2203: Data and Telecommunication [3.0 credits, 45 hours lecture] (Pre-requisite Courses: CSE-2101)**

**Introduction:** Communication model, data communication tasks, data communication network standards and organizations. Protocol architecture, communications between layers, peer to peer communication between remote layers, service access points, service primitives and communication between adjacent layers, encapsulation of PDUs, addition of headers on transmission; removal on reception, segmentation & reassembly by protocol layers. **Physical Layer:** Analog and digital data transmission, spectrum and bandwidth, transmission impairments, data rate and channel capacity. **Transmission Medium:** Characteristics and applications of various types of guided medium. **Wireless Transmission:** Characteristics and applications of wireless transmission-terrestrial and satellite microwave, radio waves, propagation mechanism, free space propagation, land propagation, path loss, slow fading, fast fading, delay spread, inter symbol interference, VSAT. **Digital transmission:** Line coding techniques- NRZ, RZ, Manchester, and differential Manchester encoding, AMI, Block coding, analog to digital conversion based on PCM, delta modulation, etc. **Analog transmission:** ASK, FSK, PSK, QPSK, QAM encodings, AM, PM, FM, etc. **Data Transmission:** Synchronous and asynchronous data transmission techniques. **Multiplexing:** FDM, international FDM carrier standards, synchronous TDM, international TDM carrier standards, statistical time division multiplexing. **Spread Spectrum:** Frequency hopping spread spectrum, direct sequence spread spectrum, code division multiple access. **Data Link Layer:** Error Detection and Correction; parity check, CRC, forward error correction technique, linear block code, hamming code, etc. **Data Link Control:** Line configurations, flow control and error control techniques- sliding window, stop and wait ARQ, selective reject ARQ and HDLC protocols.

**CSE-2204: Computer Architecture and Organization [3.0 credits, 45 hours lecture] (Pre-requisite Courses: EEE-1202)**

**Micro-computer organization and its basic components:** Carry Look Ahead adders, Carry Save adder, Multipliers (e.g. Booth's algorithm), Divider, Fixed and Floating point (IEEE754) number representations, Finite State Machine (FSM) representation. **Basic Accumulator based CPU:** Organization, instruction set, programming considerations, RISC & CISC Processors- Instruction Sets, addressing Modes. **Introduction to the Basic MIPS:** Instruction Set. **Fixed Point ALUs:** Combinational and Sequential ALUs, ALU Expansion. **Floating Point Arithmetic circuits:** Pipelined Processing, Systolic Arrays, resolving structural, data, control, and name hazards; analyzing processor performance, Memory mapping(e.g. RAM, cache); Non-blocking cache memories; memory protection, translation and virtualization, synchronization, consistency and coherence, direct-mapped and associative caches; write-through and write-back caches, pipelined caches, analyzing memory performance. **Processor Architecture:** Super-scalar execution, Out-of-order execution, register renaming, memory disambiguation, branch prediction, speculative execution; multithreaded, VLIW, and SIMD processors. **Hardwired and Micro-programmed Control Design.** Buses, bus arbitration, I/O control, interrupts and direct memory access, virtual memory mapping and addressing.

**CSE-2205: Introduction to Mechatronics [2.0 credits, 30 hours lecture] (Pre-requisite Courses: EEE-1103, EEE-1202)**

**Introduction:** Definition and applications of Mechatronics, relationship amongst different disciplines. **Basics of Electronics:** Fundamental concepts of circuits and electrics. **Basics of Mechanical Engineering:** Fundamental concepts of Mechanics, measurement systems, control systems, mechanical design, discrete linear systems. **Sensors and Transducers:** Sensors for displacement, proximity, motion, sound, light, temperature, fluid Level and flow, force, etc. **Actuation Systems:** Basics of pneumatic and hydraulic systems, mechanical actuation systems, electrical actuation systems, servos. **System Models and Controllers:** Fundamentals of electrical, mechanical, fluid and thermal systems, electromechanical systems, process controllers, control modes, PID and digital controllers, velocity, adaptive, digital logic, microprocessor control. **Programmable Logic Controllers:** Fundamentals of PLCs, mnemonics and timers, relays and counters, master and jump control, data control, analog I/O control. **Design of Mechatronics Systems:** Steps of mechatronics system design, possible design solutions, case study.

**CSE-2211: Database Management Systems - I Lab [1.5 Credits, 45 Hours Lab] (Pre-requisite Courses: CSE-2111)**

Contents related to the coursework CSE-2201 (Database System and Application).

**CSE-2212: Design and Analysis of Algorithms - I Lab [1.5 Credits, 45 Hours Lab] (Pre-requisite Courses: CSE-2111)**

Contents related to the coursework CSE-2202 (Design and Analysis of Algorithms-I).

**CSE-2213: Data and Telecommunication Lab [0.75 Credits, 22.5 Hours Lab] (Pre-requisite Courses: CSE-2111)**

Contents related to the coursework CSE-2203 (Data and Telecommunication).

**CSE-2216: Application Development Lab [1.5 Credits, 45 Hours Lab] (Pre-requisite Courses: CSE-2101, CSE-2102, CSE-2111, CSE-2112)**

Contents are based on implementation of applications maintaining rules of application development.

# Semester V (3rd Year 1st Semester)

**CSE-3101: Computer Networking [3.0 credits, 45 hours lecture]**
**(Pre-requisite Courses: CSE-2203)**

**Introduction to Computer Networks**, Protocol Layers, Network performance metrics (delay, loss, throughput), Circuit and Packet Switching. **Application Layer:** Protocol overview of HTTP, FTP, Email, DNS, SNMP, P2P Networks. **Transport Layer:** Protocol overview of UDP and TCP, Reliable data transfer, Congestion Control, TCP Reno, TCP Tahoe, TCP New Reno. **Network layer:** Overview of IPv4 and IPv6, IP Addressing, NAT, Routing Algorithms (RIP, OSPF, BGP). **Wireless Networks:** Introduction to wireless networks, Types of wireless networks, Medium Access Control in wireless networks, Routing in wireless networks, Mobility and Mobile IPv6.

**CSE-3102: Software Engineering [3.0 credits, 45 hours lecture]**
**(Pre-requisite Courses: CSE-2101, CSE-2102)**

**Introduction**, **Software process model**, generic model: framework activity, indentifying task set, prescriptive model: waterfall model, v model, evolutionary model: spiral, **Software Project Management**, schedule: people and effort, time line and schedule, *risk*: identification, refinement, mitigation, **User requirement:** stakeholders, requirement gathering, process flow **System requirement specification (SRS):** elementary business logic, function description, use cases, priority, dependency, nonfunctional requirement, SRS standard and practice(IEEE 830), Project's SRS Presentation, **Architecture Design:** Style, representing system in context, archetypes, complexity, **System Design:** pattern, modularity, separation of concern, information hiding, functional independence, refinement, refactoring , **User Interface Design:** interface design steps, interface design pattern, **Data Design:** data, data base, data flow, Design standard and practice (IEE 1016), Project's Design Presentation, **Implementation and Testing:** unit testing, integration testing, white box testing: basis path testing: flow graph, cyclomatic complexity, control structure testing, black box testing, debugging, validation testing, System testing, User Acceptance testing, **Quality Assurance:** plan, task, goal, metric, six sigma quality standard and practice (IEEE 730), **Deployment:** direct, parallel, pilot, **Maintenance:** supportability, reengineering, Final Project Presentation.

**CSE-3103: Microprocessor and Microcontroller [3.0 credits, 45 hours lecture] (Pre-requisite Courses: CSE-2204)**

Evolution of microprocessor, **8086 Microprocessor:** architecture, instruction sets, interrupts and 8259A, higher versions of 8086 (80286, 80386, 80486). **Pentium Microprocessor:** architecture, register sets, cache, floating point operations, addressing modes, paging, instruction set, opcode, interrupt, protected mode operations. **Next Generation Microprocessors:** Intel Core architecture, Intel dual core, core 2 duo, core 2 quad, core i3, core i5, core i7, mobile microprocessors, ARM, helio, atom. **Microcontrollers:** Microcontroller & embedded systems, 8051 microcontroller architecture, operation and instruction set, memory and I/O interfacing, interfacing to external devices. **Programmable Logic Controller (PLC):** Basic Structures, I/O, Programming, Mnemonics and Timers, Relays and Counters, Master and Jump control, Data Control, Analog I/O Control.

**CSE-3104: Database Management Systems - II [3.0 credits, 45 hours lecture] (Pre-requisite Courses: CSE-2201)**

**DBMS implementation technology:** Storage and file structure: different storage types, RAID and RAID levels, file and record organization, data dictionary storage, Indexing and hashing: basic concepts, ordered indices, B+-tree index files, B-tree index files, static & dynamic hashing, comparison of ordered indexing & hashing. **Information retrieval:** Query processing: overview, measures of query costs, selection operation, sorting, join operation, other operations and evaluation of expressions. Query optimization: introduction, transformation of relational expressions, evaluation plan, cost-based optimization and heuristic optimization, optimizing nested sub-queries, materialized view and view maintenance. **Introduction to modern databases:** Object-relational and object-oriented databases: complex data types - structured, array and multiset types, inheritance, object identity and reference types, object-relational query, implementation, persistent programming languages, Introduction to other databases: temporal, spatial, multimedia and mobile databases. **Data Processing and Visualization:** Data object and attribute types: nominal, binary, ordinal, numeric, basic statistical description of data, measuring data similarity and dissimilarity, Data preprocessing: data cleaning, integration and reduction, Data transformation and data discretization, Data visualization: Pixel-oriented, geometric projection, icon-based, hierarchical and

visualizing complex data and relations. **Database system architecture:** Centralized and client-server architecture; Parallel databases: architecture, speedup and scaleup, interconnection networks, I/O parallelism, interquery and intraquery parallelism, cost of parallel processing, design of parallel systems. Distributed databases: homogeneous and heterogeneous, distributed data storage: data replication and fragmentation, failure handling, distributed query processing. **Introduction to Data Mining and Machine Learning:** Decision support systems, OLAP implementation, data warehousing- components, schemas, data mining concept, applications – association rules, classification, clustering.

**MATH-3105: Multivariable Calculus and Geometry [3.0 credits, 45 hours lecture] (Pre-requisite Courses: MATH-2105)**

**Vectors and Geometry of space:** 2D and 3D vectors, Dot and Cross Products, Equations for lines, planes, cylinders and quadric surfaces, **Vector Functions:** Differentiation and integration of vector functions, Arc length and curvature, Motion in space, **Partial Derivatives:** Functions of multiple variables, Limits and Continuity, Tangent and linear approximations, chain rule, directional derivatives, Max-Min values, Lagrange Multiplier, Derivatives with vectors and matrices, **Multiple Integral:** Change of variables in multiple integral, applications, **Vector Calculus:** Vector fields, line integrals, Green's theorem, Curl and divergence, parametric surfaces, Stroke's theorem, Divergence theorem.

**CSE-3111: Computer Networking Lab [1.5 Credits, 45 hours lab] (Pre-requite Courses: CSE-2213)**

Contents related to the coursework CSE-3101 (Computer Networking).

**CSE-3112: Software Engineering Lab [0.75 Credits, 22.5 hours lab] (Pre-requisite Courses: CSE-2111, CSE-2112)**

Contents related to the coursework CSE-3102 (Software Engineering).

**CSE-3113: Microprocessor and Assembly Language Lab [1.5 Credits, 45 hours lab] (Pre-requisite Courses: None)**

Contents related to Microprocessor and Assembly Language.

**CSE-3116: Microcontroller Lab [0.75 Credits, 22.5 hours lab] (Pre-requisite Courses: None)**

Contents related to Microcontrollers.

# Semester VI (3rd Year 2nd Semester)

**CSE-3201: Operating Systems [3.0 credits, 45 hours lecture] (Pre-requisite Courses: CSE-2202, CSE-2204)**

**Introduction:** Operating system overview, computer system structure, structure and components of an operating system. **System calls:** class of system calls and description. **Process and threads:** process and thread model, process and thread creation and termination, user and kernel level thread, scheduling, scheduling algorithms, dispatcher, context switch, real time scheduling. **Concurrency and synchronization:** IPC and inter-thread communication, critical region, critical section problems and solutions. **Resource management:** introduction to deadlock, ostrich algorithm, deadlock detection and recovery, deadlock avoidance, deadlock prevention, starvation. **File management:** File Naming and structure, file access and attributes, system calls, file organization: OS and user perspective view of file, memory mapped file, file directories organization. **File System Implementation:** implementing file, allocation strategy, method of allocation, directory implementation, UNIX i-node, block management, quota, and example file system. **Memory management:** basic memory management, fixed and dynamic partition, virtual memory, segmentation, paging and swapping, MMU. **Virtual memory management:** paging, page table structure, page replacement, TLB, exception vector, demand paging and segmentation, thrashing and performance. **I/O management:** I/O Devices, I/O Bus architecture and controller, interrupts, DMA, programmed I/O. **Disk I/O management:** structure, performance, low-level disk formatting, Disk arm scheduling algorithm, error handling, and stable storage.

**CSE-3202: Numerical Methods [3.0 credits, 45 hours lecture] (Prerequisite Courses: CSE-2202)**

Locating roots of equations, number representation and errors, using MATLAB for mathematical experiments, numerical methods for nonlinear equations, numerical differentiation, numerical integration, Interpolation by polynomials and by spline functions, system of linear equations, numerical methods for ordinary differential equations, numerical methods for partial differential equations, Numerical optimization.

**CSE-3203: Design and Analysis of Algorithms - II [3.0 credits, 45 hours lecture] (Pre-requisite Courses: CSE-2202)**

**Hashing:** Linear Probe, Quadratic Probe, Double hashing, Random hashing, **Computational Geometry:** Vector Cross Product, segment

intersection, point inside a polygon (convex), area of a polygon, convex hull, Line, Segment, circle intersection, **Number Theory:** Sieve of Eratosthenes, Chinese Remainder Theorem, Euler phi, extended Euclid, application of prime factorization application of phi. **Backtracking:** Basic idea and control structure of backtracking, Permutation & Combination generation, Graph Coloring, N-queen problem, Hamiltonian cycle, Branch and Bound in backtracking. For example in traveling salesman problem, **String Matching Algorithms:** Naïve string matching algorithm, Rabin Karp algorithm, String matching with finite automata, Knuth Morris Pratt (KMP) algorithm, Trie Suffix Array. **NP Completeness:** Polynomial time, Polynomial time verification, NP-completeness and reducibility, NP-complete problems, **Online Algorithms:** Competitive Analysis, Online Paging Problem, Randomized Online Algorithms, Adversary Models, Marker Algorithm, **Parallel/Distributed/Multithreaded Algorithms:** The basics of dynamic multithreading, Recursive Fibonacci number computation

**CSE-3204: Formal Language, Automata and Computability [3.0 credits, 45 hours lecture] (Pre-requisite Courses: CSE-1102)**

**Automata and Language Theory:** Finite Automata (FA) and Regular Expressions: Equivalence of Deterministic FA, Non-Deterministic FA and Regular Expressions; Properties of Regular Languages: Pumping lemma and its application, Closure and Decision properties of Regular Languages; Equivalence and Minimization of DFAs. FA with output - Mealy machines and Moore machines, The Chomsky Hierarchy, Context Free Grammars (CFGs) and Languages (CFLs), Chomsky and Greibach Normal Form; Push Down Automata (PDA), Equivalence of PDAs & CFLs; Properties of CFLs: Pumping Lemma, Closure and Decision properties, CYK algorithm. **Computability Theory:** Turing Machines, Computation with Turing Machines, Church-Turing Hypothesis, Recursive and Recursively Enumerable Languages and their properties, Equivalence of Unrestricted Grammars and Turing Machines, Context Sensitive Languages and Linear Bounded Automata; **Complexity Theory:** Time Complexity: P, NP, NP Completeness - Cook's Theorem, Polynomial Time Reduction and NP Complete Problems, Approximation Algorithms; Space Complexity: Savitch's Theorem, PSPACE and PSPACE complete, L, NL; Hierarchy Theorems; Probabilistic Algorithms and the class BPP.

**STAT-3205: Introduction to Probability and Statistics [3.0 credits, 45 hours lecture] (Pre-requisite Courses: None)**

**Statistics:** Types and Sources of Data, Descriptive and Inferential Statistics, Uses and Abuses of Statistics, **Presentation of Data and Exploratory Data Analysis Tools:** Stem and Leaf plots,

Frequency Tables, Histograms, Skewness and Modes, Percentiles and Quartiles, Estimating Percentiles from Histograms, Extremes and Median, Hinges, Outliers and 5 Number Summaries, Box-and-Whisker plots, Use of R or MATLAB for exploratory data analysis. **Characteristics of Data:** Measures of location - Mean, Median, Mode; Measures of Spread/Scale: Spread and Variability, Range, Standard Deviation; Measures of Location and Spread under Affine Transformations; Robust Measures of Location: Trimmed Mean, Winsorized Mean; Robust Measures of Spread: Interquartile Range, Median Absolute Deviation; Markov's inequality and Chebyshev's inequality for list data, **Multivariate Data:** Scatterplots and Scatterplot Matrices, Describing Scatterplots: Linearity and Non-linearity, Homoscedasticity and Heteroscedasticity, Outliers, **Correlation and Association:** Correlation and Causality, Correlation Coefficient, the Effect of Nonlinear Association, Homoscedasticity and Heteroscedasticity, and Outliers on the Correlation Coefficient; Rank Correlation, **Experiments**, **Events**, **Set Theory**, Interpretations of Probability, Axioms of Probability and Counting Methods for Computing Probability, Conditional Probability, Independence, Conditional Independence, and Bayes' Theorem, **Discrete and Continuous Probability Distribution:** Distribution Function, Expectation, Variance, Moments and Moment Generating Functions, Transformation of Variable, **Special Discrete Distributions** - Bernoulli, Binomial, Geometric, Multinomial, Hypergeometric, and Poisson Special Continuous Distributions - Uniform, Gamma, Exponential, and Beta.**Special Continuous Distributions** - Normal Distribution and its properties Q-Q plots and the Normal Probability Plot, **Limit Theorems:** Markov's and Chebyshev's Inequality, Central Limit Theorem, Laws of Large Numbers.

**CSE-3211: Operating Systems Lab [1.5 Credits, 45 hours lab] (Pre-requisite Courses: CSE-2212)**

Contents related to the coursework CSE-3201 (Operating Systems).

**CSE-3212: Numerical Methods Lab [0.75 Credits, 22.5 hours lab] (Pre-requisite Courses: CSE-2212)**

Contents related to the coursework CSE-3202 (Numerical Methods).

**CSE-3216: Software Design Patterns Lab [1.5 Credits, 45 hours lab] (Pre-requisite Courses: CSE-3112)**

Contents related to Software Design Patterns.

**ENG-3217: Technical Writing and Presentation Lab [0.75 Credits, 22.5 hours lab] (Pre-requisite Courses: ENG-1215)**

Contents based on Technical Writing and Presentation.

# Semester VII (4th Year 1st Semester)

**CSE-4101: Artificial Intelligence [3.0 credits, 45 hours lecture] (Pre-requisite Courses: CSE-2202)**

**Introduction:** Agents and environment, **Problem solving by searching:** Un-Informed Search Strategies: breadth first search, uniform cost search, depth-first search, iterative deepening and bidirectional search. Informed search algorithms: best-first search, A* search, Beam search, Heuristic searching, Memory Bounded Search. Local Searches: Hill Climbing, Simulated Annealing, Constraint Satisfaction Problems. Genetic Algorithm: selection, crossover, mutation and fitness. Game Playing: motivation, min-max search, resource limits and heuristic evaluation, α-β pruning, stochastic games, partially observable games, continuous, embodied games. **Logic:** propositional, FOL: quantifiers, model, validity, inference, substitution, unification and Herbrand theorem. **Machine learning:** supervised learning, decision trees, reinforcement learning, Q-learning, neural networks (neuron, perceptron learning, linear and nonlinear separability, multi-layer neural networks, back propagation, variations on back propagation), **Planning:** Planning problems, partial order planning, planning as logical inference planning, **Probabilistic reasoning:** uncertainty, probability, independence, Bayes' rule, Bayesian network, exact inference in Bayesian network and approximate inference, **Knowledge representation:** ontological engineering, categories and objects, events, reasoning systems for categories, reasoning with default information, **Application:** Robotics: hardware, perception, learning, interaction.

**CSE-4102: Mathematical and Statistical Analysis for Engineers (3.0 credits, 45 hours lecture) (Pre-requisite Courses: MATH-2105, MATH-3105 and STAT-3205)**

**Linear Models:** Introduction to linear models, modeling and measurement scales, central tendency, univariate graphs, bivariate graphs, covariance, z-scores and correlation, Ordinary least squares, sampling distributions and statistical inference, confidence intervals and hypothesis testing, type I and type II errors, multiple regressions, autocorrelation, cross-correlation and covariance functions, correlation and covariance matrices.

**Laplace transforms:** Forward transform, inverse transform. Examples of transform pairs. The Laplace transform of a differential equation. The use of Laplace transforms for the solution of initial value problems, existence and uniqueness of Laplace transforms. **Fourier Transforms:** Properties of Fourier series, Fourier sine and cosine series, Fourier transform of continuous and discrete signals, Fourier Coefficients and orthogonally, General periodic functions, odd and even functions, Fourier transform of continuous and discrete signals and the discrete Fourier transform and the FFT algorithm. **Stochastic Processes:** Introduction, Poisson and Exponential processes, deterministic and nondeterministic processes, ensemble and time averages, stationary processes. **Markov Chains:** Introduction, finite Markov chain, continuous time Markov chain, Eigenvalues and Eigenvectors, Birth-Death Process, State transition matrix, initial probability distribution, probability distribution after K trials, regular Markov chains, long run behavior of a Markov chain, absorbing Markov chains, Gamblers ruin problem, Fundamental Matrix,finding steady state distribution vector – Eigenvector approach, Z-transform approach. **Queuing Model:** Basics of Queuing process, Kendall's Notation, Queue throughput, Efficiency or Access Probability, PASTA, Little's Formula, M/M/1/K Queue, $M^m$/M/c Queue, M/M/c/c Queue, D/M/1/B Queue, M/D/1/B Queue, Networks of Markovian queues: open Jackson network. **Linear Optimization:** What is optimization, objective function and constraints, linear optimization, sensitivity analysis, duality theory, Linear Programming in standard form and their duals, LP with equalities and inequalities.

**CSE-4111: Artificial Intelligence Lab [1.5 Credits, 45 hours lab] (Pre-requisite Courses: CSE-2212)**

Contents related to the coursework CSE-4101 (Artificial Intelligence).

**CSE-4113: Internet Programming Lab [1.5 Credits, 45 hours lab] (Pre-requisite Courses: CSE-2216)**

Contents related to Internet Programming.

**CSE-4114: Project [2.0 Credits]**

This is the 1st part of the final year project. The 2nd part must be completed in semester VIII by taking-4214.

# Semester VIII (4th Year 2nd Semester)

**ECO-4201: Economics [2.0 credits, 30 hours lecture] (Prerequisite Courses: None)**

**Introduction:** What is economics, macro and micro economics, methods used in microeconomics, microeconomic models, basic concepts used in economics (scarcity, opportunity cost, goods and bads, factors of production, market, equilibrium etc.). Theory of the consumer: Cardinal and ordinal utility, Concepts of diminishing marginal utility, indifference curves and diminishing marginal rate of substitution, budget line, utility maximization conditions and derivation of individual demand curves, preference structure and existence of utility function, derivation of market demand curve, law of demand, own price, cross price and income elasticity of demand, introduction to concept of inter-temporal utility maximization. **Uncertainty:** Choices under risk and uncertainty, expected utility, risk aversion, applications of expected utility-buying lottery tickets and insurance premium, maximin strategy. **Theory of the Firm:** Behavior of firms, production function, Cobb-Douglas production function, returns to scale, external economies and diseconomies, technological progress, different types of costs, cost function, profit maximization, supply curve, law of supply, own price, cross price and elasticity of supply. **Markets:** Perfect competition and the market, behavior of a competitive firm in short- run, consumer surplus, producer surplus, impact of taxes and subsidies, market equilibrium in the long run, pareto efficiency and perfect competition, price and output in imperfect competition: -monopoly, oligopoly, monopsony, monopolistic competition, imperfect competition and efficiency. **Strategies of Players in Imperfect Competition:** Normal-Form games, Nash equilibrium, dynamic games of complete information, static games of incomplete information, dynamic games of incomplete information. **Market Failure and Solutions:** Public goods, externalities, information asymmetry, problem of unobservability, moral hazard, adverse selection, principal-agent problem etc., signaling, profit sharing, cost sharing, efficiency wage, internalization of externalities, and government intervention.

**CSE-4202: Society and Technology [2.0 credits, 30 hours lecture]**
**(Pre-requisite Courses: None)**

Introduction and Overview. Evolution of Scientific Thoughts: History and Philosophy of Science. Social Complexity and Technology Change: Elman'sservice'sstagesof social complexity, relationship between social complexity and tecnological innovation, economy, craft specialiazation, population size and how they affect diffusion of technologies. Diffusion theory: The nature of technological diffusion into the society. The attributes of innovation and their rate of adoption. Use and impact of technologies in various social aspects: Robotics in warfare or replacement of workforce, Social media effect, artificial intelligence. Medical and biological technolgoies. Genetic technolgoies. Technologies for the poor. Privacy and technology. Technology and Uncertainty. Ethics of technology design and Use. Regulatory issues in governing technologies.

**CSE-4214: Project [4.0 Credits]**

This is the 2nd part of the final year project. The 1st part must be completed in semester VII by taking-4114.

# OPTION-A

## CSE 4121: Robotic Science and Systems

Introduction, microcontroller board, communication and collaboration, motor control , cameras, images, and low-level robot vision, robot control architectures and sensing, motion planning: configuration space, grasping and object transport, localization, manipulation: mechanisms and Grasp analysis, inverse kinematics, mapping, simultaneous localization and mapping (SLAM).

## CSE 4151: Robotic Science and Systems Lab

Contents related to the coursework CSE-4121 (Robotic Science and Systems).

## CSE 4123: Computational Methods in Bio-molecular Sequence & Structure Analysis

**Scoring matrices:** Protein and nucleotide scoring matrices i.e. PAM, BLOSUM, Gonett. How to construct scoring matrices. Difference between PAM and Blosum. **Database homology search:** Concepts behind BLAST: Applications & Biological Significance; homology, similarity & identity Statistical significance of BLAST: E value, Scores BLAST versions- BLASTp, BLASTn, Difference between FASTA and BLAST. **Phylogenetic analysis: Basic terminology in Phylogenetics:** Distance and parsimony methods; Clustering methods. Rooted and un-rooted trees. **Predictive methods using DNA sequences: Gene predictive methods-** searching by signal, searching by content, homology based predictions, Markov models, Hidden Markov models in gene prediction: Genscan, Glimmer, Grail. Promoter analysis and predictions. **Protein Structure Prediction:** Secondary structure prediction methods: CHAU FASMAN, GOR, NN Tertiary Structure prediction methods- Homology Modeling, Threading/Fold recognition and Ab initio.

## CSE 4153: Computational Methods in Bio-molecular Sequence & Structure Analysis Lab

Contents related to the coursework CSE-4123 (Computational Methods in Bio-molecular Sequence & Structure Analysis).

## CSE 4125: Introduction to Machine Learning

Supervised and Unsupervised Learning, issues in machine learning: parametric and non-parametric models, curse of dimensionality, over-fitting, and model selection. Linear Models for Regression: Maximum Likelihood and least squares, regularized least squares, Bias variance decomposition, Bayesian linear regression. Linear Models for classification: Fisher's linear discriminant, probabilistic generative models -parametric (maximum likelihood and Bayesian) and non-parametric density estimation. Probabilistic discriminative models: logistic regression, log-linear models, Kernel methods and Sparse Kernel Machines. Clustering, mixture models and Expectation Maximization algorithm. Sequential data and Markov models.

## CSE 4155: Introduction to Machine Learning Lab

Contents related to the coursework CSE-4125 (Introduction to Machine Learning).

## CSE 4127: Information Retrieval

Boolean Retrieval: Inverted Index, Processing boolean queries, extended Boolean retrieval; Term Vocabulary and Postings lists: Document delineation and character sequence decoding, Tokenization, Dropping common terms: stop words, Normalization (equivalence classing of terms), Stemming and lemmatization, skip pointers, Biword indexes, Positional indexes; Dictionaries and tolerant retrieval: Search structures for dictionaries, General wildcard queries, k-gram indexes for wildcard queries, Spelling correction; Index Construction: Blocked sort-based indexing, Single-pass in-memory indexing, Distributed indexing, Dynamic indexing; Scoring and Ranking: Parametric and zone indexes, Term frequency and weighting, The vector space model for scoring, variant tf-idf functions; Computing scores in a complete search system: Efficient scoring and ranking, Components of an information retrieval system; Evaluation in information retrieval: Evaluation of unranked retrieval sets, Evaluation of ranked retrieval results, Assessing relevance, Results snippets; Relevance feedback and query expansion: The Rocchio algorithm for relevance feedback, Relevance feedback on the web, Evaluation of relevance feedback strategies, Global methods for query reformulation; Language models for information retrieval; Enterprise Information Retrieval: Explore the capacity of Apache Lucene as a text search framework.

## CSE 4157: Information Retrieval Lab

Contents related to the coursework CSE-4127 (Information Retrieval).

## CSE 4131: Introduction to VLSI Design

**Current State of VLSI:** Fabrication and Size Metrics, Performance Metrics, System Complexity; **Introduction to MOS technology:** PMOS, NMOS and CMOS, Transistors, CMOS Fabrication; **Design Approaches:** Fabrication Steps, Stick Diagrams, Design Rules and Layout, Contact Cuts, Double Metal MOS Process Rules, MOS Circuits; **Delay Analysis:** Inverter Delay and its Analysis, Delay of Different Sequential and Combinational Circuit; **Design Automation and VLSI:** Layout, Placement, Routing, Silicon Compilation; S**witch logic:** Pass Transistors and Transmission Gates. **Gate logic:** The inverter, Two-Input nMOS, CMOS and BiCMOS Gate Design. Design of Parity Generator and Multiplexers. Registers, Counters and Memory Realizations, One Transistor and Three Transistors Dynamic RAM Cell Design; **Hierarchical View of VLSI System Design:** Behavioral Description High level Synthesis Scheduling, Allocation and Data Path Synthesis; **Logic synthesis:** Multilevel Minimization, PLA Reduction of Regular Structure Circuits; **Testing:** Testing of VLSI, Testing of Stuck-at fault, Testing of PLAs; **FPGA:** Introduction to FPGA.

## CSE 4161: Introduction to VLSI Design Lab

Contents related to the coursework CSE-4131(Introduction to VLSI Design).

## CSE 4133: Algorithm Engineering

**Introduction. Review of NP-Completeness:** The class P, NP, NPC, Encoding; Polynomial Verification, Polynomial Reduction, Proving NP-Completeness; **Randomized Algorithms:** Review of Randomized Quick Sort. Randomized Min-Cut, Las Vegas and Monte Carlo Algorithms, Randomized Complexity Classes, Approximation Algorithms, Review the Concept of Lower Bound, Lower Bound for Sorting, Constant-factor Approximation Algorithms, FPTAS, Inapproximability, LP Based Approximation Algorithms, Randomized Approximation Algorithms; **Amortized Analysis:** Different Methods: Aggregate analysis, Accounting Method, Potential Method, Examples: PUSH, POP, MULTIPOP; Binary Counter, Dynamic Tables; **Online Algorithms:** Competitive Analysis, Online Paging Problem, Randomized Online Algorithms, Adversary Models, Marker Algorithm, **Bioinformatics Algorithms:** Introduction, Genome Sorting, **Quantum Computing,**

Quantum Bits (Qbits), Quantum Gates and Circuits, Quantum Algorithms, Quantum Parallelism; **Practical Computing and Heuristics:** Back tracking, Branch and Bound; **Parallel/Distributed/Multithreaded Algorithms:** Preamble, The basics of dynamic multithreading, Recursive Fibonacci Number computation; **Parameterized Algorithms:** Fixed Parameter Tractability, Parameterized Algorithm (Buss Algorithm) for Vertex Cover.

## CSE 4163: Algorithm Engineering Lab

Contents related to the coursework CSE-4133(Algorithm Engineering).

## CSE 4135: Software Requirements Specification and Analysis

Review of – The Nature of Software, Software Engineering, The Software Process, Software Engineering Practices, Generic Software Process Model, Process Assessment and Improvement, Prescriptive Process Models, Specialized Process Model and Agile Development. Requirements Engineering, Establishing the ground work, Eliciting Requirements, Negotiating Requirements, Validating Requirements, Requirements Analysis, Scenario-Based Modeling, UML Models, Data Modeling Concept, Class Based Modeling, Requirements Modeling Strategies, Flow-Oriented Model, Behavioral Model, Requirements Modeling for WebApps.

## CSE 4165 Software Requirements Specification and Analysis Lab

Contents related to the coursework CSE-4135 (Software Requirement Specification and Analysis).

## CSE 4137: Cryptography and Security

**Introduction:** Key security concepts, Various types of threats, Policy vs Mechanism, Security policy life cycle, Vulnerabilities, Controls.

**Basic of Cryptography:** Historical ciphers, modern ciphers like AES and DES, symmetric cryptography, cryptanalysis, stream ciphers and RC4, cipher block modes of operation, key distribution.

Number Theory and Finite Field: Groups, ring, field, modular arithmetic, polynomial arithmetic, finite field, prime number, discrete logarithm, etc.

Public key cryptography: RSA algorithm, elliptic-curve cryptography, Diffie-Hellman key exchange, security services, secure hash functions, SHA security hash functions, message authentication code (MAC), Key and Identity Management, certificate management, Key exchange and random numbers, key/identity management, Kerberos, PKI, digital signature, hierarchical x.509.

Authentication: Password based authentication, Token based authentication, Biometric authentication, Remote user authentication, security issues for user authentication.

Access Control: Access control principles, access control policies, discretionary access control, role based access control, role based access control reference model, Unix access control, Windows access control.

**Internet Security:** Secure Sockets Layer (SSL), Transport Layer Security (TLS), HTTPS, IPv4 and IPv6 security.

**Security Policy and Implementation:** Organizational Context and Security policy. Basic risk analysis structure, Implementation of security plan. Integration of physical and logical security. Internet and Email use policies. Computer security incident response team (CSIRT). Security auditing.

## CSE 4167: Cryptography and Security Lab

Contents related to the coursework CSE-4137 (Cryptography and Security).

## CSE 4139: Computer Graphics

Standard Graphics Primitives, Graphical User Interface; Graphics Hardware Display devices, Raster refresh graphics display, Use of frame buffer and look up table Coordinate convention Device coordinate and wild coordinate system. Vector graphics and raster graphics system. Scan conversiton algorithms: Mid-point Line, Circle and ellipes Creation Algorithms. Slope independent line drawing usiing mid-point line algorithm. Polygons: Difference type of polygons, polygon filling, triangulation, polygon filling algorithm. Windowing and Clipping: Window Viewpoint, Zooming,

panning, line, text and polygon, clipping algorithms. Transformation: Homogeneous coordination, Transformation in 3D, Transformation matrices, translation, rotation, scaling. Projection: Parallel and perspective, standard projection matrices. Hidden Surface removal: Painter's algorithm, Z-Buffering, Visible surface ray-tracing algorithm. Illumination and Shading: Light Models, Ambient light, diffuse and specular reflection, light attenuations, Goraud and Phong shading, Recursive Ray Tracing. Monochorome and colored light: monochrome light, additive and suntractive light, Colored light- RGB, CMY, YIQ, HSV and HLS color model. Image File Format: PPM file, BMP file. Representing curves and surfaces: Polygonal surfaces, Parametric Cubic Curves- Hermite, Bezier and B-spline curces, parametric bi-cubic surfaces: bicubic splines. Introduction to Graphics Programming. The nature of computer animation.

**CSE 4169 Computer Graphics Lab**

Contents related to the coursework CSE-4139 (Computer Graphics).

## CSE 4221: Robot Learning

Introduction, supervised learning, linear regression learning, gradient decent learning, Markov process, discrete HMM, HMM: inference and learning, Kalman filter, reinforcement learning: MDP, bellmont equation, value/policy iteration, continuous state/ finite horizon, maximum likelihood, kernel, large margin classifier: SVM, SVM with margin, clustering, PCA and particle filters, learning by observation, learning by demonstration, model learning, deep learning, meta-learning.

## CSE 4251: Robotic Learning Lab

Contents related to the coursework CSE-4221 (Robotic Learning).

## CSE 4223: Fundamentals of Genomics and Proteomics

**Human Genome as a model**: History of Genome sequencing project. The human Genome project. Organization of the Human genome. The human genome sequence: annotation Repeats, coding regions, non-coding regions. Genome sizes. Genome Annotation. **DNA sequencing methods** – manual & automated: Maxam and Gilbert and Sangers method. Chain termination method, Pyrosequencing **Genome Sequencing methods**: Shotgun & Hierarchical (clone contig) methods, Computer tools for sequencing projects: Genome sequence assembly software. **Polymorphisms**: Repeats and Single Nucleotide Polymorphhisms (SNPs), SNP detection methods: SSCP, PCR-based, dHPLC sequencing. SNP and disease. **Molecular markers**: RFLP, VNTR, RAPD, SSR, AFLP **Managing and Distributing Genome Data**: Web based servers and software for genome analysis: ENSEMBL, VISTA, UCSC Genome Browser, NCBI genome. Selected Model Organismal Genomes and Databases.**Introduction to Proteomics**. The proteome. Analysis of proteomes. 2D-PAGE. Sample preparation, solubilization, reduction, resolution. Reproducibility of 2D-PAGE. Mass spectrometry based methods for protein identification. *De novo* sequencing using mass spectrometric data.

## CSE-4253: Fundamentals of Genomics and Proteomics Lab

Contents related to the coursework CSE-4223 (Fundamentals of Genomics and Proteomics).

## CSE-4225: Introduction to Data Mining and Warehousing

Data warehousing: Basic concepts: difference between operational DB and DW, multi-tiered architecture of DW, enterprise warehouse, data mart and virtual warehouse; Data warehouse modeling: data cube and OLAP; Data cube: A multidimensional data model; Stars, Snowflakes, and Fact Constellations: schemas for multidimensional databases; Dimensions and Measures, Typical OLAP operations: roll-up, slice and dice; Data warehouse design and usage, Data warehouse implementation, Data generalization by attribute oriented indexing.Mining frequent patterns: Definitions and background, Market basket analysis, Methods for mining frequent patterns (i) Apriori algorithm (mining frequent itemsets using candidate generation, Improving the efficiency of Apriori), (ii) FP-growth algorithm (mining frequent itemsets without candidate generation), (iii) Mining frequent itemsets using vertical data format; Mining closed and maximal frequent itemsets; Mining frequent patterns in data streams.Mining association rules and correlation: Mining association rules, generating association rules from frequent itemsets, Mining correlations from association rules, Significance of correlation mining in presence of association rules, Pattern evaluation methods, Various correlation measures: lift, chi-square, all_conf, max_conf, cosine and Kulc; their performance and applicability analysis.Mining sequential patterns: Concepts and primitives, applications, domains; mining methods in transactional databases (i) Apriori based approaches (GSP, SPADE), (ii) Pattern growth based (PrefixSpan); closed and maximal sequential patterns; Mining sequential patterns in biological databases, web access databases and time series databases.

## CSE-4255: Introduction to Data Mining and Warehousing Lab

Contents related to the coursework CSE-4225 (Introduction to Data Mining and Warehousing Lab).

## CSE-4227: Cloud Computing

**Introduction to Cloud Computing:** Definition and applications including benefits, challenges, and risks, Enabling Technologies and System Models for Cloud Computing, **Cloud Computing Models:** Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS) and emerging XaaS, **Types of Cloud Computing:**Public cloud, private cloud and hybrid clouds, Cloud OSs and platforms, **Cloud Architectures:**Architectural design of Cloud computing, Interaction among infrastructure provider, business providers and the customers, roles of cloud broker, Tradeoffs between costs and customer satisfactions, Federated Clouds, **VM Resource Provisioning:** Static and dynamic resource provisioning approaches, HARMONY architecture, Capacity provisioning approaches, **Scalability and Fault Tolerant Issues:**Scalable computing, energy optimization vs. fault tolerant service platforms, Performance, QoS, Power management in Cloud Computing data centers, **Principles of Virtualization platforms:** VMWare ESX Memory Management, Security and Privacy issues in the Cloud, **Introduction to Mobile Cloud Computing:** Architecture and applications of MCC, Code partitioning, Code offloading and VM migration techniques.

## CSE-4257: Cloud Computing Lab

Contents related to the coursework CSE-4127 (Cloud Computing).

## CSE-4229: Introduction to Reversible Computing

Introductory Concepts, Theory of reversibility, Energy and Information loss, Popular Reversible logic gates: Feynman Gate, Fredkin Gate, Toffoli Gate, Double Feynman Gate; Garbage outputs, Delay, Quantum cost, Reversible Combinational Circuits: Reversible Half Adder, Reversible Full Adder, Reversible Carry Look Ahead Adder, Reversible Carry Skip Adder, Reversible BCD Adder, Reversible Subtractor, Reversible Multiplier, Reversible Divider, Reversible Comparator, Reversible Decoder, Reversible BCD to Decimal Decoder, Reversible BCD to 7-Segment Decoder, Reversible Encoder, Reversible Multiplexer, Reversible Demultiplexer; Reversible Sequential Circuits: Reversible SR, JK, T and D Flip Flop, Reversible Register, Reversible Shift Register, Reversible Frequency Division and Counter Circuit, Reversible Synchronous Counter, Reversible Asynchronous Counter, Reversible Parallel Up-Down Counter, Reversible RAM, Reversible ROM; Reversible Complex

Circuits: Reversible PLA, PLD, CPLD, FPGA; Synthesis of Reversible Logic: Transformation based Synthesis, BDD-based Synthesis.

## CSE-4259: Introduction to Reversible Computing Lab

Contents related to the coursework CSE-4229 (Introduction to Reversible Computing).

## CSE-4231: Computational Geometry

Introduction: Course information, Course policies; Polygon Triangulation and Polygon Partitioning: Art gallery theorems: Necessity and sufficiency, Triangulation theory, Triangulation by Ear Removal, Monotone partitioning, Trapeziodalization, Triangulating monotone polygons; Convex Hull in 2D and 3D: Graham's scan, Output sensitive algorithms: Gift wrapping or Jarvi's march, Lower bound of CH, Chan's algorithm, Convex hull in 3D: Euler's formula and its consequence, gift wrapping algorithm; Voronoi Diagrams and Delaunay Triangulations: Definition and properties of Voronoi diagram and Delaunay triangulation, Incremental algorithm for construction, Relation to Nearest Neighbor graphs, MST, Largest empty circle, Medial axis and Straight skeleton; Arrangements and Duality: Arrangements of straight lines in 2D, Definition and assumption, Combinatorics of arrangements, Zone theorem, Incremental algorithm for computing the arrangements, Duality between, lines and points; Application of duality: Ham-Sandwich cut, red-blue matching; Line Segment Intersection: Intersection of Segments, Overlap of two polygons---convex and non convex polygon; Graph Drawing; Orthogonal Range Searching: Motivation from DataBase, 1d, 2d

## CSE-4261: Computational Geometry Lab

Contents related to the coursework CSE-4231 (Computational Geometry).

## CSE-4233: Software Testing and Verification

The Psychology and Economics of Software Testing, Software Testing Life Cycle (STLC), Software Testing Terminology and Methodology, V&V Model, Dynamic Black Box Testing – Boundary Value Analysis, Equivalence Partitioning, State Transition based Testing, Decision Table based Testing, Cause-Effect Graphing based Testing and Error Guessing, Dynamic White Box Testing – Basis Path Testing, Data Flow Testing and Mutation Testing, Inspections, Walkthroughs,

Technical Reviews, Unit Testing, Integration Testing, Function Testing, System Testing, Acceptance Testing, Regression Testing, Test Management – Test Organization, Test Plan, Test Design and Specifications, Software Metrics, Software Quality, Quality Control and Quality Assurance, Quality Management and Project Management, Software Quality Metrics, Testing Internet Applications - Security and Performance Testing, Debugging, Test Driven Development (TDD), Behavior Driven Development (BDD).

## CSE-4263: Software Testing and Verification Lab

Contents related to the coursework CSE-4233 (Software Testing and Verification).

## CSE-4235: Digital Forensic

Introduction: Key digital forensics concepts. Computer forensics, network forensics, mobile device forensics, malware forensics, memory forensics, scientific method of digital forensics, digital evidences, circumstantial vs digital evidence, Evidence integrity and cryptographic hash functions, chain of custody, using forensic copies, reporting and testimony, case study of real world crime investigation involving digital forensics. Legal system in Bangladesh: Legal system in Bangladesh, criminal vs civil justice system, court room scenario, Lawyers vs prosecutors, defense attorneys, law enforcement, warrant requirement, e-discovery, Judges and decision makers, laws related to cyber crimes and digital forensics, accepted digital evidences in Bangladesh legal system, finger print analysis, privacy law and digital forensics. Computer Forensics: Computer forensics investigation process, evidence acquisition and preservation, file systems, forensics duplication/imaging technique, write blockers, device configuration overlay, SSD forensics. Windows Forensics: NTFS basics, File Record attributes, NTFS analysis, file system met data files, file carving, carving with fragmented clusters, windows registry, registry keys and values, traces of user log on/off, connection of usb devices, determining installation time, recently played files in windows media player, last 25 urls visited, timestamp changes, Event Logs, Recycle bin.Windows Application Analysis: Application Metadata, MS office metadata, multi-media file metadata, web browser forensics, email forensics, pre-fetch files, Diffie-Hellman key exchange, RSA algorithm, elliptic-curve cryptography, security services, secure hash functions, SHA security hash functions. Psychological Aspects of Digital Forensics: Forensics psychology, cyber crime overview,

roles of forensics psychologists, theories of crime, psychological profiling hackers and malware distributors, Rogers's hacker circumplex, case studies: Kevin Mitnich, Edward Snowden, Gary McKinnon, Network Forensics: Network forensics concepts, investigation methodology, sources of network-based evidence, Internetworking fundamentals, OSI model, TCP/IP model, three-way handshake, TCP and IP/IPv6 header, ARP, ICMP, DNS, HTTP, DHCP, SMTP, Evidence acquisition, sniffing packets from switches and wireless networks, libpcap, tcpdump, active acquisition, strategies for collection evidence Password based authentication, Token based authentication, Biometric authentication, Remote user authentication, security issues for user authentication, packet analysis, protocol analysis, flow analysis, statistical flow analysis, flow record collection and aggregation protocol, tools: silk, argus, nfdump, analysis technique and tools, identifying port scanning through statistical analysis. Network Intrusion Detection and Analysis: NIDS/NIPS functionality, Modes and types of NIDS, NIDS/NIPS evidence acquisition, snort rules and alerts, Case study. Fraud investigations: Fraud examiner vs forensic accountant, fraud examination methodology, Bendord's law, Secure Sockets Layer (SSL), Transport Layer Security (TLS), HTTPS, IPv4 and IPv6 security, Kerberos, X.509, wireless security. Mobile Forensics: Mobile network basics, mobile OS, NAND flash memory, YAFFS2, types of evidence obtainable from mobile devices, Proper handling of evidentiary mobile devices, Android forensics, ios forensics.

## CSE-4265: Digital Forensic Lab

Contents related to the coursework CSE-4235 (Digital Forensic).

## CSE-4237: Digital Image Processing

Introduction to image processing, Differences between image processing, image analysis, and computer vision, Image Representation, Color Space, Image Sampling and Quantization, Image Quality Measurement, Image Quality Enhancement: Intensity transformations, Contrast stretching, Histogram equalization, Spatial domain filtering - mean and median filters, Sharpening filters - Laplacian and Sobel, Discrete Fourier Transform, Frequency-Domain Filtering - Gaussian and Butterworth low pass and High pass filters, Image Transform - Discrete Cosine Transform, Wavelet transform, Mutiresolution Anallysis and Discrete Wavelet Transform, Introduction to Image Restoration - Noise models,

spatial and frequency filters, Weiner filter, Morphological Image Processing, Image Feature Extraction and Representation: Edge and Line, Region Segmentation and Representation, Image and Video Compression

## CSE-4267: Digital Image Processing Lab

Contents related to the coursework CSE-4237 (Digital Image Processing).

## CSE 4239: Parallel and Distributed Systems

**Distributed System Models:** High Performance Computing, Grid Computing, Cloud Computing, Many core Computing, Many Task Computing, **Programming Systems and Models:** Processes and threads, MapReduce, Workflow Systems, Virtualization Techniques, **Distributed Storage & Filesystems:** Data Intensive Computing, Distributed Hash Tables, **Consistency and Replication:** Reasons for replication, Consistency Models, Data Centric Consistency Models, Client Centric Consistency Models, Consistency Protocols, **Fault Tolerance:** Byzantine failure and k-fault tolerant systems, Performance analysis and tuning, scalability and performance studies, scheduling, storage systems, synchronization, and tools (Cuda, Swift, Globus, Condor, Amazon AWS, OpenStack, Cilk, gdb, threads, MPICH, OpenMP, Hadoop, FUSE), **Parallel architectures:** parallel algorithms & architectures, parallel I/O, performance analysis and tuning, power, programming models (data parallel, task parallel, process-centric, shared/distributed memory), **Multithreaded programming:** GPU architecture and programming, Message passing interface (MPI), heterogeneity, interconnection topologies, load balancing, memory consistency model, memory hierarchies.

## CSE 4269: Parallel and Distributed Systems Lab

Contents related to the coursework CSE-4239 (Parallel and Distributed Systems).

# OPTION B

## CSE 4122: Mathematics for Robotics

Solution of linear equations, polynomial interpolation and approximation, solution of nonlinear equations, roots of polynomials, resultants, approximation by orthogonal functions (includes Fourier series), integration of ordinary differential equations, optimization, calculus of variations (with applications to mechanics), probability and stochastic processes (Markov chains), computational geometry, differential geometry.

## CSE 4124: Introduction to Bioinformatics

**Amino acids and Proteins:** General properties. Classification and characteristics. Acid-base properties of amino acids. Essential and Non-standard amino acids. **Introduction to Proteins & Protein Structure:** Primary, Secondary, Tertiary and Quarternary Structure. **Enzymes:** General properties, specificity, classification, efficiency, regulation of enzyme activity (rate, concentration, time, pH, temperature), enzyme kinetics---rate equations, steady state, Michaelis- Menten equation. **Carbohydrates.** Definition, classification and structure of monosaccharides, Disaccharides polysaccharides, and glycoconjugates- proteoglycans, glycoproteins and glycolipids. Structural and functional roles of carbohydrates. **Sequence databases:** Primary and secondary databases, Nucleotide sequence database, nucleotide sequence flat files. **Protein sequence databases:** Genpept, Uniprot, Swissprot, PIR, Sequence formats: Genbank, FASTA, ASN. Information retrieval from biological databases. The NCBI resource, Entrez, Pubmed, Medline. Entrez Boolean search terms and statements. Locuslink, NCBI bookshelf. **Sequence Alignment:** Pairwise sequence alignment, Global alignment, Local alignment, Scoring functions and matrices, General gap and affine gap penalty, Statistical significance. **Multiple Sequence alignment:** SP (Sum of Pairs) measure, Star alignments, Tree alignments, Motifs and Profile, Alignment representation and Applications, ClustalW, ClustalX and Tcoffee.

## CSE 4126: Introduction to Data Science

Data collection and extraction, Preprocessing: Data quality, Data cleaning: missing values, noisy data, Data Storage and integration: SQL and NoSQL databases, redundancy and correlation analysis, tuple duplication, conflict detection and resolution, Data Reduction: overview, wavelet transformation, principle

component analysis, attribute subset selection, regression and log-linear models, histograms, clustering, sampling, Data cube aggregation; Data Transformation and Discretization: overview, normalization, binning, histogram analysis, concept hierarchy generation, Data visualization, Exploratory Data Analysis, Introduction to data modeling.

## CSE 4128: Wireless Networks

**Overview of wireless communication networks and protocols:** Brief introduction to wireless physical layer fundamentals, Understand the architecture and applications of current and next generation wireless networks: Cellular, WLANs, sensor networks, mesh networks, mobile ad-hoc networks and intermittently connected mobile networks. **Modern physical layer wireless and mobile communications:** radio propagation modeling, performance of digital modulation schemes and coding techniques in fading environments; CDMA and OFDM,Diversity and MIMO. **Medium access and resource allocation techniques:** Medium access control, power control for fixed-rate and rate-adaptive systems, Aloha and CSMA-based randomized medium access, scheduling for TDMA/FDMA/CDMA-based wireless networks. **Design and analyze network layer routing protocols:** link metric estimation and neighborhood table management for proactive and reactive routing protocols- AODV, DSR, and their variants, opportunistic routing, backpressure routing, network coding, cooperative routing, routing with mobility and intermittent contacts. **Design and analyze transport layer protocols:** Emphasis on congestion control, including TCP over wireless, congestion sharing mechanisms, explicit and precise rate control, utility optimization-based approaches, and backpressure-based utility optimization.

## CSE 4130: Introduction to Quantum Logic

Overview of Nanotechnology, Quantum Building Blocks, Unitary Matrix, Hermitian Matrix, Pauli Matrix, Qubits, Single-Qubit Quantum Systems: Single Quantum Bits, Single Qubit Measurement, A Quantum Key Distribution Protocol, The State Space of a Single Qubit System; Multiple-Qubit Systems: Quantum State Spaces, Measurement of Multiple-Qubit System, Quantum State Transformation; Quantum Gates: Hadamard gate, Pauli-X gate, Pauli-Y gate, Pauli-Z gate, Phase shift gates, Swap gate, Square root of Swap gate, Controlled gates, Universal Quantum Gates, Application of Quantum Gates; Quantum Logic Synthesis, Quantum Circuits:

Quantum Adder, Quantum Subtractor, Quantum Multiplier, Quantum Divider, Quantum Decoder, Quantum Encoder, Quantum Multiplexer, Quantum Demultiplexer, Quantum Comparator; Introduction to Quantum Algorithms: Computing with Super Positions, Notions of Complexity, Deutsch's Problem, Simon's Problem

## CSE 4132: Graph Theory

Fundamental concepts, varieties of graphs, path, cycles and components, degrees and distances, clique. Trees: Properties, spanning trees, forests, centroids, generation of trees and cycles, ent cycles and co-cycles. Connectivity: Vertex and edge connectivity, blocks, eccentricity, Menge's Theorem. Traversability: Eulerian graphs, kuratowski's theorem, embedding graphs on surfaces, genus, thickness and crossing number. Graph Coloring: Vertex coloring, edge coloring, chromatic number, five color theorem, four color conjecture, critical graph. Homomorphism Digraph: Different connectedness, oriented graphs-tournaments, network flows and related algorithms. Groups, polynomials and graph enumeration, matching and factorization, perfect graphs, Ramsey number and Ramsey theorem, forbidden graph theory, miscellaneous applications.

## CSE 4134: Software Project Management

Introduction: What is project? What is project management? Program and project portfolio management, role of project manager, project management profession. Project management and information technology context: A system view of project management, understanding organization, stakeholder management, project phases and the project Lifecycle, The context of information technology projects, recent trends affecting IT project management. Project management process groups: Introduction, process groups, mapping the process groups to the knowledge areas, developing an IT project management methodology, case study. Project Integration Management: Introduction, strategic planning and project selection, developing a project management plan, directing and managing project work, monitoring and controlling project work, performing integrated change control, closing projects or phases.Project Scope Management: Introduction, planning scope management, collecting requirements, defining scope, controlling

scope.Project Time Management: Introduction, importance of project schedules, planning schedule management, defining activities, sequencing activities, estimating activity resources, estimating activity duration, developing the schedule, controlling the schedule.Project Cost Management: Introduction, importance of cost management, basic principles of cost management, planning cost management, estimating costs, determining the budget, controlling costs.Project Quality Management: Introduction, importance of project quality management, planning quality management, performing quality assurance, controlling quality, tools and techniques of quality control, modern quality management, improving IT project quality.Project Human Resource Management: Introduction, importance of human resource management, keys to managing people, developing the human resource plan, acquiring the project team, developing the project team, managing the project team.Project Communication Management: Introduction, importance of project communication management, keys to good communications, planning communications management, managing communications, controlling communications.Project Risk Management: planning risk management, common sources of risk on IT projects, identifying risks, performing qualitative risk analysis, planning risk responses, controlling risks.Project Procurement Management: Introduction, importance of project procurement management, planning procurement management, conducting procurements, controlling procurements.Project Stakeholder Management: Introduction, importance of project stakeholder management, identifying stakeholders, planning stakeholder management, managing stakeholder engagement, controlling stakeholder engagement.

## CSE 4136: Computer Security

Web security: Basic three tire model of web architecture, various attacks on web, SQL injection attacks, various types of SQL injection attacks, protection against SQL injection attacks, prepared statements, sanitizing, single origin principle, Cross site scripting attacks/protections, cross site request forgery attacks/protection, case study.Network security: Internet architecture, security flaws on the Internet, attacks on networks, DDOS attacks, reflection attacks, amplification attacks, wireless security, WEP cracking, DNS hijacking, routing attacks, case study: NTP DDOS attack, spamhaus DDOS attack. Buffer Overflow and control flow attacks: gdb tutorial, c stack frame, conversion of c code to assembly, stack push and pop while function calls, buffer over flow example, shell injections, exploiting buffer overflow, shellcode, call instruction tricks for shell code, integer over

flow, safe/unsafe functions, buffer over flow protections, stack canaries, no execution, address space layout randomization, return to libc function chaining, return oriented programming. Malware analysis: How malware run, insider attack, backdoors, analysis of brain virus and morris worm, rootkits, botnets, code injection attacks, worm propagation, malware counter measures. Reversing Malware: Introduction to IDA-Pro, ollydbg and REMnux, identifying key x86 assembly logic structure using disassembler, common malware characteristics at windows api level (DLL injection, function hooking etc), recongnizing packed malware, manual unpacking of malware using OllyDbg, interacting with malicious websites to examine their nature.

**CSE 4140: Compiler Design**

Phases of a compiler, front and back end of a compiler. Lexical Analysis: regular expressions and regular languages, Finite Automata based pattern matching, Input buffering techniques, Syntax Analysis: Context free grammars, Top-down parsing: LL parsing, Recursive Descent parsing, Bottom-up parsing ; LRparsing, syntactic error recovery, Symbol Tables, Type expressions and type checking, Runtime structures- Activation Records, Static and Dynamic Scoping. Intermediate Representation: Abstract syntax trees, 3-address code, etc. Generation of 3-address codes – Syntax directed translation for Declarations, Assignment statements, Flow of Control statements, Array reference. Target Code generation. Optimization: Control flow graphs, Data flow Analysis: Reaching definitions and Live-variable analysis and Def-use & use-def chains, Available Expression analysis and Global common sub expression elimination, Dominators, Loops in control flow graphs, Loop invariants and code motion, Elimination of Induction variables, Partial redundancy elimination, constant folding and constant propagation, copy propagation, Dealing with Aliasing, Inter-procedural Dataflow Analysis, Introduction to Static Single-Assignment (SSA) form; Global Register allocation by graph coloring, Instruction Scheduling: list scheduling, Optimization for memory hierarchies.

## CSE-4222: Human Robot Interaction

Introduction, sensors and perception for HRI, expression and gaze, multi-modal human-robot communication, Human-robot interaction architectures, museum robotics, educational robotics, assistive robotics, social robotics, shared autonomy and situation awareness, urban search and rescue: an HRI focus example, quality of life technologies: an HRI focus example.

## CSE-4224: Mobile Robotics

Introduction, legs and kinematics, wheeled locomotion, differential kinematics, wheeled kinematics, perception: camera image, omni-directional projection, stereo camera, correlation and convolution, edge and points, place recognition, error propagation, line extraction, planning: collision avoidance, potential field methods, localization and mapping, graph search.

## CSE-4226: Aerial Robotics

Introduction, stability and derivation of a dynamic model, flight dynamics and flight control, dynamic modeling of rotorcraft, autonomous flight and data collection, obstacle avoidance, path planning and formation flying, navigation and mission planning, human factors in aerial systems, design of electronics and software for control, design methods of avionics systems specific to small UAVs with civilian applications.

## CSE-4228: Application of Computational Biology

**Genome Annotation:** Introduction to the genome sequencing projects- the first bacterial genome, eukaryotic genome, traditional routes of gene identification: Experimental and *in silico* methods, software programs for finding genes: ORF finders, Genemark, Glimmer,Genscan, Grail. **Predictive Methods Using DNA Sequences:** Methods for gene identification- signal basedmethods, content based methods, homology based methods. Computational bias, machine learning methods: artificial neural networks, Markov chain, Hidden markov model. Promoter analysis, repeat finders. **Predictive Methods Using RNA Sequence:** RNA secondary structure thermodynamics, RNA secondary structure prediction, programs for prediction of RNA secondary structure: M fold, RNA fold, S fold, Vienna RNA package.

## CSE-4230: Human Computer Interaction

**Introduction to HCI. Cognitive Models. Socio – Organizational Issues.Understanding the Users:**Need finding,Communicatingwith the Users, Observation, Interviewing.**Prototyping. Research Method – I: Qualitative Approaches:** Survey Design, Introduction to Decision Analytic Approaches, Mental Models. **Design Heuristic and Evaluation Learning Strategies. Research Method – II: Quantitative Approaches:**Statistical Thinking, Introduction to Data Analytics, Uncertainty. **Design Issues with the New Media:** Online Education, Introduction to Second Life. **Design Issues with Mobile Systems. Social Usability:** Analyzing the Social Network. **Introduction to Complex Network. Research Methods – III:** Introduction to Data Scientific Processes, Introduction to Various Machine Learning Tools and Algorithms. **Visual Design:** Representation, Visual Layout, Typography, Information Design. **Designing for Children and the Society:** Playful User Interface, Interface Designs that invite Social and Physical Interactions, Games for Change, Personalization and Teaching, Health and Sports, Designing Interactions for Children, Perils of Children's Digital Life, Pro – Poor User Interface, Designing for Development. **Crowd Computing:** Designing Software for Collaboration, Augmented Reality, Wearable.

**CSE-4232: Internet of Things**

**Introduction to Internet of Things:** Definition, applications, the IoT paradigm, Smart objects, IoT components and diversities, convergence of technologies, **Industry domains:** IoT Service design and analysis in various industrial applications - IoT in Sports, IoT in Cities/Transportation, IoT in the Home, IoT in Retail, IoT in Healthcare, Profit and Satisfaction analysis for IoT-enabled utility services, **IoT Platforms:** Hardware, SoC, sensors, device drivers, IoT standards, Cloud computing for IoT, Bluetooth, Bluetooth Low Energy, beacons, **IoT Communication Protocols:** NFC, RFID, Zigbee, MIPI, M-PHY, UniPro, SPMI, SPI, M-PCIe, Wired vs. Wireless communication, GSM, CDMA, LTE, GPRS, small cell, etc. **Services/Attributes:** Big-Data Analytics and Visualization, Dependability, Security, Maintainability, **Creative Thinking Techniques:** Modifications, Combination Scenarios, Breaking Assumptions, Solving problems.

**CSE-4234: Introduction to Multiple-Valued Logic**

Multiple-Valued Logic Functions, Shannon Expansion for Multiple-Valued Logic, MVL Reed-Muller Expansion, MVL Applications, MVL in EDA-CAD Methods, Multiple-Valued Combinatorial Circuits: Multiple-Valued Half Adder, Multiple-Valued Full Adder, Multiple-Valued BCD

Adder, Multiple-Valued Carry Look-Ahead Adder, Multiple-Valued Subtractor, Multiple-Valued Multiplier, Multiple-Valued Divider, Multiple-Valued Decoder, Multiple-Valued Encoder, Multiple-Valued Multiplexer, Multiple-Valued Demultiplexer, Multiple-Valued Comparator, Multiple-Valued Sequential Circuits: Multiple-Valued SR, JK, T and D Flip Flop, Multiple-Valued Register, Multiple-Valued Shift Register, Multiple-Valued Frequency Division and Counter Circuit, Multiple-Valued Synchronous Counter, Multiple-Valued Asynchronous Counter, Multiple-Valued Parallel Up-Down Counter, Multiple-Valued RAM, Multiple-Valued ROM, Multiple-Valued PLA, Multiple-Valued PAL, Multiple-Valued PLD, Multiple-Valued CPLD, MVL Algebras, MVL Finite State Diagrams, Functional Expression for Multiple-Valued Functions, Decision Diagrams for Multiple-Valued Functions, Reduction Rules, Multiple-Valued Reversible Gates and Circuits, Quantum Multiple-Valued Decision Diagrams.

**CSE-4236: VLSI Layout Algorithms**

VLSI design cycle, physical design cycle, design styles; Basic graph algorithms and computational geometry algorithms related to VLSI layout; Partitioning algorithms: group migration algorithms, simulated annealing and evaluation, performance driven partitioning; Floor planning and placement algorithms: constraint based floor planning, rectangular dualization and rectangular drawings, integer programming based floor planning, simulation based placement algorithms, partitioning based placement algorithms; Pin assignment algorithms; Routing algorithms: maze routing algorithms, line prob algorithms, shortest-path based and steiner tree based algorithms, river routing algorithms, orthogonal drawing based algorithms; Compaction algorithms: constraint-graph based compaction, virtual grid based compaction, hierarchical compaction; Algorithms for Multi-Chip Module (MCM) physical design automation.

## CSE-4238: Concepts of Concurrent Computation

Introduction to Concurrent Computation. Challenges of Concurrency. Synchronization Algorithms. Semaphores. Simple Concurrent Object Oriented Programming (SCOOP) Principles. SCOOP Type Systems.Monitors. Calculus of Communicating Systems (CCS). CCS Advanced Topics. Communicating Sequential Processes (CSP). SCOOP Outlook. Lock – Free Approaches. Languages for Concurrency and Parallelism.

## CSE-4240: Applied Cryptography

Mathematical Background: Information theory, Entropy, mutual information, randomized algorithms, number theory, integer arithmetic, rings, fields, groups, cyclic groups, subgroups, finite fields, the Euclidean algorithm for polynomials, extended Euclidean algorithm, integer factorization problem, elliptic curve factoring, Symmetric ciphers and applications:symmetric cryptography and correctness property, analysis of one time pad, properties of perfect cipher, modern symmetric ciphers, generating random keys, modes of operations for symmetric ciphers, cryptographic hash functions, strong passwords, dictionary attacks, hash chain. Key distribution: Discrete logarithm problem and proving Diffie-Hellman key exchange, attacks against discrete logarithmic problem, implementing Diffie-Hellman, Finding large primes,primalitytest Fermat's Little Theorem, Rabin-Miller test.Key establishment with symmetric-keys, with a distribution center, Kerberos, problems with symmetric key distribution, Asymmetric Cryptosystems and Applications: Correctness of RSA, Euler's theorem, Proving euler's theorem, invisibility of RSA, security property of RSA, best known algorithm for factoring, public-key cryptography standard, insecurity of RSA in practice, using RSA to sign a document, problem with RSA. Cryptographic Protocols: SSH, TLS, TLS information leaks, certificate, signature validation. Elliptic Curve: How to compute with elliptic curves, building a discrete logarithm problem with elliptive curves, group operations on elliptic curve, Diffie-Hellman key exchange with Elliptic curves, Elliptic curve digital signature algorithm and its computational aspect. Using cryptography: Traffic analysis, onion routing, voting, digital cash, RSA blind signature, blind signature protocol, bit-coin, encrypted circuits.

## CSE-4242: Computer Vision

Review of Image formation - 3D to 2D transformation, lighting, reflection and shading models, Modern digital camera - properties, image sensing pipeline; image filtering, Template matching, Image pyramids and application; Feature detection and matching - Edge detection, Interest point and corners, local image features - Scale Invariant Feature Transform and its variants, Feature matching - Hugh transform, model fitting, RANSAC; Feature Tracking - KLT tracker, Optical Flow; Image Segmentation - Split and Merge methods, Mean shift and mode finding methods, Graph cuts and energy based methods; Object Detection and Recognition - Eigenfaces, Instance Recognition - bag of words, part based methods. Recognition and large scale data sets.

## CSE-4244: Computer and Network Security

Control hijacking attacks: exploits and defenses - Buffer Overflows: Attacks and Defenses, Basic Integer Overflows, Bypassing Browser Memory Protections; Dealing with legacy code: sandboxing and isolation, Tools for writing robust application code - Unassisted and Automatic Generation of High-Coverage Tests for Complex Systems Programs, Static Analysis of programs; Principle of least privilege, access control, and operating systems security; Exploitation techniques and fuzzing, Effective Bug Discovery; Web Security - Basic web security model, Securing Browser Frame Communication, Web application security - Cross site scripting, SQL Injection attacks, Cross-Site Request Forgery, Content Security Policies, Web workers, and extensions, Session management and user authentication - Secure Session Management, Overview of cryptography - One time pads, Hash functions, Block ciphers, Key exchange methods, Public Key Encryption, HTTPS: goals and pitfalls; Network security - Security issues in Internet protocols: TCP, DNS, and routing, IPSec, Network defense tools: Firewalls, VPNs, Intrusion Detection, and filters, denial of service attacks, Security of mobile platforms - Mobile platform security models, Mobile threats and malwares - viruses, Spyware and key-loggers.

## CSE 4246: Natural Language Processing

**Introduction and Overview:** Welcome, motivations, what is Natural Language Processing, hands-on demonstrations. Ambiguity and uncertainty in language. **Language modeling and Naive Bayes:** Probabilistic language modeling and its applications. Markov models. N-grams. Estimating the probability of a word, and

smoothing. Generative models of language. **Part of Speech Tagging and Hidden Markov Models:** The concept of parts-of-speech, examples, usage. The Penn Treebank and Brown Corpus. Probabilistic (weighted) finite state automata. Hidden Markov models (HMMs), definition and use. **Context Free Grammars:** Constituency, CFG definition, use and limitations. Chomsky Normal Form. Top-down parsing, bottom-up parsing, and the problems with each. **Probabilistic Context Free Grammars:** Weighted context free grammars. Weighted CYK. Pruning and beam search. A treebank and what it takes to create one. The probabilistic version of CYK. Also: How do humans parse? **Machine Translation:** Probabilistic models for translating French into English. Alignment, translation, language generation. IBM Model #1 and #2. Expectation Maximization. MT evaluation.