	Total	11 + 19 = 30	20.5

Fourth Year : *Semester I*

Course No	Course Title	Hours/Week Theory + Lab	Credits
SWE 420	Internship	0 + 36	18
	Total	**0 + 36 = 36**	**18**

Fourth Year: *Semester II*

Course No	Course Title	Hours/Week Theory + Lab	Credits
SWE 425	Software Project Management	2 + 0	2
SWE 426	Software Project Management Lab	0 + 2	1
SWE 429	Information and Network Security	2 + 0	2
SWE 430	Information and Network Security Lab	0 + 3	1.5
SWE 431	Human Computer Interaction	2 + 0	2
SWE 432	Human Computer Interaction Lab	0 + 3	1.5
SWE 4**	Option	3 + 0	3
SWE 4**	Option Lab	0 + 3	1.5
SWE 450	Thesis/Project	0 + 8	4
SWE 460	Comprehensive Viva Voce	---	1
	Total	**10 + 19 = 29**	**19.5**

SWE 425 SOFTWARE PROJECT MANAGEMENT

2 Hours/Week, 2 Credits

Planning and managing of software development projects. Software process models, ISO 9000, SEI's Capability Maturity Model, continuous process improvement. Planning, scheduling, tracking, cost estimation, risk management, configuration management

Text:

1. Quality Software Project Management by Linda I. Safer, Donald F. Shafer, Robert T. Futrell

SWE 426 SOFTWARE PROJECT MANAGEMENT LAB

2 Hours/Week, 1 Credits

Practical implementation of various Software Project management tasks based on SWE 425.

SWE 429 INFORMATION AND NETWORK SECURITY

2 Hours/Week, 2 Credits

Introduction: Confidentiality, Integrity, Availability, Security policies,Security mechanisms, Assurance.Basic Cryptography: Historical background, Transposition/Substitution, Caesar Cipher, Symmetric and Asymmetric cryptoprimitives, and Hash functions.**Secret Key Cryptography**: Data Encryption Standard (DES), Encrypting large messages (ECB, CBC, OFB, CFB, CTR), Multiple Encryption DES (EDE).**Message Digests**: Strong and weak collision resistance, the Birthday Paradox, MD5, SHA-1.**Public Key Cryptography**: Euclidean algorithm, Euler Theorem, Fermat Theorem, RSA, Selection of public and private keys.**Authentication**: Security Handshake pitfalls.**Trusted Intermediaries:** Public Key infrastructures, Certification authorities and key distribution centers, Kerberos. **Real-time Communication Security**: Introduction to TCP/IP protocol stack, Implementation layers for security protocols and implications, IPsec: AH and ESP, IPsec: IKE, SSL/TLS. Electronic Mail Security. DNS security, Firewalls and Web Security.**Network Security:** Security requirements and attacks, Privacy with conventional encryption, Message Authentication and Hash functions, Public-key encryption and digital signatures, Ipv4 and Ipv6 security.

Text:

1. Network Security Through Data Analysis: Building Situational Awareness-Michael Collins

Reference:

1. Data Communications and Network Security-Houston Carr, Charles Snyder
2. Innovations for Requirement Analysis-Barbara Paech, Craig Martell

SWE 430 INFORMATION AND NETWORK SECURITY LAB

3 Hours/Week, 1.5 Credit

Analysis of basic cryptography algorithms.Using a Crypto tool, demonstrate Asymmetric and Symmetric Crypto Algorithm, Hash and Digital/PKI signatures.Getting familiar with port scanning using a port scanner tool.Examining SSL using Wireshark. Examining an Intrusion Detection System using SNORT or any other tool.Studying Firewall.

SWE 431 HUMAN COMPUTER INTERACTION

3hours/week, 3.0 credits

Foundations of Human–Computer Interaction (Human Capabilities, The Computer. The Interaction, Paradigms)
The Design Process (Interaction Design Basics, HCI in the Software Process, Design Rules, Universal Design)
Implementation Support (Implementation Tools)
Evaluation and User Support (Evaluation, User Support)
Users Models (Cognitive Models, Socio-organizational Issues and Stakeholder Requirements)
Task Models and Dialogs (Analyzing Tasks, Dialog Notations and Design)
Groupware, Ubiquitous Computing, Virtual and Augmented Reality, Hypertext and Multimedia (Groupware and Computer-supported Collaborative Work, Ubiquitous Computing, Virtual Reality and Augmented Reality, Hypertext, Multimedia and the World Wide Web)

Text book:

1. Dix A. et al., Human-Computer Interaction. Harlow, England: Prentice Hall, 2004, ISBN-10: 0130461091

Yvonne Rogers, Helen Sharp, Jenny Preece, Interaction Design: Beyond Human Computer Interaction, 3rd Edition, Wiley, 2011, ISBN-10: 0470665769

SWE 432 HUMAN COMPUTER INTERACTION LAB

3hours/week, 1.5 credits

The laboratory works will be based on theory classes where several programming exercises will need to be performed

SWE 450 THESIS/PROJECT

8 Hours/Week, 4 Credits

Project work based on all major courses.

SWE 460 COMPREHENSIVE VIVA VOCE

Optional Courses:

SWE 423 COMPUTER GRAPHICS AND IMAGE PROCESSING

3 Hours/Week, 3 Credits

Computer Graphics Programming: OpenGL. **Camera Analogy:** Viewing, Windowing, Clipping. **Projective Transformation(Ray-tracing):** Orthogonal Projection, Perspective Projection, **Vector:** Normal Vector, View Vector, **Matrix:** 2D and 3D Rotation and Translation Matrix, **Raster Graphics:** Line Drawing, Anti-aliasing, Polygon Filling Algorithms, **Hidden Surface Removal:** z-buffering, **Lighting and Surface Property:** Diffused Light, Ambient Light, Specular Light, Lighting Models for reflection, **Shading:** Flat Shading, Lambert Shading, Phong Shading, **Texture Mapping:** Texture Fundamentals, **Animation:** Real time animation.**Image Processing**: Image Fundamentals, **Image Enhancement:** Background, Enhancement by Point-Processing, Spatial Filtering, Enhancement in Frequency Domain, Color Image Processing. **Image Restoration:** Degradation Model, Diagonalization of Circulant and Block-Circulant Matrices, Algebraic Approach to Restoration, Inverse Filtering, Geometric Transformation. **Image Segmentation:** Detection of Discontinuities, Edge Linking and Boundary Detection, Thresholding, Region-Oriented Segmentation, The use of Motion in Segmentation. **Image Compression|**.

Text:

1. **Computer Graphics: Principles and Practice**, Folley, Van Damn, Feiner, Hughes,
2. **Computer Graphics:** A Programming Approach: Steven and Harrington.

Reference:

OpenGL(r) 1.2 Programming Guide, Third Edition: The Official Guide to Learning OpenGL, Version 1.2: by Mason Woo, Jackie Neider, Tom David, Dave Shriner, OpenGL Architecture Review Board, Tom Davis, Dave Shreiner.
Graphics Programming in C: Roger T. Stevens.
Texture and Modeling: by David S. Ebert.
Digital Image Processing – Rafael C. Gonzalez and Richard E. Woods, Pearson Education Asia.
Non-Linear Digital Filter: Principles and Applications – I. Pitas and A. N. Venetsanopoulos, Kluwer Academic Publications.

SWE 424 COMPUTER GRAPHICS AND IMAGE PROCESSING LAB

3 Hours/Week, 1.5 Credits

Tool to use for lab: OpenGL, Line Drawing: Bresenhams, Region Filling: Scan Line Algorithm, Transformation: 2D and 3D translation, Rotation, Scaling, Clipping: Line and Polygon, Projection: Perspective and Parallel, Animation: Morphing

SWE 433 ADVANCED DATA STRUCTURE AND ALGORITHM

3 Hours/Week, 3 Credits

Red-Black Tree, Binary Index Tree, Segment Tree, Range minimum query, lowest common ancestor, k-d Tree, Interval tree, R-tree. Advanced Application of Dynamic Programming and Backtracking.
Advanced String Structure and algorithm: tree, suffix tree, suffix array, Aho-Corasic.

Computational Geometry: Line Sweeping algorithms, Binary Space Partition Trees and Painter's algorithm (otheradvanced computational geometry). **Optimization of network flow:** Dinic's algorithm, Hungarian algorithm, Min cost max flow, min cut, graph coloring.Genetic algorithm and its different applications, Basic Game theory, Linear programming, Polynomials and Fast Fourier Transform, Encryption and Decryption.

Textbook

1. Introduction to Algorithms Thomas H. Cormen , Charles E. Leiserson.
2. Advanced Data Structures – Peter Brass.

SWE 434 ADVANCED DATA STRUCTURE AND ALGORITHM LAB

3 Hours Week, 1.5 Credits

Red-Black Tree, K-d Tree, Suffix Tree, Suffix Array, Line Sweeping algorithms, Painter's algorithm, Hungarian algorithm, Dinic's algorithm, Min cost max flow and the selected problem assign by the corresponding instructor.

SWE 435 NEURAL NETWORK AND DEEP LEARNING

3 hours/week, 3 credits

History and Introduction: History, Basic overview of Neural Networks and Deep Learning and current advances in deep learning. **Applied Math and Machine Learning Basics:** Linear algebra and basic Calculus, Gradient descent, Logistic regression, Probability and information theory, Bayes' Rule, Numerical computation, Machine Learning basics. **Neural Networks Basics:** What are neural networks?, The linear classifier, The perceptron, activation functions, backpropagation, dropout, Overfitting and underfitting,Gradient-Based Optimization, Feedforward Networks, Shallow neural networks, Deep Neural Networks, Training Neural Networks. **Convolutional Networks:** The convolution Operation, The Neuroscientific Basis for Convolutional Networks, Overview of Convolutional Neural Networks(CNN), Pooling etc. **Recurrent and Recursive Nets:** Recurrent Neural Networks(RNN), LSTM, **Autoencoders:** Undercomplete Autoencoders, Regularized Autoencoders, Stochastic Encoders and Decoders, Denoising Autoencoders etc. **Research topics:** May include linear factor models, auto encoding, representation learning, Monte Carlo methods, Boltzmann machines, generative models. **Applications of Deep Learning:** Some applications of deep learning i.e. in Vision applications, NLP application, Speech Recognition etc.

Textbooks:

1. Deep Learning. by Ian Goodfellow, Yoshua Bengio, Aaron Courville.
2. Pattern Recognition and Machine Learning by Christopher Bishop.
3. The Matrix Cookbook by Kaare Brandt Petersen, Michael Syskind Pedersen.

SWE 436 NEURAL NETWORK AND DEEP LEARNING LAB

3 hours/week, 1.5 credits

Student should be able solve the mathematical, statistical and computational challenges of building stable representations for high-dimensional data, such as images, text and audio.Student should be able to use some Deep Learning Softwares like Caffe, Torch, Theano, TensorFlow, Keras, PyTorch, Scikit-Learn etc. Student also learn to solve problem like classification / pattern recognition using deep learning. There will be regular homework and programming assignments based on theory.

SWE 437 ADVANCED DATABASE SYSTEM

3 Hours/Week , 3 Credits

Query Processing and Optimization: Query Interpretation, Equivalence of Expressions, Estimation of Query-ProcessingCost, Estimation of Costs of Access Using Indices, Join Strategies, Join Strategies for parallel Processing, Structure of the query Optimizer, Transformation of Relational Expression, Rewrite parse Tree **Transactions and Concurrency Control:** Schedules, Testing for Serializability, Lock-Based Protocols, Timestamp-BasedProtocols, Validation Techniques, Multiple Granularity, Multiversion Schemes, Insert and Delete Operations, Deadlock Handling. **NoSQL:** Scalability, CAP Theorem, BASE System, ACID vs BASE. **Spatial Database:** Object Relational Model, Spatial data, Geometry types, Data Model - (Element, Geometry, Layer), Co-ordinate System, Tolerance, R-Tree etc. **Data Mining:** Type of Data, Type of Interestingness, Data Mining vs Statistical Interference, Data Preprocessing, Types ofAttributes**Data mining Concepts:**Association Rule Mining (Apriori Algorithm), Classification (Decision Tree, Support Vector Machine, Naïve Bayes Classifier), Clustering - (K-means with variations, KNN, Genetic Algorithm) etc. **Data Warehousing:** Basic concepts and algorithms.

Textbook

1. Introduction to Data Mining - Pang-Ning Tan, Michael Steinbach, Vipin Kumar.
2. Advanced Database Systems - Carlo Zaniolo et al (The Morgan Kaufmann Series).
3. Oracle Advanced PL/SQL Programming with CD-ROM- ScottUrman.

SWE 438 ADVANCED DATABASE SYSTEM LAB

3 Hours/Week, 1.5 Credits

Laboratory works based on theory classes including NoSQL and Spatial Database.

Textbook

1. Oracle Spatial User's Guide and Reference, 10g Release 1 - Chuck Murray

SWE 439 BIO-INFORMATICS

3 Hours/Week, 3 Credits

Cell concept: Structural organization of plant and animal cells, nucleus, cell membrane and cell wall. Cell division: Introducing chromosome, Mitosis, Meiosis and production of haploid/diploid cell. Nucleic acids: Structure and properties of different forms of DNA and RNA; DNA replication. Proteins: Structure and classification, Central dogma of molecular biology. Genetic code: A brief account

Genetics: Mendel's laws of inheritance, Organization of genetic material of prokaryotes and eukaryotes, C-Value paradox, repetitive DNA, structure of chromatin - euchromatin and heterochromatin, chromosome organization and banding patterns, structure of gene - intron, exon and their relationships, overlapping gene, regulatory sequence (lac operon), Molecular mechanism of general recombination, gene conversion, Evolution and types of mutation, molecular mechanisms of mutation, site-directed mutagenesis, transposons in mutation. Introduction to Bioinformatics: Definition and History of Bioinformatics, Human Genome Project, Internet and Bioinformatics, Applications of Bioinformatics Sequence alignment. Dynamic programming. Global versus local. Scoring matrices. The Blast family of programs. Significance of alignments, Aligning more than two sequences. Genomes alignment. Structure-based alignment. Hidden Markov Models in Bioinformatics: Definition and applications in Bioinformatics. Examples of the Viterbi, the Forward and the Backward algorithms. Parameter estimation for HMMs. Trees: The Phylogeny problem. Distance methods, parsimony, bootstrap. Stationary Markov processes. Rate matrices. Maximum likelihood. Felsenstein's post-order traversal. Finding regulatory elements. Finding regulatory elements in aligned and unaligned sequences. Gibbs sampling. Introduction to microarray data analysis: Steady state and time series microarray data. From microarray data to biological networks. Identifying regulatory elements using microarray data. Pi calculus: Description of biological networks, stochastic Pi calculus, Gillespie algorithm.

Text:

1. Introduction to Bioinformatics by Arthur Lesk

Reference:

1. Beginning Perl for Bioinformatics by James Tisdall

SWE 440 BIO-INFORMATICS LAB

3 Hours/Week, 1.5 Credits

Laboratory works based on SWE 437

SWE 441 NATURAL LANGUAGE PROCESSING

3 Hours/Week, 3 Credits

Introduction; Word Modeling: Automata and Linguistics, Statistical Approaches and Part of Speech Tagging; Linguistics and Grammars; Parsing Algorithms; Parsing Algorithms and the Lexicon; Semantic; Feature Parsing; Tree Banks and Probabilistic Parsing; Machine Translation; Evolutionary Models of Language Learning and Origins.

Text:

1. Jurafsky, D. and Martin, J. H. Speech and Language Processing. Prentice Hall. 2000. ISBN: 0130950696
2. Manning, C. D. and H. Schütze: Foundations of Statistical Natural Language Processing. The MIT Press. 1999. ISBN 0-262-13360-1.
2. Barton, E., Berwick, R., and Ristad, E. Computational Complexity and Natural Language: The MIT Press. 1987. ISBN 0-26-02266-4.
3. Allen, J. Natural Language Understanding. The Benajmins/Cummings Publishing Company Inc. 1994. ISBN 0-8053-0334-0.

4. Brady, J., and Berwick, R. Computational Models of Discourse. The MIT Press, 1983. ISBN-0-262-02183-8.

SWE 442 NATURAL LANGUAGE PROCESSING LAB

3 Hours/Week, 1.5 Credits

Processing of words, Phrase structure parsing, Semantic Interpretation with Phrase Structure Grammars

SWE 443 CLOUD COMPUTING

3 Hours/Week, 3 Credits.

Introduction to different types of computing: Edge computing, Grid computing, Distributed Computing, Clustercomputing, Utility computing, Cloud computing. **Cloud computing architecture:** Architectural framework; Cloud deployment models; Virtualization in cloud computing; Parallelization in cloud computing; Green cloud. Cloud Bus; **Cloudservice models**: Software as a Service (SaaS); Infrastructure as a Service (IaaS); Platform as a Service (PaaS). **Foundational elements of cloud computing**: Virtualization; Cloud computing operating System; Browser as a platform;Advanced web technologies (Web 2.0, AJAX and Mashup); Introduction to autonomic systems; Service Level Agreements(SLA); Security/Privacy; Cloud economics; Risks assessment; Current challenges facing cloud computing.

Case studies.

Textbook

1. Distributed and Cloud Computing: From Parallel Processing to the Internet of Things- Kai Hwang, Jack Dongarra, Geoffrey C. Fox.
2. Cloud Computing, Principles , System and Applications- Antonopoulos, Nikos, Gillam, Lee.

SWE 444 CLOUD COMPUTING LAB

3 Hours/Week, 1.5 Credits.

Creating Windows servers on the cloud; Creating Linux servers on the cloud; Deploying applications on the cloud; Major cloud solutions and troubleshootings.

SWE 451 INTRODUCTION TO DevOps

What is devops, History of devops, . Foundational Terminology and Concepts, **Software Development Methodologies** (Waterfall, Agile, Scrum), **Operations Methodologies** (ITIL, COBIT, Systems Methodologies, Lean, Development, Release) and **Deployment Concepts**(Version Control, Test-Driven Development, Application Deployment, Continuous Integration, Continuous Delivery, Continuous Deployment, Minimum Viable Product, Infrastructure Concepts, Configuration Management, Cloud Computing, Infrastructure Automation, Artifact Management, Containers, Cultural Concepts, Retrospective, Postmortem, Blamelessness, Organizational Learning), **Tools**: (Ecosystem Overview, Software Development, Local Development Environment, Version Control , Artifact Management, Automation, Server Installation, Infrastructure Automation, System Provisioning, Test and Build Automation, Monitoring Metrics, Logging, Alerting, Events, Evolution of the Ecosystem)

Reference books:

1. Effective DevOps: Building a culture of collaboration, affinity, and tooling at scale (Jennifer Davis and Ryn Daniels)
2. The DevOps Handbook: How to create world-class agility, reliability, & security in technology organizations (Gene Kim, Jez Humble, Patrick Debois, & John Willis)

SWE 452 INTRODUCTION TO DevOps LAB

The practical implementation of the various topics that are described in the theory portion. Ubuntu basics, version controlling basics, getting familiar with version controlling tools like github, gitlab, bitbucket, learning application deployment technologies, implement continuous deployment, continuous integration in applications, learning to use containerization tools like docker and kubernetes. Getting used to monitoring logs and events in server.

SWE 453 INTRODUCTION TO CRYPTOGRAPHY

3 hours/week, 3.0 credits

Basic terminology and concepts; Goals of cryptography, terminology and notation, players, Classical crypto systems, Basic number theory, Basic notation, Congruence, CRT (Chinese Remainder Theorem), Modular exponentiation, Euler's theorem, Fermat's little theorem, EEA (Extended Euclidean Algorithm), Finite fields, Ciphers, Block ciphers (substitution, transposition, product), Stream ciphers, Modes of operation (ECB, CBC, CFB, OFB), Crytposystems; Block cipher: DES (Data Encryption Standard), AES (Advanced Encryption Standard), Public-key: RSA (Rivest-Shamir-Adelman), ElGamal, Hash functions, One-way hash function: SHA and MD5 (Message Digest 5), Birthday attacks, Multicollisions, Digital Signature, RSA Signature, ElGamal Signature, Digital Signature Algorithm (DSA), Digital Signature Standard (DSS), Advanced concepts, Secret sharing, Zero-knowledge technique

Books:

- Introduction to Cryptography – Wade Trappe and Lawrence Washington
- Handbook of Applied Cryptography - Alfred J. Menezes, Paul C. van Oorschot and Scott A. Vanstone

SWE 454 INTRODUCTION TO CRYPTOGRAPHY LAB

3 hours/week, 1.5 credits

The laboratory works will be based on theory classes where several programming exercises will need to be performed.

SWE 455 APPLIED DATA SCIENCE

What is Data Science? The importance of Data, Data Driven World, Program flow, data structures, DataFrame, Series, data ingestion and transformation, Data structures, algorithms, classes, Data aggregation, Data formats, Multi-dimensional arrays and vectorization, Data munging, Data manipulation and cleaning techniques, Applied plotting, charting and data visualization, Introduction to Machine Learning, Principal Component Analysis and Dimensionality Reduction, feature engineering, Regression and classification, Statistical methods and nonparametric analysis, probability distributions, Metrics and over fitting, cross validation, Ensemble methods, Model selection, Understanding supervised and unsupervised algorithms, understanding classification and clustering techniques, Understanding Reinforcement Learning tricks, Support Vector Machine and Natural Language Processing, text mining, text manipulation.

Reference books:

1. Data Science From Scratch: First principles with Python (Joel Grus)
2. Machine Learning: An Algorithmic Perspective (Stephen Marsland)

SWE 456 APPLIED DATA SCIENCE LAB

Basics of the python programming environment, including fundamental python programming techniques such as lambdas, reading and manipulating csv files, and the numpy library. Introduction data manipulation and cleaning techniques using the popular python pandas data science library. information visualization basics, with a focus on reporting and charting using the matplotlib library. introduce users to best practices when creating basic charts, explore matplotlib library functionalities. Getting used to python Scikit Learn library for Machine Learning algorithms. Implementing the machine learning techniques in Scikit Learn library including (Classification algorithms: Naïve bayes, SVM, MLP, Random Forest. Clustering algorithms: K means. Regression: Linear, Logistic. Feature engineering: PCA). Getting used to NLTK library for text data processing.

Optional : *Option*

Course No	Course Title	Hours/Week Theory + Lab	Credits	Prerequisite
SWE 423	Computer Graphics and Image Processing	3 + 0	3	
SWE 424	Computer Graphics and Image Processing Lab	0 + 3	1.5	
SWE 433	Advanced Data Structure and Algorithm	3 + 0	3	
SWE 434	Advanced Data Structure and Algorithm Lab	0 + 3	1.5	
SWE 435	Neural Network and Deep Learning	3 + 0	3	
SWE 436	Neural Network and Deep Learning Lab	0 + 3	1.5	
SWE 437	Advanced Database System	3 + 0	3	
SWE 438	Advanced Database System Lab	0 + 3	1.5	
SWE 439	Bio-informatics	3 + 0	3	
SWE 440	Bio-informatics Lab	0 + 3	1.5	
SWE 441	Natural Language Processing	3 + 0	3	
SWE 442	Natural Language Processing Lab	0 + 3	1.5	
SWE 443	Cloud Computing	3 + 0	3	
SWE 444	Cloud Computing Lab	0 + 3	1.5	
SWE 451	Introduction to DevOps	3 + 0	3	
SWE 452	Introduction to DevOps Lab	0 + 3	1.5	
SWE 453	Introduction to Cryptography	3 + 0	3	
SWE 454	Introduction to Cryptography Lab	0 + 3	1.5	
SWE 455	Applied Data Science	3 + 0	3	
SWE 456	Applied Data Science Lab	0 + 3	1.5	
SWE 457	Contemporary Course on Software Engineering	3 + 0	3	
SWE 458	Contemporary Course on Software Engineering Lab	0 + 3	1.5	

Total Credits offered: 160

Credits required for graduation: 160

Major courses offered: 120.5 credits

Non-major courses offered: 39.5 credits