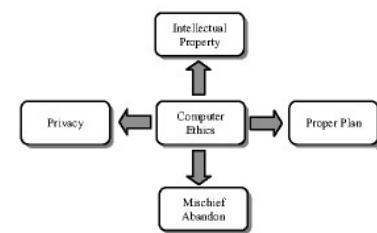


# 22CS310 COMPUTING ETHICS

Hours Per Week :

L	T	P	C
1	2	0	2



Source: Figure 2  
 from Computer and  
 Information Security  
 Ethics -- Models |  
 Semantic Scholar

**PREREQUISITE KNOWLEDGE:** General awareness on ethical guidelines.

## COURSE DESCRIPTION AND OBJECTIVES:

The course will provide students with an understanding on Engineering Ethics and the nature of moral issues and dilemmas faced by Computer Science and engineers in their professional lives. It will give them an awareness on professional rights and responsibilities of an engineer and acquaint them on the Code of Conduct and Ethics prescribed by professional bodies like IEEE, ACM etc. for its members.

## MODULE - 1

### UNIT-1

**4L+8T+0P=12 Hours**

#### INTRODUCTION

##### Introduction to Sociotechnical Computer Ethics

Introduction: Why Computer Ethics? The Sociotechnical Systems Perspective, Sociotechnical Computer Ethics, Micro- and Macro-Level Analysis.

##### Ethics and Information Technology

**Introduction:** Doing Ethics, Ethical Theories and Concepts.

### UNIT-2

**4L+8T+0P=12 Hours**

##### Ethics in IT Configured Societies

Technology as the Instrumentation of Human Action, Three Features of IT-Configured Activities, IT Configured Domains of Life, Democracy and the Internet.

##### Information Flow, Privacy and Surveillance

Introduction: Information Flow with and without Information Technology, why care about Privacy, Is Privacy over? Strategies for shaping Personal Information Flow.

#### PRACTICES:

- Surprises about Social Networking
- RFID and caring for the Elderly People
- Turing does not need to know
- Turnitin Dot Com
- Email Privacy and Advertising
- Workplace Spying
- Data Mining and e-Business

**MODULE - 2****UNIT-1****4L+8T+0P=12 Hours****Digital Intellectual Property**

The complexities of Digital Property, Protecting Property rights in Software, The Philosophical Basis of Property, Free and Open Source Software, PS Versus FOSS.

**Introduction:** Law and Order in the Internet, Sociotechnical Order, Online Crime, Hackers and Hacker Ethic, Sociotechnical Security.

**UNIT-2****4L+8T+0P=12 Hours****Professional Ethics**

Introduction: Why Professional Ethics, The Paradigm of Professions, Characteristics of Professions, Sorting out Computing and its Status as a Profession, Codes of Ethics, Professional Relationships, A Legal perspective on professionalism in Computing.

**PRACTICES:**

Laboratory session of this course is designed in such a way that the student should complete three projects of the given type by performing the below experiments.

- Obtaining pirated Software Abroad
- Free Software that follows Proprietary Software
- Using Public Domain Software in Proprietary Software
- Wiki Warfare
- Yahoo and Nazi Memorabilia
- Bot Roast
- Software Safety
- Conflicts of Interest
- Security in a Custom Database

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Engage in an informed critical reflection on the nature of professionalism and ethical challenges inherent in engineering profession	2	1	8
2	Understand the role of professional bodies, and the code of ethics and industrial standards prescribed for engineers	2	2	8
3	Apply awareness of professional rights and responsibilities of an engineer to conduct themselves ethically within an organization	3	1	8
4	Apply understanding of safety norms to highlight ethical issues in risky situation	3	2	8

**TEXT BOOKS:**

1. Deborah G. Johnson, Keith W. Miller and Prentice Hall, "Computer Ethics", 4th Edition, Pearson, 2009.

**REFERENCE BOOKS:**

1. Charles E. Harris, Michael S. Pritchard and Michael J. Rabins, "Engineering Ethics: Concepts and Cases", 4th edition, Wadsworth Thompson Learning, 2009.
2. M. Govindarajan, S.Natarajan and V. S. Senthil Kumar, "Engineering Ethics", Prentice Hall of India, Reprint 2013.



# 22CSXX CRYPTOGRAPHY AND NETWORK SECURITY

Hours Per Week :

L	T	P	C
2	0	2	3

**PREREQUISITE KNOWLEDGE:** Computer networks.

## COURSE DESCRIPTION AND OBJECTIVES:

This course focuses on the modern concepts of network security using various cryptographic algorithms and underlying network security applications. It enables to understand various symmetric and asymmetric cryptographic techniques. It focuses on providing security services in applications such as e-mail functioning, web security and secure electronic transactions protocol and system security.

## MODULE-1

### UNIT-1

**8L+0T+8P=16 Hours**

#### INTRODUCTION

**Introduction To Computer and Network Security Concepts:** Computer Security Concepts, Need of data security, privacy, and authentication, Security attacks, Security services, Security mechanisms, Fundamental Security Design Principles, Attack Surfaces and Attack trees, A model for network security.

**Classical Encryption Techniques:** Symmetric cipher model, Substitution techniques, Transposition techniques

### UNIT-2

**8L+0T+8P=16 Hours**

#### PRIVACY PRESERVATION USING CRYPTOGRAPHY

**Symmetric Ciphers:** Block cipher principles, Data encryption standard, Strength of DES, Blockcipher design principles, AES cipher, Multiple encryption and triple DES, Block cipher modes of operation, RC4.

**Asymmetric Ciphers and Cryptographic Hash Functions:** Principles of public key cryptosystems, RSA algorithm, Diffie-Hellman Key Exchange, Message Authentication requirements, Authentication functions, Message authentication Codes, Hash functions, Security of hash functions and MACs, Digital signature standard.

#### PRACTICES:

- Implement Substitution and Transposition Ciphers
  - Ceaser cipher
  - Playfair cipher
  - Hill cipher
  - Rail fence cipher
- Implement Symmetric Cipher
  - S-DES
  - RC4
- Implement Asymmetric Cipher
  - RSA
  - Diffie-Hellman
  - Hash Function

Source: [https://www.brainkart.com/subject/CRYPTOGRAPHY-AND-NETWORK-SECURITY-PRINCIPLES-AND-PRACTICE\\_136/](https://www.brainkart.com/subject/CRYPTOGRAPHY-AND-NETWORK-SECURITY-PRINCIPLES-AND-PRACTICE_136/)

**SKILLS:**

- ✓ Design various security services for appropriate applications.
- ✓ Identifying the appropriate firewall, password management and anti-virus models for specific applications.
- ✓ Test and resolve threats and malfunctions in network.
- ✓ Apply different security mechanisms for web applications.
- ✓ Build authentication system for security protocols.

**MODULE-2****UNIT-1****8L+0T+8P=16 Hours****SECURITY APPLICATIONS****Network Security Applications:** Kerberos, X.509 authentication service, Public key infrastructure,**E-Mail Security:** Pretty good privacy, S/MIME.**IP Security Overview:** IP security architecture, Authentication header, Encapsulating security payload, Combining security associations, key management.**UNIT-2****8L+0T+8P=16 Hours****WEB AND SYSTEM SECURITY****Web Security:** Secure socket layer and transport layer security, HTTPS, Secure Shell (SSH)**System Security:** Intruders, Intrusion detection, Malicious software, Firewalls**PRACTICES:**

- Configure IP Address in a system in LAN (TCP/IP Configuration)
- Configure DNS to establish interconnection between systems
- Configuring Windows Firewall
- Adding users, setting permissions
- Configure Mail server
- Demonstrate the usage of Wireshark to identify abnormal activity in network communication.
- Demonstrate usage of NMAP (Zenmap) Tool in Network Scanning.

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

<b>CO No.</b>	<b>Course Outcomes</b>	<b>Blooms Level</b>	<b>Module No.</b>	<b>Mapping with POs</b>
1	Apply cryptographic techniques in various security service solutions effectively in everyday professional and social contexts.	Apply	1,2	1,2
2	Analyze the usage of secure protocols to safeguard sensitive data using internet.	Analyze	1,2	1,2
3	Usage of tools to Identify abnormal activity in network communication to take appropriate action.	Apply	2	5
4	Apply various security protocols to safe guard the data internet using SSL/TLS.	Apply	2	1,2

**TEXT BOOK:**

1. William Stallings, "Cryptography and Network security", 7th Edition, Pearson Education, 2017.

**REFERENCE BOOKS:**

1. William Stallings "Network Security Essentials Applications and Standards", 2nd Edition, Pearson Education, 2009.
2. Eric Malwald, "Fundamentals of Network Security", 4th Edition, Pearson Education, 2010.
3. Buchmann, "Introduction to Cryptography", 2nd Edition, Pearson Education, 2009.
4. Charlie Kaufman, "Rafael Perlman and Mike Speciner, Network Security - Private Communication in a Public World", 1st Edition, Pearson Education, 2009.

# 22CS402 BIG DATA AND ANALYTICS

Hours Per Week :

L	T	P	C
3	0	2	4

**PREREQUISITE KNOWLEDGE:** Basics of databases, Data mining.

## COURSE DESCRIPTION AND OBJECTIVES:

This course serves as an introductory course to gain knowledge on analyzing Big Data. Expecting to face Big Data storage, processing, analysis, visualization, and application issues on both workplaces and research environments. Get insight on what tools, algorithms, and platforms to use on which types of real world use cases.

## MODULE-1

### UNIT-1

**12L+0T+8P=20 Hours**

#### INTRODUCTION TO BIG DATA

Data, Characteristics of data and Types of digital data, Sources of data, Working with unstructured data, Evolution and Definition of big data, Characteristics and Need of big data, Challenges of big data.

**Big data analytics:** Overview of business intelligence, Data science and Analytics, Meaning and Characteristics of big data analytics, Need of big data analytics, Classification of analytics, Challenges to big data analytics, Importance of big data analytics, Basic terminologies in big data environment, analysis of big data in local and global applications.

### UNIT-2

**12L+0T+8P=20 Hours**

#### INTRODUCTION TO HADOOP

Introducing Hadoop, need of Hadoop, limitations of RDBMS, RDBMS versus Hadoop, Distributed Computing Challenges, History of Hadoop, Hadoop Overview, Use Case of Hadoop, Hadoop Distributors, HDFS (Hadoop Distributed File System), Processing Data with Hadoop, Managing Resources and Applications with Hadoop YARN (Yet another Resource Negotiator), Interacting with Hadoop Ecosystem.

#### PRACTICES:

- Hadoop installation in standalone machine.
- Pig installation.
- Setup of Hadoop cluster.
- HDFS basic command-line file operations.
- HDFS monitoring User Interface.

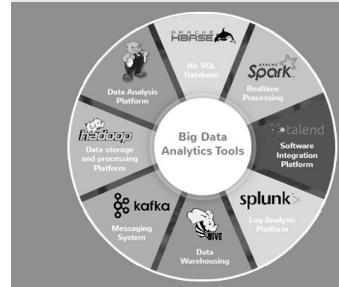
## MODULE-2

### UNIT-1

**12L+0T+8P=20 Hours**

#### MAPREDUCE PROGRAMMING

Introduction, Mapper, Reducer, Combiner, Partitioner, Searching, Sorting, Compression, Real time applications using Map Reduce, combiner, Partitioner, matrix multiplication using Map Reduce and page rank algorithm using Map Reduce.



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**SKILLS:**

- ✓ Build and maintain reliable, scalable, distributed systems with Apache Hadoop.
- ✓ Develop Map Reduce based applications for Big data.
- ✓ Design and build applications using Hive and pig based Big data applications.
- ✓ Learn tips and tricks for big data use cases and solutions.

**UNIT-2****12L+0T+8P=20 Hours****PIG**

**Introduction to Pig, The Anatomy of Pig, Pig on Hadoop, Pig Philosophy, Use Case for Pig:** ETL Processing, Pig Latin Overview, Data Types in Pig, Running Pig, Execution Modes of Pig, HDFS Commands, Relational Operators, Piggy Bank, Word Count Example using Pig, Pig at Yahoo!.

**Hive:** Introduction to Hive, Hive Architecture, Hive Data Types, Hive File Format, Hive Query Language (HQL), Partitions and bucketing, working with XML files, User-Defined Function (UDF) in Hive, Pig versus Hive.

**Spark Programming:** Introduction, features of Spark, components of Spark, Programming with Resilient Distributed datasets (RDDS).

**PRACTICES:**

- Word Count Map Reduce program using Hadoop.
- Implementation of word count with combiner Map Reduce program.
- Practice on Map Reduce Monitoring User Interface.
- Implementation of Sort operation using Map Reduce.
- Map Reduce program to count the occurrence of similar words in a file by using partitioner.
- Design Map Reduce solution to find the years whose average sales is greater than 30.
  - input file format has year, sales of all months and average sales.
  - Year Jan Feb Mar April May Jun July Aug Sep Oct Nov Dec Average.
- Map Reduce program to find Dept wise salary.
  - Empno Emp Name Dept Salary.
- Designing of Pig Latin scripts to sort, group, join, project and filter the data.
- Implementation of Word count using Pig.
- Creation of Database and tables using Hive query language.
- Implementation of partitions and buckets using Hive query language.
- Implementation of word count using spark RDD.

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Use of Big data frameworks like Hadoop and NOSQL to efficiently store and process Big data to generate analytics.	Apply	1	1, 2, 5,9,10,12
2	Design a solution for data intensive problems using Map Reduce paradigm.	Apply	1	1, 2, 5, 9,10,12
3	Design and analyze the solutions of Big data using Pig and Hive to solve data intensive and to generate analytics.	Apply	2	1, 2, 3, 5, 9,10,12
4	Analyze Big data using Spark programming.	Analyze	2	1, 2, 3, 5, 9,10,12

**TEXT BOOKS:**

1. Seema Acharya, Subhashini Chellappan, "Big Data Analytics", Wiley, 2015.
2. Holden Karau, Andy Konwinski, Patrick Wendell, Matei Zaharia, "Learning Spark: Lightning-Fast Data Analysis", O'Reilly Media, Inc., 2015.

**REFERENCE BOOKS:**

1. Boris Lublinsky, Kevin T. Smith, Alexey Yakubovich, "Professional Hadoop Solutions", Wiley, 2015.
2. Chris Eaton, Dirk deRoos et al. , "Understanding Big data ", McGraw Hill, 2012.
3. Tom White, "HADOOP: The definitive Guide", O Reilly 2012.

# 22CS403 CLOUD COMPUTING

Hours Per Week :

L	T	P	C
3	0	2	4



**PREREQUISITE KNOWLEDGE:** Operating systems and Computer networks.

## COURSE DESCRIPTION AND OBJECTIVES:

This course deals with the computing model, which enables information, software, and shared resources to be provisioned over the network as services in an on-demand manner. The main objective of this course is to enable the student to understand the evolution of cloud computing through its supporting technologies virtualization and the architectures of top cloud platforms.

## MODULE-1

**UNIT-1** **12L+0T+8P=20 Hours**

### INTRODUCTION

**Introduction:** Definition, Historical developments, Computing platforms, and technologies.

**Principles Of Parallel and Distributed Computing:** Parallel versus distributed computing, Elements of parallel computing, Elements of distributed computing, Technologies for distributed computing.

**UNIT-2** **12L+0T+8P=20 Hours**

### VIRTUALIZATION

Introduction, Characteristics, Virtualization techniques, Virtualization and cloud computing, Pros. and cons. of virtualization, Technology examples.

**Cloud Computing Architecture:** Introduction, Cloud reference model, Types of clouds, Economics of clouds, Open challenges.

**Cloud Platforms in Industry:** Amazon web Services, Google app engine, Microsoft Azure.

### PRACTICES:

- Performing hardware virtualization using Vmware workstation.
- Launch Amazon Linux EC2 Instance and connect the windows client to it.
- Launch Windows EC2 instance in AWS and connect windows client to it.
- Configure Web Server on Amazon Linux instance with Elastic IP.
- Manage Elastic Block Storage(EBS).
- Configure Amazon Simple Storage Service (Amazon s3).
- Configure Amazon S3 Glacier.
- Configure Amazon EFS.

## MODULE-2

**UNIT-1** **12L+0T+8P=20 Hours**

### ANEKA

Cloud application platform, Framework overview, Anatomy of the Aneka container, Building Aneka clouds, Cloud programming, and management.

**High Throughput Computing- Task Programming:** Task computing, Task-based application models, Aneka task-based programming.

Source: <https://tse4.mm.bing.net/th/id/OIP.vN86IZCAdr3RDSXc0cuHcAHaE8?pid=ImgDet&rs=1>

**SKILLS:**

- ✓ Gain knowledge of different types of Cloud Service Providers.
- ✓ Explore basic design issues of Cloud Applications.
- ✓ Compare & evaluate the optimum costs in the data transmissions.

**UNIT-2****12L+0T+8P=20 Hours**

**CLOUD APPLICATIONS & GLOBAL AND LOCAL IMPACT OF CLOUD COMPUTING ON SOCIETY:** Scientific applications in healthcare, biology, geo science; Business applications in CRM and ERP, productivity, social networking, media applications, multiplayer online gaming.

**ETHICAL CONSIDERATION FOR CLOUD COMPUTING:** Cloud Security Risks, Security: The Top Concern for Cloud Users, Privacy and Privacy Impact Assessment, Trust, Operating System Security, Virtual Machine Security.

**PRACTICES:**

- Configure Amazon Virtual Private Cloud (VPC).
  - a) Create your own VPC.
  - b) Create a public subnet.
  - c) Create a private subnet.
  - d) Create an Internet gateway and attach to your VPC.
  - e) Create Public Routing Table, associate subnet and add routing rules.
  - f) Create Private Routing Table, associate subnet and add routing Rules.
  - g) To launch Windows instance in Public subnet.
- Configure Amazon Elastic Load Balancer.
- Configure Relational Database Service (RDS).

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Deploying a VM Image to understand the evolution of cloud computing in contrast to the traditional approach.	Apply	1	1,5
2	Evaluate the concepts of various virtualization technologies.	Evaluate	1	2,5
3	Analyze the trade-offs, security, and privacy issues among application deployment in the various cloud and the local infrastructure.	Analyze	2	2,5
4	Deploy applications over commercial cloud computing infrastructures.	Apply	2	1,5

**TEXT BOOKS:**

1. Raj Kumar Buyya, C Vecchiola and S TSelvi , "Mastering Cloud Computing", 1st Edition, Tata McGraw Hill Education (India), 2013.
2. RajKumarBuyya, Broberg J and GoscinskiA, "Cloud Computing - Principles and Paradigms", 1st Edition, Wiley, 2011.

**REFERENCE BOOKS:**

1. David S. Linthicum, Cloud Computing and SOA Convergence in Your Enterprise A Step-by-Step Guide, Pearson 2010.
2. Dr. Kumar Saurabh, Cloud Computing, 2nd Edition, Wiley India 2012.
3. Rittinghouse J W, and Ransome J F, "Cloud Computing - Implementation, Management, and Security", 1st Edition, CRC Press, 2009.
4. Michael Wittig and Andreas Wittig, "Amazon Web Services in Action", 2nd Edition, Manning Publications, 2015.
5. Tim Mather, Subra KumaraSwamy, Shahed Latif, "Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance", O'ReillyMediaInc, 2009.

# 22CS804 DEEP LEARNING

Hours Per Week :

L	T	P	C
3	0	2	4

**PREREQUISITE KNOWLEDGE:** Machine learning, Python programming.

## COURSE DESCRIPTION AND OBJECTIVES:

This course offers sufficient details required to understand the basic building blocks of various deep learning based models. Especially, focuses on different types of neural network models like feed forward neural networks, convolutional neural networks, recurrent neural networks, and deep auto encoders. During this course the students build, train, and evaluate deep neural network models for various applications in image, text, and speech domains. In addition, throughout this course students will be able to understand hyper parameter tuning and other best-practices to be followed while training deep neural network models.

## MODULE-1

### UNIT-1

**12L+0T+8P=20 Hours**

#### EVOLUTION OF DEEP NEURAL NETWORKS

**Deep Learning Intuition:** History of Deep Learning, what is Deep Learning? Applications of Deep Learning.

**Neural Network Basics:** McCulloch–Pitts neuron, Perceptron learning rule, Perceptron convergence theorem, Sigmoidal neuron, Multi-layer feed forward neural network, back propagation algorithm, Gradient descent method, Stochastic gradient descent method. Shallow Neural Networks and Deep Neural Networks.

**REGULARIZATION and OPTIMIZATION for training Deep Models:** Optimization methods - Adagrad, Adadelta, RMSProp, Adam; Regularization Methods-Dropout, Drop connect, Batch normalization; Activation functions - Linear, sigmoid, sigmoid, ReLU and variations of ReLU; Loss Function, Improving the training process – Dataset Augmentation, Noise Robustness, Weight Initialization methods, Early stopping, Parameter sharing and tying, bagging and other ensemble methods;

### UNIT-2

**12L+0T+8P=20 Hours**

#### CONVOLUTIONAL NEURAL NETWORKS

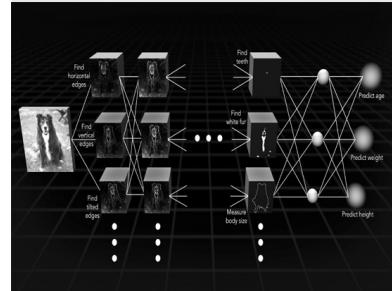
**Convolutional Neural Networks (CNNs):** Foundations of Convolutional Neural Network, Popular Deep CNN Models: LeNet, AlexNet, VGGNet, ResNet, Google Net and other architectures.

#### INSTRUCTIONS FOR PRACTICES:

- Practice Assignments can be implemented using the Keras / Tensorflow APIs of Python
- Relevant data sets can be downloaded from standard repositories such as Kaggle/UCI or can be developed by the students.

#### PRACTICES:

- Implement Logistic regression With Neural Network Mindset.
  - logistic regression classifier for classification.
  - Plot the loss over each epoch.
  - Plot the accuracy over each epoch.
  - Report final Accuracy.



Source: [https://www.symmetrymagazine.org/sites/default/files/images/standard/neural\\_network\\_visual\\_final.jpg](https://www.symmetrymagazine.org/sites/default/files/images/standard/neural_network_visual_final.jpg)

**SKILLS:**

- ✓ *Developing Vision and text based applications*
- ✓ *Hyperparameter Tuning of a deep Neural network model.*
- ✓ *Tensor Flow/ Keras tool usage for neural network implementation.*

- Implement Shallow Neural Network model:
  - Implement a binary classification neural network with a single and multiple hidden layers.
  - Implement a Multi-class classification neural network with a single and multiple hidden layers.
  - Vary the number of neurons at suitable layers.
- Hyper parameter Tuning of a Neural Network model implemented for hand-written digit classification:
  - Vary the type of activation functions.
  - Choose suitable Loss functions.
  - Vary the number of neurons at suitable layers.
  - Vary Weight Initialization methods.
  - Save the Best Model and load the saved model.
- Building a Deep Neural Network:
  - Implement a multi-class classification neural network with number of layers of your choice.
  - Include Batch Normalization layers.
  - Vary Optimization methods.
  - Add drop out layers.
- Convolutional Neural Network Models.
  - Design a Convolutional neural network with the layers of your choice
  - Compare the performance by changing the
  - Kernel size
  - Number of feature maps at each convolutional layer
  - Stride.
  - Padding.
  - Number of fully connected layers.
- Visualization of CNN Models.
  - Design a Convolutional Neural Network Model for image classification.
  - Plot Model Architecture.
  - Visualize feature maps after training of CNN.
  - Visualize class activation maps.

**MODULE-2****UNIT-1****14L+0T+10P=24 Hours****DEEP UNSUPERVISED LEARNING**

**Transfer learning Approaches:** Deep Pre-trained architectures- AlexNet, VGG16, VGG19, ResNET. Use deep Convolutional architectures for feature extraction and fine-tuning tasks.

**Deep Unsupervised Learning:** Autoencoders- Under complete Autoencoders, regularized auto encoders, Representation power, layer size and depth, stochastic encoders and decoders, Denoising auto-encoders, Sparse auto encoder, Contractive auto-encoders

**UNIT-2****10L+0T+6P=16 Hours****RECURRENT NEURAL NETWORKS**

Architecture of an RNN, unfolding of an RNN, Backpropagation through time, Long short term memory (LSTM), Gated recurrent units, Applications- Text Classification, Sentiment Analysis.

**PRACTICES:**

- Using Deep pre-trained CNN model for feature extraction:
  - Extract features from the FC1 of VGG network.
  - Train any traditional ML model like SVM for classification.
  - Repeat the above by considering FC2 of VGG for feature extraction.



- Fine-tuning Deep pre-trained CNN for Classification:
  - Fine-tune VGG network for the task under consideration.
  - Check the performance by making all the layers trainable.
  - freezing the initial layers.
  - freezing the entire network except the final layer.
- Design MLFFNN with 3-level stacked autoencoder based pre-training for Black and white image data, Display features extracted by different levels of stacked autoencoder at the end of pre-training.
- Sentiment Analysis
  - Pre-process the text.
  - Convert the text into word embeddings.
  - Implement the classification network using LSTMs/ GRUs.
  - Pre-process the text.
  - Convert the text into word embeddings.
  - Implement the classification network using LSTMs/ GRUs.

#### COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Implementation of Deep learning models to solve various real-time problems.	Apply	1,2	1, 3
2	Analyse performance of a deep network and tune its capacity and hyper parameters.	Analyze	1	2
3	Leveraging tools to Build deep networks and apply them for real world tasks.	Apply	1,2	1,5
4	Developing core components for deep learning algorithms.	Design	1,2	3

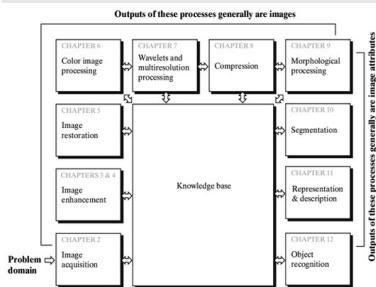
#### TEXT BOOKS:

1. Ian Good Fellow and Yoshua Bengio and Aaron, "Deep Learning", 1st Edition, MIT Press, 2016.
2. Charu C Aggarwal "Neural Networks and Deep learning", Springer International Publishing, 2018.

#### REFERENCE BOOKS:

1. Francois Chollet, "Deep learning with python", 1st edition, Manning Publications, 2017.
2. S. Haykin, "Neural Networks and Learning Machines", 3rd edition, Prentice Hall of India, 2011.
3. Josh Patterson and Adam Gibson, "Deep Learning: A Practitioner's Approach", 1st Edition, O'Reilly, 2017.
4. Satish Kumar, "Neural Networks, A Classroom Approach", Tata McGraw-Hill, 2007.

# 22CS805 DIGITAL IMAGE PROCESSING



Source: [https://www.researchgate.net/figure/Fundamental-steps-in-digital-image-processing\\_fig10\\_333856607](https://www.researchgate.net/figure/Fundamental-steps-in-digital-image-processing_fig10_333856607)

Hours Per Week :

L	T	P	C
2	2	2	4

**PREREQUISITE KNOWLEDGE:** Probability and Statistics.

## COURSE DESCRIPTION AND OBJECTIVES:

This course focuses on imparting knowledge about the aspects of Image Processing and its applications. The main objective of the course is to learn digital image fundamentals, image transforms, image enhancement, restoration and compression, morphological image processing, representation and description.

## MODULE-1

### UNIT-1

**6L+6T+6P=18 Hours**

#### FUNDAMENTALS OF IMAGE PROCESSING

Fundamental steps in digital image processing, Components of image processing system, A simple image formation model, Image sampling and quantization, Basic relationships between pixels, Introduction to Fourier Transform and DFT – properties of 2D Fourier Transform, FFT.

### UNIT-2

**10L+10T+10P=30 Hours**

#### IMAGE ENHANCEMENT IN THE SPATIAL AND FREQUENCY DOMAINS

Basic gray - level transformations, Histogram processing, Basics of spatial filtering, Smoothing spatial filters, Sharpening spatial filters, The basics of filtering in the frequency domain, Image smoothing in frequency domain filters, Image sharpening in frequency domain filters.

Image Segmentation: Fundamentals, Point, Line and edge detection, Thresholding, Region-based segmentation, Segmentation using morphological watersheds, The use of motion in segmentation.

#### PRACTICES:

- Develop a module to enhance the image by using image arithmetic and logical operations.
- Develop a module for an image enhancement using kernel operations.
- Develop a module for gray level slicing with and without background.
- Develop a module for image enhancement using histogram equalization.
- Develop a module to filter an image using low pass & high pass filter in spatial domain. Compare the performance of both filters.
- Develop a module for smooth an image using low pass & high pass filters in frequency domain. Compare the performance of both filters.
- Develop a module for detecting lines & edges in an image.
- Develop a module for segmenting region of interest.

## MODULE-2

### UNIT-1

**8L+8T+8P=24 Hours**

#### IMAGE RESTORATION

A model of image degradation/restoration, Noise models, inverse filtering, wiener filtering, Constrained Least Squares Filtering, Geometric Mean Filter.

**Image Compression:** Fundamentals, Huffman coding, Golomb coding, LZW coding, Run-length coding

**SKILLS:**

- ✓ Apply knowledge of science and engineering principles to image related problems.
- ✓ Undertake image problem identification and formulate solutions.
- ✓ Implement algorithms for enhancement, restoration, compression etc.

**UNIT-2****8L+8T+8P=24 Hours****MORPHOLOGICAL IMAGE PROCESSING**

Erosion, Dilation, Opening, Closing, The hit-or-miss transformation; Basic morphological algorithms - boundary extraction, hole filling, extraction of connected components, thinning, thickening, skeletons, pruning.

**Feature Extraction:** Background, Boundary preprocessing, Boundary Feature Descriptors, Region Feature Descriptors, Principle Components as feature descriptors, Whole-image features.

**PRACTICES:**

- Develop a module to perform add & removal of salt and pepper noise. Compute PSNR & MSE and check the impact before and after removal of noise.
- Develop a module to remove noise using average filter and median filter. Compute PSNR & MSE before and after removal of noise.
- Develop a module for image compression and decompression.
- Develop a module for morphological image operations - erosion, dilation, opening & closing.
- Develop a module for morphological image operations - hit-or-miss transformation.
- Develop a module for morphological image operations - thinning, thickening
- Develop a module for extracting boundary features of an image.
- Develop a module for extracting features of an image using GLCM.

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Understand the fundamental concepts of a digital image processing system.	Understand	1	1,2
2	Learn different techniques employed for the enhancement of images.	Analyse	1	1,2,3,5,12
3	Employ image segmentation and representation techniques to extract region of interest.	Apply	1	1,2,3,5,12
4	Learn different causes for image degradation and overview of image restoration techniques.	Evaluate	2	1,2,3,5,12
5	Apply various compression techniques to reduce image size and morphological operations to extract features.	Apply	2	1,2,3,5,12
6	Learn different feature extraction techniques for image analysis and recognition.	Apply	2	1,2,3,5,12

**TEXT BOOKS:**

1. Rafeal C Gonzalez and Richard E.Woods, "Digital Image Processing", 4th edition, Pearson Education/ PHI, 2018.
2. Rafeal C Gonzalez and Richard E.Woods, "Digital Image Processing using MATLAB", 4th edition, Pearson Education/ PHI, 2020.

**REFERENCE BOOKS:**

1. Milan Sonka, Vaclav Hlavac and Roger Boyle, "Image Processing, Analysis and Machine Vision", 4th Edition, Cengage, 2015.
2. Alasdair McAndrew, "Introduction to Digital Image Processing with Matlab", Thomson Course Technology, 2004 Course Technology Press, Boston, MA, United States, 2004.
3. William K. Pratt, "Digital Image Processing", 4th Edition, Wiley-Interscience, A John Wiley & Sons, Inc., Publication, 2007.

## Mobile Ad Hoc Network



Source: <https://www.educba.com/mobile-ad-hoc-network/>

# 22CS807 MOBILE AD-HOC NETWORKS

Hours Per Week :

L	T	P	C
3	0	2	4

**PREREQUISITE KNOWLEDGE:** Computer networks.

### COURSE DESCRIPTION AND OBJECTIVES:

This course focuses on major aspects of ad hoc networking, from design through performance issues to application requirements. It starts with the design issues and challenges associated with implementations of ad hoc network applications. This includes mobility, disconnections, and battery power consumption. The course provides a detailed treatment of proactive, reactive, and hybrid routing protocols in mobile wireless networks. It also covers the IEEE 802.11 Wireless LAN and discusses their characteristics and operations. Through activities, the course gives students hands-on experience in designing a mobile ad hoc network using the NS2 simulator.

### MODULE-1

#### UNIT-1

8L+0T+6P=14 Hours

#### INTRODUCTION

Introduction to ad-hoc networks-definition, characteristics, features, applications; Characteristics of the wireless channel; Ad-hoc mobility models-indoor and outdoor models.

#### UNIT-2

16L+0T+10P=26 Hours

#### MEDIUM ACCESS PROTOCOLS

MAC protocols- design issues, goals and classification; Contention-based protocols – with reservation, without reservation; Scheduling algorithms; Protocols using directional antennas; IEEE standards - 802.11a, 802.11b, 802.11g, 802.15; HIPERLAN.

**Network Protocols:** Routing protocols - design issues, goals, and classification; Proactive Vs reactive routing; Unicast routing algorithms; Multicast routing algorithms; Hybrid routing algorithm; Energy-aware routing algorithm; Hierarchical routing; QoS aware routing.

#### PRACTICES:

- Installation of NS-2 and basics of TCL scripting.
- TCL script for
  - a) computing the arithmetic operations on two operands.
  - b) finding the given number is prime or not using functions.
  - c) finding the factorial value of a given number.
- Set the node property and routing protocol in the same MANET scenario.
- Analyse the performance of the MANET.
- Develop MAC Protocol using any suitable Network Simulator for MANETs to send the packet without any contention through wireless link using the following MAC protocols (CSMA/CA (802.11)). Analyze its performance with increasing node density and mobility.
- Simulate MANET environment using suitable Network Simulator and test with various mobility model such as Random walk, Random waypoint and Group mobility. Analyze throughput, PDR and delay with respect to different mobility models.

**SKILLS:**

- ✓ Evaluate various routing protocols.
- ✓ Analyse the performance of MAC protocols for Ad-hoc networks.
- ✓ Analyse the performance of Network protocols for Ad-hoc networks.

**MODULE-2****UNIT-1****12L+0T+8P=20 Hours****END-END DELIVERY AND SECURITY**

Transport layer - issues in designing, transport layer classification, ad-hoc transport protocols; Security issues in ad-hoc networks - issues and challenges, network security attacks; Secure routing protocols.

**UNIT-2****12L+0T+8P=20 Hours****CROSS LAYER DESIGN**

Cross layer design - need for cross layer design, cross layer optimization; Parameter optimization techniques; Cross layer cautionary perspective; Integration of adhoc with mobile IP networks.

**PRACTICES:**

- Create CBR traffic over UDP and TCP.
- Write an awk script that takes data from trace file and give the report for performance metrics such as packet delivery ratio, and throughput.
- Implement Transport Control Protocol in Sensor Network.
- Design and Implementation of Security algorithm for Wireless networks (b)Implementation of security protocol for mobile network.

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

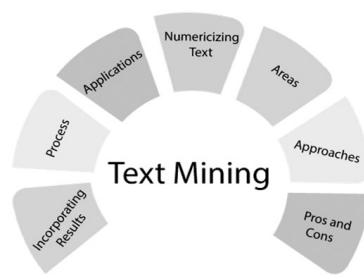
CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Summarize the protocols used at the MAC layer and scheduling mechanisms to express the mathematical properties.	Evaluate	1	1, 12
2	Apply proactive and reactive routing algorithms to find optimal paths.	Apply	1	1, 2, 5, 12
3	Analyze types of routing protocols used for unicast and multicast routing.	Analyse	1	1, 2, 5, 12
4	Compare the performance of various routing protocols in ad-hoc networks.	Analyse	2	1, 2
5	Develop the network security solution and routing mechanism.	Apply	2	1, 2, 12

**TEXT BOOKS:**

1. C. Siva Ram Murthy and B. S. Manoj, "Ad hoc Wireless Networks Architecture and Protocols", 2nd Edition, Pearson Edition, 2007.
2. Charles E. Perkins, "Ad hoc Networking", 1st Edition, Addison – Wesley, 2000.

**REFERENCE BOOKS:**

1. Stefano Basagni, Marco Conti, Silvia Giordano and Ivan Stojmenovic, "Mobile ad-hoc networking", Wiley-IEEE press, 1st Edition, 2004.
2. Mohammad Ilyas, "The Handbook of Adhoc Wireless Networks", 1st Edition, CRC press, 2002.
3. T. Camp, J. Boleng and V. Davies "A Survey of Mobility Models for Ad Hoc Network Research" Wireless Commun. and Mobile Comp., Special Issue on Mobile Ad Hoc Networking Research, Trends and Applications, vol. 2, no. 5, 2002, pp. 483–502.
4. A survey of integrating IP mobility protocols and Mobile Ad hoc networks, Fekri M. Abduljalil and Shrikant K. Bodhe, IEEE communication Survey and tutorials, v no.1, 2007.
5. V. T. Raisinhani and S. Iyer "Cross Layer Design Optimization in Wireless Protocol Stacks" Comp. Communication, Vol 27 no. 8, 2004.



# 22CS809 TEXT MINING

Hours Per Week :

L	T	P	C
3	0	2	4

**PREREQUISITE KNOWLEDGE:** Data analysis skills, Database, Machine learning or Deep learning algorithms..

## COURSE DESCRIPTION AND OBJECTIVES:

This course introduces the fundamental concepts and techniques used in Text Processing. Students will gain an in-depth understanding of the computational properties of natural languages and the commonly used algorithms for processing linguistic information. The course examines models and algorithms used in both the traditional symbolic and the more recent statistical approaches.

## MODULE-1

### UNIT-1

**10L+0P+6P=16 Hours**

#### INTRODUCTION

NLP tasks in syntax, semantics, and pragmatics. Applications such as information extraction, question answering, and machine translation. The role of machine learning. Brief history of the field.

Regular Expressions, Text Normalization, Edit Distance: Regular Expressions, words, Corpora, Text Normalization and Minimum edit distance.

### UNIT-2

**14L+0P+10P=24 Hours**

#### N-GRAMS, VECTOR SEMANTICS AND EMBEDDING

**N-Gram Language Models:** N-Grams, Evaluating Language Models, Generalization and Zeros, Smoothing, Kneser-Ney Smoothing, Huge Language Models and Stupid Back off.

**Vector Semantics and Embeddings:** Lexical semantics, Vector semantics, words and vectors, cosine for measuring similarity, TF-IDF: weighing terms in the vector, Point wise Mutual Information, Applications of TF/ IDP and PPMI vector models, word 2 vec, visualizing embeddings, semantic properties of embeddings, bias and embeddings, evaluating vector models.

#### PRACTICES:

- Perform basic text pre-processing using the following approaches:
  - Stop word Elimination.
  - Removal of Special Characters.
  - Stemming.
  - Lemmatization.
  - N-gram Tokenization.
- Design and develop a text classification model with various machine learning algorithms over the following feature extraction methods and compare their performance.
  - TF-IDF.
  - Word2 Vec.
- Perform Exploratory Data Analysis using following:
  - Word Cloud.
  - Frequent Word Detection.
  - Keyword Extraction based on ranking.

**SKILLS:**

- ✓ *Exploratory Data analysis.*
- ✓ *Opinion Mining/ Sentiment Analysis using various deep Learning models.*
- ✓ *Text Summarization and Categorization etc.*

**MODULE-2****UNIT-1****12L+0P+8P=20 Hours****SEQUENCE LABELING FOR PARTS OF SPEECH AND NAMED ENTITIES**

Part-of-Speech Tagging, Named Entities and Named Entity Tagging, HMM Part-of-Speech Tagging, Conditional Random Fields, Evaluation of Named Entity Recognition.

**UNIT-2****12L+0P+8P=20 Hours****SEQUENCE AND TRANSLATION PROCESSING**

**Deep Learning Architectures for Sequence Processing:** Language Models Revisited, Self-Attention Networks: Transformers.

**Machine Translation and Encoder-Decoder Models:** The Encoder-Decoder Model, Encoder-Decoder with RNNs, Attention, Beam Search, Encoder-Decoder with Transformers.

**PRACTICES:**

- Perform Named Entity Recognition to extract required entities from a given unstructured text using NLTK.
- Perform POS Tagging with HMM and also optimize the performance of HMM with Viterbi.
- Design and develop a text classification model using Latent Dirichlet allocation and compare its performance with TF-IDF and Word2Vec.
- Perform text classification using following methods and compare their performance in terms of various evaluation metrics such as Accuracy, Precision, Recall and F-Score.
  - CNN
  - LSTM
  - GRU
  - Encoder-Decoder
  - Transformers
- Design and develop text classification model using Attention.

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Understand and apply the usage of regular expressions to process the raw text.	Apply	1	1
2	Apply various approaches to sentiment analysis using Machine Learning methods.	Apply	1,2	1
3	Analyze the vector semantics and embedding in the representation of the text.	Analyze	1	2
4	Design and development various statistical approaches to machine translation.	Evaluate	1,2	3,4,5

**TEXT BOOK:**

1. Daniel Jurafsky and James H Martin, "Speech and Language processing: An introduction to Natural Language Processing, Computational Linguistics and speech Recognition", 3rd Edition, 2020.

**REFERENCE BOOKS:**

1. Steven Bird, Ewan Klein, Edward Loper, "Natural Language Processing with Python", 1st Edition, O'Reilly Publishers, 2009.
2. Nitin Indurkha, Fred J. Damerau, "Handbook of Natural Language Processing", 2nd Edition, CRC Publishers, 2010.

## 22CS907 – OPERATING SYSTEMS AND SHELL PROGRAMMING

Hours per week:

L	T	P	C
2	2	2	4

**PRE REQUISITE KNOWLEDGE:** Knowledge of computers fundamentals, Computer organization & Digital logic and its design.

### COURSE DESCRIPTION AND OBJECTIVES:

This course aims at concepts and principles of Operating Systems, its overall responsibility in acting as an interface between the system's hardware components and the user. Further, it also helps students to understand the different scheduling policies, process synchronization mechanisms, deadlock handling mechanisms and memory management techniques.

### MODULE-1

#### UNIT-1

**10L+10T+10P=30 Hours**

#### LINUX FILE SYSTEM & PROCESS SCHEDULING:

**Introduction to LINUX File System:** The LINUX file System, File System Hierarchy, File system Commands, File Attributes, File Permissions.

**Filters:** cmp, comm, diff, head, tail, find, cut, paste, sort, uniq.

**Regular Expressions:** grep, egrep, fgrep, Sed- line addressing, context addressing, text editing, substitution.

**Introduction to Operating System:** What Operating System do; Operating System Structure; Process concept-overview, Process Scheduling, Operations on Process; Inter Process Communication; Threads;

**Process (CPU) Scheduling**-Scheduling Criteria, Scheduling Algorithms; Multiple-Processor scheduling;

#### UNIT-2

**6L+6T+6P=18Hours**

#### PROCESS SYNCHRONIZATION & DEADLOCKS:

**Process Synchronization:** The critical-section problem; Peterson's solution; Synchronization hardware; Semaphores; Classical problems of synchronization; Monitors.

**Deadlocks:** Deadlock characterization; Methods of handling deadlocks; Deadlock prevention; Deadlock avoidance; Deadlock detection and recovery.

### PRACTICES:

- Use the cat command to create a file containing the following data. Call it mytable.txt  
use tabs to separate the fields.

1425	ravi	15.65
4320	ramu	26.27
6830	sita	36.15
1450	raju	21.86

- a. Use the cat command to display the file, mytable.txt.
- b. Use the vi command to correct any errors in the file, mytable.txt.
- c. Use the sort command to sort the file mytable.txt according to the first field.
- d. Call the sorted file mytable.txt (same name)
- e. Print the file mytable.txt.
- f. Use the cut & paste commands to swap fields 2 and 3 in mytable. Call it mytable.txt (same name)

- g. Print the new file, mytable.txt.
- Write a shell script that takes a command -line argument and reports on whether it is directory, a file, or something else.
- Write a shell script that accepts one or more file name as arguments and converts all of them to uppercase, provided they exist in the current directory.
- Write a shell script that displays a list of all the files in the current directory to which the user has read, write and execute permissions.
- Write a shell script that computes the total and average marks of a student according to the following;
  - If average marks  $\geq$  69 then result is - Distinction.
  - If average marks  $\geq$  59 and  $\leq$  70 then result is – First Class.
  - If average marks  $\geq$  49 and  $\leq$  60 then result is – Second Class
  - If average marks  $\leq$  50 then result is —Pass.
  - Note that any subject marks  $\leq$  40 then result is - Fail.
- Accept student name and six subject marks through the keyboard.
- Write an interactive file-handling shell program. Let it offer the user the choice of copying, removing, renaming, or linking files. Once the user has made a choice, have the program ask the user for the necessary information, such as the file name, new name and so on.
- Write a shell script, which receives two file names as arguments. It should check whether the two file contents are same or not. If they are same then second file should be deleted.
- Write a shell script that accepts a file name starting and ending line numbers as arguments and displays all the lines between the given line numbers.
- Write a shell script that deletes all lines containing a specified word in one or more files supplied as arguments to it.
- Implementation of new process creation and its communications.
- Implement of thread creation and deletion.
- Implementation of FCFS scheduling.
- Implementation of SJF and RR Scheduling.
- Implementation of producer consumer problem.
- Implementation of Banker's algorithm for Dead lock avoidance.

## MODULE-2

**UNIT-1** **8L+8T+8P=24 Hours**

### **MEMORY MANAGEMENT:**

**Memory Management:** Basic concept of memory management, Swapping, Contiguous Memory Allocation, Paging, Structure of the Page Table, Segmentation.

**Virtual Memory Management:** Demand Paging, Page Replacement: Optimal, First in First Out (FIFO), Second Chance (SC), Not recently used (NRU), Least Recently used (LRU), Allocation of Frames.

**SECONDARY STORAGE STRUCTURE:**

**Secondary Storage Structure:** Overview of mass-storage structure, disk structure, disk scheduling;

**File System Interface** - File concept, Access Methods, Directory & Disk Structure, File-System Mounting, File Sharing, Protection; File-system structure.

**File System Implementation-** Directory implementation, Allocation Methods, Free Space Management.

**PRACTICES:**

- Assume that you have a page-reference string for a process with  $m$  frames (initially all empty). The page-reference string has length  $p$ , and  $n$  distinct page numbers occur in it.
  - What is a lower bound on the number of page faults?
  - What is an upper bound on the number of page faults?
- Consider the following page-replacement algorithms. Rank these algorithms on a five-point scale from “bad” to “perfect” according to their page-fault rate. Separate those algorithms that suffer from Belady’s anomaly from those that do not.
  - LRU replacement.
  - FIFO replacement.
  - Optimal replacement.
  - Second-chance replacement.
- Consider the page reference string: 1, 2, 3, 4, 2, 1, 5, 6, 2, 1, 2, 3, 7, 6, 3, 2, 1, 2, 3, 6. How many page faults would occur for the following replacement algorithms, assuming one, two, three, four, five, six, and seven frames? Remember that all frames are initially empty, so your first unique pages will cost one fault each.
  - LRU replacement.
  - FIFO replacement.
  - Optimal replacement.
- How many page fault occur for your algorithm for the following reference string with four page frames? 1, 2, 3, 4, 5, 3, 4, 1, 6, 7, 8, 7, 8, 9, 7, 8, 9, 5, 4, 5, 4, 2.
- What is the minimum number of page faults for an optimal page replacement strategy for the reference string above with four page frames?
- Consider a demand-paged computer system where the degree of multiprogramming is currently fixed at four. The system was recently measured to determine utilization of the CPU and the paging disk. Three alternative results are shown below. For each case, what is happening?
  - Can the degree of multiprogramming be increased to increase the CPU utilization? Is the paging helping?
  - CPU utilization 13 percent; disk utilization 97 percent.
  - CPU utilization 87 percent; disk utilization 3 percent.
  - CPU utilization 13 percent; disk utilization 3 percent.
- Implementation of Disk scheduling algorithm–FCFS.
- Implementation of Disk scheduling algorithm–SSTF and SCAN.

**SKILLS:**

- Manage open-source operating systems like Ubuntu, Fedora etc.
- Understand the concepts of Processes scheduling and File Systems.
- Identification of different disk scheduling methodologies.

**COURSE OUTCOMES:**

Upon completion of the course, the student will be able to achieve the following outcomes:

<b>CO No.</b>	<b>Course Outcomes</b>	<b>Blooms Level</b>	<b>Module No.</b>	<b>Mapping with POs</b>
1.	Apply the concepts of process scheduling algorithms and process synchronization techniques to derive the efficiency of resource utilization.	Apply	1	1, 2, 3, 5, 12
2.	Apply the concepts of file system interface and implementation.	Apply	1,2	2,5
3.	Classify the basic concepts of operating system and explore Linux ecosystem.	Analyze	1	1
4.	Analyze the requirements for attempting Operating systems principles.	Analyze	1,2	1,2,12
5.	Design the various memory management schemes For a given scenario.	Create	2	3,5

**TEXTBOOKS:**

1. Sumitabha Das, Unix concepts and applications, TMH Publications, 4<sup>th</sup> Edition, July 2017.
2. B.A. Forouzan & R.F. Giberg, - Unix and shell Programming, Thomson, 1<sup>st</sup> Edition, New Delhi, 2003.
3. Abraham Silberschatz, Peter Baer Galvin and Greg Gagne, “Operating System Concepts”, 9<sup>th</sup> Edition, John Wiley & SonsInc, 2013.

**REFERENCE BOOKS:**

1. Richard. Stevens and Stephen A. Rago, “Advanced Programming in the Unix Environment”, 3<sup>rd</sup> Edition, Addison-Wesley, 2013.
2. William Stallings, “Operating Systems-Internals and Design principles” PHI, 7<sup>th</sup> Edition, 2012.
3. Gary J. Nutt. Addison-Wesley, “Operating Systems: A Modern Perspective”, 2<sup>nd</sup> Edition, Aug 2001.