AC – 07/07/2023
Item No. **- 6.32 (N)**

As Per NEP 2020

University of Mumbai

Title of the program

A- P.G. Diploma in IT - Security
B- M.Sc. (IT - Security) (Two Year) } **2023-24**

C- M.Sc. (IT - Security) (One Year) - **2027-28**

Syllabus for

Semester – Sem I & II

Ref: GR dated 16th May, 2023 for Credit Structure of PG

Preamble

1) **Introduction**

Security is a critical concern in today's digital age, where organizations and individuals face a wide range of cyber threats, data breaches, and privacy issues. Cybersecurity is in **high demand**. There are many reasons for this. First, cyberattacks are becoming more common. Second, organizations are constantly being compromised. Also, the attackers are getting more advanced. Third, the costs of cyber attacks are rising. As well as the risks of not having a cybersecurity plan are also rising. This program will provide you with a comprehensive understanding of security principles, technologies, and practices to address these challenges.

2) **Aims and Objectives**

This Program aims to produce professionals who are well-versed in security principles, possess technical expertise in securing digital systems and networks, and can effectively manage security risks and compliance in various organizational settings.

Objectives:

Comprehensive Understanding of Security Concepts with a deep understanding of security principles, theories, and concepts.

Technical Skills Development with the aim to equip students with the necessary technical skills to identify, assess, and mitigate security risks.

Given the increasing prevalence of cyber threats and attacks, the program aims to develop students' expertise in cybersecurity. Students will learn about various types of cyber threats, such as malware, phishing, social engineering, and hacking, and study methods to prevent, detect, and respond to these threats.

Educate students with Risk Management and Compliance in the security field. Students will learn how to identify and assess security risks, develop risk mitigation strategies, and ensure compliance with relevant regulations and standards.

Security Architecture and Design: Students will develop skills in designing secure systems and architectures. They will understand the principles of secure system design, secure network architecture, secure software development practices, and secure cloud infrastructure. Students will be able to analyze system vulnerabilities, implement security controls, and design resilient and secure solutions.

Foster Ethical and Legal Considerations with an understanding of ethical and legal issues in security. Students will also gain knowledge of relevant laws, regulations, and privacy concerns, enabling them to navigate legal and ethical challenges in security operations.

3) **Learning Outcomes**

Knowledge of Cybersecurity Concepts: Students will gain a comprehensive understanding of cybersecurity principles, theories, and concepts. They will become familiar with topics such as threat landscape, types of cyber threats and attacks, security frameworks, risk management, and security controls.

Technical Skills Development: Students will acquire a strong set of technical skills related to cybersecurity. They will learn to use security tools, technologies, and practices to identify, prevent, detect, and respond to cyber threats. This includes areas such as network security, encryption, access control, incident response, vulnerability assessment, and secure coding practices.

Cyber Threat Analysis and Intelligence: Students will develop the ability to analyze and assess cyber threats. They will learn techniques to identify vulnerabilities, analyze attack patterns, and investigate security incidents. They will also gain knowledge of cyber threat intelligence and its role in proactive threat mitigation.

Security Architecture and Design: Students will learn to design secure systems, networks, and applications. They will understand the principles of secure architecture, secure network design, and secure software development. They will be able to apply security best practices to minimize vulnerabilities and protect sensitive information.

Risk Management and Compliance: Students will develop skills in identifying, assessing, and managing cybersecurity risks. They will learn about risk assessment methodologies, risk mitigation strategies, and the importance of compliance with relevant laws, regulations, and industry standards. They will be able to develop and implement security policies and procedures to ensure compliance.

Incident Response and Forensics: Students will learn the fundamentals of incident response and digital forensics. They will understand how to effectively respond to security incidents, including

4) Any other point (if any)

Industry relevant skills and stepping stone for industry partnership will be enabled. Professional Certifications and Exam Preparation: Look for programs that integrate professional certifications into the curriculum or provide exam preparation resources. These skills will make the students more competitive in the job market and keep you updated with the latest developments in the field.

5) Credit Structure of the Program (Sem I, II, III, IV)

R:_____

Credit Distribution Structure for Two Years/ One Year PG (Sem I, II, III, IV)
M.Sc (IT-Security)

<table>
<tr><th rowspan="2">Year</th><th rowspan="2">Level</th><th rowspan="2">Sem</th><th colspan="4">Major</th><th rowspan="2">RM</th><th rowspan="2">OJT/ FP</th><th rowspan="2">R P</th><th rowspan="2">Cum. Cr.</th><th rowspan="2">Degree</th></tr>
<tr><th colspan="3">Mandatory</th><th>Electives</th></tr>
<tr><td rowspan="11">1</td><td rowspan="11">6.0</td><td rowspan="6">Sem I</td><td colspan="3">2*4+2*2 + 2</td><td>4</td><td>4</td><td>4</td><td>-</td><td>22</td><td rowspan="12">PG Diploma (after 3 Years Degree)</td></tr>
<tr><td>Data Science and Analytics(IT 501)</td><td>TH</td><td>4</td><td rowspan="5">Introduction to Artificial Neural Networks (506a)
(OR)
Cloud Computing (506b)
(OR)
Cryptography and Network Security (506c)</td><td rowspan="5">Research Methodology (510)</td></tr>
<tr><td>Data Science and Analytics Practical(502)</td><td>PR</td><td>2</td></tr>
<tr><td>Advanced Computer Networks(IT 503)</td><td>TH</td><td>4</td></tr>
<tr><td>Advanced Computer Networks Practical(IT 504)</td><td>PR</td><td>2</td></tr>
<tr><td>Software Testing(IT 505)</td><td>TH</td><td>2</td></tr>
<tr><td rowspan="6">Sem II</td><td colspan="3">2*4+2*2 + 2</td><td>4</td><td>-</td><td>517</td><td>-</td><td>22</td></tr>
<tr><td>Image Processing (511)</td><td>TH</td><td>4</td><td rowspan="5">Fuzzy Systems & Genetic Algorithms (516a)
(OR)
Virtualization (516b)
(OR)
Security Fundamentals for Cloud (516c)</td></tr>
<tr><td>Image Processing Practical (512)</td><td>PR</td><td>2</td></tr>
<tr><td>Big Data Systems(513)</td><td>TH</td><td>4</td></tr>
<tr><td>Big Data Systems Practical(514)</td><td>PR</td><td>2</td></tr>
<tr><td>Distributed Computing (515)</td><td>TH</td><td>2</td></tr>
<tr><td colspan="3">Cum. Cr. For PG Diploma</td><td colspan="3">28</td><td>8</td><td>4</td><td>4</td><td></td><td>44</td></tr>
<tr><td colspan="12">Exit Option: PG Diploma (44 credits) after Three Year UG Degree</td></tr>
</table>

Year	Level	Sem (2yr)	Major				RM	OJT/FP	RP	Cum. Cr.	Degree
2	6.5	Sem III	2*4+2*2 + 2			4	-	-	(607)4	22	PG Degree after 3-yr UG or PG Degree after 4-yr UG
			Security Breaches and Counter Measures (601)	TH	4	Blockchain(606a) **(OR)** Cloud Economics(606b) **(OR)** BioMedical Image Processing(606c)					
			Security Breaches and Counter Measures Practical (602)	PR	2						
			Offensive Security(603)	TH	4						
			Offensive Security Prcatical(604)	PR	2						
			ISA(605)	TH	2						
		Sem IV	2*4+2*2			4	-	-	(616)6	22	
			Cyber Forensics(611)	TH	4	Augmented Reality & Virtual Reality(615a) **(OR)** Digital Image Forensics(615b) **(OR)** Edge Computing(615c)					
			Cyber Forensics Practical(612)	PR	2						
			Security Operations Centre(613)	TH	4						
			Security Operations Centre Practical(614)	PR	2						
Cum. Cr. For 1 Yr PG Degree			26			8			10	44	
Cum. Cr. For 2 Yr PG Degree			54			16	4	4	10	88	

Sign of HOD
Dr. Mrs. R. Srivaramangai
Dept of Information Technology

Sign of Dean
Prof. Shivram Garje
Science & Technology

Syllabus

M.Sc(IT-Security)
(Sem. I & II)

Semester I

Programme Name: M.Sc(IT-Security)

Course Code:501 [Mandatory] **Total Credits:** 04 (60 Lecture Hrs) **University assessment:** 50 marks	**Course Name:** Data Science and Analytics (Theory) **Total Marks:** 100 marks **College/Department assessment:** 50 marks

Pre requisite:

1. Sound knowledge of Python
2. Sound knowledge of concepts in probability, statistics & mathematics

Course Objectives (COs)

To enable the students to:

CO1 : Understand the importance of data science, its applications, tools & platforms used, and implementation methodologies.

CO2 : Prepare a sound base for further data science and future machine learning, artificial intelligence operations by implementing functions in different python libraries

CO3 : Familiarize, understand and explore the statistics necessary to implement data science

CO4 : Demonstrate data analysis in depth while implementing concepts like data wrangling, exploratory data analysis, model development & evaluation & data visualize techniques

CO5 : Acquire knowledge, understand & implement machine learning models.

MODULE I:	**(2 CREDITS)**
Unit 1: Data Science Introduction & Basics a. **What is Data Science?** – Definition, examples, Data Science Tools – Different tools & platforms used – Anaconda, Rapidminer, Weka, IBM Watson Studio, etc b. **Data Science Methodology** – Processes in Data Science Methodologies, Different methodologies - KDD, SEMMA, CRISP-DM, TDSP c. **Python Libraries for Data Science -** Introduction to essential libraries & important functions: Numpy, Pandas, Matplotlib, Seaborn, Scikit-learn	15 Hrs [OC1, OC2, OC3]
Unit 2: Statistics for Data Science a. **Statistics Fundamentals** - Statistics and its importance in Data Science, Types of Statistics, Types of Data, Levels of Measurement, Measures of Dispersion, Random Variables, Variance, Skewness, Kurtosis b. **Probability Distribution** – Normal, Uniform, Poisson, Bernoulli, continuous, probability density function, Mass Function, Cumulative Distribution Function, Central Limit Theorem, Estimation Theory c. **Advanced Statistics -** Hypothesis Testing and Mechanism, Null and Alternative Hypotheses, Confidence Interval, Margin of Error, Confidence Levels, Comparing and Contrasting T-Test and Z-Test, Bayes' Theorem, Chi-square Distribution, Analysis of Variance or ANOVA, Types of ANOVA, Partition of Variance	15 Hrs [OC4, OC5, OC6]
MODULE II :	**(2 CREDITS)**
Unit 3: Data Analysis with Python & Data Visualization a. **Data Wrangling** - Pre-processing Data, dealing with Missing Values, Data Formatting, Data Normalization, Binning, Turning categorical variables into quantitative variables b. **Exploratory Data Analysis -** Discover patterns in the dataset, Spot anomalies in the dataset, Frame hypothesis from the dataset, gain insights by plotting different kinds of graphs c. **Model Development, Evaluation & Data Visualization -** Model Selection, Model Evaluation using Visualization, Measures for In-Sample Evaluation, Prediction and Decision Making, Model Evaluation and Refinement, Overfitting & Under fitting, Data Visualization with Python & Tableau	15 Hrs [OC7, OC8, OC9, OC10]
Unit 4: Machine Learning for Data Science a. **Introduction to Machine Learning** - Emergence of artificial intelligence, Relationship between AI, ML, and data science, Machine learning approach b. **Supervised Learning: Regression and Classification -** Supervised learning: process flow, Types of regression algorithms, Maximum Likelihood Estimation, Naive Bayes theorem, Model evaluating using accuracy score and confusion matrix **Decision Trees and Random Forest** - Decision trees, Overfitting and pruning, Random forest, Bagging and bootstrapping	15 Hrs [OC11,OC12, OC13, OC14]

c. **Unsupervised Learning** -Process flow, Clustering, K-means clustering, Elbow method, Hierarchical clustering	

References:

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	Big Data and Analytics	Seema Acharya, Subhashini Chellappan	Wiley	2nd edition	2019
2.	Principles of Data Science	Sinan Ozdemir	PACKT	2nd edition	2016
3.	Data Science from Scratch	Joel Grus	O'Reilly	2nd edition	2019
4.	Doing Data Science	Cathy O'Neil and Rachel Schutt	O'Reilly	2nd edition	2014
5.	The Data Science Handbook	Field Cady	Wiley	1st edition	2017

Course Outcomes(OCs)

1. Understand the basic concepts of data science
2. Understand the processes of data science methodology
3. Understand & apply different python libraries used in data science
4. Understand & different statistical methods used to prepare data
5. Understand & apply probability distribution methods on data for analysis
6. Understand & apply hypothesis tests to re-verify the data
7. Understand & apply data wrangling process
8. Understand & apply Exploratory Data Analysis to discover patterns and spot anomalies in the dataset
9. Understand & apply how to select a model and evaluate its performance
10. Understand & apply data visualization methods using python & tableau
11. Understand basics of Machine Learning, relationship between AI, ML, and data science
12. Understand & apply Supervised Learning methods of Regression and Classification
13. Understand & apply Decision Trees and Random Forest Classification
14. Understand & apply Unsupervised Learning method of clustering

Course Code:502 [Mandatory] **Total Credits:** 02 (60 Lecture Hrs) **University assessment:** 25 marks	**Course Name:** Data Science and Analytics Practical **Total Marks:** 50 marks **College/Department assessment:** 25 marks

Prerequisite:

1. Sound knowledge of Python
2. Sound knowledge of concepts in probability, statistics & mathematics

Course Objectives (COs):

To enable the students to:

a. Understand the data science tools & platforms used, and implementation methodologies.
b. Prepare a sound base for further data science and future machine learning, artificial intelligence operations by implementing functions in different python libraries
c. Familiarize, understand and explore the statistics necessary to implement data science
d. Perform data analysis in depth while implementing concepts like data wrangling, exploratory data analysis, model development & evaluation & data visualize techniques
e. Acquire knowledge, understand & implement machine learning models.

Prac No	Practical Description	2 CREDITS (60 hrs)
	Data Science Introduction & Basics	
1a	**Explore existing Packages, API's, Data Sets and Models** Explore GitHub Explore Jupyter Notebook, RStudio Explore Google Colab for Python/R Explore IBM Watson Studio	2 hrs [OC1]
1b	**Data Science Methodology** Problem to Approach, Requirements to Collection, Understanding to Preparation, Modelling to Evaluation, Deployment to Feedback	3 hrs [OC2]
	Python Libraries for Data Science	
2a	**Numpy** Arrays, Dimensions- 2D, 3D, ND, Broadcasting, Indexing, Slicing Numpy Functions: array manipulation, string, arithmetic, statistical Numpy Functions: arrange, linspace, random number generation, seed, reshape, ravel	2 hrs [OC3]
2b	**Pandas** Series functions: empty, ndim, size, dtype, values, head, tail DataFrame functions: datatype, transpose, empty, ndim, shape, size, values, head, tail DateTime	2 hrs [OC3]
2c	**Matplotlib, Seaborn** Plyplot, plotting, markers, line, labels, grid, subplot, scatter, bar, histogram, pie charts, countplot	2 hrs [OC3]
2d	**Scipy, Scikit-learn** Import & use existing datasets, Standardization, Normalization, Imputation, Encoding Categorical Variables	2 hrs [OC3]
	Statistics for Data Science	
3a	Central Tendency of Data, Standard Deviation, Skewness, Kurtosis	2 hrs [OC4]
3b	**Probability Distribution & its types,** Binomial, Poisson, Normal, Uniform Distribution, Probability Density Function and Mass Function Cumulative Distribution Function, Central Limit	3 hrs [OC5]
3c	**Hypothesis Testing, Confidence Intervals** Hypothesis Testing and Mechanism, Null and Alternative Hypotheses, Confidence Interval, Margin of Error, Confidence Levels, Comparing and Contrasting T-Test and Z-Test	3 hrs [OC6]
	Data Analysis with Python & Data Visualization	

4a	**Data Analysis** Import Libraries & datasets, load data, check data type, shape, drop columns, merge datasets, sort, concatenate, statistical summary of data, skewness, co-relation, outlier detection	3 hrs [OC7]
4b	**Data Wrangling** Pre-processing Data - Dealing with Missing Values, Correcting Data Format, Data standardization, Data Normalization, Binning, Turning categorical variables into quantitative variables	3 hrs [OC7]
5	**Exploratory Data Analysis, Descriptive Statistics,** Analyzing Individual Feature Patterns Using Visualization Continuous Numerical Variables - Positive Linear Relationship, Weak Linear Relationship Categorical Variables - box plots, Univariate analysis, Multivariate analysis Descriptive Statistical Analysis - describe, Value Counts,	3 hrs [OC8]
6	**Analysis of Variance, Correlation** Analysis of Variance or ANOVA, Types, Partition of Variance, F-Distribution, Co-relation & Causation	3 hrs [OC8]
	Model Development & Evaluation	
7a	Model Selection, Model Evaluation using Visualization, Measures for In-Sample Evaluation	3 hrs [OC9]
7b	Prediction and Decision Making, Model Evaluation and Refinement	3 hrs [OC9]
7c	Overfitting & Underfitting	3 hrs [OC9]
	Data Visualization	
8a	Data Visualization with Python,	3 hrs [OC10]
8b	Data Visualization using Tableau	3 hrs [OC10]
	Machine Learning for Data Science	
9a	Regression – Linear, Logistic	3 hrs [OC11]
9b	Classification, Decision Trees, Random Forest	3 hrs [OC12]
10a	Clustering, Types, Optimal number of clusters	3 hrs [OC13]

Upon completing this course, the student will be able to:

- OC 1. Familiarize different platforms & frameworks for executing data science
- OC 2. Effectively apply the data science methodology for solving problems
- OC 3. Use different python libraries in data science for various operations
- OC 4. Effectively use different statistical methods used to prepare data
- OC 5. Apply probability distribution methods on data for analysis
- OC 6. Apply hypothesis tests to re-verify the data
- OC 7. Understand & apply data wrangling process
- OC 8. Understand & apply Exploratory Data Analysis to discover patterns and spot anomalies in the Dataset
- OC 9. Understand & apply how to select a model and evaluate its performance
- OC 10. Understand & apply data visualization methods using python & tableau
- OC 11. Understand & apply Supervised Learning methods of Regression and Classification
- OC 12. Understand & apply Decision Trees and Random Forest Classification
- OC 13. Understand & apply Unsupervised Learning methods

Course Code: 503 [Mandatory] **Total Credits:** 04 (60 Lecture Hrs) **University assessment:** 50 marks	**Course Name:** Advanced Computer Networks **Total Marks:** 100 marks **College/Department assessment:** 50 marks

Pre-requisite: Basic Knowledge on computer networks

Course Objectives (COs):

To enable the students to:

CO1: Understand concepts of dynamic Routing protocols such as Routing Information Protocol (RIP), Open Shortest Path First (OSPF) and Border Gateway Protocol (BGP)

CO2: Acquire knowledge of MPLS, VPN Technology and benefits of NAT.

CO3: Understand the various standards for wireless networks.

CO4: Understand the functionality of each wireless component in cellular networks.

CO5: Understand the functionality of LTE and 5G

CO6: Understand the conceptual knowledge of Software Defined Networks (SDN) and Network Functions Virtualization (NFV)

MODULE I:	**(2 CREDITS)**
Unit I **a) Basics of Data Communications & Dynamic Routing** - Data Communications, Data Networks, and the Internet, Protocol Architecture, TCP/IP, and Internet-Based Applications, Internet Multicasting, Routing Architecture: Cores, Peers, And Algorithms, Routing Among Autonomous Systems (BGP), Routing within an Autonomous System (RIP, RIPng, OSPF, IS-IS) **b) Multiprotocol label Switching**- Background. MPLS Operation, Labels, FECs, LSPs, and Labels, Label Distribution, Traffic Engineering, Virtual Private Networks, Packet Classification, Network Virtualization: VPNs, NATs, And Overlays, Internetwork Quality of Service	15 Hrs OC1
Unit II **a) Wireless Networks:** IEEE 802.16 and WiMAX, Wireless Local Area Network (WLAN), Universal Mobile Telecommunications Systems (UMTS)	15 Hrs OC2
MODULE II:	**(2 CREDITS)**
Unit III **a) Cellular Networks**: Global System for Mobile Communications (GSM), General Packet Radio Service (GPRS) and EDGE, General Packet Radio Service (GPRS) and EDGE. **b) LTE and 5G:** Long Term Evolution (LTE) and LTE-Advanced Pro VoLTE, VoWifi, and Mission Critical Communication, G New Radio (NR) and the 5G Core	15 Hrs OC3
Unit IV a) **SDN:** Introduction to Software Defined Networking Software-Defined Networks: Perspectives and Applications, Its Applications, Software-Defined Networks and Its Applications, b) **NFV:** Network Functions Virtualization and SDN, SDN-Enabled Network Virtualization and Its Applications	15 Hrs OC4

References:

a) Internetworking With TCP/IP Vol I: Principles, Protocols, and Architecture by Douglas Comer Sixth Edition, Pearson Education, Inc

b) Beyond 3G – Bringing Networks, Terminals and the Web Together LTE, WiMAX, IMS, 4G Devices and the Mobile Web 2.0 by Martin Sauter, John Wiley and Sons, Ltd,

c) From GSM to LTE-Advanced Pro and 5G: An Introduction to Mobile Networks and Mobile Broadband by Martin Sauter, 4th Edition, John Wiley & Sons Ltd

d) Software Defined Networks Architecture and Applications by Anand Nayyar Bhawna Singla and Preeti Nagrath, 1st Edition, John Wiley & Sons, Inc

Course Outcomes (OCs):

Upon completing this course, the student will be able to:

OC 1. Understand the concept of Routing algorithms MPLS, NAT, VPN technologies Quality of service parameter in networking.

OC 2. Understand the wireless network standards, functionality of WLAN

OC 3. Understand the core components of cellular networks. GSM network, GPRS, Understand the LTE and 5G functional standards and system architecture.

OC 4. Compare the advantages and disadvantages of adopting SDN to more conventional networking approaches., Examine the roles and elements of the SDN architecture.

Course Code: 504 [Mandatory] **Total Credits:** 02 (60 Lecture Hrs) **University assessment:** 25 marks	**Course Name**: Advanced Computer Networks Practical **Total Marks:** 50 **College/Department assessment:** 25 marks

Pre-requisite:

1. Basic understanding of computer hardware and operating systems.
2. Basic understanding of Networking such as classless IP addressing, use of netmask, subnetting.

Course Objectives (COs):

CO 1. Enable students to understand the Network simulators & their uses, and configuration of the router's protocols

CO 2. To understand the SDN and virtualization for designing next generation networks

	MODULE 1	**2 CREDITS (60 hrs)**
Prac No	**Practical Description**	**Hours**
1	Implement the concept of static routing	2 hrs [OC1]
	Dynamic Routing Protocol (RIP)	
2a	Implement the concept of RIPv1 and RIPv2 routing protocol	2 hrs [OC2]
2b	Implement the concept of RIPng (RIP Next Generation) routing protocol	2 hrs [OC2]
	Dynamic Routing Protocol (OSPF)	
3a	Implement the concept of OSPF Virtual-Link Configuration	2 hrs [OC3]
3b	Implement the concept OSPF Standard Area and Backbone Area	2 hrs [OC3]
3c	Implement the concept OSPF Stub and Totally Stubby Area	2 hrs [OC3]
	Dynamic Routing Protocol (BGP)	
4a	Implement the concept of BGP routing protocol	2 hrs [OC4]
4b	Implement the concept of BGP Path Attributes – MED	2 hrs [OC4]
4c	Implement the concept of BGP AS Path Attribute	2 hrs [OC4]
4d	Implement the concept of BGP Path Attribute - Local Preference	3 hrs [OC4]
4e	configure Internal BGP(IBGP) and External BGP(EBGP) and	3 hrs [OC4]
	IP Multicasting	
5a	Implement the concept of Multicast Tunneling	3 hrs [OC5]
5b	Implement the concept of Multicast PIM Sparse-Dense Mode	3 hrs [OC5]
5c	Implement the concept of Multicast PIM Sparse Mode	3 hrs [OC5]
5d	Implement the concept of Multicast PIM NBMA Mode	3 hrs [OC5]
	Multiprotocol Label Switching (MPLS)	
6a	Implementing MPLS VPNs	3hrs [OC6]
6b	Implementing MPLS Traffic Engineering per VRF	3 hrs [OC6]
6c	Implementing MPLS Traffic Engineering per L2TPV3	3 hrs [OC6]
	Virtual Private Networks	
7	Configuring Site-to-Site IPsec VPN Tunnel between Routers	3 hrs [OC7]
	Network Address Translation	
8a	Implementing of Static NAT (Network Address Translation)	3 hrs [OC8]
8b	Implementing of Dynamic NAT (Network Address Translation)	3 hrs [OC8]
9	Configuration of WLAN	3 hrs [OC9]
10	Install & Configure OpenDayLight SDN Controller for Mininet	3 hrs [OC10]

Course Outcomes (OCs):

Upon completing this course, the student will be able to:

OC1: Do configuration of the static routing protocol

OC2: Do configuration of the RIP V1 ,RIP V2 and protocol

OC3: Do configuration of various attributes of OSPF protocol

OC4: Do configuration of attributes of BGP Protocol
OC5: Do configuration modes of IP Multicast PIM in the routers.
OC6: Do configuration of MPLS VPNs, Traffic Engineering in the routers
OC7: Do configuration Virtual Private Networks in the network environments
OC8: Do configuration of Static NAT and Dynamic NAT in the routers.
OC9: Do configuration the WLAN environment
OC10: Configure the OpenDayLight SDN Controller for Mininet

Course Code: 505 [Mandatory] **Total Credits:** 02 (30 Lecture Hrs) **University assessment:** 25 marks	**Course Name**: Software Testing **Total Marks:** 50 marks **College/Department assessment:** 25 marks

Pre-requisite:

- Knowledge about Software Development Life Cycle (SDLC)
- Basic knowledge of Software Testing, Level of Testing and Types of Testing

Course Objectives (COs):

To enable the students to:

CO 1. Understand difference between Mobile Testing and Mobile Application Testing
CO 2. Acquire knowledge of various tests that can be performed on mobile applications
CO 3. Understand the difference between game playing and game testing
CO 4. Acquire knowledge of various tests that can be performed on game applications

MODULE I:	**(2 CREDITS)**
Unit 1: Mobile Application Testing a) **Introduction to Mobile Business and Technology Drivers, Mobile Application Test Types** – Business Models, Mobile Device Types, Types of Mobile Application, Challenges, Risk & Strategies, Testing for Compatibility with Device Hardware, Testing for App Interactions with Device Software, Testing for Various Connectivity Methods b) **Common Test Types and Test Process for Mobile Applications, Mobile Application Platforms, Tools and Environment** - Common Test Types Applicable for Mobile Application, Additional Test Levels applicable for Mobile Applications, Experience-based Testing Techniques, Mobile Test Process and Approaches, Development Platforms for Mobile Applications, Common Development Platform Tools, Emulators & Simulators, Setting up a Test Lab **c)** **Automating the Test Execution, Mobile App testing tools** - Automation Approaches, Automation Methods, Automation Tools Evaluation, Approaches for setting up an Automation Test Lab, Introduction to open source and paid testing tools, Appium – Installation creating test cases for calculator app, Introduction to Selendroid and execution of test cases	15 Hrs [OC1, OC2, OC3, OC4, OC8]
Unit 2: Game Testing a) **Specificity of Game Testing, Testing Game Mechanics, Graphics Testing** – Game Testing Basics, Typical Roles of the Game Development Team, Testing Activities throughout the Game Software Development Lifecycle, Game Mechanics, Approaches to Testing Game Mechanics, Principles and Concepts of Game Graphics, Approaches to Testing Graphics in Game Products, Graphics Test Execution, Tools Support for Graphics Testing b) **Sound Testing, Game Level Testing, Game Controllers Testing** - Features of the Sound Content of the Game Product, Types of Defects in Sound Content, Approaches to Testing Sound Content in Game Products, Sound Test Execution, Tools Support for Sound Testing, Level Design Principles and Concepts, Stages and Execution of Game Level Testing, Tools Support for Game Level Testing, Principles and Concepts of Game Controllers, Approaches to Testing Controllers in Game Products, Tools Support for Game Controllers Testing **c)** **Localization Testing, Demonstration and Case studies for Game Testing: -** Principles and Concepts of Localization Testing, Types of Localization Defects and their Causes, Localization Testing Approaches and Execution, Introduction to Game Driver, creating test cases for downloading the application, Launching, Login registration, Update & notification, Security, Performance	15 Hrs [OC5, OC6, OC7, OC8]

References:

1. Certified Tester Specialist Mobile Application Testing Foundation Level, ISTQB syllabus
2. Certified Tester Game Testing (CT-GaMe), ISTQB syllabus
3. Hands-On Mobile App Testing - A Guide for Mobile Testers and Anyone Involved in the Mobile App Business - Daniel Knott, Addison-Wesley
4. Game Development Essentials Game QA & Testing, Luis Levy, Jeannie Novak, Cengage Learning
5. Game Testing All in One, Charles P. Schultz, Robert Bryant, Tim Langdell, 2005, Course Technology PTR
6. https://www.lambdatest.com/learning-hub/gaming-platform-test-case-template
7. https://tfortesting.wordpress.com/2012/10/04/test-cases-for-games-apps-checklist-for-games-apps/

Course Outcomes (OCs):

Upon completing this course, the student will be able to:

OC 1. Differentiate between Mobile Testing and Mobile Application Testing
OC 2. Understand mobile application test types and test process
OC 3. Gain knowledge about mobile testing environment, platform and tools
OC 4. Use Test Automation tools and requirement knowledge
OC 5. Differentiate between game playing and game testing
OC 6. Acquire knowledge about the types of testing done on game application
OC 7. Acquire Knowledge about localization and how to find defect in localization
OC 8. Creating Test Cases for Mobile Applications & Game Applications

Course Code: 506a [Elective] **Total Credits:** 04 (60 Lecture Hrs) **University assessment:** 50 marks	**Course Name**: Introduction to Artificial Neural Networks **Total Marks:** 100 marks **College/Department assessment:** 50 marks

Pre-requisite:

a. Basics of Artificial Intelligence
b. Knowledge of AI algorithms

Course Objectives (COs):

To enable the students to:

CO 1. Understand the fundamentals of Artificial Neural Network
CO 2. Understand the difference between pattern and data
CO 3. Understand the basic neural network structure
CO 4. Understand the neural network structure for complex tasks

MODULE I:	**(2 CREDITS)**
Unit 1: a) **Introduction**: Trends in Computing, Pattern and Data, Pattern recognition Tasks and its Methods b) **Basics of Artificial Neural Networks**: Characteristics and History of Neural Network, Terminologies of ANN, Models of Neuron, Topology, Basic Learning Laws, Demonstration and implementation: simple neural network, calculate the output of the neural network c) **Activation and Synaptic Dynamics** – Activation Dynamics Models, Synaptic Dynamics Models, Learning Methods, Stability and Convergence, Recall	15 Hrs [OC1, OC2, OC3]
Unit 2: a) **Functional units of ANN for pattern Recognition Tasks**: Problems of Pattern Recognition, Basic Functional Units, Pattern Recognition Tasks by the Functional Units, Demonstration and Implementation: AND, XOR, AND/NOT function using McCulloch Pitts Neural Network, Hebb's Rule and Delta Rule b) **Feedforward Neural Networks**: Analysis of Pattern Association Networks, Analysis of Pattern Classification Networks, Analysis of Pattern Mapping Networks, Demonstration and Implementation: Linear Separable Problem, Back Propagation, Supervised Learning Algorithms	15 Hrs [OC3, OC4, OC5]
MODULE II :	**(2 CREDITS)**
Unit 3: a) **Feedback Neural Networks**: Analysis of Linear Autoassociative FF Network, Analysis of Pattern Storage Networks, Stochastic Networks and Simulated Annealing, Boltzmann Machine, Demonstration and Implementation: Autoassociative Memor, Boltzmann Machine **b) Competitive Learning Neural Network**: Components of Competitive Learning Network, Analysis of Feedback Layer for Different Output Functions, Analysis of Pattern Clustering Network, Analysis of Feature Mapping Network, Demonstration and Implementation: Unsupervised Learning, Kohenon Self-organizing map.	15 Hrs [OC6, OC7]
Unit 4: a) **Architectures for Complex Pattern Recognition Tasks**: Associative Memory, Pattern Mapping, Stability-Plasticity Dilemma- ART, Temporal Patterns, Pattern Variability: Neocognitron, Demonstration and Implementation: ART b) **Applications of ANN**: Direct Application of ANN, Application Areas, Demonstration and Implementation: Radial Basis Function	15 Hrs [OC1 & OC8]

References:

1. Artificial Neural Network, B. Yegnanarayana, PHI
2. Principles of Soft computing, S.N.Sivanandam S.N.Deepa, 3rd, Wiley
3. Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis & Applications, S.Rajasekaran,G. A.Vijayalakshami, Prentice Hall of India

Course Outcome (OCs)

Upon completing this course, the student will be able to:

OC 1. Recognizes the areas where ANN is applied and used
OC 2. Understands the basic difference between data and patterns, recognition and understanding

OC 3. Understands the basic terminologies used in ANN
OC 4. Understands the basic architectural structure of neural networks
OC 5. Able to identify the areas where feedforward network can be used
OC 6. Able to identify the areas where feedback network can be used
OC 7. Understands the concepts of pattern clustering and feature mapping
OC 8. Able to identify which structure to be applied for the complex pattern recognition tasks

Course Code: 506b [Elective]	**Course Name**: Cloud Computing
Total Credits: 04 (60 Lecture Hrs)	**Total Marks:** 100 marks
University assessment: 50 marks	**College/Department assessment:** 50 marks

Pre-requisite: Knowledge of operating systems, Networking, Databases & Basics of Security and Privacy

Course Objectives (COs)

To enable the students to:

CO 1. Understand the fundamental concepts of cloud computing
CO 2. Acquire knowledge of various cloud technologies.
CO 3. Learn different types of Virtualization Techniques.
CO 4. Evaluate the cloud services offered by major cloud players
CO 5. Understand the different types of cloud storage and cloud security

MODULE I:	**(2 CREDITS)**
Unit I **a) Overview of Cloud Computing**: Introduction to cloud computing, Characteristics of cloud computing, Advantages of cloud computing, Disadvantages of cloud computing, Cloud service models, Cloud computing deployment models, Cloud computing deployment models **b) Cloud Architecture and Applications:** Cloud architecture, Components of cloud computing architecture, Working of cloud computing, Applications of cloud computing **c) Case Study**: public cloud, Private cloud and hybrid cloud, Infrastructure as a Service, Software as a Service and Platform as a service	15 Hrs OC1
Unit II **a) Scalability and Redundancy:** Meaning of scalability, Key features of cloud scalability, Types of scalability, Ways to scale cloud, Concept of redundancy, Benefits of redundancy **b) Cloud Services:** Cloud services, Benefits of cloud services, Types of cloud service models-Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS), Network as a Service (NaaS), Identity as a Service (IdaaS) **c) Case Study:** Study and implementation of Storage as a Service (IaaS), Working with Goggle Docs, Sheets and Notes (SaaS)	15 Hrs OC2
MODULE II:	**(2 CREDITS)**
Unit III **a) Cloud Deployment Models:** Public Cloud-Public cloud architecture, Private cloud deployment model, Comparison between private and public cloud, Community cloud deployment model, Hybrid cloud deployment model, Comparative study for all clouds, Multi cloud **b) Virtualization:** Features of virtualization How does virtualization work? Benefits of virtualization Difference between cloud computing and virtualization, Types of virtualization-Hardware virtualization, Software virtualization, Server virtualization, Storage virtualization, Operating system virtualization **c) Cloud Management:** Cloud provisioning, Cloud management benefits, Cloud management tools, Components of cloud computing management Cloud management security Challenges faced during cloud management Demonstrate and Implement Software Virtualization using Hypervisors (VMWARE). eg VMware ESX and ESXi , Microsoft Hyper-V, Citrix XenServer	15 Hrs OC3
a) Data Storage and Security: Cloud storage basics, Types of cloud storage, Advantages and risks of cloud storage, Infrastructure Data protection process Cloud security Measures and controls in cloud security, Encryption **b) Cloud Operations and Challenges:** Defining cloud operations, Cloud operations objective, Cloud operations management, Benefits of cloud operations, Challenges related to cloud computing **c) Technologies and Service Models Structure:** Cloud computing technologies, Types of cloud computing technologies. Service providers, MeghRaj, Case study on data storage security in private cloud, A Case Study on Cyber-Attacks in Cloud Computing, Case Study on data breaches in cloud computing	15 Hrs OC4

References:

a) Cloud Computing Simplified Explore Application of Cloud, Cloud Deployment Models, Service Models and Mobile Cloud Computing by Surbhi Rastogi ,1st edition BPB Publications, India
b) Cloud Computing - Master the Concepts, Architecture and Applications with Real-world examples and Case studies by Kamal Kant Hiran Ruchi Doshi Dr. Temitayo Fagbola Mehul Mahrishi,1st edition, BPB Publications, India
c) Cloud Computing, Sandeep Bhowmik by 1st edition Cambridge University Press
d) Cloud Computing For Dummies®, by Daniel Kirsch & Judith Hurwitz, 2nd Edition John Wiley & Sons,

Inc

Course Outcomes (OCs)

Upon completing this course, the student will be able to:

OC 1. Explain concepts, features of cloud delivery model, Service Model, and advantages and disadvantages of cloud computing as well as determine the cloud computing architecture and infrastructure

OC 2. Differentiate the different types of Cloud Services, their advantage and disadvantages, needs of cloud scalability and redundancy.

OC 3. Differentiate the different types of cloud's deployment model, different types of virtualization techniques, Cloud managements tools,

OC 4. Analyze cloud storage systems, cloud security, as well as the associated risks, cloud operations and their challenges in the cloud computing, different types of cloud computing technologies

Course Code: 506c [Elective]	**Course Name**: Cryptography and Network Security
Total Credits: 04 (60 Lecture Hrs)	**Total Marks:** 100 marks
University assessment: 50 marks	**College/Department assessment:** 50 marks

Pre requisite:

Basic Algebra, Set theory, Logical Reasoning, Fundamentals of Computer Networks and Internet.

Course Objectives (COs)

To enable the students to:

CO 1. Understand the basic principles of security, types security.
CO 2. Understand the Standard algorithms used for security.
CO 3. Analyze and use methods for cryptography
CO 4. Develop a workable knowledge of the mathematics used in Cryptography
CO 5. Differentiate various hardware and software security systems
CO 6. Know the applications of these techniques in real world
CO 7. Have the basic knowledge on Image Forgery and protection

MODULE I:	**(2 CREDITS)**
Unit 1: a) **Attacks on Computer and Computer Security**: Introduction, Need for Security, Security Approaches, principles of Security, Types of Attacks. **b) Cryptography Concepts and Techniques**: Introduction to Plain text and Cipher text, Substitution Techniques, Transpositions Techniques, **c) Encryption and Decryption**: Symmetric and Asymmetric key Cryptography, Steganography, Key range and size, Possible types of Attacks.	15 Hrs [OC1, OC2]
Unit 2: **a) Symmetric Key Cryptography:** Introduction, Algorithmic types and modes, An Overview of symmetric key cryptography, DES, IDEA, RC4, RC5, Blowfish, AES . **b) Asymmetric Key Cryptography and Digital Signatures:** Introduction, Overview of AKC, RSA algorithm. **c) Digital Signatures and Other Methods**: Digital Signatures, Knapsack Algorithm, Hybrid algorithms with symmetric and Asymmetric techniques.	15 Hrs [OC3, OC4]
MODULE II:	**(2 CREDITS)**
Unit 3: **a) Digital Certificates and PKI:** Introduction, Digital Certificates, Private key management, PXIX Model, PKCS, PKI and Security. **b) Internet Security Protocols:** Introduction, Basic Concepts, SSL, TLS, SHTTP, TSP, SET, 3D secured Protocol. **c) Security in technologies**: Electronic Money, Email Security, WAP Security, Security in GSM, Security in 3G,4G,5G.	15 Hrs [OC5]
Unit 4: **a) User Authentication and Kerberos:** Introduction, Authentication basics, passwords and tokens, Certificate based authentications, biometric authentication, Kerberos, KDC, SSO Approaches **b) Network Security, Firewalls and VPN:** Introduction, TCP/IP, Firewalls, VPN, Intrusion. c) **Case Studies:** SSO, DDOS, IP Spoofing Attacks, Cookies and Privacies, VPN creation, Latest attacks.	15 Hrs [OC6, OC7]

References:

1. Atul Kahate, "Cryptography and Network Security", 2nd Edition and above, TMH
2. William Stallings, "Cryptography and Network Security, Principles and Practice", 7th Edition, Pearson.
3. Behrouz, Forouzon, Debdeep Mukhopadyay, "Cryptography and Network Security", McGrawHill

Course Outcomes (OCs)

Upon completing this course, the student will be able to:

OC 1. Acquire knowledge on standard algorithms used to meet the principles of security such as confidentiality, integrity and Authenticity
OC 2. Understand the mathematical concepts and techniques for encryption and decryption
OC 3. Understand the applications of symmetric key, asymmetric key cryptographic algorithms
OC 4. Understand the technique and use of digital signatures.
OC 5. Understand and implement the technologies of internet such as digital certificates, Internet security protocols and tools
OC 6. Understand authentication mechanisms and network security mechanisms like firewall, VPN etc.
OC 7. Understand clearly the various real-time case studies on how to implement the acquired knowledge on the syllabus

Course Code: 510 **Total Credits:** 04 (60 Lecture Hrs) **University assessment:** 50 marks	**Course Name**: Research Methodology **Total Marks:** 100 marks **College/Department assessment:** 50marks

Pre requisite:

Basic programming skills, orientation towards research and conceptual understanding of IT subjects

Course Objectives (COs)

To enable the students to:

CO1. Know basics of how research problems are defined, research methods are adopted and/or developed, research is undertaken

CO2. Make understand how research results are communicated to the peers.

CO3. Learn research methods, some of which are general in nature and the remaining specific to the field of Information Technology and the specialization.

MODULE I:	**(2 CREDITS)**
Unit 1: **Research Methodology and Problem Identification and Formulation:** Meaning and objectives, motivation of research, types of research, research methods v/s methodology, research and scientific methods, research process and stages of research, defining and formulating the research problem, technique involved in defining a problem, importance of literature review in defining a problem, role of literature review, ways to perform literature review, methods to find open problem and research problems, critical literature review, identifying gap areas from literature study, hypothesis building	15 Hrs [OC1]
Unit 2: **Research Design and Data Collection and Analysis:** Need of research design, concepts related to research design, different research designs, research plan, basic principles of experimental design and setup, collection of primary data, observation methods, interview methods, collection of data through questionnaire and schedules, collection of secondary data, selection of appropriate method for data collection, case study method, guidelines for developing questionnaire, successful interview, survey v/s experiment, processing and data analysis, use of statistical packages, measure of asymmetries and other measures. Fieldwork-The Nature of Field Work, Selection and Training of Investigators, Sampling Frame and Sample Selection, Field Operation, Field Administration.	15 Hrs [OC2, OC3]
MODULE II:	**(2 CREDITS)**
Unit 3: **Probability Distribution and Hypothesis Testing:** Sampling and probability distribution, definitions and basic concepts of hypothesis testing, procedures of hypothesis testing, flow diagram for hypothesis testing, test of hypothesis, important parametric test, hypothesis testing of mean, proportion, tests for equality of mean and variances of two population, confidence interval, z-test, and X2 test for goodness to fit, limitation of test of hypothesis. **Analysis of Variance and Covariance:** Basic principle of Analysis of Variance, ANOVA Technique, Setting up Analysis of Variance Table, short-cut method for one- way ANOVA, Coding method, Two-way ANOVA, ANOVA in Latin-square design, analysis of co-variance (ANCOVA), assumptions in ANCOVA.	20 Hrs [OC4]
Unit 4: **Academic Ethics:** Plagiarism, exposure on anti-plagiarism tools. **Technical Writing and IPR:** Academic writing, sources of information, assessment of quality of journals and articles, writing scientific report, structure and component of research report, types of report – technical reports and thesis,	10 Hrs

SCOPUS Index, citations, search engines beyond google, impact factor, H-Index. **IPR:** What is IPR?, importance of patents, types of IPR, process of patent.	[OC5, OC6, OC7]

References:

1. Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS Publishers' Distributors.
2. Kothari, C.R.,1985, Research Methodology-Methods and Techniques, New Delhi, Wiley Eastern Limited.
3. Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners, (2nd.ed), Singapore, Pearson Education.
4. Neeraj Pandey, Intellectual Property Rights ,1st Edition, PHI
5. Shrivastava, Shenoy& Sharma, Quantitative Techniques for Managerial Decisions, Wiley
6. Goode W J &Hatt P K, Methods in social research, McGraw Hill
7. Basic Computer Science and Communication Engineering – R. Rajaram (SCITECH)

Course Outcomes (OCs)

Upon completing this course, the student will be able to:

OC1: Basic understanding of research and how to formulate a research problem
OC2: Understand and develop methodological design for the research problem
OC3: Identify the required data and use data collection methods for acquiring data
OC4: Set hypothesis for the given research problem and apply testing methods
OC5: Follow the research ethics
OC6: Write research proposals, documentations related with research
OC7: Understand and apply IPR and patent filing

Semester II

Course Code: 511 [Mandatory] **Total Credits:** 04 (60 Lecture Hrs) **University assessment**: 50 marks	**Course Name:** Image Processing Theory **Total Marks:** 100 marks **College/Department assessment**: 50 marks

Pre-requisite:

Fundamentals of Mathematics, Differential and Integral Calculus, Basic knowledge on working with Graphics. Some exposure to Scilab/Pyton/Matlab.

Course Objectives (COs):

To enable the students to:

CO 1. Understand the fundamental concepts of digital image processing system and its mathematical formulation
CO 2. Analyze images in the using Image enhancement techniques
CO 3. Clarify the concepts of image segmentation, morphological operations and able to understand the internal parameters of images and in various patterns,
CO 4. Categorize and interpret various compression techniques
CO 5. Perform image retrieval in various forms
CO 6. Acquire basic knowledge on Image Forgery and protection

MODULE I:	**(2 CREDITS)**
Unit 1: a) **Introduction to Digital image Processing**: Introduction, Typical Image Processing Operations, History of Digital Image Processing, Human Visual System, Classification of Digital Images, Digital Image File Types, Components of an Image Processing System, Applications of Digital Image Processing. b) **Image Representation**: Digital Image, Sampling and Quantization, Colour Models, Basic Relationships between Pixels, Adjacency, Digital Path, Connected set. c) **Mathematical tools for image Processing:** Introduction, Distance Function, Convexity Property, Topological Properties, Interpolation, Circularly Symmetric Signals, Statistics, Transforms, Wavelet Transform, Discrete Cosine Transform (DCT), Walsh Transform (WT), Matrix Operations, Set Theory.	15 Hrs [OC1, OC2]
Unit 2: a) **Image Enhancement: Spatial Domain:** Introduction, Point Processing, Mask processing, Smoothing Filters, Sharpening Filters, Bit-Plane Slicing, Arithmetic Operations, Logical Operations, Geometric Operations, Histogram and Histogram Processing, b) **Image Enhancement: Frequency Domain:** Introduction, Low-Pass Filtering, High-Pass Filtering, High-Frequency Emphasis Filter, c) **Image Denoising:** Introduction, Image Noise Types, Image Denoising, Performance Evaluation of Denoising Techniques.	15 Hrs [OC3]
MODULE II:	**(2 CREDITS)**
Unit 3: a) **Image Segmentation:** Introduction, Techniques of Image Segmentation, Discontinuity-based Image Segmentation Techniques, Thresholding-based Image Segmentation, Region Based Image Segmentation, Watershed Based Image Segmentation. b) **Mathematical Morphology:** Introduction, Morphological Operations. c) **Image Understanding:** Introduction, Contour-Based Shape Representation and Description, Boundary Segments Description, Object Recognition.	15 Hrs [OC4, OC5, OC6]
Unit 4: a) **Image Compression:** Introduction, History of Compression Technologies, Image File Types, Compression Quality Measures, Image Redundancy, Fundamental Building Blocks of Image Compression, Image Compression Model, Image Compression Standards, b) **Image Retrieval:** Text-Based Image Retrieval System, Content-Based Image Retrieval Systems, Image Pre-Processing, Feature Extraction, Feature Selection, Similarity Measure and Performance Evaluation, c) **Image Forgery:** Introduction, History of Image Forgery, Image Forgery Detection Techniques	15 Hrs [OC7, OC8, OC9]

References:

1. Vipin Tyagi, “Understanding Digital Image processing”, CRC Press (Taylor and Francis Group)
2. Gonzalez, Rafeal C., “Digital Image Processing”, Prentice Hall, Edition IV, 2018
3. Anil K. Jain, “Fundamentals of Digital Image Processing”, PHI (Pearson)
4. Chris Solomon, Toby Breckon, “Fundamental of Digital Image Processing: A Practical Approach with Examples in Matlab”, Wiley Blackwell.

Course Outcomes (OCs)

Upon completing this course, the student will be able to:

OC1: Have the fundamental knowledge of digital images and its processing.
OC2: Understand the mathematical concepts behind Digital image processing
OC3: Use image enhancements techniques
OC4: Perform Digital Image Segmentation.
OC5: Perform Morphological Operations on Digital Images
OC6: Understand the segmented/enhanced images for further processing and interpretations
OC7: Perform Image compression
OC8: Perform Image retrieval processes
OC9: Understand the act of Image forgery and its methods and perform protections techniques

Course Code:512 [Mandatory] **Total Credits:** 02 (60 Lecture Hrs) **University assessment:** 25 marks	**Course Name:** Image Processing (Practical) **Total Marks:** 50 marks **College/Department assessment:** 25 marks

Pre-requisite:
Fundamentals of Mathematics, Differential and Integral Calculus, Basic knowledge on working with Graphics. Some exposure to Scilab/Pyton/Matlab.

Course Objectives (COs):
To enable the students to:

CO 1. Understand the fundamental concepts of digital image processing system and its mathematical formulation
CO 2. Analyze images in the using Image enhancement techniques
CO 3. Clarify the concepts of image segmentation, morphological operations and able to understand the internal parameters of images and in various patterns,
CO 4. Categorize and interpret various compression techniques
CO 5. Perform image retrieval in various forms
CO 6. Acquire basic knowledge on Image Forgery and protection

Prac No	Practical Description	2 CREDITS (60 hrs)
1	Image Representation	4 hrs [OC1]
2	Mathematical Tools for Image processing	4 hrs [OC2]
3	Image Enhancement in Spatial Domain	6 hrs [OC3]
4	Image Enhancement in Frequency Domain	6 hrs [OC3]
5	Application of Image denoising techniques	6 hrs [OC3]
6	Illustration of various segmentation techniques	6 hrs [OC4]
7	Application of morphological operations on images	6 hrs [OC5]
8	Image understanding by means of different representations	4 hrs [OC6]
9	Image Compression techniques	4 hrs [OC7]
10	Various Image retrieval techniques	6 hrs [OC8]
11	Illustrations of Image Forgery	4 hrs [OC9]
12	Application of Image forgery detection techniques	4 hrs [OC10]

Course Outcomes (OCs)
Upon completing this course, the student will be able to:

OC1: Perform basic image operations
OC2: Use the mathematical tools on images
OC3: Perform image enhancements techniques
OC4: Perform Digital Image Segmentation.
OC5: Perform Morphological Operations on Digital Images
OC6: Represent the images in various forms to understand its properties
OC7: Perform Image compression
OC8: Perform Image retrieval processes for further processing
OC9: Demonstrate an image forgery
OC10 : Use Image forgery detection techniques

Course Code: 513 [Mandatory] **Total Credits:** 04 (60 Lecture Hrs) **University assessment:** 50 marks	**Course Name:** Big Data Systems Theory **Total Marks:** 100 marks **College/Department assessment:** 50 marks

Pre-requisite:

a) Sound knowledge of Linux Environment
b) Sound knowledge of Java, Python Programming Language
c) Sound knowledge of SQL (queries and sub queries)

Course Objectives (COs):

To enable the students to:

CO 1. Understand the key issues in existing technologies leading to the evolution of big data analytics and its associated applications in business analytics.
CO 2. Understand the architecture of Hadoop and its components
CO 3. Explore MapReduce framework and optimize its jobs.
CO 4. Explore popular Hadoop tools like Hive, Pig, Hbase, Spark

MODULE I:	**(2 CREDITS)**
Unit 1: Introduction to Big Data a) **Overview of Big data:** Evolution of Big Data, Definition of Big Data, Challenges with Big Data, Traditional Business Intelligence (BI) versus Big Data. b) **Big data analytics:** Classification of Analytics, Importance and challenges facing big data, Terminologies Used in Big Data Environments, The Big Data Technology Landscape, NoSQL	10 Hrs [OC1, OC2]
Unit 2: Introduction to Hadoop Framework & Hadoop Concepts a) **Introduction to Hadoop:** Introducing Hadoop, RDBMS versus Hadoop, Distributed Computing Challenges, History and overview of Hadoop, Use Case of Hadoop, Hadoop Distributors, Processing Data with Hadoop, Interacting with Hadoop Ecosystem b) **Hadoop Distributed File System (HDFS):** The Design of HDFS, HDFS Concepts, Basic Filesystem Operations, Hadoop Filesystems, The Java Interface, Data Flow c) **Hadoop I/O**: Compression, Serialization, Avro and File-Based Data structures.	15 Hrs [OC3, OC4]
MODULE II:	**(2 CREDITS)**
Unit 3: Understanding MapReduce Fundamentals a) **How MapReduce Works:** Anatomy of a Map Reduce Job Run, Failures, Shuffle and Sort, Task Execution b) **MapReduce Types and Formats** – MapReduce Types, Input Formats, Output Formats c) **MapReduce Features** – Counters, Sorting, Joins	15 Hrs [OC5]
Unit 4: Hadoop Ecosystem a) **Avro:** Data Types and Schema, Serialization, Datafiles, Schema Resolution **Flume:** Transactions and Reliability, Fan Out, Distribution **Sqoop:** Sqoop Connectors, Imports, Working with Imported Data, Importing Large Objects b) **Pig**: Execution Modes of Pig, Comparison of Pig with Databases, Grunt, Pig Latin, User Defined Functions, Data Processing operators **Hive**: Hive Shell, Hive Services, Hive Metastore, Comparison with Traditional Databases, HiveQL, Tables, Querying, Data and User Defined Functions. **Spark:** Spark Applications, Jobs, Stages, and Tasks, Resilient Distributed Datasets, Anatomy of a Spark Job Run c) **Hbase:** HBasics, Concepts, Clients, Example, Hbase Versus RDBMS	20 Hrs [OC6, OC7]

ZooKeeper: Group Membership, ZooKeeper Service Oozie, Solr, Storm	

References:					
Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	Big Data and Analytics	Seema Acharya, Subhashini Chellappan	Wiley	2nd edition	2019
2.	Hadoop: The Definitive Guide	Tom White	O'reily	4th Edition	2012
3.	Big Data Science and Analytics – A hands on approach	Arshdeep Bagha, Vijay Madisetti		1st edition	2019
4.	Data Analytics with Hadoop- An Introduction for Data Scientists	Benjamin Bengfort and Jenny Kim	O'reily	1st edition	2016

Course Outcomes (OCs):

Upon completing this course, the student will be able to:

OC 1. Familiarize & understand what is Big Data, its evolution, describe the elements of big data-volume, variety, velocity and veracity & understand the importance and challenges of big data.

OC 2. Understand the importance and challenges of big data & define big data analytics advantages and its applications.

OC 3. Analyze the core components of hadoop with basic commands & explain the key features of hadoop in processing big data

OC 4. Understand architectural components involved in hadoop ecosystem, describe in detail about Distributed file system, Understand the concept of Hadoop cluster architecture.

OC 5. Understand architecture & concepts of MapReduce framework

OC 6. Understand & explain the architecture frameworks like Pig, Hive, Hbase, Sqoop, Avro, Flume, Spark, Zookeeper

OC 7. Familiarize with frameworks like Oozie, Solr, Storm

Course Code:514 [Mandatory] **Total Credits:** 02 (60 Lecture Hrs) **University assessment:** 25 marks	**Course Name:** Big Data Systems (Practical) **Total Marks:** 50 marks **College/Department assessment:** 25 marks

Pre-requisite:

1. Sound knowledge of Python & Java
2. Sound knowledge of concepts in probability, statistics & mathematics

Course Objectives (COs):

Upon completing this course, the student will be able to:

CO 1. Understand the big data platform of hadoop
CO 2. Have a sound base for further analysis on big data platform
CO 3. Implement the architecture of Hadoop and its components
CO 4. Implement map reduce framework and optimize its jobs.
CO 5. Explore popular Hadoop tools like Hive, Pig, Hbase, Spark

	MODULE 1	**2 CREDITS**
Prac No	**Practical Description**	**Hours**
1	Install, configure and run Hadoop and HDFS	5 hrs [OC1]
2	File Management tasks in Hadoop File System	5 hrs [OC2]
3	Implement word count program using MapReduce	5 hrs [OC3]
4	Implement map reduce program to analyse time-temperature statistics and generate report with max/min temperature.	5 hrs [OC4]
5	Implementing Matrix Multiplication with Hadoop Map Reduce	5 hrs [OC5]
6	Install, configure and run Pig. Execute Pig Latin scripts to sort, group, join, project and filter data.	5 hrs [OC6]
7	Install, configure and run Hive. Execute commands on Hive Databases, Tables, Views, Functions and Indexes	5 hrs [OC7]
8	Install MongoDB and manipulate it using Python	5 hrs [OC8]
9	Install, configure and run Apache Spark. Create & transform RDDs	5 hrs [OC9]
10	Install, configure and run Apache Flume. Configure Source, Sink & Flume Agent	5 hrs [OC10]
11	Install, configure and run Apache Storm	5 hrs [OC11]
12	Install, configure and run Apache Solr	5 hrs [OC12]

Course Outcomes (OCs):

Upon completing this course, the student will be able to:

OC1) Install Hadoop in pseudo-distributed mode
OC2) Apply File Management tasks in Hadoop File System
OC3) Implement word count program using MapReduce
OC4) Implement map reduce program to analyse time-temperature statistics and generate report with max/min temperature.
OC5) Implement Matrix Multiplication with Hadoop Map Reduce
OC6) Install, configure apache pig and execute Pig Latin scripts to sort, group, join, project and filter data.
OC7) Install, configure and run Hive. Execute commands on Hive Databases, Tables, Views, Functions and Indexes
OC8) Install MongoDB and manipulate it using Python
OC9) Install, configure and run Apache Spark. Create & transform RDDs
OC10) Install, configure and run Apache Flume. Configure Source, Sink & Flume Agent
OC11) Install, configure and run Apache Storm
OC12) Install, configure and run Apache Solr

Course Code: 515 [Mandatory] Total Credits: 02 (30 Lecture Hrs) University assessment: 25 marks	Course Name: Distributed Computing. Total Marks: 50 marks College/Department assessment: 25 marks

Pre-requisite: Data Structures and Algorithms, fundamental of networking, Basic concepts of operating system e.g. processes, threads, synchronization, file systems, scheduling etc. Advanced programing language e.g. Java, C/C++, Python

Course Objectives (COs):

To enable the students to:

CO1: Introduce students to the fundamental problems, concepts, and techniques used in the design and evaluation of distributed computing systems and its applications.

CO2: Understand the concerns and challenges while designing the distributed systems

CO3: Acquire knowledge on techniques and methods about concurrent and distributed systems.

MODULE I:	**(2 CREDITS)**
Unit I **a. Introduction:** Advantages of Distributed Systems, Defining Distributed Systems, Challenges of a Distributed System, Goals of Distributed System, A simple classification of distributed systems. **b. Architectures:** Architectural styles, Middleware and distributed systems, Layered-system architectures, symmetrically distributed system architectures, Hybrid system architectures, Process to Process Communication: Communication Types and Interfaces, Socket Programming, Remote Procedure Call, Remote Method Invocation, Demonstration and implementation of TCP /UDP Socket, RPC and RMI. **c. Clock Synchronization and Event Ordering:** The Notion of Clock Time, External Clock Based Mechanisms, Cristian's Algorithm, Symmetric Mode of Operation, Logical Clock, Causal Ordering of Messages, Multicast Message Ordering, Interval Events, Demonstration and implementation the working of Cristian's algorithm, Berkeley's algorithm.	15 Hrs OC1, OC2, OC3
Unit II **a. Leader Election:** Impossibility Result, Bully Algorithm, Ring-Based Algorithms, Hirschberg and Sinclair Algorithm, Distributed Spanning Tree Algorithm, Leader Election in Trees, Leased Leader Election, Demonstration and implementation of Bully algorithm, Ring-Based algorithm. **b. Mutual Exclusion:** System Model, Coordinator-Based Solution, Assertion-Based Solutions, Token-Based Solutions Agreements and Consensus: System Model, Byzantine General Problem (BGP), Commit Protocols, Consensus, Demonstration and implementation of mutual exclusion algorithm. **c. Peer-to-Peer Systems and Distributed Shared Memory:** The Origin and the Definition of P2P, P2P Models Chord Overlay, Multicore and S-DSM, Manycore Systems and S-DSM, Programming Abstractions, Memory Consistency Models DSM Access Algorithms.	15 Hrs OC4, OC5

References:

a) Distributed Systems: Theory and Applications by Ratan K. Ghosh, Hiranmay Ghosh John Wiley & Sons, Inc.

b) Distributed Systems By Maarten Van Steen, Andrew S. Tanenbaum, Fourth Version 4.01 (January 2023) Distributed-Systems.Net

c) Distributed Computing: Simply In Depth 3rd Edition

d) Distributed Computing: Principles, Algorithms, and Systems by Ajay D. Kshemkalyani, Mukesh Singhal1st edition, Cambridge University Press 2008

e) Understanding Distributed Systems: What every developer should know about large distributed application by Roberto Vitillo 2nd Version 2.0.0 March 2022

Course Outcomes:

Upon completion of this course, the student will be able to:

OC1: Learn the fundamental principles, models and architecture of distributed computing systems, as well as the challenges of design and implementation.

OC2: Gain knowledge about types of process communication.

OC3: Understand the concept of clock synchronization processes and its techniques.

OC4: Understand the concept and algorithms used for election process, mutual exclusion and deadlock detection.

OC5: Differentiate between peer-to-peer and distributed shared memory systems.

Course Code: 516a [Elective] **Total Credits:** 04 (60 Lecture Hrs) **University assessment:** 50 marks	**Course Name:** Fuzzy Systems and Genetic Algorithms **Total Marks:** 100 marks **College/Department assessment**: 50 marks

Pre-requisite:

a. Basic knowledge of Artificial Intelligence
b. Understanding of Artificial Intelligence algorithms
c. Basic concepts of set theory, relations

Course Objectives (COs):

To enable the students to:

CO1: Understand the concepts of fuzzy systems
CO2: Acquire knowledge about rule based and decision making with fuzzy systems
CO3: Understand the concepts of genetic algorithms
CO4: Acquire knowledge of various types of genetic algorithm
CO5: Acquire knowledge on genetic programming

MODULE I: Fuzzy Systems	**(2 CREDITS)**
Unit 1: a) **Introduction to fuzzy system, Classical sets and fuzzy Sets, Classical Relations and fuzzy relations**: Introduction to fuzzy systems, operations on classical sets and fuzzy sets, properties of classical sets and fuzzy sets, crisp relations, fuzzy relations, tolerance & equivalence, value assignment, Demonstrating and implementing membership and identity operator **b) Properties of Membership Functions, Fuzzification, Defuzzification, Logic & Fuzzy Systems**: Features of the membership function, fuzzification, defuzzification, α-cut for fuzzy relation, classical logic, fuzzy logic, natural language, linguistic hedges, fuzzy (rule-based) systems, graphical techniques of inference, Demonstrating and implementing fuzzy logic and tipping problem **c) Development of Membership function, Automated Methods for Fuzzy systems**: Membership value assignments, Batch squares algorithm, recursive least square algorithm, gradient method, clustering method	12 Hrs [OC1, OC2, OC3]
Unit 2: **a) Fuzzy System Simulation, Rule base Reduction system & Decision Making with fuzzy Information**: fuzzy relational equations, nonlinear simulation using fuzzy systems, fuzzy associative memory, fuzzy system theory and rule reduction, singular value decomposition, combs method, Fuzzy synthetic evaluation, fuzzy ordering, preference and consensus, multi-objective decision making, fuzzy Bayesian decision method **b) Fuzzy Classification & Pattern Recognition Fuzzy Arithmetic and the extension principle, Fuzzy Control system**:, classification by equivalence relation, clustering analysis and validity, fuzzy c-means, classification metrics, feature analysis, multi feature pattern recognition, image processing, syntactic recognition, extension principle, fuzzy arithmetic, approximate methods of extension -vertex method, DSW algorithm, control design problems, fuzzy engineering process control, fuzzy statistical process control c) **Miscellaneous Topics, Monotone measures, Demonstration and implementation of examples**: Fuzzy optimization, fuzzy cognitive mapping, system identification, fuzzy linear regression, monotone measures, belief and plausibility, evidence theory, probability measures, possibility and necessity measures, possibility distribution as fuzzy sets, possibility distributions derived from empirical intervals, introduction to Fuzzy Logic Toolbox & Simulink in MATLAB, Demonstration and implementation of Water level control in tank, Temperature control in shower, Fuzzy PID Control with Type-2 FIS using MATLAB	18 Hrs [OC4, OC5]
MODULE II: Genetic Algorithms	**(2 CREDITS)**
Unit 3: **a) Evolutionary computation, Genetic algorithms**: Historical development of Evolutionary Computation (EC), features of EC, advantages of EC, Applications of EC, Biological background, Genetic algorithm, conventional optimization and search techniques, a simple genetic algorithm, comparison of genetic algorithm with other	15 Hrs [OC6]

optimization techniques, advantages and limitations of genetic algorithm, applications **b) Terminologies and Operators of GA**: Basic terminologies of genetic algorithm, data structure, search strategies, encoding, breeding, search termination, why do genetic algorithms work, solution evaluation, search refinement, constraints, fitness scaling c) **Advanced Operators & Techniques in GA**: Diploidy, Dominance and Abeyance, Multiploid, Inversion and Reordering, Niche and Speciation, Few Micro-operators, Non-binary Representation, Multi-Objective Optimization, Combinatorial Optimizations, Knowledge Based Techniques, Demonstration and Implementation in python: Simple Genetic algorithm, Travelling Salesman Problem, Function optimization	
Unit 4: **a) Classification of GA, Genetic Programming**: Simple Genetic Algorithm (SGA), Parallel and Distributed Genetic Algorithm (PGA and DGA), Hybrid Genetic Algorithm (HGA), Adaptive Genetic Algorithm (AGA), Fast Messy Genetic Algorithm (FmGA), Independent Sampling Genetic Algorithm (ISGA), Comparison of GP with Other Approaches, Primitives of Genetic Programming, Attributes in Genetic Programming, Steps of Genetic Programming, Characteristics of Genetic Programming, Applications of Genetic Programming, Haploid Genetic Programming with Dominance **b) Genetic Algorithm Optimization Problems, Applications of Genetic Algorithms**: Fuzzy Optimization Problems, Multi objective Reliability Design Problem, Combinatorial Optimization Problem, Scheduling Problems, Transportation Problems, Network Design and Routing Problems, Mechanical Sector, Electrical Engineering, Machine Learning, Civil Engineering, Image Processing, Data Mining, Wireless Networks, Very Large Scale Integration (VLSI) **c) Introduction to Particle swarm Optimization and Ant colony optimization, Demonstration and Implementation of examples**: Particle Swarm Optimization (PSO) – background, operation, basic flow, comparison between PSO & GA, application of PSO, Ant Colony Optimization (ACO) – biological, similarities between real ants and artificial ants, characteristics of ant colony optimization, ant colony optimization algorithms, applications of ACO, Demonstration and Implementation in MATLAB**:** Introduction to Global Optimization Toolbox, Direct Search, Particle Swarm, Simulated Annealing	15 Hrs [OC7, OC8, OC9]

References:

1. Fuzzy Logic with Engineering Applications, Timothy J.Ross, McGraw-Hill
2. Introduction to Genetic algorithm, S.N.Sivanandam, S.N.Deepa, Springer
3. Fuzzy Sets and Fuzzy Logic - Theory Applications, George J Klir/ Bo Yuan, Prentice Hall
4. A course in Fuzzy Systems & Control, Li-Xin Wang, Prentice Hall
5. Fuzzy Set Theory-and Its Applications, Fourth Edition, H.-J. Zimmermann, 4th, Springer Science Business Media
6. Introduction to Fuzzy Sets, Fuzzy Logic, and Fuzzy Control Systems, Guanrong Chen, Trung Tat Pham, CRC Press
7. An Introduction to Genetic Algorithms for Scientists and Engineers, David A Coley , World scientific
8. An Introduction to Genetic Algorithms, Mitchell Melanie, MIT Press
9. https://in.mathworks.com/help/fuzzy/fuzzylogiccontroller.html
10. https://in.mathworks.com/help/gads/index.html?s_tid=CRUX_topnav

Course Outcomes (OCs)

Upon completing this course, the student will be able to:

OC1: Understands the basics terminologies, operators and concepts of fuzzy systems
OC2: Understands the difference between classical and fuzzy systems
OC3: Apply the knowledge how to perform fuzzification & defuzzification
OC4: Understands the monotone measures of fuzzy system
OC5: Identify the areas where fuzzy systems can be applied
OC6: Understands the basic terminologies, operators and concepts of genetic algorithms
OC7: Understands difference between genetic programming and traditional programming
OC8: Identify the areas where genetic algorithms can be applied
OC9: Understand the basic of Particle Swarm Optimization and Ant Colony Optimization.

Course Code: 516b [Elective] **Total Credits:** 04 (60 Lecture Hrs) **University assessment:** 50 marks	**Course Name:** Virtualization **Total Marks:** 100 **College/Department assessment:** 50 marks

Pre-requisite:

- Knowledge of operating systems and hardware, different types of Operating systems
- Knowledge of the networking concepts and storage devices
- Knowledge of cloud computing

Course Objectives (COs):

To enable the students to:

CO1: Understand the fundamentals of cloud computing and virtualization technologies.

CO2: Configure & implement virtual machines, hypervisors, virtual networks, and virtual storage interact with each other.

CO3: Implement and create cloud infrastructure

CO4: Acquire in-depth knowledge of virtualization and cloud computing technologies.

CO5: Manage virtual machines, virtual storage, virtual networking, and troubleshooting.

MODULE I:	**(2 CREDITS)**
Unit 1: a) **Understanding Virtualization:** Describing Virtualization, Microsoft Windows Drives Server Growth, Explaining Moore's Law, Understanding the Importance of Virtualization, Examining Today's Trends, Virtualization and Cloud Computing, Hyperconverged Infrastructure, Understanding Virtualization Software Operation, Virtualizing Servers, Virtualizing Desktops, Virtualizing Applications. Understanding Hypervisors: Describing a Hypervisor, Exploring the History of Hypervisors, Understanding Type 1 Hypervisors, Understanding Type 2 Hypervisors, Understanding the Role of a Hypervisor, Holodecks and Traffic Cops, Resource Allocation, Comparing Today's Hypervisors, VMware ESX, Citrix Hypervisor (Xen), Microsoft Hyper-V, Other Solutions. b) **Understanding Virtual Machines**: Describing a Virtual Machine, Examining CPUs in a Virtual Machine, Examining Memory in a Virtual Machine, Examining Network Resources in a Virtual Machine, Examining Storage in a Virtual Machine, Understanding How a Virtual Machine Works, Working with Virtual Machines, Understanding Virtual Machine Clones, Understanding Templates, Understanding Snapshots, Understanding OVF, Understanding Containers. c) **Creating a Virtual Machine:** Performing P2V Conversions, Investigating the Physical-to-Virtual Process, Hot and Cold Cloning, Loading Your Environment, Loading VMware Workstation Player, Exploring VMware Workstation Player, Loading VirtualBox, building a New Virtual Machine, Thinking About VM Configuration, Creating a First VM.	15 Hrs OC1
Unit 2: a) **Installing Windows on a Virtual Machine:** Loading Windows into a Virtual Machine, Installing Windows 11, Installing VMware Tools, Understanding Configuration Options, Optimizing a New Virtual Machine b) **Installing Linux on a Virtual Machine:** Loading Linux into a Virtual Machine, Exploring Oracle VM VirtualBox, Installing Linux into a Virtual Machine, Installing VirtualBox Guest Additions, Understanding Configuration Options, Optimizing a New Linux Virtual Machine. c) **Managing CPUs for a Virtual Machine:** Understanding CPU Virtualization, Configuring VM CPU Options, Tuning Practices for VM CPUs, Choosing Multiple vCPUs vs a Single vCPU, Hyperthreading, Working with Intel and AMD Servers.	15 Hrs OC2
MODULE II :	**(2 CREDITS)**
Unit 3: a) **Managing Memory for a Virtual Machine:** Understanding Memory Virtualization, Configuring VM Memory Options, Tuning Practices for VM Memory, Calculating Memory Overhead, Memory Optimizations b) **Managing Storage for a Virtual Machine:** Understanding Storage Virtualization, Configuring VM Storage Options, Tuning VM Storage. c) **Managing Networking for a Virtual Machine:** Understanding Network Virtualization, Configuring VM Network Options, Tuning Practices for Virtual	15 Hrs OC3

Networks.	
Unit 4: a) **Copying a Virtual Machine:** Cloning a Virtual Machine, Working with Templates, saving a Virtual Machine State, creating a Snapshot, Merging Snapshots. b) **Managing Additional Devices in Virtual Machines:** Using Virtual Machine Tools, Understanding Virtual Devices, configuring a CD/DVD Drive, Configuring a Floppy Disk Drive, Configuring a Sound Card, Configuring USB Devices, Configuring Graphic Displays, Configuring Other Devices. c) **Understanding Availability:** Increasing Availability, Protecting a Virtual Machine, Protecting Multiple Virtual Machines, Protecting Data Centers. Understanding Applications in a Virtual Machine: Examining Virtual Infrastructure Performance Capabilities, Deploying Applications in a Virtual Environment, Understanding Virtual Appliances and vApps, Open Stack and Containers, Cloud and the Future of Virtualization	15 Hrs OC4

References:

a. Virtualization Essentials by Matthew Portnoy, 3rd ed, John Wiley & Sons, Inc.
b. Virtualization for DUMMIES by Bernard Golden, 3rd ed, HP special edition
c. Virtualization A Manager's Guide by Dan Kusnetzky O'Reilly Media, Inc.

Course Outcomes (OC's)

Upon completing this course, the student will be able to:

OC 1. Understand the concept of Virtualization, Types of Virtualizations, different types of Virtual machine manager, creation of virtual machine of different types of operating systems using different types of Hypervisors

OC 2. Install Windows and Linux operating systems on virtual computers using VMWare Workstation, Workstation Player, Microsoft Hypervisor and Oracle VirtualBox, Types of Physical CPU Architectures, Calculating and Configuring VM CPU.

OC 3. Examine of Memory in a Virtual Machine, Creation of Virtual Storage Environments, Calculating and Configuring Memory Settings, Creation and Management of Virtual Network.

OC 4. Create a clone of VM, Understand the different types of data storage technologies and media, Utilization of Peripheral Devices in VM Environments, Configuration of USB and Other Devices to Work with VMs, employ standard procedures to demonstrate how to deploy applications in a virtual environment, Understand the important of "availability" in the context of virtual machines

Course Code: 516c [Elective] **Total Credits:** 04 (60 Lecture Hrs) **University assessment:** 50 marks	Course Name: Security Fundamentals for Cloud Total Marks: 100 marks College/Department assessment: 50 marks

Pre-requisite:

a. Knowledge of the fundamental concepts of security, types of cloud services models and deployment models.
b. Basic knowledge of Software Development Lifecycle (SDLC).

Course Objectives (COs):

To enable the students to:

CO1: Understand the physical and virtual elements of cloud-based systems.
CO2: Understand the issues while designing the cloud data security policy.
CO3: Learn about the components required to design the data center and importance of business continuity and disaster recovery plans for the data center.
CO4: Aware of the concerns, threats of cloud application security.
CO5: Learn about the different operations performed in a cloud environment.
CO6: Understand the legal & audit process in cloud environment

MODULE I:	**(2 CREDITS)**
Unit I **a) Identifying Information Security Fundamentals**: Exploring the Pillars of Information Security, Threats, Vulnerabilities, and Risks, Deciphering Cryptography, Grasping Physical Security, Realizing the Importance of Business Continuity and Disaster Recovery, Implementing Incident Handling **b) Cloud Concepts, Architecture and Design**: Cloud Computing Concepts, Cloud Reference Architecture, Identifying Security Concepts Relevant to Cloud Computing, Comprehending Design Principles of Secure Cloud Computing, Evaluating Cloud Service Providers	15 Hrs OC1
Unit II **a) Cloud Data Security**: Describing Cloud Data Concepts, Designing and Implementing Cloud Data Storage Architectures, Designing and Implementing Data Security Technologies and Strategies, Implementing Data Discovery, Implementing Data Classification, Designing and Implementing Information Rights Management (IRM), Planning and Implementing Data Retention, Deletion, and Archiving Policies, Designing and Implementing Auditability, Traceability and Accountability of Data Events, Case studies on Cloud Data Storage, Auditability, Traceability.	15 Hrs OC2
MODULE II:	**(2 CREDITS)**
Unit III **a) Cloud Platform and Infrastructure Security**: Comprehending Cloud Infrastructure Components, Designing a Secure Data Center, Analyzing Risks Associated with Cloud Infrastructure, Designing and Planning Security Controls, Planning Business Continuity (BC) and Disaster Recovery (DR). Case studies on Business Continuity Plan and Disaster Recovery in cloud. **b) Cloud Application Security:** Advocating Training and Awareness for Application Security, Describing the Secure Software Development Lifecycle (SDLC) Process, Applying the SDLC Process, Applying Cloud Software Assurance and Validation, Using Verified Secure Software, Comprehending the Specifics of Cloud Application Architecture, Designing Appropriate Identity and Access Management (IAM) Solutions. Case studies on Security Issues on Software-as-a-Service	15 Hrs OC3, OC4
Unit IV **a) Cloud Security Operations**: Implementing and Building a Physical and Logical Infrastructure for Cloud Environment, Operating Physical and Logical Infrastructure for a Cloud Environment, Managing Physical and Logical Infrastructure for a Cloud Environment, Implementing Operational Controls and Standards, Supporting Digital Forensics, Managing Communication with Relevant Parties, Case Studies on Digital Forensics in cloud.	15 Hrs OC4, OC5

b) Legal, Risk and Compliance: Articulating Legal Requirements and Unique Risks within the Cloud Environment, Understanding Privacy Issues, Understanding Audit Process, Methodologies, and Required Adaptations for a Cloud Environment, Understanding the Implications of Cloud to Enterprise Risk Management, Understanding Outsourcing and Cloud Contract Design	

References:

a. CCSP® For Dummies® with Online Practice by Arthur J. Deane, John Wiley & Sons, Inc.

b. (ISC)2® CCSP® Certified Cloud Security Professional Official Study Guide by Mike Chapple, David Seidl, 3rd edition, John Wiley & Sons, Inc.

c. ALL IN ONE CCSP® Certified Cloud Security Professional EXAM GUIDE by Daniel Carter 3rd edition McGraw Hill

d. Certified Cloud Security Professional (CCSP) Technology Workbook by Nouman Ahmed Khan, Abubakar Saeed, Muhammad Yousuf, Farah Qadir and Farah Qadir, Version 1. IPSpecialist LTD.

Course Outcomes (OCs):

Upon completing this course, the student will be able to:

OC1: Understand the cloud environment's risks, vulnerabilities, threats, and attacks.

OC2: Learn the concept and strategy for the security measures in the cloud infrastructure.

OC3: Gain knowledge of data storage in different platforms, data security techniques and designing of Information Rights Management.

OC4: Gain knowledge of designing and planning of security controls in cloud infrastructure.

OC5: Learn about risk, threats of applying the SLDC process in the cloud and countermeasures for the same.

OC6: Understand the importance of risk assessment, the principles of data privacy & the standards and operational controls to be implemented in a cloud environment.

Evaluation Scheme

Theory courses of 4 credits: Total marks 100. Out of the total, 50 % each for internal and external evaluation.

A. Internal Evaluation (30m + 10m + 10m = 50 Marks)

The internal assessment marks shall be awarded as follows:

1. **30 marks (Any one of the following):**
   a. Written Test of 30 Marks
   b. SWAYAM (Advanced Course) of minimum 20 hours and certification exam completed or
   c. NPTEL (Advanced Course) of minimum 20 hours and certification exam completed or
   d. Valid International Certifications (Prometric, Pearson, Certiport, Coursera, Udemy and the like)
   e. Certification marks of one completed exam shall be awarded to one course only. For four courses, the students will have to complete four certifications.
   (Note: Only those certification/courses suggested by the department shall be deemed valid, Student cannot do any certification on their own)
2. **10 marks**
   10 marks from every course (Two 4 credits mandatory courses, one 2 credits mandatory course, one 4 credits elective course) coming to a total of 40 marks, shall be awarded on publishing of research paper in UGC approved / Other Journal with plagiarism less than 15%. The marks can be awarded as per the impact factor of the journal, quality of the paper, importance of the contents published, social value.
3. **10 marks**
   Open Book examination based on problem solving related to the respective subject.

i. Suggested format of Question paper of 30 marks for the written test.

Q1.	Attempt *any two* of the following:	16 marks
a.		
b.		
c.		
d.		
Q2.	Attempt *any two* of the following:	14 marks
a.		
b.		
c.		
d.		

B. External Examination: (50 marks) Duration : 2 hrs

	All questions are compulsory	
Q1	(Based on all units) Attempt *any two* of the following:	10 marks
a.	Unit 1	
b.	Unit 2	
c.	Unit 3	
d.	Unit 4	
Q2	(Based on Unit 1) Attempt *any two* of the following:	10 marks
Q3	(Based on Unit 2) Attempt *any two* of the following:	10 marks
Q4	(Based on Unit 3) Attempt *any two* of the following:	10 marks
Q5	(Based on Unit 4) Attempt *any two* of the following:	10 marks

Theory courses of 2 credits: Total marks 50. Out of the total, 50 % each for internal and external evaluation.

A. Internal Evaluation (25 Marks)

The internal assessment marks shall be awarded as follows:

1. 10 marks from every course (Two 4 credits mandatory courses, One 2 credits mandatory course, One 4 credits elective course) coming to a total of 40 marks, shall be awarded on publishing of research paper in UGC approved / Other Journal with plagiarism less than 15%. The marks can be awarded as per the impact factor of the journal, quality of the paper, importance of the contents published, social value.
2. 10 marks - Open Book examination based on problem solving related to the respective subject.
3. 5 marks - Assignment/Group discussion.

B. External Examination: (25 marks) Duration : 1 hr

	All questions are compulsory	
Q1	(Based on Unit 1) Attempt *any two* of the following:	13 marks
Q2	(Based on Unit 2) Attempt *any two* of the following:	12 marks

Practical courses of 2 credits: Total marks 50. Out of the total, 50 % each for internal and external evaluation.

A. Practical Evaluation Internal (25 marks)

1.	Performance during all practical sessions	10
2.	Problem solving with the acquired programming skills	10
3.	Viva Voce	5

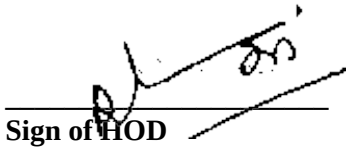
B. Practical Evaluation External (25 marks)

A Certified copy of hard-bound journal is essential to appear for the practical examination.

1.	Practical Question	15
2.	Journal	5
3.	Viva Voce	5

Letter Grades and Grade Points

Semester GPA/Program CGPA Semester/Program	Percentage of Marks	Alpha-Sign/Letter Grade Result
9.00 – 10.00	90.00-100.00	O (Outstanding)
8.00 -<9.00	80.00-<90.00	A+ (Excellent)
7.00-<8.00	70.00-<80.00	A (Very Good)
6.00-<7.00	60.00-<70.00	B+ (Good)
5.50-<6.00	55.00-<60.00	B (Above Average)
5.00-<5.50	50.00-<55.00	C (Average)
4.00-<5.00	40.00-<50.00	P (Pass)
Below 4.00	Below 40.00	F (Fail)
Ab(Absent)	-	Absent



Sign of HOD
Dr. Mrs. R. Srivaramangai
Dept of Information Technology

Team for Creation of Syllabus

Name	Organization	Sign
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Mrs. Shraddha Kadam Shah	Dept of Information Technology (Special Invitee)	
Mr. Jayesh Shinde	Dept of Information Technology (Special Invitee)	
Mr. Nikhil K Pawanikar	Dept of Information Technology (Special Invitee)	
Mr. Mohammed Imran Ansari (Industry Expert)	Principal DevOps Engineer Ingram Micro (Special Invitee)	
Mr. Survendran Kulkarni (Industry Expert)	Director ALTRES Technologies (Special Invitee)	

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Dr. Mrs. R. Srivaramangai
Department of Information Technology

Sign of Dean,
Prof. Shivram Garje
Science and Technology

Appendix B

Justification for M.Sc(IT-Security)

1.	Necessity for starting the program:	The demand for security professionals in the job market has been consistently high and continues to grow. As technology becomes more integrated into various aspects of our lives, the need for cybersecurity experts to protect sensitive information, systems, and infrastructure becomes increasingly critical. So it becomes essential in creating new opportunities for professionals with specialized skills in areas like penetration testing, incident response, ethical hacking, threat intelligence, and cybersecurity governance.
2.	Whether the UGC has recommended the program:	Yes
3.	Whether all the programs have commenced from the academic year 2023-24	The program has commenced from 2022-2023 academic year onwards
4.	The programs started by the University are self-financed, whether adequate number of eligible permanent faculties are available?:	Yes. Some experts are called as visiting faculties
5.	To give details regarding the duration of the program and is it possible to compress the program?:	2 years. Not possible
6.	The intake capacity of each program and no. of admissions given in the current academic year:	40 seats. 2023-2024 admission is yet to start
7.	Opportunities of Employability / Employment available after undertaking these courses:	The field of security offers a wide range of career opportunities and strong employability prospects due to the increasing importance of protecting digital assets, data, and infrastructure from cyber threats. As technology continues to advance, so does the demand for skilled security professionals like ethical hacker, penetration tester, cyber security analyst, security consultant, security architect and so on.

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