Babu Banarasi Das University, Lucknow

Department of Computer Science & Engineering

School of Engineering

Master of Technology (Computer Network) -Regular

Evaluation Scheme

SEMESTER I									
Course Category	**Course Code**	**Code Title**	**Contact Hours**			**Evaluation Scheme**			**Credits**
			L	**T**	**P**	**CIA**	**ESE**	**Course Total**	
C	MCS4101	Advanced Computer Networks	4	0	0	40	60	**100**	**4**
C	MCS4102/ MCS4202	Network and System Security	4	0	0	40	60	**100**	**4**
C	MAS4001	Probability and Statistical Analysis	4	0	0	40	60	**100**	**4**
C	MCS4103	Fundamentals of Theoretical Computer Science	4	0	0	40	60	**100**	**4**
GE		**Generic Elective I**	4	0	0	40	60	**100**	**4**
C	MCS4154	Network and System Security Lab	0	0	2	40	60	**100**	**1**
C	MCS4155	Network Simulation Lab	0	0	2	40	60	**100**	**1**
C	MCS4153	Seminar	0	0	2	100	0	**100**	**1**
Total			**20**	**0**	**6**	**380**	**420**	**800**	**23**

SEMESTER II									
Course Category	Course Code	Code Title	Contact Hours			Evaluation Scheme			Credits
			L	T	P	CIA	ESE	Course Total	
C	MCS4201	TCP/IP Concepts and Programming	4	0	0	40	60	**100**	**4**
C	MCS4203	Mobile Computing	4	0	0	40	60	**100**	**4**
C	MCS4204	Advanced Methods in Distributed Computing	4	0	0	40	60	**100**	**4**
GE		**Generic Elective II**	4	0	0	40	60	**100**	**4**
GE		**Generic Elective III**	4	0	0	40	60	**100**	**4**
C	MCS4254	Mobile Computing Lab	0	0	2	40	60	**100**	**1**
C	MCS4255	Distributed Systems Lab	0	0	2	40	60	**100**	**1**
C	MCS4253	Seminar	0	0	2	100	0	**100**	**1**
Total			**20**	**0**	**6**	**380**	**420**	**800**	**23**

SEMESTER III									
Course Category	Course Code	Code Title	Contact Hours			Evaluation Scheme			Credits
			L	T	P	CIA	ESE	Course Total	
C	MCS4351	State of the art seminar[#]	-	-	-	200	-	**200**	**4**
C	MCS4352	Thesis I[*]	-	-	-	400	-	**400**	**16**
Total			**-**	**-**	**-**	**600**	**-**	**600**	**20**

SEMESTER IV									
Course Category	Course Code	Code Title	Contact Hours			Evaluation Scheme			Credits
			L	T	P	CIA	ESE	Course Total	
C	MCS4451	Thesis II[**]	-	-	-	200	800	**1000**	**28**
Total			**-**	**-**	**-**	**200**	**800**	**1000**	**28**

[#]**SOTA:** The student need to perform a literature survey, will give presentation on state of art topics and will submit a synopsis already mentioned in the problem statement. This will be evaluated internally within two months of the start of the semester and result will be intimated to the students, so to precede for Thesis I.

[*]The student will develop a workable model for the problem they have proposed in the synopsis

[**]This is in continuation with Thesis I. The required experimental/ mathematical verification of the proposed model will be done in this semester.

Legends:

L Number of Lecture Hours per week
T Number of Tutorial Hours per week
P Number of Practical Hours per week
CIA Continuous Internal Assessment
ESE End Semester Examination

Category of Courses:

F Foundation Course
C Core Course
GE Generic Elective
OE Open Elective

Course Code	Generic Elective I
GE44711	IT Security Metrics
GE44712	Introduction to Wireless Networking
GE44713	Cloud Computing
GE44714	Fundamentals of Operating System and DBMS

Course Code	Generic Elective II
GE44721	Internet Routing Design Principles
GE44722	Digital Forensics for Network, Internet, and Cloud Computing
GE44723	Grid Computing
GE44724	Service-Oriented Computing

Course Code	Generic Elective III
GE44731	Multimedia Networking
GE44732	Wireless Broadband Networks
GE44733	Advance Network Security
GE44734	Wireless Network Security and Privacy

Credit Summary Chart						
	Semester					
Course Category	I	II	III	IV	Total Credits	%age
F	0	0	0	0	0	0
C	19	15	20	28	82	87.23
GE	4	8	0	0	12	12.77
Total	**23**	**23**	**20**	**28**	**94**	**100**

Discipline Wise Credit Summary Chart						
	Semester				Total Credits	%age
Course Category	I	II	III	IV		
Basic Sciences	0	0	0	0	0	0
Professional Subject Core	18	14	16	28	76	80.85
Professional Subject -General Elective	4	8	0	0	12	12.77
Project Work, Seminar and / or Internship in Industry or elsewhere.	1	1	4	0	6	6.38
Total	**23**	**23**	**20**	**28**	**94**	**100**

MCS4101 Advanced Computer Networks

Course Outcome:

1. Apply the knowledge about QoS, VPNs, and tunnelling and overlay networks and to understand mobile networking and wireless sensor networking.
2. Acquire foundational understanding on the concept of Internetworking in terms of the technologies and techniques that drive Internet.
3. Deepen understanding of advanced concepts of TCP/IP protocol suite and its architecture.
4. Deepen understanding of advanced concepts of OSI protocol suite and its architecture.

Learning Outcome:

At the end of the course, the student should be able to:

1. Understand packet switching networks and routing in packet switching networks with different routing algorithms.
2. Identify and explain the essential components that drive internetworking
3. Understand the important issues encompassing internetworking and how these issues affect the evolution of Internet and its applications.
4. Describe traffic management at packet level, flow level and flow aggregate levels of packet switching networks.
5. Explain the architecture of TCP/IP and protocols associated with TCP/IP and to analyse the network applications, network management and security issues.
6. Understand the complete architecture of Internetworking and the operations of underlying protocols and software.

Course Contents

Module	Course Topics	Total Hours	Credits
I	**Overview and Network Models** **Foundation:** Requirements, Connectivity, Cost- Effective Resource Sharing, Network Architecture, Layering and Protocols, OSI Architecture, Implementing Network Software, Application Programming Interface (Sockets) , **Asynchronous Transfer Mode:** ATM layered model, switching and switching fabrics, network layer in ATM, QOS, LAN emulation.	30 Hours	1

	Reliable Protocol: Transmission Control Protocol (TCP): Error Control, Flow Control, Congestion Control, Timers, And TCP Options: NOP, MSS, Window Scale Factor, Timestamp, SACK-Permitted and SACK Options		
II	**Application Layer and Security Network** Application Layer: Network application architectures: Client-server, P2P and hybrid; Application layer protocols: DNS, FTP, TFTP, TELNET, HTTP and WWW, SMTP and electronic mail; Network management and SNMP 8 5. Wireless and Mobile Networks: Wireless links and network characteristics, 802.11 wireless LANs, mobility management, addressing and routing, mobile IP, WAP, mobility in cellular networks. **Physical Layer, Media and Data link Layer** -Direct Link Networks, Physically Connecting Hosts, Hardware Building Blocks, Nodes, Links, Encoding (NRZ, NRZI, Manchester, 4B/5B), Framing, Byte- Oriented Protocols (PPP), Bit-Oriented Protocols (HDLC), Clock-Based Framing (SONET), Error Detection, Two-Dimensional Parity, Internet Checksum Algorithm, Cyclic Redundancy Check, Reliable Transmission, Stop-and- Wait, Sliding Window, Concurrent Logical Channels, Rings (802.5, FDDI, RPR), FDDI, Wireless, Bluetooth (802.15.1), Wi-Fi (802.11), WiMax (802.16), Cell Phone Technologies. Packet Switching, Switching and Forwarding, Datagrams, Virtual Circuit Switching.	30 Hours	1
III	**Network Layer and Transport Layer** Transport Layer: Elements of transport protocols; Internet transport protocols: TCP and UDP, TCP connection management, congestion control. Internetworking, Simple Internetworking (IP), What Is an Internetwork? Service Model, Global Addresses, Datagram Forwarding in IP, Address Translation (ARP), Host Configuration (DHCP), Error Reporting (ICMP) Virtual Networks and Tunnels, Routing, Network as a	30 Hours	1

	Graph, Distance Vector (RIP), Link State (OSPF), Metric, Routing for Mobile Hosts, Router Implementation, Global Internet. End-to-End Protocol, Simple Demultiplexer (UDP), Reliable Byte Stream (TCP), End to- End Issues, Segment Format, Connection Establishment and Termination, Sliding Window Revisited, Triggering Transmission, Adaptive Retransmission Record Boundaries, TCP Extensions , Alternative Design Choices ,Remote Procedure Call, RPC Fundamentals, RPC Implementations (SUNRPC, DCE), Transport for Real-Time Applications (RTP), Requirements, RTP Details, Control Protocol, Performance, Open Issue: Application-Specific Protocols. Data Compression, Lossless Compression Algorithms Image Compression (JPEG), Video Compression (MPEG), Transmitting MPEG over a Network		
IV	**Next Generation Network:** Unicast Routing Protocols: RIP, OSPF; Multicasting and Multicast Routing Protocols: Introduction, Multicast Addresses, IGMP, Multicast Routing, Routing Protocols, MBone **Internet Protocol Version 6:** IPV6 Addressing: Introduction, Address Space Allocation, Global Unicast Addresses, Auto configuration, Renumbering; IPV6 Protocol: Packet Format, Transition from Ipv4 TO Ipv6; Generic Routing Encapsulation (GRE) For Tunnelling. **ICMPv6:** Error Messages, Informational Messages, Neighbours-Discovery Messages, Group Membership Messages **Wireless LAN:** Infrared vs. Radio Transmission, Infrastructure and Ad Hoc Networks. IEEE 802.11, System Architecture, Protocol Architecture, Physical Layer, Medium Access Control Layer, MAC Management, Future Development, HIPERLAN, Protocol Architecture, Physical Layer, Channel Access Control Sublayer, Medium Access Control Sublayer, Information Bases and Networking, Bluetooth, User Scenarios, Physical Layer,	30 Hours	1

	MAC Layer, Networking, Security, Link Management		

Text/Reference Books:

1. A. Tanenbaum, "Computer Network", Prentice Hall, 2002.
2. Behrouz A. Forouzan , "TCP/IP Protocol Suite", McGraw- Hill, 4/e, 2009.
3. J.F. Kurose and K.W. Ross, "Computer Networking, A Top-Down Approach Featuring the Internet", Addison-Wesley, 2002.
4. D.E. Comer, "Computer Networks and Internets with Internet Applications", Prentice-Hall, 2001.
5. L.L. Peterson and B.S. Davie, "Computer Networks, A Systems Approach", Morgan Kaufmann, 2000.
6. James F. Kurose, Keith W. Ross, "Computer Networking", Pearson, 2012.

MCS4102/ MCS4202 Network and System Security

Course Outcome:

1. Develop Concept of Security needed in Communication of data through computers and networks along with Various Possible Attacks
2. Understand Various Encryption mechanisms for secure transmission of data and management of key required for required for encryption
3. Understand authentication requirements and study various authentication mechanisms
4. Understand network security concepts and study different Web security mechanisms.

Learning Outcome:

By studying this course, students will be able to

1. Understand cryptography and network security concepts and applications
2. Apply security principals to system design
3. Identify and investigate network security threats
4. Analysis of network traffic and security threats

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction** Introduction to Cryptography and Symmetric Ciphers Security Attacks: Security Services and mechanism; Classical encryption techniques: Substitution ciphers and Transposition ciphers, Steganography, Cryptanalysis; Modern Block Ciphers: Stream and Block Cipher, Block Cipher Principles, Block Cipher Modes of Operations; Shannon's theory of Confusion and Diffusion; Fiestal structure; Data encryption standard(DES); Strength of DES; Idea of differential cryptanalysis; Triple DES; Symmetric Key Distribution; Finite Fields: Introduction to groups, rings and fields, Modular Arithmetic, Euclidean	30 Hours	1

	Algorithm, Finite Fields of the form GF(p).		
II	**Mathematics of symmetric key cryptography** Introduction to Number Theory: Prime and Relative Prime Numbers, Fermat's and Euler's theorem, Testing for Primality, Chinese Remainder theorem, Discrete Logarithms; **Symmetric Key Cipher**: SDES – Block cipher Principles of DES – Strength of DES – Differential and linear cryptanalysis - Block cipher design principles – Block cipher mode of operation – Evaluation criteria for AES – Advanced Encryption Standard - RC4 – Key distribution.	30 Hours	1
III	**Message Authentication And Integrity** Authentication requirement – Authentication function – MAC – Hash function – Security of hash function and MAC – SHA –Digital signature and authentication protocols – DSS- Entity Authentication: Biometrics, Passwords, Advanced Encryption Standard (AES) encryption and decryption, Authentication applications - Kerberos, X.509	30 Hours	1
IV	Security Practice and System Security Electronic Mail Security: Pretty Good Privacy, S/MIME; IP Security: IP Security Architecture, Authentication Header, Encapsulating security payloads, Combining Security Associations; Web Security: Secure Socket Layer and Transport Layer Security, Secure Electronic transaction; Intruder; Viruses; Firewalls.	30 Hours	1

Text/Reference Books:

1. William Stallings, "Cryptography and Network Security: Principals and Practice", Pearson Education, 2010.
2. Behrouz A. Frouzan, "Cryptography and Network Security", Tata McGraw- Hill.
3. Bruce Schiener, "Applied Cryptography".2008 John Wiley & Sons
4. Bernard Menezes," Network Security and Cryptography", Cengage Learning,2010.
5. Atul Kahate, "Cryptography and Network Security", Tata McGraw-Hill, 2006.

MCS4103 Fundamentals of Theoretical Computer Science

Course Objective:

1. To capture, study and compare different models and views of the abstract notion of computation and its various aspects.
2. To understand important notions in computer science like state, non-determinism and minimization are captured in the simple model of finite automata.
3. Automata provide the basis for the implementation of many programming languages, with parsing being a typical example for the application of pushdown automata, which recognize the more powerful class of context-free languages.
4. To characterize the notion of computation as a process which can be physically implemented.

Learning Outcome:

After completing the course, the students should be able to:

1. The overall aim of the course is to provide students with a profound understanding of computation and effective computability through the abstract notion of automata and the language classes they recognize.
2. Along with this, the students will get acquainted with the important notions of state, non-determinism and minimization.
3. After the course, the successful student will be able to perform the following constructions:

   a. Determining and minimizing automata.

   b. Construct an automaton for a given regular expression.

   c. Construct a pushdown automaton for a given context-free language.

   d. Construct a Turing machine deciding a given problem.

   e. Prove undecidability of a given problem by reducing from a known undecidable problem

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Discrete Structures**: Sets, Relations and Functions, Proof Techniques, Algebraic Structures, Morphisms, Posets, Lattices and Boolean Algebras. Logic: Propositional calculus and Predicate Calculus, Satisfiability and validity, Notions of soundness and completeness.	**30**	**1**
II	**Languages & Automata Theory:** Chomsky Hierarchy of Grammars and the corresponding acceptors, Turing Machines, Recursive and Recursively Enumerable Languages; Operations on Languages, closures with respect to the operations.	**30**	**1**
III	**Computability** -- Church-Turing Thesis, Decision Problems, Decidability and Undecidability, Halting Problem of Turing Machines; Problem reduction (Turing and mapping reduction).	**30**	**1**
IV	**Computational complexity:** Time Complexity -- Measuring Complexity, The class P, The class NP, NP-Completeness, Reduction, co-NP, Polynomial Hierarchy. Space Complexity -- Savich's Theorem, The class PSPACE and PSPACE-complete; Intractability: hierarchy theorem, Relativization, Circuit complexity.	**30**	**1**

Text/Reference Books:

1. Introduction to Antomata Theory, Languages of Computations, J. E.

Hopcroft and J. Ullman. Addison Wesley.2001.
2. W. Thomas, Languages, automata, and logic. In G. Rozenberg and A. Salomaa, editors, Handbook of Formal Languages, volume III. Springer, New York, 1997.
3. J.P. Trembley and R. Manohar -- Discrete Mathematical Structures with Applications to Computer Science, McGraw Hill Book Co., 35th edition 2008.
4. Michael Sipser -- Introduction to The Theory of Computation, Thomson Course Technology. 4th edition 2010.
5. H.R. Lewis and C.H.Papadimitrou -- Elements of the Theory of Computation, Prentice Hall, International, Inc, 2005.

MCS4154: Network and System Security Lab

The following programs should be implemented preferably on 'UNIX/WINDOWS' platform using 'C'

LIST OF EXPERIMENTS:

1. Implement Caesar cipher encryption-decryption.
2. Implement Monoalphabetic cipher encryption-decryption.
3. Implement Playfair cipher encryption-decryption.
4. Implement Polyalphabetic cipher encryption-decryption.
5. Implement Hill cipher encryption-decryption.
6. To implement Simple DES or AES.
7. Implement Diffi-Hellmen Key exchange Method.
8. Implement RSA encryption-decryption algorithm.
9. Write a program to generate SHA-1 hash.
10. Implement a digital signature algorithm

MCS4155 Network Simulation Lab

List of Experiments:

1. To study about NS2 simulator in detail.
2. Initialization and Termination of TCL Script in NS-2
3. Including C++ modules into NS2 and make utility Linkage between Otcl and C++ in NS2
4. To create scenario and study the performance of token bus protocol through simulation
5. To create scenario and study the performance of token ring protocols through simulation.
6. To Simulate and to study stop and Wait protocol
7. To study the concept and different frames of HDLC protocol.
8. To simulate and study the Distance Vector routing algorithm using simulation.
9. To simulate and study the link state routing algorithm using simulation.
10. To implement Data encryption and decryption
11. To implement error detection and error correction techniques.
12. To create scenario and study the performance of CSMA / CD protocol through simulation.

MCS4201 TCP/IP Concepts and Programming

Course Objective:

1. To learn the basics of socket programming using TCP Sockets.
2. To develop knowledge of threads for developing high performance scalable applications.
3. To understand simple network management protocols & practical issues
4. To learn the basics of UDP sockets.

Learning Outcome:

After completing the course, the students should be able to:

1. Realize network communication skills through programming.
2. Understand and apply the principles and practices of socket programming.
3. Acquire a good knowledge of the TCP/IP, its architecture and operation.
4. Follow trends of internetworking

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** ISP services, Internet concepts, IP addressing, IP header, ARP, subnetting and Supernetting, Bootstrapping, Routing Fundamentals, PPP, ICMP, Inter-domain routing: GGP, EGP, BGP Interior gateway protocols: RIP, OSPF, Protocol Layering, UDP, ICMP, TCP, TCP: header, connection establishment, ISN, half close, delayed acks, header flags, TCP state transitions, sliding window, Slow Start, Congestion Avoidance, Fast Retransmit, Fast Recovery, DNS, multicasting, IGMP.	**30**	**1**
II	**Client-Server Interaction Model (Socket Interface, BOOTP, DHCP):** Introduction, The Client-Server Model, Complexity of Server, RARP Servers, The Unix I/O Paradigm and Network		

	I/O, Sending and Receiving data through a Socket, IP address manipulation routines, Obtaining Information about Host, BOOTP and DHCP:BOOTP Operations, BOOTP Message format, DHCP Operations, DHCP Message format. Mobile IP, Private IP, NAT, SONET, ATM(LANE and MPOA), TCP/IP over ATM (Classical IP over ATM)	**30**	**1**
III	**Telnet, Rlogin and Voice over IP(RTP):** Concept of Telnet, Telnet Protocol and options, Time Sharing Environment , Network Virtual Terminals, Mode of operations, Rlogin, Real Time Transport Protocol(RTP) :RTP encapsulation , RTP control protocol, RTCP operations, RSVP, QOS and QOS issues.	**30**	**1**
IV	**World Wide Web, Electronic Mail and File Transfer:** File Transfer Protocol (FTP): FTP features, FTP, Process Model. TFTP, NFS: NFS Implementation. RPC, Simple Mail Transfer Protocol: User Agent, Addresses, Mail Transfer Agent, Mail Transfer, phases. MIME: MIME Multipart Messages. POP, HyperText Transfer Protocol: Architectural Components, URL, HTTP Transactions, HTTP Message Format(Header, Response message)	**30**	**1**

Text/Reference Books:

1. Douglas E.Comer, "Internetworking with TCP/IP, Principles, Protocols and Architectures", PHI.5th edition 2006.
2. Forouzan BA, "TCP/IP Protocol Suite", TMH.4th edition 2010.
3. "TCP/IP Unleashed", Pearson Education.3rd Edition 2002.

4. TCP/IP Illustrated, Vol. 1. by Richard Stevens, Addison Wesley Publisher.2nd edition 2011.
5. TCP/IP Network Administration by Craig Hunt, O'Reilly & Associates, Inc 3rd edition 2002.

MCS4203 Mobile Computing

Course Objective:

- Study the basic concepts and functions of Wireless Networks.
- Study the basic concepts of Security Primitives and Wireless Networks.
- Study the basic concepts of Fundamental of Cellular system.
- Study the basic concepts of Security Issues in Single & Multi hop Wireless Network.
- Study the basic concepts of Security Issues in Wireless Systems.

Learning Outcome:

After completing the course, the students should be able to:

- Understand the basics of Wireless Networks.
- To analyze the concept of cellular system.
- To analyze and understand the Security Primitives and Wireless Networks.
- To analyze the basic concepts of Security Issues in Wireless Systems.
- Understand the basic concepts of Security Issues in Single & Multi hop Wireless Network.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction to Mobile Computing**: Applications of Mobile Computing, Generations of Mobile Communication Technologies, Multiplexing ,Spread spectrum, MAC Protocols :-SDMA,TDMA, FDMA,CDMA	30	**1**
II	**Telecommunication System:** GSM: - Channel allocation, call routing Architecture, PLMN interface, addresses and identifiers, network aspects, frequency allocation, authentication and security, Handoffs Technique.	30	1

	GPRS: network operation, data services, Applications, Billing and charging		
III	**MOBILE NETWORK LAYER** Mobile IP: DHCP, AdHoc, Proactive protocol: DSDV, Reactive Routing Protocols: DSR, AODV, Hybrid routing: ZRP, Multicast Routing: ODMRP, Vehicular Ad Hoc networks (VANET), MANET Vs VANET, Security**.** **MOBILE TRANSPORT AND APPLICATION LAYER:-** Mobile TCP, WAP, Architecture , WDP,WTLS,WTP ,WSP,WAE,WTA Architecture ,WML	30	1
IV	**MOBILE PLATFORMS AND APPLICATIONS** Mobile Device Operating Systems: Special Constraints & Requirements, Commercial Mobile Operating Systems, Software Development Kit: iOS, Android, BlackBerry, Windows Phone, Commerce, Structure, Pros & Cons, Mobile Payment System, Security Issues	30	1

Text/Reference Books:

1. Mobile Communications J. Schiller, Pearson education publishing 2003 2.
2. Wireless Communications and Networks W. Stallings, Pearson education publishing 2002
3. Mohammad Ilyas and Imad Mahgoub, "Mobile Computing Handbook", CRC
4. Amjad Umar, "Mobile Computing And Wireless Communications", Nge Solutions
5. Mazliza Othman, "Principles of Mobile Computing and Communications", AUERBACH (October 26, 2007)

MCS4204 Advanced Methods in Distributed Computing

Course Objective:

1. Have knowledge and understanding of the main principles, techniques and methods involved when dealing with distributed systems.
2. Have detailed knowledge and understanding of major issues related to the design of a distributed system, such as: - how to communicate between distributed objects by means of remote invocation
3. Have detailed knowledge and understanding of the absence of global physical time in distributed systems.
4. Have detailed knowledge and understanding of how processes can coordinate their actions in distributed transactions.
5. Have the ability to design and implement prototypical distributed computing applications using different technologies.

Learning Outcome:

After completing the course, the students should be able to:

1. Understand the contrasting features between the distributed views of computing with the centralized one.
2. Understand in detail how distributed applications work and what requirements they aim to satisfy.
3. Understand in detail how distributed applications work and what issues And challenges they must contend with.
4. Understand in detail how distributed applications work and what architecture they exhibit.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Introduction to distributed systems: A model of distributed computations, A distributed program, A model of distributed executions, Models of communication networks, Global state of a distributed system, Cuts of a distributed computation, Past and future cones of an event, Models of process communications. Logical Time: A framework for a system of logical clocks: Scalar time, Vector time, Matrix time, Virtual time, Physical clock synchronization. Global State: Local State and state of channel, System Model And Definitions, Snapshot recording	30 Hrs	**1**

	Algorithms : Snapshot recording algorithm for FIFO Channels, Variations of the Chandy–Lamport algorithm, Snapshot algorithms for non-FIFO channels, Snapshots in a causal delivery system, Monitoring global state, Necessary and sufficient conditions for consistent global snapshots, Finding consistent global snapshots in a distributed computation.		
II	Message ordering: Message ordering paradigms, Asynchronous execution with synchronous communication, Synchronous program order on an asynchronous system; Group communication : Causal order (CO) , Total order , A nomenclature for multicast, Propagation trees for multicast, Classification of application-level multicast algorithms, Distributed multicast algorithms at the network layer. Termination Detection: System model of a distributed computation, Termination detection using distributed snapshots, Termination detection by weight throwing, A spanning-tree-based termination detection algorithm, Message optimal termination detection, Termination detection in a very general distributed computing model, Termination detection in the atomic computation model, Termination detection in a faulty distributed system	30 Hrs	**1**
III	Mutual Exclusion: Non- Token based mutual exclusion algorithms: Lamport's algorithm, Ricart–Agrawala algorithm, Quorum-based mutual exclusion algorithms: Maekawa's algorithm, Agarwal–El Abbadi quorum-based Algorithm, Token-based Algorithms: Suzuki–Kasami's broadcast algorithm, Raymond's tree-based algorithm. Deadlock detection in distributed systems :Models of deadlocks, Knapp's classification of distributed deadlock detection	30 Hrs	**1**

	algorithms, Mitchell and Merritt's algorithm for the single resource model, Chandy–Misra–Haas algorithm for the AND model Chandy–Misra–Haas algorithm for the OR model.		
IV	Transactional concurrency control: Transactions , Nested transactions Locks, Optimistic concurrency control. Interprocess communication: characteristics group communication, Multicast Communication, Remote Procedure call Network virtualization.	30 Hrs	1

Text/Reference Books:

1. Coulouris, Dollimore, Kindberg, "Distributed System: Concepts and Design" Pearson Education Press, 1994.
2. Gerald Tel, "Distributed Algorithms", Cambridge University Press, 2002.

MCS4254 Mobile Computing Lab

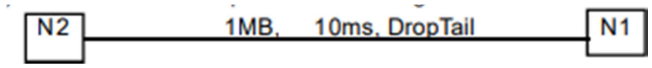
List of Experiments

1. Study of GSM architecture and signalling techniques.
2. Study of Cellular system and related concepts.
3. Study of GPRS services.
4. Study of WAP architecture.
5. Design a web page using WML.
6. Study of Bluetooth architecture.
7. Study of IEEE 802.11 network topology.
8. Study of Distributed mobile computing.

9) Installing NS2 or NS3.

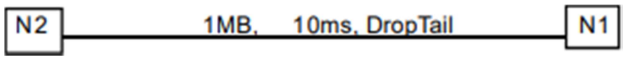
10) Create a TCL Script for the following network.

N2 1MB, 10ms, DropTail N1.



Create FTP traffic over TCP. Find out the throughput using GREP command.

11)) Create a TCL Script for the following network.



Create CBR traffic over UDP. Find out the throughput using GREP command.

MCS4255 Distributed System Lab

List of Practicals

1. Logical Clocks: Implement a Logical Clock, Jard–Jourdan's adaptive technique
2. Learn to compile and deploy a grid service using Globus Toolkit.
3. Shortcut deployment of grid service using ant.
4. Implement Vector Clocks.
5. Simulate Balanced Sliding Window Protocol.
6. Implement Distributed mutual exclusion algorithms: Singhal's dynamic information-structure algorithm, Lodha and Kshemkalyani's fair mutual xclusion algorithm, Agarwal–El Abbadi quorum-based algorithm, Raymond's tree-based algorithm.
7. Implement Deadlock detection in distributed systems: Mitchell andMerritt's algorithm for the single resource model, Chandy–Misra–Haas algorithm for the AND model, Chandy–Misra–Haas algorithm for the OR model.
8. Testing and debugging distributed programs using global predicates.

GE44711 IT Security Metrics

Course Objective:

1. IT security metrics provide a practical approach to measuring information security.
2. Evaluating security at the system level.
3. IT security metrics are tools that facilitate decision making and accountability through collection, analysis.
4. It security metrics tools facilitates reporting of relevant performance data.

Learning Outcome:

After completing the course, the students should be able to:

1. Define the metrics program goals and objectives
2. Decide which metrics to generate
3. Develop strategies for generating the metrics
4. Establish benchmarks and targets
5. Determine how the metrics will be reported
6. Create an action plan and act on it
7. Establish a formal program review/refinement cycle

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction** What Is a Security Metric? Metric and Measurement, Security Metrics Today; Designing Effective Security Metrics: Choosing Good Metrics; GQM for Better Security Metrics; More Security Uses for GQM; Understanding Data: What Are Data?, Data Sources for Security Metrics.	30	1
II	**Infrastructure and Network Security** Python programming environment Overview. Introduction to System Security, Server Security, OS Security, Physical Security, Introduction to Networks, Network packet Sniffing, Network Design Simulation. DOS/ DDOS attacks. Asset Management and Audits, Vulnerabilities and Attacks. Intrusion detection and Prevention Techniques, Host based Intrusion prevention Systems, Security Information Management, Network Session Analysis, System Integrity Validation.	30	1

III	**Measurements of Security** Measurements Security Operations :Sample Metrics for Security Operations, Sample Measurement Project for Security Operations ;Measuring Compliance and Conformance :The Challenges of Measuring Compliance, Sample Measurement Projects for Compliance and Conformance; Measuring Security Cost and Value, The Importance of Data to Measuring Cost and Value; Measuring People, Organizations, and Culture: Sample Measurement Projects for People, Organizations, and Culture.	30	1
IV	**Security in Evolving Technology** Biometrics, Mobile Computing and Hardening on android and ios, IOT Security, Web server configuration and Security. Introduction, Basic security for HTTP Applications and Services, Basic Security for Web Services like SOAP, REST etc., Identity Management and Web Services, Authorization Patterns, Security Considerations, Challenges. Open Source/ Free/ Trial Tools: adb for android, xcode for ios, Implementation of REST/ SOAP web services and Security implementations Reviews and Conclusion	30	1

Text/Reference Books:

1. "IT Security Metrics", Lance Hayden, TATA McGraw-HILL.2010
2. "Security Metrics", CAROLINE WONG, TATA McGraw-HILL 2000
3. William Stallings, "Cryptography and Network Security", Pearson Education/PHI, 2006.
4. Gupta Sarika, "Information and Cyber Security", Khanna Publishing House, Delhi.2019
5. Atul Kahate, "Cryptography and Network Security", McGraw Hill. 2006
6. V.K. Pachghare, "Cryptography and Information Security", PHI Learning 2019

GE44712 Introduction to Wireless Networking

Course Objective:

1. Study the basic concepts and functions of Wireless Local Area Networks.
2. Study the basic concepts of IEEE 802.11.
3. Study the basic concepts of Bluetooth.
4. Study the basic concepts of Mobile and Ad Hoc Network.
5. Study the basic concepts of wireless sensor network.

Learning Outcome:

At the end of the course, the student should be able to:

1. An ability to understand the basics of Wireless Local Area Networks.
2. To analyze the concept of Bluetooth.
3. To analyze and understand the Mobile and Ad Hoc Network.
4. To analyze the basic concepts of IEEE 802.11.
5. An ability to understand the basic concepts of wireless sensor network.

Module	Course Topics	Total Hours	Credits
1	**INTRODUCTION WLAN:-** Wireless Networking Trends, Key Wireless Physical Layer Concepts, Multiple Access Technologies -CDMA, FDMA, TDMA, Spread Spectrum technologies, Frequency reuse, Radio Propagation and Modelling, Radio Wave Propagation, Radio Transmitters and Receivers, Challenges in Mobile Computing: Resource poorness, Bandwidth, energy etc. **WIRELESS LAN:-** IEEE 802.11 Wireless LANs Physical & MAC layer, 802.11 MAC Modes (DCF & PCF) IEEE 802.11 standards, Architecture & protocols, Problems, Fading Effects in Indoor and outdoor WLANs, WLAN Deployment issues. **Wi-MAX** (Physical layer, Media access control, Mobility and Networking), IEEE 802.22 Wireless Regional Area Networks, IEEE 802.21 Media Independent Handover Overview WIRELESS SENSOR NETWORKS Introduction, Application, Physical, MAC layer and Network Layer, Power Management, Tiny OS Overview, VoWiFi, DECT, Bluetooth.	30 Hours	1
2	**MOBILE Ad Hoc Network and Wireless network:-** Mobile Ad-Hoc Networks; Physical Layer and MAC,	30 Hours	1

	Routing in Ad Hoc Networks; Wireless Sensor Networks, Applications; Plant Network Layouts; Plant Network Architecture; Sensor Subnet Selection; Functional Requirements; Reliable Wireless Networks for Industrial Applications; Benefits of Using Wireless; Issues in Deploying Wireless Systems; Wireless Formats; Wireless Mesh Networks; Industrial Applications of Wireless Mesh Networks; Applications and Technologies; Wireless Local Area Networks (WLAN); Bluetooth; Zigbee; Conflict and Compatibility; Ultra-wideband Technology.		
3	**INTERNETWORKING BETWEEN WLANS AND WWANS: -** Internetworking objectives and requirements, Schemes to connect WLANS and 3G Networks, Session Mobility, Internetworking Architecture for WLAN and GPRS, System Description, Local Multipoint Distribution Service, Multichannel Multipoint Distribution System. **Mobile Network Layer:-** Mobile Network Layer Mobile IP: IP packet delivery, Agent discovery, tunneling and encapsulation, IPV6- Network layer in the internet- Mobile IP session initiation protocol – mobile ad-hoc network: Routing: Destination Sequence distance vector, IoT: CoAP.	30 Hours	1
4	**Security in Wireless Local Area Networks:-** Indoor Networks: Behind Closed Doors, Microwave Properties of Building Materials, Realistic Metal Obstacles, Real Indoor Propagation, Indoor Interferers, Tools for Indoor Networks; Security in Wireless Local Area Networks; Key Establishment in 802.11; Anonymity in 802.11; Authentication in 802.11; Confidentiality in 802.11; Data Integrity in 802.11; Loopholes in 802.11 Security; 10.8 WPA; 10.9 WPA2; (802.11i) Voice Over Wi-Fi and Other Wi-Fi and Cellular Networks.	30 Hours	1

Text/Reference Books:

1. J.Schiller, "Mobile Communication", Addison Wesley, 2000.
2. William Stallings, "Wireless Communication and Networks", Pearson Education, 2003.
3. Singhal, "WAP-Wireless Application Protocol", Pearson Education, 2003.
4. Lother Merk, Martin. S. Nicklaus and Thomas Stober, "Principle of Mobile Computing", Second Edition, Springer, 2003.
5. William C. Y. Lee, "Mobile Communication Design Fundamentals", John Wiley, 1993.

GE44713 Cloud Computing

Course Objective:

1. To impart fundamental concepts in the area of cloud computing
2. To impart knowledge in applications of cloud computing.
3. This course covers a series of current cloud computing technologies, including technologies for IaaS, PaaS and SaaS models.
4. To impart knowledge of the different layers of the cloud technologies, practical solutions such as Google, Amazon, Microsoft, SalesForce.com, etc.
5. To impart knowledge of security, Analytic and Machine Learning in cloud computing.

Learning Outcome:

After completing the course, the students should be able to:

1. Understanding the systems, protocols and mechanisms to support cloud computing.
2. Develop applications for cloud computing
3. Understanding the hardware necessary for cloud computing.
4. Design and implement a novel cloud computing application.
5. Accessing the services and virtualization of the cloud computing.
6. Understand the concept of the IoT and Machine Learning in cloud computing.

Course Contents:

Module	**Course Topics**	**Total Hours**	**Credits**
I	**Cloud Computing Basics:** Introduction: Cloud Computing Overview, Cloud Components, Services Infrastructure, Applications, Storage, Cloud Application Architectures, The Value of Cloud Computing, Cloud Infrastructure Models, Database Services, Intranets and the Cloud components, Hypervisor Applications, First Movers in the Cloud: Amazon, Google, Microsoft	30	**1**

II	**Organization and Cloud Computing:** Use of Cloud Computing, Benefits, Scalability, Simplicity, Knowledgeable More Internal Resources Security Limitations, Developing Your Own Applications, Platforms, Web Application Framework, Web Hosting Service, Proprietary Methods, Web Applications, Sample Applications Web APIs	30	**1**
III	**Cloud Security, Virtualization Cloud Application Development**: Cloud security risks, Security: The top concern for cloud users, Privacy and privacy impact assessment, Trust, Operating system security, Virtual machine Security, Security of virtualization, Security risks posed by shared images, Security risks posed by a management OS, A trusted virtual machine monitor, Amazon web services: EC2 instances, Connecting clients to cloud instances through firewalls, Security rules for application and transport layer protocols in EC2. Resource Virtualization: Virtualization, Layering and virtualization, Virtual machine monitors, Virtual Machines, Performance and Security Isolation, Full virtualization and paravirtualization, Hardware support for virtualization.	30	**1**
IV	**Analytics and future trends in cloud computing**: MapReduce, Usage of Amazon's MapReduce Hadoop, IoT-Driven Analytics in Cloud, Real-Time Decision-Making Support Systems, Machine Learning in a Public Cloud, Current Limitations of Cloud Computing, Emergence of Internet of Things (IoT), Emergence of Machine Learning, Emergence of Edge Computing, Security Issues & Solutions in Edge Computing, Outsourced Computing Using Homomorphic Encryption, Patching for Security, Machine Learning for Security, Future Work Needed	**30**	**1**

Text/Reference Books:

1. Anthony T Velte and Toby J Velte, "A Cloud computing: Practical Approach", Mc-GrawHill. Year (2010)

2. Syed A Ahson, "Cloud computing and Software Services", CRC Press. Year 2010

3. George Reese, "Cloud Application Architectures", O'Reilly Press. Year 2009.

4. Naresh Kumar Sehgal, Pramod Chandra P. Bhatt, John M. Acken' Cloud Computing with Security: Concepts and Practices"' Second Edition, Springer International Publishing, Year: 2012.

GE44714 Fundamental of Operating System and DBMS

Course Objective:

1. Study the basic concepts and functions of operating systems.
2. Study the basic concepts of Database management system.
3. Understand the structure and functions of OS.
4. Learn about Processes, Threads and Scheduling algorithms.
5. Understand the principles of concurrency and Deadlocks.
6. Learn various memory management schemes.
7. Study I/O management and File systems.

Learning Outcome:

After completing the course, the students should be able to:

1. Design various Scheduling algorithms.
2. Apply the principles of concurrency.
3. Design deadlock, prevention and avoidance algorithms.
4. Compare and contrast various memory management schemes.
5. Design and Implement a prototype file systems

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Operating System Introduction:** Structures - Simple Batch, Multi programmed, time-shared, Personal Computer, Parallel, Distributed Systems, Real-Time Systems, System components, Operating-System services, System Calls, Virtual Machines, System Design and Implementation. Process and CPU Scheduling - Process concepts and scheduling, Operation on processes, Cooperating Processes, Threads, and Interposes Communication Scheduling Criteria, Scheduling Algorithm, Multiple -Processor Scheduling,	30	1
II	**Memory Management and Virtual Memory:** Logical versus Physical Address Space, Swapping, Contiguous Allocation, Paging, Segmentation, Segmentation with Paging. Demand Paging, Performance of Demanding Paging, Page Replacement, Page Replacement Algorithm, Allocation of Frames, Thrashing. Deadlocks - System Model, Dead locks Characterization, Methods for Handling Dead locks Deadlock	30	1

	Prevention,Deadlock Avoidance, Deadlock Detection, and Recovery from Deadlock. Process Management and Synchronization - The Critical Section Problem, Synchronization Hardware, Semaphores, and Classical Problems of Synchronization, Critical Regions, Monitors.		
III	**Relational algebra and calculus:** Relational Algebra: Selection, Projection, Set Operations, Renaming, Joins, Division, Relational Calculus, Tuple Relational Calculus ,Domain Relational Calculus, Expressive Power of Algebra and Calculus; Structure query language: Queries, Programming, Triggers. The Form of a Basic SQL Query: Expressions and Strings in the SELECT Command, UNION, INTERSECT.,EXCEPT, Nested Queries, Aggregate Operators, Null Values, Embedded SQL, Cursors, ODBC, JDBC; Complex Integrity Constraints in SQL: Triggers and Active Databases, Constraints versus Triggers; The Memory Hierarchy; RAID; Data Striping; Redundancy; Disk Space Management; Files and Indexes: File organizations and indexes: Cost Model; Heap Files, Sorted Files, Hashed Files, Choosing a File Organization, Indexes, Properties of Indexes; Tree- structured indexing: Indexed Sequential Access Method (ISAM), B+ Trees, Format of a Node, Search Insert, Delete; Hash-based indexing: Static Hashing, Extendible Hashing, Linear Hashing, Extendible Hashing versus Linear Hashing; Evaluation of relational operators: Introduction to Query Processing, The Selection Operation, General Selection Conditions, The Projection Operation, The Join Operation, The Set Operations, Aggregate Operations; Introduction to query optimization: Overview of Relational Query Optimization, System Catalogue in a Relational DBMS, A typical relational query optimizer, Translating SQL Queries into Algebra, Estimating the Cost of a Plan, Relational Algebra Equivalences, Enumeration of Alternative Plans, Nested Sub queries, Other Approaches to Query Optimization.	30	1

IV	**Schema refinement and normal forms:** Functional Dependencies, Normal Forms, Decompositions, Normalization, Other Kinds of Dependencies; introduction to Database Security: Access Control, Discretionary Access Control, Mandatory Access Control; Transaction management overview: The Concept of a Transaction, Transactions and Schedules, Concurrent Execution of Transactions, Lock-Based Concurrency Control; Introduction to Crash Recovery: Lock-Based Concurrency Control Revisited, Lock Management, Specialized Locking Techniques, Transaction Support in SQL, Concurrency Control without Locking; Crash recovery: Recovering from a System Crash, Media Recovery, Other Algorithms and Interaction with Concurrency Control.	30	1

Text/Reference Books:

1. J. Peterson, A. Silberschatz, and P. Galvin, "Operating System Concepts", Addison Wesley. 2012
2. A. V. Aho, R. Sethi, and J. D. Ullman, "Compilers: Principles, Techniques and Tools", Addison-Wesley. 2013
3. R. El. Masri and S. B. Navathe, "Fundamentals of Data Base Systems", Benjamin Cummings. 2013

GE44721 Internet Routing Design Principles

Course Objective:

1. This course deals with general concepts and design alternatives for interdomain routing, i.e., routing between autonomous systems in the Internet.
2. Students will get a deep understanding of the design, configuration, and operation of inter-domain routing in general.
3. In particular, students will get hands-on experience in using the Border Gateway Protocol (BGP).

Learning Outcome:

After completing the course, the students should be able to:

1. Identify design principles of an scalable converged networks
2. Describe at a conceptual level, the principles underlying scalable routing protocols e.g. multi area OSPF, EIGRP, BGP
3. Identify and effectively communicate the advantages and limitations of scalable routing protocols and their suitability for the small, medium and large enterprise
4. Configure the routers of a designed internet with the appropriate scalable routing protocols for internal connectivity and access to an Internet Service Provider (ISP)
5. Explain internal and external Border Gateway Protocol (BGP) properties and limits, and configure routers for a typical enterprise to ISP connection scenario
6. Optimize an internet's use of routing updates in a multi-protocol scenario
7. Compare and contrast interior and exterior scalable routing protocols.
8. Configure routers using a mixture of IPv4 and IPv6 protocols

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction** Networking and Network Routing: An Introduction; Addressing and Internet Service: An Overview, Network Routing, IP Addressing, Service Architecture; Protocol Stack	30 Hours	1

	Architecture; Router Architecture; Network Topology; Architecture; Network Management Architecture; Public Switched Telephone Network		
II	**Routing Algorithms** Shortest Path and Widest Path: Bellman–Ford Algorithm, Distance Vector Approach, Dijkstra's Algorithm, Widest Path Algorithm, Dijkstra-Based Approach, Bellman–Ford-Based Approach, k-Shortest Paths Algorithm; OSPF and Integrated IS-IS: OSPF, Protocol Features: OSPF Packet Format, Integrated ISIS: Key Features, comparison; BGP: Features, Operations, Configuration Initialization, phases, Message Format; IP Routing; Distance Vector Protocol Family: RIPv1, RIPv2.	30 Hours	1
III	**Routing Protocols** Framework and Principles, Routing Protocol, Routing Algorithm, Routing Table, Routing Information Representation, Protocol Messages, Distance Vector Routing Protocol, Link State Routing Protocol, Path Vector Routing Protocol, Link Cost **IP Address Lookup Algorithms:** Impact of Addressing on Lookup, Longest Prefix Matching, Naïve Algorithms, Binary Tries, Multi bit Tries, Search by Length Algorithms, Search by Value Approaches	30 Hours	1
IV	**Router Architectures**: Functions of a Router, Types of Routers, Elements of a Router, Packet Flow, Packet Processing: Fast Path versus Slow Path, Router Architectures **Introduction to IP Packet Filtering and Classification**: Importance of Packet	30 Hours	1

	Classification, Packet Classification Problem, Packet Classification Algorithms **Towards Next Generation Routing**: QoS Routing, MPLS and GMPLS: Background of QoS and QoS Routing, QoS Attribues, Traffic Engineering Extension to Routing Protocols, Multiprotocol Label Switching (MPLS), Generalized MPLS, MPLS Virtual Private Networks		

Text/Reference Books:

1. Computer Networking: A Top-Down Approach, 7th edition, by James Kurose and Keith Ross, 2016
2. Deepankar Medhi, Kartikeyan Ramasamy , "Network Routing – Algorithms, Protocols, Architecture", Morgan Kauffman Series Publication, 2007
3. Subir Kumar Sarkar, T G Basavaraju and C Puttamadappa, "Ad Hoc Mobile Wireless Networks – Principles, Protocols and Applications", Auerbach publications, 2nd edition, 2016
4. Computer Networks: A Systems Approach, by Peterson and Davies, 5th Ed, Morgan Kaufmann, 2011
5. Computer Networks by A. Tanenbaum, Prentice Hall, 5th ed, 2013

GE44722 Digital Forensics for Network, Internet and Cloud Computing

Course Objective:

1. Study the basic concepts of Computer Forensics and Investigations
2. Elaborate on, compare and evaluate theories of digital forensics.
3. Support digital forensics specialists by collecting, preserving, storing and analyzing digital forensic evidence
4. Learn about the importance of DHCP Logs and Snort
5. Understand the principles of Commercial Net Flow Applications and Silent Runner.
6. Study Internet Forensics and Cloud Forensics.
7. Study of Machine Learning Techniques in Cloud Forensics

Learning Outcome:

After completing the course, the students should be able to:

1. Define and discuss the concepts of computer forensics
2. Explain the career of a computer forensics professional.
3. Explain and apply the concepts of computer investigations.
4. Setup and operate in an investigator's office and laboratory.
5. Select and apply current computer forensics tools.
6. Identify and apply current practices for processing crime and incident scenes.
7. Explain and apply digital evidence controls.
8. Explain and perform forensic analysis in various operating system environments.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Introduction to digital Forensics, Computer Forensics and Investigations Methodologies, Role of technology in crime, Ethics in Digital Forensics, Data Acquisition, Computer Forensics Tools, Forensics Analysis and Validation, Network Forensics, Introduction to Cloud Computing, Introduction to the Incident Response Process, Investigative and Forensics Methodologies,	30	**1**

	Where Network Forensics Fits In?, Capturing Network Traffic, The Importance of DHCP Logs, Using TCPDump/ WinDump, Using Wireshark, Using SPAN Ports or TAPS, Using Fiddler, Firewalls, Placement of Sensors, Using Snort for Network-Based Forensics, IDS Overview, Snort Architecture, Snort Preprocessor Component ,Snort Detection Engine Components, Network Forensics Evidence Generated with Snort		
II	Other Network Evidence, Overview of Botnets and Other Network-Aware Malware, Temporal, Relational, and Functional Analyses and Victimology, First Responder Evidence, Dynamic Evidence Capture, Malware Analysis: Using Sandbox Technology, Deciphering a TCP Header, OSI and TCP Reference Models, TCP Header ,Decipherment of a TCP Segment, TCP Signature Analysis, Incorporating Network Forensics into Incident Response Plans, Investigation Method ,Incident Response, DMCAViolations, Web Site Compromise: Search Engine Spam and Phishing	30	**1**
III	Commercial Net Flow Applications, What Is Net Flow? What Is an FNF? What Is an sFlow? Which Is Better: NetFlow or sFlow? Scrutinizer, Using Flow Analytics to Identify Threats within NetFlow. NetWitness Investigator, NetWitness Investigator Architecture, Import/Live Capture Network Traffic, Collections, Parsers, Feeds, and Rules, Navigation Views, Data Analysis, Exporting Captured Data, Silent Runner by Access Data, History of Silent Runner, Installing Silent Runner, Silent Runner Terminology.	**30**	**1**
IV	Machine Learning Forensics, Digital Investigative Maps and Models, Extractive Forensics: Link Analysis and Text Mining. Inductive Forensics Clustering Incidents and Crime s, Deductive Forensics-Anticipating Attacks and Precrime, Fraud Detection: On the Web, Wireless, and in Real Time, Forensic Ensemble Techniques Overview of Cloud Computing, Cloud Components, Services Infrastructure, Applications, Storage, Cloud Application Architectures, The Value of Cloud Computing, Cloud Infrastructure Models, Database Services, Intranets	**30**	**1**

	and the Cloud components, Hypervisor Applications, Current State of Cloud Computing, Next Phases of Cloud Computing, The Future of Network. Forensics, Today's Challenges with Existing Devices for Network Forensics, Network Forensics Quadrants of Focus Network Forensics Analysis Tools.		

Text/Reference Books:

1. Clint Garrison, "Digital Forensics for Network, Internet and Cloud Computing", Syengress Year 2010
2. Bill Nelson, Amelia Phillips, Christopher Steuart, "Guide to Computer Forensics and Investigations" CRC Press Year 2018
3. Jesus Mena "Machine Learning Forensics for Law Enforcement, Security, and Intelligence" CRC Press Year 2011

GE44723 Grid Computing
Course Objective:

1. To provide an overview of the basic concepts of Grid Computing.
2. To highlight the advantages of deploying Grid Computing.
3. To illustrate the practical adoption of a Grid deployment through real life case Studies.
4. To impart the knowledge of the Globus tool kit.

Learning Outcome:

At the end of the course, the student should be able to:

1. Understand and explain the basic concepts of Grid Computing.
2. Explain the advantages of using Grid Computing within a given environment.
3. Prepare for any upcoming Grid deployments and be able to get started with a Potentially available Grid setup.
4. Learn the implementations and developing the applications using Globus tool Kit.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**INTRODUCTION AND OVERVIEW OF GRID COMPUTING ARCHITECTURE:-**Parallel and Distributed Computing**,** Cluster Computing**,** Grid Computing**,** cloud computing, Anatomy and Physiology of Grid**,** Worldwide Initiatives Grid Computing Organizations**,** Roles of the Grid Computing**,** The Grid Computing Road Map**,** and OGSA**:** Some Sample Use Cases that Drive the OGSA**,** The OGSA Platform Components**,** OGSA Trends, Challenges and applications, WSRF.	30 Hours	1
II	**Grid Monitoring:-** Grid Monitoring Architecture (GMA)- An Overview of Grid Monitoring Systems- R-GMA-GridICE– MDS- Service Level Agreements (SLAs)- Other Monitoring Systems- Ganglia, GridMon, Hawkeye and Network Weather Service. **GRID MIDDLEWARE :-** List of globally available Middlewares - Case Studies- Recent version of Globus Toolkit and gLite - Architecture, Components and Features. Features of Next generation grid.	30 Hours	1

III	**Gid Security and Resource Management:-** Grid Security**,** Security Primer**,** PKI-X509 Certificates**,** Working principles of Scheduling, A Review of Condor, SGE, PBS and LSF**,** Grid Scheduling with QoS, Grid Scheduling**,** Scheduling Paradigms**,** Resource Management.	30 Hours	1
IV	**Data Management and Grid Tool kit:-** Data Management**:** Categories and Origins of Structured Data**,** Data Management Challenges**,** Architectural Approaches**,** Collective Data Management Services**,** Federation Services**,** Grid Portals**,** First Generation Grid Portals**,** Second Generation Grid Portals**,** GLOBUS GT3 Toolkit**:** Architecture GLOBUS GT3 Toolkit**,** Implementation GLOBUS GT3 Toolkit.	30 Hours	1

Text/Reference Books:

1. Fran Berman, Geoffrey Fox and Tony Hey, "Grid Computing: Making the Global Infrastructure a Reality", Wiley, 2003.
2. Bart Jacob, "Enabling application for Grid Computing with Globus",IBM.Com/Red Books, 2003.
3. Vladimir Silva," Grid Computing for developers", 1/E, Charles River Media, 2005.
4. Joshy Joseph, Craig Fellenstein,"Grid Computing", IBM Press, 2003.
5. Ahmar Abbas, "Grid Computing: A Practical Guide to technology And Applications", Charles River media – 2003.

GE44724 Service Oriented Computing

Course Objective:

1. This course describes the foundation of Service Oriented Architecture with its characteristics and advantages.
2. It strongly describes distinction between client-server, two-tier, three-tier and Enterprise architectures.
3. Course continuous with Basic of web services and Introduction to SOAP, REST, WSDL and UDDI.
4. It also highlights the SOAP and REST architecture along with its importance and standards.
5. WS-BPEL specifies the framework for Web services.

Learning Outcome:

After learning the course, the student will be able:

1. To understand the Service oriented architecture.
2. To understand and describe the standards & technologies of modern web services implementations.
3. To properly use market-leading development tools to create and consume web services.
4. To analyze and select the appropriate framework components in the creation of web service solutions.
5. To apply object-oriented programming principles to the creation of web service solutions.
6. To identify the requirements of a medium-difficulty programming task, and create software that meets the requirements.

Course Contents:

Module	Course topic	Total Hrs	credit
1	**SOC Introduction** Distributed computing in the large, Motivations for composition, Challenges for composition, Web Services Architectures and Standards, Computing with Services, W3C **Roots of SOA** Fundamental of SOA, Characteristics of SOA, Comparing SOA to client-server and distributed internet architectures, Anatomy of	30	1

	SOA, How components in an SOA interrelate,		
2	**Enterprise Architectures and SOC Principles** Introduction, Integration versus interoperation , Model Driven Architecture , Concepts of Distributed Computing, XML, Use cases: Intra-enterprise and Inter-enterprise Interoperation, Application, Configuration, Dynamic Selection, Software Fault Tolerance,	30	1
	Service Oriented Analysis Business-centric SOA – Deriving business, Services, Service modeling, Service Oriented Design; WSDL Basics, SOAP Basics, UDDI Basics, REST Basics, Difference between SOAP v/s REST		
3	**Web Service Basics** Service Description, Messaging with SOAP, Message Exchange pattern, Coordination, Transaction, Business Activities, **Orchestration, Choreography.** Service layer Abstraction - Application Service Layer, Business Service Layer, Orchestration Service Layer **Service Composition** Service composition guidelines – Entity-centric business service design, Application service design, Task centric business, service design	30	**1**
4	**SOA Platform basics** SOA support in J2EE: Java API for XML based web services (JAX-WS), Java architecture for XML binding (JAXB), Java API for XML Registries (JAXR), Java API for XML based RPC (JAX- RPC), Web Services Interoperability **Technologies (WSIT).** SOA support in .NET: Common Language Runtime, ASP.NET web forms, ASP.NET web services, Web Services Enhancements (WSE).	30	1

Reference Books:

- Munindar Singh & Michael Huhns, "Service Oriented Computing: Semantics, Processes, Agents", Wiley Publication, 2004
- Thomas Erl, "Service-Oriented Architecture: Concepts, Technology, and

Design", Pearson Education, 2005
- Thomas Erl, "SOA Principles of Service Design" (The Prentice Hall Service-Oriented Computing Series from Thomas Erl), 2005
- Mark D Hansen, "SOA using Java™ Web Services", Prentice Hall Publication, 2007
- Dan Woods and Thomas Mattern, "Enterprise SOA Designing IT for Business Innovation" O'REILLY.
- Shankar Kambhampaty, "Service-oriented Architecture for Enterprise Applications", John Wiley & Sons, 2008

GE44731 Multimedia Networking

Course Outcomes:

1. The course allows students to support or design networks which run effectively multimedia applications.
2. Developers for multimedia applications will understand the influences of the network and means to adapt to them by existing methods.
3. familiarize himself/herself with video compression standards
4. Students will understand the market drivers and the directions for further development

Learning Outcomes:

At the end of the course, the student should be able to:

1. Understand the basics of analog and digital video: video representation and transmission
2. Analyse analog and digital video signals and systems
3. Know the fundamental video processing techniques
4. Acquire the basic skill of designing video compression
5. know the basic techniques in designing video transmission systems: error control and rate control
6. Students will learn to use and configure essential office applications including word processing, spreadsheets.

Course Content

Module	Course Topics	Total Hours	Credits
I	**Introduction to Multimedia Computing and Networking-** Networking Introduction (Applications, TCP, UDP), Wireless networks: WLAN, Cellular networks, Multimedia concepts - Compression basics, JPEG, MPEG, H.264, Scalable video coding, Performance metrics. Telematics: Infotainment in automobiles, Major components of Multimedia Networking. **Digital Speech Coding-** Digital Speech Coding: LPC modelling and Vocoder, Regular Pulse Excitation with long-term prediction, Code-Excited Linear Prediction (CELP),	30 Hours	1

	Multiple Pulse-Excitation Coding. **Digital Audio Coding**: Human Psychoacoustics, Sub band Signal Processing and Polyphase Filter implementation, MPEG-1 Audio Layers, Dolby AC3 Audio Codec, MPEG-2 Advanced Audio Coding (AAC), MPEG-4 AAC (HE-AAC).		
II	**Multimedia networking** - RTSP, RTP, RTCP, SIP Video streaming, HTTP streaming (e.g., YouTube, Netflix), Content delivery networks (CDN), overlay and P2P networks, Video over wireless networks. **Online social networks** (e.g., Facebook, Twitter, etc)- Community detection, Node classification, Content dissemination and influence. **Digital Multimedia Broadcasting-** Moving from DVB-T to DVB-H, T-DMB Multimedia broadcasting for portable devices. Multimedia Quality of Service of IP networks, Layered Internet Protocol (IP), IP	30 Hours	1
III	**Video As a Datatype-** Video Compression, Overview of general techniques, Details of MPEG as a specific example. **Audio As a Datatype-** Application-Level Framing, Adaptive Playout Delay and Jitter Control, Synchronization, Media Scaling, Layered Coding, TCP-Friendliness and TCP-Based Streaming, Periodic Broadcasting, Peer-to-peer Streaming **Digital Video Coding**, Evolution of Digital Video Coding, Compression Techniques for Digital Video Coding, H.263 and H.263þ Video Coding, MPEG-1 and MPEG-2 Video Coding, MPEG-4 Video Coding and H.264/AVC, H.264/MPEG-4 AVC, Scalable extension of H.264/AVC by HHI.	30 Hours	1

IV	**Wireless Broadband and Quality of Service**, Evolution of 3G and 4G Technologies, Wi-Fi Wireless LAN (802.11), QoS enhancement support of 802.11, Worldwide Interoperability for Microwave Access (WiMAX), Internetworking between 802.16 and 802.11. Multimedia over Wireless Broadband, End- To-End Transport error control, Error resilience and power control at the source coding layer, Multimedia over Wireless mesh, Wireless VoIP and scalable video. Digital rights management of multimedia, A generic DRM architecture, Encryption, Digital watermarking, MPEG-21. Implementations of multimedia networking, Speech and audio compression module, Image and video compression module, IP networking module, Audio and video capturing and displaying, Encoding and decoding of video or audio, building a client–server video streaming system, Creating a small P2P video conferencing system.	30 Hours	1

Text/Reference Books:

1. Ze-Nian Li and Mark S. Drew, "Fundamentals of Multimedia," Pearson Prentice Hall, 2004 •
2. James F. Kurose and Keith W. Ross, "Computer Networking: A TopDown Approach Featuring the Internet," Pearson 2017
3. Larry L. Peterson and Bruce S. Davie, "Computer Networks, Fifth Edition: A Systems Approach," Morgan Kaufmann Publishers Inc., 2011

GE44732: Wireless Broadband Networks

Course Outcome:

1. To learn the technical, economic and service advantages of next generation networks.
2. To learn the basic architecture of a next generation network (NGN) with reference to understand NGN services
3. To learn the role of P Multimedia Sub-System (IMS), network attachment and admission control functions.
4. To learn and compare the various methods of providing connection-oriented services over NGN.

Learning Outcome:

By studying this course, students will be able to

1. To be able to design routing mechanism meeting the desired QoS in NGN.
2. To be able to compare various methods of providing connection-oriented services over a NGN.
3. To be able to compare various NGN virtual network services with reference to VPNs, VLANs, pseudo wires, VPLS and typical applications.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	INTRODUCTION TO BROADBAND WIRELESS Evolution of Broadband Wireless; Fixed Broadband Wireless and Mobile Broadband Wireless; WiMAX, 3G & Wi-Fi Systems; Spectrum Options for Broadband Wireless; Technical Challenges for Broadband Wireless - Wireless Radio Channel :Path loss and Shadowing; Spectrum Scarcity, Quality of Service, Mobility, Portability, Security, Supporting IP in Wireless. Orthogonal Frequency Division Multiplexing, Multicarrier Modulation – OFDM; Introduction to Multiple Antenna Techniques.	30 Hours	1

II	**WIRELESS PROTOCOL** Mobile network layer- Fundamentals of Mobile IP, data forwarding procedures in mobile IP, IPv4, IPv6, IP mobility management, IP addressing - DHCP, Mobile transport layer-Traditional TCP, congestion control, slow start, fast recovery/fast retransmission, classical TCP improvements Indirect TCP, snooping TCP, Mobile TCP. **OVERVIEW OF WiMAX** WiMAX; Salient Features of WiMAX – Physical Layer & MAC-Layer Overview; Advanced Antenna Systems; Improved Frequency Reuse; Performance Characterization - Throughput and Spectral Efficiency and Sample Link Budgets and Coverage Range	25 Hours	1
III	**3G EVOLUTIONS** IMT-2000 - W-CDMA, CDMA 2000 – radio & network components, network structure, packet-data transport process flow, Channel Allocation, core network, interference-mitigation techniques, UMTS-services, air interface, network architecture of 3GPP, UTRAN – architecture, High Speed Packet Data-HSDPA,HSUPA.	20 Hours	1
IV	**LTE AND EVOLUTION TO 4G** LTE System Overview, The Evolution from UMTS to LTE; Requirements and Targets for LTE; LTE Radio Access –Transmission Scheme, Spectrum Flexibility, Channel Dependent Scheduling and Rate Adaptation, Inter-Cell Interference Combining, MultiAntenna Transmission.; Technologies for LTE; Network Architecture – Overall Architecture Overview, Protocol Architecture **LTE ADVANCED** LTE Advanced – Introduction, Requirements, Main	30 Hours	1

	Features, Backward Compatibility, Deployment Aspects, UE Categories for LTE Advanced.		

Text/Reference Books:

1. Jeffrey. G, Andrews, ArunabhaGhosh and RiasMuhamed, "Fundamentals of WiMAX: Understanding Broadband Wireless Networking", Pearson Education, 2007.
2. Yan Zhang and Hsiao-Hwa Chen, "Mobile WiMAX : toward broadband wireless metropolitan area networks",Auerbach Publications, 2007
3. Moray Rumney, "LTE and Evolution to 4G Wireless: Design and Measurement Challenges", Agilent Technologies, 2008.
4. StefaniaSesia, IssamToufik, Matthew Baker, "LTE – The UMTS Long Term Evolution: From Theory to Practice", John Wiley & Sons, 2e, 2011.
5. Luis .M, Correia, "Mobile Broadband Multimedia Networks: Techniques, Models and Tools for 4G", Elseiver, 2006.

GE44733 Advanced Network Security

Course Objective:

1. Examine the principles of firewall design and implementation.
2. Describe standard firewall functionality and common implementation practices Real-time scheduling and schedulability analysis
3. Define the function of IPSec in a networked environment.
4. Examine IPSec policy management.

Learning Outcome:

At the end of the course, the student should be able to:

1. Explain computer networking security and voice concepts to both technical peers and non-technical management.
2. Describe the fundamentals of wireless local area networks, including their operations, IEEE 802.11 framing options, configuration essentials, and vulnerabilities.
3. Examine the process of intrusion detection and how behavioral use is implemented in the IDS.
4. Compare and contrast host-based and network-based IDSs.
5. View and analyze network traffic fragmentation.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Computer Network Security** Basic background , Current Issues, Internet Security: Secure Routing, Networking Technologies, Attacks in Networks, State of the Art Designing Firewalls, Firewall Classification, Firewall Deployment: Management, Security in Virtual Private Networks: VPN Technology, VPN Taxonomy IP Security (IPSecs): IPSecs Architecture and Components , Benefits and Applications of IPSec, IDs for Networks: Background, Modern NIDSs, Intrusion Detection versus Intrusion Protection: IPS Deployment and Advantages, IPS Requirements Denial of Service Attacks, DoS and DDoS Attacks and Defence mechanism, Secure Architectures	30 Hours	1

	with Active Networks		
II	**Security for mobile commerce applications:** M-Commerce Applications, M-Commerce Initiatives, Security Challenges in mobile e-commerce, Types of attacks on mobile e-commerce, A Secure M-commerce model based on wireless local area network, Some of M-Commerce Security Solutions.	30 Hours	1
III	**Voice Over IP Security** Security Issues in VoIP, Vulnerability Testing, Intrusion Detection Systems, Grid Security: Security Challenges for Grids, Grid Security Infrastructure, Grid Computing Environments, Grid Network Security, Mobile Agent Security: Taxonomy of Solutions, Security Mechanism for Mobile Agent Systems	30 Hours	1
IV	**Wireless Network Security:** Mobile Device Security, IEEE 802.11i, Wireless LAN Security. **Cloud Security -** Cloud Security Risks, Trust, Operating System Security, VM Security, Security of Virtualization, Security Risks Posted by Shared Images, Security Risks Posted by Management OS, Data privacy and security Issues, Identity & Access Management, Access Control, Authentication in cloud computing.	30 Hours	1

Text/Reference Books:

1. Christos Douligeris, Dimitrios N. Serpanos, "Network security: current statusand future directions", Wiley Inderscience, 2007
2. Chris McNab, "Network Security Assessment", O'Reilly Media ,2016
3. Ankit Fadia, "Network Security 2e Paperback", 2006

GE44734 Wireless Network Security and Privacy

Course Objective:

1. Study the basic concepts and functions of Wireless Networks.
2. Study the basic concepts of Security Primitives and Wireless Networks.
3. Study the basic concepts of Fundamental of Cellular system.
4. Study the basic concepts of Security Issues in Single & Multi hop Wireless Network.

5. Study the basic concepts of Security Issues in Wireless Systems.

Learning Outcome:

1. After completing the course, the students should be able to:
   Understand the basics of Wireless Networks.
2. To analyze the concept of cellular system.
3. To analyze and understand the Security Primitives and Wireless Networks.
4. To analyze the basic concepts of Security Issues in Wireless Systems.
5. Understand the basic concepts of Security Issues in Single & Multi hop Wireless Network.

Module	Course Topics	Total Hours	Credits
I	**Introduction :** Introduction: Protecting the Means of Communication, Protecting Privacy, Promoting Safety, Understanding Wireless Forecasts, and Reasonable Degrees of Security. Security issues and Economic tradeoffs. Cellular Networks and Bearer Technologies. Generations of Wireless systems: 1G,2G, Spread Spectrum, CDMA,TDMA,GSM,3G and 4G.	30	1
II	**Introduction to Security Primitives and Wireless Networks**: Introduction to Cryptography; Symmetric Key Cryptography; Public Key Cryptography; Hash Function Authentication Protocol; Miscellaneous Techniques; Hash Chain; Secret Sharing	30	1
III	**Security Issues in Single & Multi hop Wireless Network:** Cellular Network and WLAN Security: Access Control, Roaming Issues, Mobile IP Security, RFID Security, Pervasive Computing Security; Security Issues in Multihop Wireless Networks; Mobile Ad hoc Network Security: Trust Management and Routing Issues, Wireless Sensor; Network Security: Key Management and False Data Filtering, Vehicular Network Security	30	1

IV	**Wireless Security protocols**: The Need for Wireless Network Security; Attacks on Wireless Networks ,The Wireless Local Area Network (WLAN). Wireless Application Protocol (WAP), Wireless Transport Layer Security Bluetooth.	**30**	1

Text/Reference Books:

1. Levente Buttyan and Jean-Pierre Hubaux, "Security and Cooperation in Wireless Networks", Cambridge University Press, 2007.
2. Garg, "Wireless Network Evolving: 2G to 3G", Pearson Education, 2002.
3. William Stallings, "Wireless Communications and Networks", Pearson Education, 2005.