



SRM

UNIVERSITY

(Under section 3 of UGC Act 1956)

**M.TECH. (FULL TIME)
SOFTWARE DEFINED NETWORKING
CURRICULUM
2017 – 2018**

**DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
FACULTY OF ENGINEERING AND TECHNOLOGY
SRM UNIVERSITY
SRM NAGAR, KATTANKULATHUR – 603 203**

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
M.Tech- SOFTWARE DEFINED NETWORKING
CURRICULUM – 2017-18

COURSE CODE	COURSE NAME	L	T	P	C
SEMESTER I					
CS2051	Advanced Networks and Communication Systems	3	0	0	3
CS2052	SDN and NFV Research Review	0	0	2	1
CS2053	Software Defined Networks	3	0	2	4
CS2054	Data Center Networks	4	0	0	4
CAC2001	Career Advancement Course For Engineers - I	1	0	1	1
	Program Elective- I	3	0	0	3
	Program Elective- II	3	0	0	3
TOTAL		17	0	5	19
Total Contact Hours: 22					
SEMESTER II					
CS2055	Cloud Orchestration and NFV	4	0	0	4
CS2056	Mobile Computing and Internet of Things	3	0	2	4
CS2057	SDN and NFV Research Proposal	0	0	2	1
CS2058	Software Defined Optical Networks	3	0	0	3
CAC2002	Career Advancement Course For Engineers - II	1	0	1	1
	Program Elective- III	3	0	0	3
	Program Elective- IV	3	0	0	3
TOTAL		17	0	5	19
Total Contact Hours: 22					
SEMESTER III					
	Program Elective- V	3	0	0	3
	Program Elective- VI	3	0	0	3
CAC2003	Career Advancement Course For Engineers-III	1	0	1	1
CS2047	Seminar	0	0	2	1
CS2049	Project Phase I	0	0	12	6
TOTAL		7	0	15	14
Total Contact Hours: 22					

SEMESTER IV					
CS2050	Project Phase II	0	0	32	16
	Semester I-III				
	Supportive course (1 course of 3 credits in I or II or III sem.)	3	0	0	3
	Interdisciplinary Elective (1course of 3 credits in I or II or III sem.)	3	0	0	3
TOTAL		6	0	0	6
TOTAL CREDITS		74			

Total credits to be earned for the award of M.Tech degree – 74 credit

PROGRAM ELECTIVES

Course Code	Name of the course	L	T	P	C
CS2151	Cooperative Communication Systems	3	0	0	3
CS2171	Security in Software Defined Networking	3	0	0	3
CS2172	Software Defined Radios	3	0	0	3
CS2159	Advanced Distributed Systems	3	0	0	3
CS2158	SDN and NFV for IoT	3	0	0	3
CS2162	Cloud Storage and Computing	3	0	0	3
CS2131	Embedded Systems	3	0	0	3
CS2174	Virtualization Technologies	3	0	0	3
CS2175	Applications of SDN to Real Networks	3	0	0	3

SUPPORTIVE COURSES

Course Code	Name of the course	L	T	P	C
MA2013	Mathematical Foundations of Computer Science	3	0	0	3
MA2010	Graph Theory and Optimization Techniques	3	0	0	3
MA2011	Stochastic Processes and Queueing Theory	3	0	0	3

NOTE:

Students have to register for the courses as per the following guidelines:

Sl. No.	Category	Credits				
		I Semester	II Semester	III Semester	IV Semester	Category total
1	Core courses	11 (3 courses)	11 (3 courses)	---	---	22
2	Program Elective courses	18 (in I to III semesters)			---	18
	Interdisciplinary	3 (One course to be taken in				3
3	elective courses (any one program elective from other programs)	Semester I or II or III)				
4	Supportive courses - mandatory	3 (One course to be taken in Semester I or II or III)			---	3
5	Career Advancement Courses	1	1	1		3
6	Seminar/ Research Review/ Research Proposal	1	1	1(Seminar)	---	3
7	Project work	---	---	06	16	22
Total						74

Legend:

L- Number of lecture hours per week

T- Number of tutorial hours per week

P- Number of practical hours per week

C- Number of credits for the course

SEMESTER I

CS2051		L	T	P	C
	ADVANCED NETWORKS AND COMMUNICATION SYSTEMS	3	0	0	3
	Total Contact Hours - 45				
	Prerequisite				
	Nil				
PURPOSE					
This course gives an overview of advanced networks and communication system protocols, and also covers security and network management techniques. The course introduces the students to the emerging areas in Internetworking					
INSTRUCTIONAL OBJECTIVES					
1.	Resource allocation and management				
2.	Routing protocols and network management				
3.	IPV4 and IPV6 routing protocols				
4.	Network security system				

UNIT I INTRODUCTION TO PROTOCOLS AND ARCHITECTURE 8 hours

Introduction – Protocols and Architecture – TCP and IP – High Speed Networks – Frame relay- ATM – High Speed LANs Performance modeling and estimation – Queuing analysis – self similarity and self similar traffic.

UNIT II NETWORK ROUTING AND TRAFFIC MANAGEMENT 9 hours

Internet Protocol-Connectionless Datagram Delivery- Forwarding IP Datagrams-IPV4 data grams -Packet format – Routing Architecture –Core, Peers and Algorithms- Routing between peers-Routing within Autonomous systems-Routing Information Protocol- RIP-OSPF. Congestion control in data networks and internets – Link level flow and error control – TCP traffic control – Traffic and Congestion control in ATM Networks – Internet routing – graph theory and least cost paths –Interior routing protocols.

UNIT III WIRELESS NETWORK TECHNIQUES 9 hours

Network planning – topologies – fundamentals – signal to interference ratio calculation – capacity expansion techniques – network planning for CDMA systems – Wireless network operations – mobility – radio resources and power management – security.

UNIT IV AD HOC NETWORK AND NETWORK ADDRESSING 9 hours

Internet Addresses- Subnetting and Supernetting- ARP- ARP Packet format, Encapsulation & operation- ARP over ATM- Proxy ARP- RARP-ICMP –ICMP message

types. Introduction WLANs – IEEE 802.11 WLANs – Wireless ATM and HIPERLAN – Adhoc Networking and WPAN – Wireless Geo location systems architecture.

UNIT V INTERNET SECURITY AND NETWORK MANAGEMENT 10 hours

Protecting resources - IPsec- Authentication Header-Encapsulating security payload – Secure sockets-Secure Socket Layer (SSL) - Firewalls and Internet access- Packet filter firewall- Proxy firewall- IPv6-Features and packet format-IPv6 Source routing types- Comparison between IPv4 and IPv6. Network Management – Choosing a configuration method – Management Information Base – SNMP – XML – choosing a configuration protocol – COPS Advanced Applications – IP encapsulation – VPNs – Mobile IP – Header Compression – Voice over IP – IP and ATM IP over dial-up links.

TOTAL- 45 HRS

REFERENCES

1. William Stallings, High Speed Networks, Internet Performance and QoS, Prentice Hall, 2003. (UNIT 1 and 2)
2. Kaveh Pahlevan and Prashant Krishnamoorthy, Principles of Wireless Networks, Prentice Hall of India, 2006. (UNIT 3 and 4)
3. Adrian Farrel, "The Internet and its Protocols" First India Reprint 2005, Elsevier publications (Units 5)
4. Douglas E. Comer, "Internetworking with TCP/IP", Principles, Protocols and Architectures", Pearson Education, Vol. 1, 5th Edition, 2006.
5. Larry L. Peterson and Bruce S. Davie, "Computer Networks" Third Edition, Elsevier Publications 2003.
6. William Stallings, Local & Metropolitan Area Networks, 6th edition, Prentice Hall, 2000
7. Behrouz A. Forouzan, "Data Communication and Computer Networking", 3rd edition, 2004
8. Behrouz A. Forouzan, "TCP/IP protocol suite", Tata McGraw Hill, 4th Edition, 2010.
9. Douglas E. Comer, "Computer Networks and Internet", Addison Wesley, 4th Edition, 2011.

CS2052	SDN and NFV Research Review	L	T	P	C
	Total Contact Hours 30	0	0	2	1
	Pre requisite : Nil				
PURPOSE	To identify and analyze research papers and critically evaluate them				
INSTRUCTIONAL OBJECTIVES					
At the end of the course, student will be able to					
	Review existing SDN and NFV literature and critically analyze them				

Existing SDN and NFV literature should be identified and reviewed. Each such identified literature should be discussed during the classes and assignments to be submitted by students regularly from their chosen papers of interest.

TOTAL- 30 HRS

REFERENCES

1. Latest SDN and NFV research papers published in peer reviewed journals and conferences.

CS2053	SOFTWARE DEFINED NETWORKS	L	T	P	C
	TOTAL- 75 HRS	3	0	2	4
Prerequisite:	Nil				

PURPOSE	This course introduces software defined networking, an emerging paradigm in computer networking that allows a logically centralized software program to control the behavior of an entire network.				
INSTRUCTIONAL OBJECTIVES					
At the end of the course, student will be able to					
1	Differentiate between traditional networks and software defined networks				
2	Understand advanced and emerging networking technologies				
3	Obtain skills to do advanced networking research and programming				
4	Learn how to use software programs to perform varying and complex networking tasks				
5	Expand upon the knowledge learned and apply it to solve real world problems				

UNIT I INTRODUCING SDN

12 hrs

SDN Origins and Evolution – Introduction – Why SDN? - Centralized and Distributed Control and Data Planes - The Genesis of SDN

UNIT II SDN ABSTRACTIONS

14 hrs

How SDN Works - The Openflow Protocol - SDN Controllers: Introduction - General Concepts - VMware - Nicira - VMware/Nicira - OpenFlow-Related - Mininet - NOX/POX - Trema - Ryu - Big Switch Networks/Floodlight - Layer 3 Centric - Plexxi - Cisco OnePK

UNIT III PROGRAMMING SDN'S

11 hrs

Network Programmability - Network Function Virtualization - NetApp Development, Network Slicing

UNIT IV SDN APPLICATIONS AND USE CASES

14 hrs

SDN in the Data Center - SDN in Other Environments - SDN Applications - SDN Use Cases - The Open Network Operating System 3

UNIT V SDN'S FUTURE AND PERSPECTIVES

9 hrs

SDN Open Source - SDN Futures - Final Thoughts and Conclusions

TOTAL- 60 HRS

Lab:

Introducing Mininet 3

Setting up the Environment and Implementation of Controllers in Mininet 3

Mininet, Custom Topologies in POX, ODL, Floodlight 3

Click, ONOS, Northbound – Southbound Interfacing, ONOS deployment
ONOS – OPNFV – SDN Application development 3

TOTAL- 15 HRS

REFERENCES

1. Software Defined Networks: A Comprehensive Approach by Paul Goransson and Chuck Black, Morgan Kaufmann Publications, 2014
2. SDN - Software Defined Networks by Thomas D. Nadeau & Ken Gray, O'Reilly, 2013
3. Software Defined Networking with OpenFlow By SiamakAzodolmolky, Packt Publishing, 2013
4. Feamster, Nick, Jennifer Rexford, and Ellen Zegura. "The road to SDN: an intellectual history of programmable networks." ACM SIGCOMM Computer Communication Review 44.2 (2014): 87-98.
5. Kreutz, Diego, et al. "Software-defined networking: A comprehensive survey." Proceedings of the IEEE 103.1 (2015): 14-76.
6. Nunes, Bruno AA, et al. "A survey of software-defined networking: Past, present, and future of programmable networks." Communications Surveys & Tutorials, IEEE 16.3 (2014): 1617-1634.
7. Lantz, Bob, Brandon Heller, and Nick McKeown. "A network in a laptop: rapid prototyping for software-defined networks." Proceedings of the 9th ACM SIGCOMM Workshop on Hot Topics in Networks. ACM, 2010.
8. Monsanto, Christopher, et al. "Composing software defined networks." Presented as part of the 10th USENIX Symposium on Networked Systems Design and Implementation (NSDI 13). 2013.

CS2054	DATA CENTER NETWORKS	L	T	P	C
	Total Hours 60	4	0	0	4
PURPOSE	To understand the underlying principles of Data Center Networking over the conventional network.				
INSTRUCTIONAL OBJECTIVES					
At the end of the course, student will be able to					
1	Understand the principles behind the Data Center Networking over the conventional network.				
2	Ability to analyze Data Center topologies and virtualized environment				
3	Understand the data traversal over SDN				
4	Design algorithms for virtualization over multi-tenant environments				
5	Understand the various types of key routing and switching techniques used in modern computer networks.				

UNIT I DATA CENTER EVOLUTION AND SWITCH FABRICS 12 Hours

Networking Basics - Cloud Data Centers and Cloud Networking Characteristics - Mainframes and Servers - Enterprise Cloud and Virtualized Data Centers - Movement to Cloud - Switch Fabric Architecture - Switch Fabric Congestion Management and Flow Control - Switch Fabric Traffic Management - Switch Chip Architecture

UNIT II CLOUD DATA CENTER NETWORKING AND STANDARDS 12 Hours

Traditional Multi-tiered Enterprise Networks - Data Center Network Switch Types - Flat Data Center Networks - Rack Scale Architectures - Network Function Virtualization - Ethernet Data Rate Standards - Data Center Bridging - Improving Network Bandwidth - Remote Direct Memory Access

UNIT III VIRTUALIZATION AND NETWORKING 12 Hours

Virtual Machines - Virtual Switching - PCI Express and Edge Virtual Bridging - VM Migration - Multi-tenant Environments - Traditional Network Tunneling Protocols - VXLAN and NVGRE Protocols - Tunnel Locations - Load Balancing Algorithms

UNIT IV SOFTWARE-DEFINED STORAGE AND NETWORKING 12 Hours

Conventional Storages - Advanced Storage Technologies - Storage Communication Protocols - Software-Defined Storage - Storage in Cloud Data Centers - Data Center Software - OpenStack and OpenFlow - Network Function Virtualization - SDN Deployment

UNIT V HIGH-PERFORMANCE COMPUTING AND TRENDS 12 Hours

HPC System Architectures - Multi-socket CPU Boards - HPC Networking Standards - HPC Network Performance Factors - HPC Networking Software - Rack Scale Architectures - Memory and Cabling Technology - Switch Fabric Technology - Software-Defined Infrastructure

TOTAL- 60 HRS

REFERENCES

1. "Cloud Networking - Understanding Cloud-based Data Center Networks", Gary Lee, Elsevier, 2014
2. "NX-OS and Cisco Nexus Switching: Next-Generation Data Center Architectures", Kevin Corbin, Ron Fuller, David Jansen, Cisco Press; 1 edition [ISBN: 9781587058929], 2010.
3. Computer Networks – a system approach – Larry L. Peterson, Bruce S. Davie, 2/e,2007,Harcourt Asia PTE LTD.
4. Internetworking Technologies Handbook, Inc. Cisco Systems, ILSG Cisco

	ELECTIVE - I	L	T	P	C
	Total Contact Hours - 45	3	0	0	3
Students to choose one Elective course from the list of courses mentioned in the curriculum					

	ELECTIVE - II	L	T	P	C
	Total Contact Hours - 45	3	0	0	3
Students to choose one Elective course from the list of courses mentioned in the curriculum					

	SUPPORTIVE COURSE	L	T	P	C
	Total Contact Hours - 45	3	0	0	3
Students to choose one course from the list of supportive courses mentioned in the curriculum either in I, II or III semester					

	INTER DISCIPLINARY ELECTIVE	L	T	P	C
	Total Contact Hours - 45	3	0	0	3
Students to choose one Elective course from the list of Post Graduate courses specified under the Faculty of Engineering and Technology other than courses under M.Tech (CSE), M.Tech (IOT), M.Tech (SDN) , M.Tech(Mobile and Pervasive Computing) curriculum either in I, II or III semester					

SEMESTER II

CS2055	CLOUD ORCHESTRATION AND NFV	L	T	P	C
	Total Hours - 60	4	0	0	4
	Prerequisite				
	Nil				
PURPOSE					
INSTRUCTIONAL OBJECTIVES					
1.	To learn about advanced OS technologies				
2.	To learn virtualization techniques and Cloud orchestration				
3.	To design next generation cloud applications				

UNIT I Introduction

12 Hours

The cloud as the next OS , Need and Importance of Cloud as OS - Cloud Challenges - Types of clouds- Public/Private/Hybrid Clouds - Case Studies - OpenStack – Amazon- Google - Microsoft

UNIT II Advanced OS Technologies

12 Hours

Introduction to virtualization - Xen , Hyper-V , KVM, Hardware support for virtualization - Memory virtualization (IOMMU) - Network virtualization - SR-IOV -VMQ

UNIT III The Cloud OS

12 Hours

Overview & Terminology - The common layers: IaaS, PaaS, SaaS , OpenStack / Amazon / Google / Microsoft , Cloud Protocols - Representational state transfer REST - Web Server Gateway Interface (WSGI)

UNIT IV Cloud Storage

12 Hours

CAP theory - Replication Vs. Erasure coding - Consistent hashing - Case Studies - Swift - Hadoop Distributed File System (HDFS) Vs. Amazon's Simple Storage Service (S3)

UNIT V Cloud Network

12 Hours

Software Defined Networking (SDN) - Network Functions Virtualization (NFV)

TOTAL-

60 HRS

REFERENCE:

- Adnan Ahmed Siddiqui - OpenStack Orchestration, PACKT Publishing 2015

CS2056	MOBILE COMPUTING AND INTERNET OF THINGS	L	T	P	C
	Total Hours - 75	3	0	2	4

	Prerequisite					
	Nil					
	PURPOSE					
	To learn mobile computing concepts and their relevance to Internet of Things					
	INSTRUCTIONAL OBJECTIVES					
1.	To introduce the terminology, technology and its applications					
2.	To introduce the concept of M2M (machine to machine) with necessary protocols					
3.	To introduce the Python Scripting Language which is used in many IoT devices					
4.	To introduce the Raspberry PI platform, that is widely used in IoT applications					
5.	To introduce the implementation of web based services on IoT devices.					

UNIT I Introduction & Mobility Management

11 hours

Introduction-Challenges In Mobile Computing, Coping With Uncertainties, Resource Poorness, Banwidth, Etc. Cellular Architecture, Co-Channel Interference, Frequency Reuse, Capacity Increase By Cell Splitting. Evolution Of Mobile System: Cdma, Fdma, Tdma, Gsm. Mobility Management-Cellular Architecture, Co-Channel Interference, Mobility: Handoff, Types Of Handoffs; Location Management, Hlr-Vlr Scheme, Hierarchical Scheme, Predictive Location Management

UNIT II Data Mobility & Mobile Transaction

13 hours

Publishing & Accessing Data In Air- Pull And Push Based Data Delivery Models, Data Dissemination By Broadcast, Broadcast Disks, Directory Service In Air, Energy Efficient Indexing Scheme For Push Based Data Delivery, File System Support For Mobility-Distributed File Sharing For Mobility Support, Coda And Other Storage Manager For Mobility Support, Mobile Transaction And Commerce-Models For Mobile Transaction. Kangaroo And Joey Transactions, Team Transaction. Recovery Model For Mobile Transactions. Electronic Payment And Protocols For Mobile Commerce

UNIT III Introduction To Internet Of Things , IoT and M2M 14 hours

Introduction To Internet Of Things –Definition And Characteristics Of IoT, Physical Design Of IoT – IoT Protocols, IoT Communication Models, IoT Communication APIs. IoT Enabled Technologies – Wireless Sensor Networks, Cloud Computing, Big Data Analytics, Communication Protocols, Embedded Systems, IoT Levels And Templates. Domain Specific IoTs – Home, City, Environment, Energy, Retail, Logistics, Agriculture, Industry, Health And Lifestyle. IoT and M2M – Software defined networks, network function virtualization, difference between SDN and NFV for IoT. Basics of IoT System Management with NETCONF, YANG- NETCONF, YANG, SNMP NETOPS

UNIT IV Introduction to Python & IoT Physical Devices and Endpoints 12 hours

Introduction to Python - Language features of Python, Data types, data structures, Control of flow, functions, modules, packaging, file handling, data/time operations, classes, Exception handling, Python packages - JSON, XML, HTTPLib, URLLib, SMTPLib IoT Physical Devices and Endpoints - Introduction to Raspberry PI- Interfaces (serial, SPI, I2C) Programming – Python program with Raspberry PI with focus of interfacing external gadgets, controlling output, reading input from pins.

UNIT V IoT Physical Servers and Cloud Offerings 10 hours

IoT Physical Servers and Cloud Offerings – Introduction to Cloud Storage models and communication APIs Webserver – Web server for IoT, Cloud for IoT, Python web application framework, Designing a RESTful web API.

TOTAL- 60 HRS

Practicals:

1. Start Raspberry Pi and try various Linux commands in command terminal window: *ls, cd, touch, mv, rm, man, mkdir, rmdir, tar, gzip, cat, more, less, ps, sudo, cron, chown, chgrp, ping etc*
2. Run some python basic programs on Pi like reading name, number, calculating area of shape etc., Light an LED through Python program, Get input from two switches and switch on corresponding LEDs, Flash an LED at a given on time and off time cycle, where the two times are taken from a file, Flash an LED based on cron output (acts as an alarm).
3. Access an image through a Pi web cam, Control a light source using web page, Implement an intruder system that sends an alert to the given email, Get the status of a bulb at a remote place (on the LAN) through web, Get an alarm from a remote area (through LAN) if smoke is detected.

TOTAL- 15 HRS

References

1. Mobility: Processes, Computers And Agents, Dejan Milojevic, Frederick Douglass, Richard Wheeler, Addison-Wesley Professional; 1st Edition(April 19, 1999).
2. Ivan Stojmenovic (Editor), Handbook Of Wireless Networks & Mobile Computing, Wiley, Isbn:0-471-41902-8, February 2002
3. Yi-Bing Lin & Imrich Chlamtac, "Wireless And Mobile Networks Architectures"
4. Raj Pandya, " Mobile And Personal Communications System And Services". Prentice Hall Of India,2001.
5. Internet of Things - A Hands-on Approach, Arshdeep Bahga and Vijay Madisetti, Universities Press, 2015, ISBN: 9788173719547
6. Getting Started with Raspberry Pi, Matt Richardson & Shawn Wallace, O'Reilly (SPD), 2014, ISBN: 9789350239759

CS2057	SDN and NFV Research Proposal			L	T	P	C
	Total Contact Hours 30			0	0	2	1
	Prerequisites: CS2052						
	Data Book: NIL						
PURPOSE	To write a project proposal from the review of SDN and NFV literature done during the previous semester						
INSTRUCTIONAL OBJECTIVES							
At the end of the course, student will be able to							
1	Write a research proposal						

Problems and challenges identified from reviewing the literature done during the pre-requisite course CS2052, should be modeled into a research project proposal, that can be developed as their final year project.

TOTAL- 30 HRS

REFERENCES

1. Latest SDN and NFV research papers published in peer reviewed journals and conferences.

CS2058	SOFTWARE DEFINED OPTICAL NETWORKS	L	T	P	C
			3	0	0
	Total Hours - 45				
	Prerequisite				
	Nil				
PURPOSE					
This course is designed to provide students with a knowledge of Software Defined Optical networks. In addition to learning the fundamentals of Optical networks, students will also learn how to apply software defined principles could be used to network and manage the optical networking environments.					
INSTRUCTIONAL OBJECTIVES					
1.	To acquire knowledge of Optical networks and its basic principles				
2.	To acquire knowledge of SDN and its application areas				
3.	To learn the use of SDN in Optical network environments and its applications				

UNIT I – INTRODUCTION

9 hours

Basic Packet-Switching Terminology, Modern Data Center, Traditional Switch Architecture , Autonomous and Dynamic Forwarding Tables, Open Source and Technological Shifts, Evolution of Switches and Control Planes, SDN Implications for Research and Innovation, The Genesis of SDN , The Evolution of Networking Technology, Sustaining SDN Interoperability, Open Source Contributions, Network Virtualization

UNIT II – FUNDAMENTALS OF SDN

9 hours

SDN Operation , SDN Devices , SDN Controller, The OpenFlow Specification, OpenFlow Overview, OpenFlow 1.0 and OpenFlow Basics, OpenFlow 1.1 Additions, OpenFlow 1.2 Additions, OpenFlow 1.3 Additions, OpenFlow Limitations, Alternative Definitions of SDN, Potential Drawbacks of Open SDN, SDN via APIs, SDN via Hypervisor-Based Overlays, SDN via Opening Up the Device, Network Functions Virtualization, Alternatives Overlap and Ranking

UNIT III – SDN IN OTHER ENVIRONMENTS

9 hours

Wide Area Networks , Service Provider and Carrier Networks , Campus Networks, Hospitality Networks, Mobile Networks, In-Line Network Functions, Optical Networks, SDN vs. P2P/Overlay Networks

UNIT IV – OPTICAL NETWORKS TECHNOLOGY**9 hours**

Propagation of Signals in Optical Fiber, Components, Modulation and Demodulation, Transmission System Engineering , Evolution from Wavelength-Switched to Flex-Grid Optical Networks, Taking Advantage of Elastic Optical Networks, Routing and Spectrum Allocation, Transmission in Elastic Optical networks

UNIT V – SDN IN OPTICAL NETWORKS AND MANAGEMENT**9 hours**

Client Layers of the Optical Layer, WDM Network Elements, WDM Network Design , Control and Management, Access Networks, Photonic Packet Switching, Node Architectures for Elastic and Flexible optical networks, Sliceable bandwidth variable transponders, GMPLS Control Plane, SDN in Optical networks, Application based network operations, In-Operation network planning

Total- 45 hrs**REFERENCES:**

1. Paul Goransson Chuck Black, " Software Defined Networks", 1st Edition, A Comprehensive Approach, Morgan Kaufmann, 2014.
2. Victor Lopez, Luis Velasco , "Elastic Optical Networks: Architectures, Technologies and Control". Optical Network series, Springer International Publications , 2016.
3. Rajiv Ramaswami, Kumar Sivarajan, Galen Sasaki, "Optical Networks, A Practical Perspective, 3rd Edition", Morgan Kaufmann, 2009.
4. Wei Wei, Jianjun Yu, "Software-defined Optical Communications and Networking: Principles and Applications", Taylor and Francis ,CRC Press, 2017.

	ELECTIVE - III	L	T	P	C
	Total Contact Hours - 45	3	0	0	3
Students to choose one Elective course from the list of courses mentioned in the curriculum					

	ELECTIVE - IV	L	T	P	C
	Total Contact Hours - 45	3	0	0	3
Students to choose one Elective course from the list of courses mentioned in the curriculum					

SEMESTER III

	ELECTIVE - V	L	T	P	C
	Total Contact Hours - 45	3	0	0	3
Students to choose one Elective course from the list of courses mentioned in the curriculum					

	ELECTIVE - VI	L	T	P	C
	Total Contact Hours - 45	3	0	0	3
Students to choose one Elective course from the list of courses mentioned in the curriculum					

CS2047	SEMINAR	L	T	P	C
		0	0	2	1
PURPOSE	To train the students in preparing and presenting technical topics.				
INSTRUCTIONAL OBJECTIVE					
The student shall be capable of identifying topics of interest related to the program of study and prepare and make presentation before an enlightened audience.					

The students are expected to give at least two presentations on their topics of interest which will be assessed by a committee constituted for this purpose. This course is mandatory and a student has to pass the course to become eligible for the award of degree. Marks will be awarded out of 100 and appropriate grades assigned as per the regulations

CS2049		L	T	P	C
	PROJECT PHASE I (III SEMESTER)	0	0	12	6
CS2050	PROJECT PHASE II (IV SEMESTER)	0	0	32	16
PURPOSE	To undertake research in an area related to the program of study				
INSTRUCTIONAL OBJECTIVES					
The student shall be capable of identifying a problem related to the program of study and carry out wholesome research on it leading to findings which will facilitate development of a new/improved product, process for the benefit of the society.					

M.Tech projects should be socially relevant and research oriented ones. Each student is expected to do an individual project. The project work is carried out in two phases – Phase I in III semester and Phase II in IV semester. Phase II of the project work shall be in continuation of Phase I only. At the completion of a project the student will submit a project report, which will be evaluated (end semester assessment) by duly appointed examiner(s). This evaluation will be based on the project report and a viva voce examination on the project. The method of assessment for both Phase I and Phase II is shown in the following table:

Assessment	Tool	Weightage
In- semester	I review	10%
	II review	15%
	III review	35%
End semester	Final viva voce examination	40%

Student will be allowed to appear in the final viva voce examination only if he / she has submitted his / her project work in the form of paper for presentation / publication in a conference / journal and produced the proof of acknowledgement of receipt of paper from the organizers / publishers.

PROGRAMME ELECTIVES

COOPERATIVE COMMUNICATION SYSTEMS		L	T	P	C
CS2151	Total Hours - 45	3	0	0	3
	Prerequisite				
	Nil				
PURPOSE					
The purpose of this course is to impart knowledge on the communication in Cooperative networking					
INSTRUCTIONAL OBJECTIVES					
1.	To be familiar with the concepts of Cooperative communication in networking				
2.	To learn the various modes of Cooperative communication in different networking scenarios				
3.	To study different cooperative routing methodologies				
4.	To provide an insight on the relaying techniques in Cooperative networking				
5.	To enhance the knowledge of communication quality in cooperative cross layered networks				

UNIT -I AN OVERVIEW ON COOPERATIVE COMMUNICATIONS **9 hours**

Brief History of Cooperative and Relay Channels- Characteristics of Wireless Channels
-Techniques to Exploit Spatial Diversity-Capacity of Wireless -Diversity-and-Multiplexing Tradeoff- Decode-and-Forward Relaying Schemes

UNIT-II MODES OF COOPERATIVE COMMUNICATIONS **9 hours**

Cooperation protocols- Hierarchical cooperation- Cooperative communications with single relay- Multi-node cooperative communications- Relay selection: when to cooperate and with whom

UNIT-III COOPERATIVE NETWORKING **9 hours**

Cognitive multiple access via cooperation- Content-aware cooperative multiple access- Distributed cooperative routing- Broadband cooperative communications

UNIT-IV COOPERATION RELAYING **9 hours**

Resource Allocation in Pair-Wise Cooperative OFDM- Cooperative OFDM Systems with Multiple Relays- Cooperation with Slotted ALOHA- Cooperation with CSMA/CA- Throughput Optimal Scheduling Protocols for Cooperative Networks

UNIT-V CROSS-LAYER ISSUES IN COOPERATIVE NETWORKS**9 hours**

QoS in Cooperative Networks- Routing in Cooperative Networks- Security Issues in Cooperative Networks - Network lifetime maximization via cooperation

TOTAL- 45 HRS**REFERENCES**

1. Y.W. Peter Hong, Wan-Jen Huang C.-C. Jay Kuo, "Cooperative Communications and Networking", Springer edition,2013
2. K. J. Ray Liu, Ahmed K. Sadek, Weifeng Su and Andres Kwasinski, "Cooperative Communications and Networking", Cambridge University Press New York, USA(<http://www.cambridge.org/catalogue/catalogue.asp?isbn=9780521895132&resID=SBN13=9780521895132&parent=7032&ss=res#resource>)
3. Murat Uysal, "Cooperative Communications for Improved Wireless Network Transmission: Framework for Virtual Antenna Array Applications", Information Science Reference, Hershey- New York, 2012
4. Yan Zhang, Hsiao-Hwa Chen, Mohsen Guizani, "Cooperative Wireless Communications", CRC Press, 2014

CS2171	SECURITY IN SOFTWARE DEFINED NETWORKING	L	T	P	C
	Total Hours – 45	3	0	0	3
	Prerequisite : Nil				
PURPOSE					
To learn the security principles and methodologies for software defined networking.					
INSTRUCTIONAL OBJECTIVES					
1.	To learn about security issues in existing networks				
2.	To learn about challenges and issues facing SDN				

UNIT – I - Introduction to Physical Security

9 Hours

Fundamental Concepts - Access Control Models - Cryptographic Concepts - Physical Protections and Attacks - Locks and Safes - Authentication Technologies Direct Attacks Against Computers - Physical Intrusion Detection.

UNIT – II - Network Security

9 Hours

Network Security Concepts - The Link Layer - The Network Layer - The Transport Layer - Denial-of-Service Attacks - The Application Layer and DNS – Firewalls - Tunneling - Intrusion Detection - Wireless Networking.

UNIT – III - New-Generation Protocols

9 Hours

OpenFlow - VXLAN - NVGRE (Network Virtualization using Generic Routing Encapsulation) - MEF Ethernet - Carrier-Grade Ethernet- TRILL (Transparent Interconnection of a Lot of Links) - LISP (Locator/Identifier Separation Protocols)

UNIT – IV - SDN Security Principles

9 Hours

Clearly Define Security Dependencies and Trust Boundaries - Assure Robust Identity - Build Security based on Open Standards - Protect the Information Security Triad - Protect Operational Reference Data - Make Systems Secure by Default - Provide Accountability and Traceability - Properties of Manageable Security Controls

Unit – V – Challenges and Issues

9 Hours

Characteristics of SDN - Security Analysis and Potential attacks in SDN - Solutions to the security issues in SDN - Network Security enhancement using the SDN Framework – Issues and Challenges

TOTAL- 45 HRS

REFERENCES:

1. Introduction to Computer Security Michael Goodrich, University of California, Irvine Roberto Tamassia, Brown University ©2011

2. Software Networks: Virtualization, SDN, 5G, Security Guy Pujolle
3. https://www.opennetworking.org/images/stories/downloads/sdn-resources/technical-reports/Principles_and_Practices_for_Securing_Software-Defined_Networks_applied_to_OFv1.3.4_V1.0.pdf
4. S. Scott-Hayward, S. Natarajan and S. Sezer, "A Survey of Security in Software Defined Networks," in IEEE Communications Surveys & Tutorials, vol. 18, no. 1, pp. 623-654, Firstquarter 2016. doi: 10.1109/COMST.2015.2453114

CS2172	SOFTWARE DEFINED RADIOS				L	T	P	C
	Total Contact Hours 45				3	0	0	3
	Prerequisite: CS2051							
PURPOSE	To understand the underlying principles of Software Defined Radios and Cognitive Radio Networks.							
INSTRUCTIONAL OBJECTIVES								
At the end of the course, student will be able to								
1	Understand the principles behind the Software Defined Radios over the conventional Cognitive Radios.							
2	Ability to analyze Software Defined Networking protocols and cognitive radio techniques							
3	Understand the data traversal over SDN							
4	Design algorithms for Software Defined Radio and cognitive radio environments							
5	Understand the various types of key routing and switching techniques used in adaptive networks.							

UNIT I: SOFTWARE DEFINED RADIO CONCEPTS

9 Hours

Need for Software Radios - Characteristics and Benefits of a Software Radio - Design Principles of a Software Radio - RF Receiver Front-End Topologies - Importance of the Components to Overall Performance - Transmitter Architectures and Their Issues - Noise and Distortion in the RF Chain ADC and DAC Distortion - Flexible RF Systems

UNIT II: SDR AS A PLATFORM FOR COGNITIVE RADIO

9 Hours

Hardware Architecture: Baseband Processors - Hardware Architecture: Multi-Core Systems - Software Architecture: Design Philosophies - GNU Radio - Software Communications Architecture - Application Software - Component Development - Waveform Development - Cognitive Waveform Development

UNIT III: COGNITIVE RADIO: TECHNOLOGIES REQUIRED

9 Hours

Software Capable Radios - Software Programmable Radios - SDR Examples - Aware Adaptive and CRs - Radio Capabilities and Properties Comparison - Spectrum Awareness and Frequency Occupancy - Software Technology - Funding and Researches in CRs - Directions and Standards

UNIT IV: OBJECT ORIENTED REPRESENTATION OF RADIOS

9 Hours

Introduction to Network Resources - Network Resources - Object Oriented Programming - Object Request Broker Architecture - Object Brokers and Software Radios - Mobile Application Environments - Security in Software Radios - Joint Tactical Radio Systems - SCA Architectures

UNIT V: CASE STUDIES IN SOFTWARE RADIO DESIGNS

9 Hours

Intrinsic Architectural Characteristics to Software Radios - Important Architectural Characteristics to Software Radios - Practical Software Radios - CA Architectural Details - Wireless Information Transfer Systems - SDR Digital Transceiver Sub Systems - Spectrum ware Systems - Layered Radio Architecture - Case Study on Trending Software-Defined Radio Architecture

TOTAL- 45 HRS

REFERENCES

1. Software Radio: A Modern Approach to Radio Engineering By Jeffrey H. Reed
Pearson Education Low Price Edition
2. "Cognitive Radio Technology", Bruce A Fette, Academic Press, 2009
3. Cognitive Radio Networks by Wyglinski, Alexander M. Nekovee, Maziar, Hou, Y. Thomas, 2010 Elsevier.
4. "Cognitive Radio, Software Defined Radio and Adaptive wireless system, Huseyin Arslan , Springer, 1 edition ,September 24, 2007

CS2159	ADVANCED DISTRIBUTED SYSTEMS	L	T	P	C
	Total Contact Hours - 45	3	0	0	3
	Prerequisite				
	Nil				
PURPOSE					
The purpose of this course is to impart knowledge on design concepts and system level and support required for distributed system.					
INSTRUCTIONAL OBJECTIVES					
To learn of the concepts, principles and technologies of Distributed systems					
To introduce advanced idea of peer to peer and file system management.					
To understand the issues involved in resource management and process.					

UNIT I DISTRIBUTED SYSTEMS

9 hours

Introduction to Distributed Systems - Characterization of Distributed Systems - Distributed Architectural Models - Remote Invocation - Request-Reply Protocols - RPC - RMI - Group Communication - Coordination in Group Communication - Ordered Multicast - Time Ordering - Physical Clock Synchronization - Logical Time and Logical Clocks.

UNIT II DISTRIBUTED SECURITY AND TRANSACTIONS

9 hours

Introduction - Overview of security techniques - Cryptographic algorithms - Digital signatures - Cryptography pragmatics - Flat and nested distributed transactions - Atomic commit protocols - Concurrency control in distributed transactions - Distributed deadlocks - Transaction recovery

UNIT III DISTRIBUTED MUTUAL EXCLUSION ALGORITHMS

9 hours

Introduction - Lamport's algorithm - RicartAgrawala algorithms - Singhal's dynamic information structure algorithm - Lodha and Kshemkalyani's fair mutual exclusion algorithms - Quorum based algorithm - Mackawa's algorithms - Token based algorithms - Roymaond's tree based algorithms

UNIT IV DEADLOCK DETECTION IN DISTRIBUTION SYSTEMS

9 hours

System Model - Models of deadlocks - Knapp's classification of distributed deadlock detection algorithms - Mitchell & Merritt's algorithm for the single resource model - ChandyMisra Haas algorithm for the AND & OR Model - Kshemkalyanisinghal algorithm for P out of Q model - Global predicate detection

UNIT V ADVANCED IN DISTRIBUTED SYSTEMS

9 hours

Authentication in distributed systems - Protocols based on symmetric cryptosystems - Protocols based on asymmetric cryptosystems - Password-based authentication - Authentication protocol failures - Self-stabilization - Peer-to-peer computing and

overlay graphs - Unstructured overlays - Chord distributed hash table - Content addressable networks (CAN) - Tapestry - Some other challenges in P2P system design - Tradeoffs between table storage and route lengths - Graph structures of complex networks - Internet graphs - Generalized random graph networks - Small-world networks - Scale-free networks - Evolving networks.

TOTAL -45 HRS

REFERENCES

1. George Coulouris, Jean Dollimore, Tim Kindberg, "Distributed Systems Concepts and Design", Fifth Edition, Pearson Education Asia, 2012.
2. Ajay D. Kshemkalyani, MukeshSinghal, "Distributed Computing: Principles, Algorithms, and Systems", Cambridge University Press, 2008
3. Liu, "Distributed Computing: Principles and Applications", Pearson Education , 2004

CS2158	SDN and NFV FOR IoT			L	T	P	C
	Total Contact Hours 45			3	0	0	3
	Prerequisite: Nil						
PURPOSE	To understand the underlying principles of Data Center Networking over the conventional network.						
INSTRUCTIONAL OBJECTIVES							
At the end of the course, student will be able to							
1	Understand the principles behind the Modern Network approaches such as SDN NFV and IoT						
2	Ability to analyze Data Center topologies and virtualized environment						
3	Understand the data traversal over virtualized environment for IoT						
4	Design algorithms for virtualization over multi-tenant environments						
5	Understand the various types of key routing and switching techniques used in modern networks.						

UNIT I: MODERN NETWORKING

9 Hours

Cloud Computing - Internet of Things - Types of Network and Internet Traffic - Demand: Big Data, Cloud Computing, and Mobile Traffic - Requirements: QoS and QoE - Routing Congestion Control - SDN and NFV - Modern Networking Elements

UNIT II: SOFTWARE DEFINED NETWORKS

9 Hours

Network Requirements - The SDN Approach - SDN- and NFV-Related Standards - SDN Data Plane - OpenFlow Logical Network Device - OpenFlow Protocol - SDN Control Plane Architecture - REST API - SDN Application Plane Architecture

UNIT III: VIRTUALIZATION

9 Hours

Background and Motivation for NFV - Virtual Machines - NFV Concepts - NFV Reference Architecture - NFV Infrastructure - Virtualized Network Functions - NFV Management and Orchestration - NFV Use Cases - SDN and NFV

UNIT IV: THE INTERNET OF THINGS: COMPONENTS

9 Hours

The IoT Era - Scope of the Internet of Things - Components of IoT-Enabled Things - IoT World Forum Reference Model - ITU-T IoT Reference Model - IoTivity - Cisco IoT System - ioBridge - SDN and NFV over IoT Deployment

UNIT V: SECURITY

9 Hours

Security Requirements - SDN Security - NFV Security - ETSI Security Perspective - IoT Security - The Patching Vulnerability - IoT Security and Privacy Requirements Defined by ITU-T - An IoT Security Framework - The Impact of the New Networking on IT Careers

TOTAL -45 HRS

REFERENCES

1. William Stallings ,“Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud” Publisher: Addison-Wesley 2015 ISBN: 9780134175393
2. Jim Doherty , “SDN and NFV Simplified: A Visual Guide to Understanding Software Defined Networks and Network Function Virtualization” 1st Edition
3. Paresh Shah, Syed Farrukh Hassan, Rajendra Chayapath , “Network Function virtualization with a touch of sdn”
4. Paul Goransson Chuck Black, “ Software Defined Networks A Comprehensive Approach”

CS2162	CLOUD STORAGE AND COMPUTING	L	T	P	C
	Total Contact Hours – 45	3	0	0	3
	Prerequisite : Nil				
PURPOSE					
To gain the basic principles of cloud storage and computing					
INSTRUCTIONAL OBJECTIVES					
1.	To learn cloud computing basics				
2.	To learn about cloud storage and security				
3.	To learn about optimization of cloud storage				
4.	To know about various cloud service provider				

UNIT I- CLOUD COMPUTING

9 hours

Introduction to the Cloud Computing, History of cloud computing, Cloud service options, Cloud Deployment models, Business concerns in the cloud, Exploring virtualization, Load balancing, Hypervisors, Machine imaging, Cloud marketplace overview, Comparison of Cloud providers

UNIT II - INFORMATION STORAGE SECURITY AND DESIGN

9 hours

Storage strategy and governance; security and regulations. Designing secure solutions; the considerations and implementations involved. Securing storage in virtualized and cloud environments. Monitoring and management; security auditing and SIEM.

UNIT III - STORAGE NETWORK DESIGN

12 hours

Architecture of storage, analysis and planning. Storage network design considerations; NAS and FC SANs, hybrid storage networking technologies (iSCSI, FCIP, FCoE), design for storage virtualization in cloud computing, host system design considerations.

UNIT IV - OPTIMIZATION OF CLOUD STORAGE

6 hours

Global storage management locations, scalability, operational efficiency. Global storage distribution; terabytes to petabytes and greater. Policy based information management; metadata attitudes; file systems or object storage.

UNIT V – CLOUD SERVICE PROVIDER

9 hours

Cloud Service Providers: EMC, EMC IT, Captiva Cloud Toolkit, Google Cloud Platform, Cloud Storage, Google Cloud Connect, Google Cloud Print, Google App Engine, Amazon Web Services, Amazon Elastic Compute Cloud, Amazon Simple Storage Service, Amazon Simple Queue Service, Microsoft Windows Azure, Microsoft

Assessment and Planning Toolkit, SharePoint, IBM Cloud Models, IBM Smart Cloud, SAP Labs, SAP HANA Cloud Platform, Virtualization Services Provided by SAP, Sales force, Sales Cloud, ServiceCloud: Knowledge as a Service, Rack space, VMware, Manjra soft Aneka Platform

TOTAL – 45 HRS

REFERENCES

1. Cloud Computing: Principles and Paradigms by RajkumarBuyya, James Broberg and Andrzej M. Goscinski, Wiley, 2011.
2. Distributed and Cloud Computing , Kai Hwang, GeofferyC.Fox, Jack J.Dongarra, Elsevier, 2012.
3. Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance, Tim Mather, Subra Kumaraswamy, Shahed Latif, O'Reilly, SPD, 2011.
4. Cloud Computing Bible. Barrie Sosinsky. John Wiley & Sons. ISBN-13: 978-0470903568.
5. Amazon Web Services For Dummies. Bernard Golden. For Dummies. ISBN-13: 978-18571835
6. RajkumarBuyya, Cloud Computing: Principles and Paradigms, John Wiley & Sons, First Edition
7. Greg Schulz, "Cloud and Virtual Data Storage Networking", Auerbach Publications [ISBN: 978-1439851739], 2011.
Marty Poniowski, "Foundations of Green IT" Prentice Hall; 1 edition [ISBN: 978-137043750] , 2009.

CS2131	EMBEDDED SYSTEMS				L	T	P	C	
	Total contact hours:45					3	0	0	3
	Prerequisite:								
	nil								
Purpose:									
To familiarize the student with the architecture of embedded systems in general and introduce the design concepts of distributed embedded systems.									
Instructional Objectives:									
1.	To learn the rationale and concepts for designing embedded systems.								
2.	To understand the design principles of distributed embedded systems.								
3.	To understand the real time environment, task management and scheduling.								
4.	To emphasize on programming embedded systems.								

UNIT- INTRODUCTION TO EMBEDDED SYSTEMS

9 Hours

Embedded system model – embedded standards – block diagrams – powering the hardware - embedded board using von Neuman model. EMBEDDED processors: ISA architecture models – application specific ISA models – general purpose ISA models – instruction level parallelism.

UNIT II - REAL-TIME ENVIRONMENT

9 Hours

Real-time computer system requirements – classification of real time systems – simplicity – global time – internal and external clock synchronization – real time model. Real – time communication – temporal relations – dependability.

UNIT III - REAL-TIME OPERATING SYSTEMS

9 Hours

Real –time communication – event triggered – rate constrained – time triggered. Inter component communication – task management – dual role of time – inter task interactions – process input/output – agreement protocols – error detection.

UNIT IV -SYSTEM DESIGN

9 Hours

Scheduling problem - static & dynamic scheduling – system design – validation – time-triggered architecture.

UNIT V – CASE STUDY ON PROGRAMMING EMBEDDED SYSTEMS

9 Hours

Building the blinking LED program-eCos Examples-Embedded linux examples-Extending functionality-optimization techniques.

TOTAL- 45 HRS

REFERENCES

1. Tammy Noergaard, "Embedded system architecture", 2nd Edition , Elsevier, 2012
2. Hermann Kopetz, "Real-Time systems – Design Principles for distributed Embedded Applications", 2nd Edition, Springer 2011
3. Michael Barr, Anthony Massa," Programming Embedded Systems-With C and GNU Development Tools", 2nd Edition, O'Reilly Media, 2009.
4. Raj Kamal , "Embedded Systems – Architecture Programming and Design," , Tata McGraw Hill, 2nd Edition, 2011.
5. <https://www.elsevier.com/books/embedded-systems-architecture/noergaard/978-0-12-382196-6#maincontent>
6. <https://link.springer.com/book/10.1007%2F978-1-4419-8237-7>
7. <http://stepsmail.com/download/Career-In-Embedded-System.PDF>

CS2174	VIRTUALIZATION TECHNOLOGIES	L	T	P	C
			3	0	0
	Total Contact Hours - 45				
	Prerequisite				
	Nil				
PURPOSE					
This course is designed to provide students with a working knowledge of Virtualization Technologies. In addition to learning how to install and configure commercial technologies, students will also learn how to apply virtualization technology to set up virtual networks, provide for disaster recovery, create high availability solutions with clustering, improve security and performance, and use management software to administer virtual data centers.					
INSTRUCTIONAL OBJECTIVES					
1.	To acquire knowledge of Virtualization and its basic principles				
2.	Ability to use commercial software for Virtualization				
3.	Ability to set up virtual networks, provisioning the memory, and I/O systems				
4.	To apply the concepts of Virtualization techniques on applications				

UNIT I – INTRODUCTION

9 hours

Overview: Why server virtualization –History and re-emergence – Classic virtual machines; VMware, VSphere, KVM, Xen; Taxonomy and basic principles, Architectures comparison - CPU virtualization -Privileged instructions handling - Hypervisor – Para virtualization. Hardware-assisted virtualization. Booting up. Time keeping. CPU scheduling. Commercial examples

UNIT II – MEMORY MANAGEMENT IN VIRTUALIZATION

9 hours

Memory management in virtualization: Virtual Storage, partitioning –reclamation – ballooning. Memory sharing. OS-level virtualization –VM Ware –Red Hat Enterprise Virtualization.

UNIT III – I/O VIRTUALIZATION

9 hours

I/O virtualization: Virtualizing I/O devices -monolithic model -virtual I/O server. Virtual networking –tunneling –overlay networks. Commercial examples. Virtual storage: Granularity –Centralized and Distributed File system, system level, blocks level.

UNIT IV – VIRTUALIZED COMPUTING

9 hours

Virtualized computing: Virtual machine based distributed computing, elastic cloud computing, clustering, cold and hot migration. Commercial examples. Challenges and future trends.

UNIT V – APPLICATIONS

9 hours

Applications: In distributed computing: Grid and Cloud, Virtual Machine Provisioning, Desktop Virtualization, Application Virtualization, Security for virtualized environments, Business Continuity in virtual environments

Total : 45 hrs

REFERENCES

1. Virtual Machines: Versatile Platforms for Systems and Processes (1st Ed): Jim Smith, Ravi Nair, Morgan Kaufmann (2005)
2. Applied Virtualization Technology - Usage models for IT professionals and Software Developers (1st Ed): Sean Campbell Intel Press (2006).
3. IEEE Computer special issue on virtualization technologies, Renato J. Figueiredo, Jose A. B. Fortes, Peter A. Dinda, Editors (May 2005)
3. "Survey of Virtual Machine Research", Robert P. Goldberg, IEEE Computer, June 1974, pp 34-45.
4. "Architecture of Virtual Machines", Robert P. Goldberg, Proc. Workshop on Virtual Computer Systems, Cambridge, MA, 1973, pp 74-112.
5. "Formal Requirements for Virtualizable Third Generation Architectures", Gerald J. Popek, Robert P. Goldberg, Communications of the ACM, 17(7), July 1974, pp 413-421.
6. "On the Relationship Between Virtual Machines and Emulators", Efreem G. Mallach, Proc. Workshop on Virtual Computer Systems, Cambridge, MA, 1973, pp 117-126
7. "Virtualizing I/O Devices on VMware Workstation's Hosted Virtual Machine Monitor", Jeremy Sugerman, Ganesh Venkitachalam and Beng-Hong Lim, Proc. 2001 USENIX Annual Technical Conference, Boston, MA June 2001.
8. "A user-mode port of the linux kernel", Jeff Dike, Proceedings of the USENIX Annual Linux Showcase and Conference, Atlanta, GA, Oct 2000
9. "Xen and the Art of Virtualization", Paul Barham, Boris Dragovic, Keir Fraser, Steven Hand, Tim Harris, Alex Ho, Rolf Neugebauer, Ian Pratt and Andrew Warfield, Proceedings of the ACM Symposium on Operating Systems Principles (SOSP), October 2003
10. "Scale and Performance in the Denali Isolation Kernel", A. Whitaker, M. Shaw, S. Gribble, Proceedings of the 5th USENIX Operating Systems Design and Implementation (OSDI), 2001.
11. "A Comparison of Software and Hardware Techniques for x86 Virtualization", K. Adams and O. Agesen, Proceedings of ASPLOS, 2006.

12. B. Lin, and P. Dinda, "VSched: Mixing Batch and Interactive Virtual Machines Using Periodic Real-time Scheduling", Proceedings of ACM/IEEE SC 2005 (Supercomputing), November, 2005
13. Christopher Clark et al, "Live Migration of Virtual Machines", Proceedings of the 2nd ACM/USENIX Symposium on Networked Systems Design and Implementation (NSDI), 2005.
14. "Application and Analysis of the Virtual Machine Approach to Information System Security and Isolation", Stuart E. Madnick and John J. Donovan, Proc. Workshop on Virtual Computer Systems, Cambridge, MA, 1973, pp 210-224.
15. "Terra: a virtual machine-based platform for trusted computing", T. Garfinkel, B. Pfaff, J. Chow, M. Rosenblum, D. Boneh, Proceedings of the nineteenth ACM symposium on Operating systems principles, 2003
16. "Analysis of the Intel's Pentium Ability to Support a Secure Virtual Machine Monitor", John S. Robin, Cynthia E. Irvine, Proc. 9th USENIX Security Symposium, Denver, CO, August 2000.
17. G. Dunlap, S. King, S. Cinar, M. Basrai, and P. Chen. ReVirt: Enabling Intrusion Analysis through Virtual-Machine Logging and Replay. Proceedings of OSDI 2002
18. Virtual networks and applications in distributed systems:, Sundararaj, P. Dinda, "Towards Virtual Networks for Virtual Machine Grid Computing", Proceedings of the third USENIX Virtual Machine Research and Technology Symposium (VM 04), May, 2004.
19. Xuxian Jiang, Dongyan Xu, "VIOLIN: Virtual Internetworking on OverLayINfrastructure", Department of Computer Sciences Technical Report CSD TR 03-027, Purdue University, July 2003
20. Tsugawa, Maurício; and Fortes, José A.B. "A Virtual Network (ViNe) Architecture for Grid Computing". In Proceedings of 20th International Parallel and Distributed Processing Symposium (IPDPS-2006), Rhodes Island, Greece, April, 2006
21. Ganguly, Arijit , Abhishek Agrawal, P. Oscar Boykin, Renato Figueiredo "WOW: Self-Organizing Wide Area Overlay Networks of Virtual Workstations". In Proc. High Performance Distributed Computing (HPDC)
22. "The PUNCH Virtual File System: Seamless Access to Decentralized Storage Services in a Computational Grid", R. J. Figueiredo, N. H. Kapadia, and J. A. B. Fortes. Proceedings of the Tenth IEEE International Symposium on High Performance Distributed Computing. IEEE Computer Society Press, August 2001.
23. "Distributed File System Support for Virtual Machines in Grid Computing", Proceedings of the IEEE International Symposium on High Performance Distributed Computing. IEEE Computer Society Press, August 2004.
24. "Virtual Appliances for Deploying and Maintaining Software", C. Sapuntzakis, D. Brumley, R. Chandra, N. Zeldovich, J. Chow, M. S. Lam, and M. Rosenblum, In Proceedings of the 17th Large Installation Systems Administration Conference (LISA 2003), pages 181-194, October 2003

25. "The Collective: A Cache-Based System Management Architecture", R. Chandra, N. Zeldovich, C. Sapuntzakis, and M. S. Lam In Proceedings of the Second Symposium on Networked Systems Design and Implementation (NSDI 2005)
26. "Are Virtual-Machine Monitors Microkernels Done Right?", Gernot Heiser, Volkmar Uhlig, and Joshua LeVasseur, ACM Sigops Operating System Review (OSR), January 2006

CS2175	APPLICATIONS OF SDN TO REAL NETWORKS	L	T	P	C
	Total Contact Hours - 45	3	0	0	3
	Prerequisite				
	Nil				
PURPOSE					
To learn about the application of SDN techniques to existing networks					
INSTRUCTIONAL OBJECTIVES					
1	To learn techniques to migrate legacy networks towards SDN				
2	To apply SDN techniques for converging wired and wireless networks				

UNIT I Software-Defined Networking

9 Hours

Software-Defined Networking– The Basics-SDN Controllers-A Little History about SDN Controller Platforms-Open Daylight SDN Controllers-What is Open SDN?- SDN in the data center: Sustainable support for tomorrow's applications-Benefits that SDN offers in the data center.

UNIT II Software Defined Networking for Cloud Computing

9 Hours

Applying Software-defined Networks to Cloud Computing-. Cloud Computing and Network Virtualization-. Software-defined Networks (SDNs)- Cloud Network Virtualization using SDN- Case Study with Open Daylight and Open Stack- Final Considerations, Challenges and Perspectives

UNIT III Software Defined Networking for Internet-of-Things

9 Hours

Why SDN for the IoT? -SDN—Simplicity for the IoT-SDN architecture for IOT - SDN— Scalability for the IoT-SDN—Traffic Flow Optimization for the IoT-Security and Connectivity-The Telco Role

UNIT IV SDN for Artificial Intelligence

9 Hours

What is Artificial Intelligence?-Artificial Intelligence in SDN- Load Balance and Flow Routing- Network Security- Intelligent Network Applications.

UNIT V SDN for The 5G Networks

9 Hours

Introduction- Evolution of the Wireless Communication towards the 5G- Network Function Virtualization- Information-Centric Networking- Mobile and Wireless Networks- Ubiquitous Connectivity- Mobile Clouds- Cooperative Cellular Networks- Unification of the control plane- Supporting automatic QoS provisioning- Cognitive Network Management and Operation- Role of Satellites in the 5G networks

TOTAL-45 HRS

REFERENCES:

1. <https://www.sdxcentral.com/sdn/definitions/software-defined-networking-tutorial/>
2. <http://sbrc2015.ufes.br/wp-content/uploads/Ch1.pdf>.

SUPPORTIVE COURSES

MA2013	MATHEMATICAL FOUNDATIONS OF COMPUTER SCIENCE	L	T	P	C
	Total Contact Hours - 45	3	0	0	3
	Prerequisite				
	Nil				
PURPOSE					
To impart analytical ability and to solve real life problems pertaining to branches of Computer Science and Engineering.					
INSTRUCTIONAL OBJECTIVES					
1	To be exposed with logic				
2	To be thorough in mathematical induction				
3	To understand algebraic systems such as relations				
4	To be familiar with the basic concepts of lattices				

UNIT I – LOGIC

9 hours

Logic - Statements - Connectives - Truth tables - Normal forms - Predicate calculus - Inference Theory for Statement calculus and predicate calculus.

UNIT II – COMBINATORICS

9 hours

Combinatory - Mathematical Induction - Pigeonhole principle - Principle of inclusion and exclusion.

UNIT III - RECURSIVE FUNCTIONS

9 hours

Recursive Functions- Recurrence relation - Solution of recurrence relation using characteristic polynomial and using generating function - Recursive functions - Primitive recursive functions, Computable and non computable functions.

UNIT IV - ALGEBRAIC STRUCTURES

9 hours

Algebraic Structures - Groups - Definition and examples only - Cyclic groups
Permutation group (S_n and D_n) - Subgroups - Homomorphism and Isomorphism - Cosets - Lagrange's Theorem - Normal subgroups - Cayley's representation theorem.

UNIT V – LATTICES

9 hours

Lattices - Partial order relations, Poset - Lattices, Hasse diagram - Boolean algebra.

REFERENCES

1. Tremblay J.P. and Manohar R., "*Discrete Mathematical Structures with applications to Computer Science*", McGraw Hill International Edition, 1987

2. Kenneth H. Rosen, Discrete Mathematics and Its Applications, 4th Edition, Tata McGraw Hill, 2002.
3. Venkataraman M.K. et al., "*Discrete Mathematics*", National Publishing Co.,2000.
4. Prof. Sundaresan V., Ganapathy Subramanian K.S.and Ganesan K., "*Discrete Mathematics*", New Revised Edition, 2001.
5. Alan Doerr and Kenneth Levasseur, "*Applied Discrete Structures for Computer Science*", Galgotia Publications (P) Ltd.,1992.
6. Liu C.L., "*Elements of Discrete Mathematics*", 2nd Edition, McGraw Hill Publications, 1985.
7. Gersting. J.L. , "*Mathematical Structures for Computer Science*", 3rd Edition, W.H. Freeman and Co., 1993.
8. Lidl and Pitz, "*Applied abstract Algebra*", Springer - Verlag, New York, 1984.

MA2010	GRAPH THEORY AND OPTIMIZATION TECHNIQUES				L	T	P	C
	Total Contact Hours - 45				3	0	0	3
	Prerequisite							
	Nil							
PURPOSE								
To develop analytical capability and to impart knowledge in graphs, linear programming problem and statistical methods and their applications in Engineering & Technology and to apply their concepts in engineering problems they would come across								
INSTRUCTIONAL OBJECTIVES								
1	Student should be able to understand graphs ,linear programming problems and statistical concepts.							
2	Students should be able to apply the concepts in solving the Engineering problems							

UNIT I - BASICS OF GRAPH THEORY

9 hours

Graphs - Data structures for graphs - Subgraphs - Operations on Graphs Connectivity – Networks and the maximum flow - Minimum cut theorem - Trees - Spanning trees - Rooted trees – Matrix representation of graphs.

UNIT II - CLASSES OF GRAPHS

9 hours

Eulerian graphs and Hamiltonian graphs - Standard theorems - Planar graphs - Euler's formula - Five colour theorem - Coloring of graphs - Chromatic number (vertex and edge) properties and examples - Directed graphs

UNIT III- GRAPH ALGORITHM

9 hours

Computer Representation of graphs - Basic graph algorithms - Minimal spanning tree algorithm - Kruskal and Prim's algorithm - Shortest path algorithms - Dijkstra's algorithm - DFS and BFS algorithms.

UNIT IV - OPTIMIZATION TECHNIQUES

9 hours

Linear programming – Graphical methods – Simplex method (Artificial variables not included) – Transportation and assignment problems.

UNIT V – STATISTICS

9 hours

Tchebyshev's inequality – Maximum likelihood estimation – Correlation – Partial correlation – Multiple correlations.

REFERENCES

1. Narsingh Deo, "Graph Theory with Applications to Engineering and Computer Science", PHI 1974.
2. Rao S.S., "Engineering Optimization: Theory and Practice", New Age International Pvt. Ltd., 3rd Edition 1998.

MA2011	STOCHASTIC PROCESSES AND QUEUEING THEORY		L	T	P	C
	Total Contact Hours - 45		3	0	0	3
	Prerequisite					
	Nil					
PURPOSE						
To impart knowledge on probability concepts to study their applications in stochastic processes & queueing theory						
INSTRUCTIONAL OBJECTIVES						
1	Compute the characteristics of the random variable given the probabilities					
2	Understand and apply various distribution					
3	Solve cases of different Stochastic processes along with their properties.					
4	Use discrete time finite state Markov chains					
5	Gain sufficient knowledge in principles of queueing theory					

UNIT I - RANDOM VARIABLES

9 hours

One dimensional and two dimensional Random Variables – Characteristics of Random Variables : Expectation, Moments.

UNIT II - THEORETICAL DISTRIBUTIONS

9 hours

Discrete : Binomial, Poisson, Negative Binomial, Geometric, Uniform Distributions. Continuous: Uniform, Exponential, Erlang and Gamma, Weibull Distributions.

UNIT III - STOCHASTIC PROCESSES

9 hours

Classification of Stochastic Processes – Bernoulli process – Poisson process – Pure birth process – Birth and Death process.

UNIT IV - MARKOV CHAINS

9 hours

Introduction – Discrete-Parameter Markov Chains – Transition Probability Matrix – Chapman Kolmogorov Theorem – State classification and limiting distributions.

UNIT V- QUEUEING THEORY

9 hours

Introduction – Characteristics of Markovian Single server and Multi server queueing models [(M/M/1) : (∞ / FIFO), (M/M/1) : (N / FIFO), (M/M/s) : (∞ / FIFO)] – M/G/1 Queueing System – Pollaczek Khinchin formula.

REFERENCES

1. Kishore.S.Trivedi, "Probability & Statistics with Reliability, Queuing and Computer Science Applications", PHI, New Delhi, 1995.
2. Veerajan T, "Probability, Statistics and Random Processes", 3rd Edition Tata McGraw Hill, New Delhi, 2002.
3. Gupta S.C and Kapoor V.K, "Fundamentals of Mathematical Statistics", 9th revised edition, Sultan Chand & Co., New Delhi 2003.
4. Gross.D and Harris.C.M. "Fundamentals of Queuing theory", John Wiley and Sons, 1985.
5. Allen.A.O., "Probability, Statistics and Queuing Theory", Academic Press, 1981.

SEMESTER I

CAC2001	CAREER ADVANCEMENT COURSE FOR ENGINEERS – I	L	T	P	C
	Total Contact Hours - 30	1	0	1	1
	Prerequisite				
	Nil				
PURPOSE					
To enhance holistic development of students and improve their employability skills					
INSTRUCTIONAL OBJECTIVES					
1	To improve aptitude, problem solving skills and reasoning ability of the student.				
2	To collectively solve problems in teams & group.				
3	Understand the importance of verbal and written communication in the workplace				
4	Understand the significance of oral presentations, and when they may be used.				
5	Practice verbal communication by making a technical presentation to the class				
6	Develop time management Skills				

UNIT I-BASIC NUMERACY

- Types and Properties of Numbers, LCM, GCD, Fractions and decimals, Surds

UNIT II-ARITHMETIC – I

- Percentages, Profit & Loss, Equations

UNIT III-REASONING - I

- Logical Reasoning

UNIT IV-SOFT SKILLS - I

- Presentation skills, E-mail Etiquette

UNIT V-SOFT SKILLS - II

- Goal Setting and Prioritizing

ASSESSMENT

Soft Skills (Internal)

Assessment of presentation and writing skills.

Quantitative Aptitude (External)

Objective Questions- 60 marks

Descriptive case lets- 40 marks*

Duration: 3 hours

*Engineering problems will be given as descriptive case lets.

REFERENCE:

1. Quantitative Aptitude by Dinesh Khattar – Pearsons Publicaitons
2. Quantitative Aptitude and Reasoning by RV Praveen – EEE Publications
3. Quantitative Aptitude by Abijith Guha – TATA Mc GRAW Hill Publications
4. Soft Skills for Everyone by Jeff Butterfield – Cengage Learning India Private Limited
5. Six Thinking Hats is a book by [Edward de Bono](#) - Little Brown and Company
6. IBPS PO - CWE Success Master by Arihant - Arihant Publications(I) Pvt.Ltd – Meerut

SEMESTER II

CAC2002	CAREER ADVANCEMENT COURSE FOR ENGINEERS – II	L	T	P	C
	Total Contact Hours - 30	1	0	1	1
	Prerequisite				
	Nil				
PURPOSE					
To enhance holistic development of students and improve their employability skills					
INSTRUCTIONAL OBJECTIVES					
1	To improve aptitude, problem solving skills and reasoning ability of the student.				
2	To collectively solve problems in teams & group.				
3	Understand the importance of verbal communication in the workplace				
4	Understand the significance of oral presentations, and when they may be used.				
5	Understand the fundamentals of listening and how one can present in a group discussion				
6	Prepare or update resume according to the tips presented in class.				

UNIT I-ARITHMETIC – II

- Ratios & Proportions, Mixtures & Solutions

UNIT II - MODERN MATHEMATICS

- Sets & Functions, Data Interpretation, Data Sufficiency

UNIT III – REASONING - II

- Analytical Reasoning

UNIT IV – COMMUNICATION – I

- Group discussion, Personal interview

UNIT V - COMMUNICATION - II

- Verbal Reasoning test papers

ASSESSMENT

Communication (Internal)

- Individuals are put through formal GD and personal interviews.
- Comprehensive assessment of individuals' performance in GD & PI will be carried out.

Quantitative Aptitude (External)

Objective Questions- 60 marks (30 Verbal +30 Quants)

Descriptive case lets- 40 marks*

Duration: 3 hours

*Engineering problems will be given as descriptive case lets.

REFERENCES

1. Quantitative Aptitude by Dinesh Khattar – Pearsons Publicaitons
2. Quantitative Aptitude and Reasoning by RV Praveen – EEE Publications
3. Quantitative Aptitude by Abijith Guha – TATA Mc GRAW Hill Publications
4. General English for Competitive Examination by A.P. Bharadwaj – Pearson Educaiton
5. English for Competitive Examination by Showick Thorpe - Pearson Educaiton
6. IBPS PO - CWE Success Master by Arihant - Arihant Publications(I) Pvt.Ltd - Meerut
7. Verbal Ability for CAT by Sujith Kumar - Pearson India
8. Verbal Ability & Reading Comprehension by Arun Sharma - Tata McGraw – Hill Education

CAC2003	CAREER ADVANCEMENT COURSE FOR ENGINEERS – III	L	T	P	C
	Total Contact Hours - 30	1	0	1	1
	Prerequisite				
	Nil				
PURPOSE					
To develop professional skills abreast with contemporary teaching learning methodologies					
INSTRUCTIONAL OBJECTIVES					
1	Acquire knowledge on planning, preparing and designing a learning program				
2	prepare effective learning resources for active practice sessions				
3	facilitate active learning with new methodologies and approaches				
4	create balanced assessment tools				
5	hone teaching skills for further enrichment				

UNIT I- DESIGN

(2 hrs)

- Planning & Preparing a learning program.
- Planning & Preparing a learning session

UNIT II – PRACTICE

(2 hrs)

- Facilitating active learning
- Engaging learners

UNIT III – ASSESSMENT

(2 hrs)

- Assessing learner's progress
- Assessing learner's achievement

UNIT IV – HANDS ON TRAINING

(10 hrs)

- Group activities – designing learning session
- Designing teaching learning resources
- Designing assessment tools
- Mock teaching session

UNIT V – TEACHING IN ACTION

(14 hrs)

- Live teaching sessions
- Assessments

ASSESSMENT (Internal)

Weightage:

Design - 40%

Practice – 40%

Quiz – 10%

Assessment – 10%

REFERENCES

1. Cambridge International Diploma for Teachers and Trainers Text book by Ian Barker - Foundation books
2. Whitehead, Creating a Living Educational Theory from Questions of the kind: How do I improve my Practice? Cambridge J. of Education

