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

<table>
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Total credits to be earned for the award of M.Tech degree – 74 credit
## PROGRAM ELECTIVES

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## SUPPORTIVE COURSES

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**NOTE:**

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

ADVANCED NETWORKS AND COMMUNICATION SYSTEMS

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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

UNIT II NETWORK ROUTING AND TRAFFIC MANAGEMENT 9 hours

UNIT III WIRELESS NETWORK TECHNIQUES 9 hours

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

UNIT V  INTERNET SECURITY AND NETWORK MANAGEMENT   10 hours

TOTAL- 45 HRS

REFERENCES
3. Adrian Farrel, “The Internet and its Protocols “First India Reprint 2005, Elsevier publications (Units5)
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

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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

UNIT II SDN ABSTRACTIONS

UNIT III PROGRAMMING SDN'S
Network Programmability - Network Function Virtualization - NetApp Development, Network Slicing

UNIT IV SDN APPLICATIONS AND USE CASES
SDN in the Data Center - SDN in Other Environments - SDN Applications - SDN Use Cases - The Open Network Operating System

UNIT V SDN'S FUTURE AND PERSPECTIVES
SDN Open Source - SDN Futures - Final Thoughts and Conclusions

Lab:
Introducing Mininet
Setting up the Environment and Implementation of Controllers in Mininet
Mininet, Custom Topologies in POX, ODL, Floodlight

TOTAL- 60 HRS
Click, ONOS, Northbound – Southbound Interfacing, ONOS deployment
ONOS – OPNFV – SDN Application development 3

TOTAL- 15 HRS

REFERENCES
2. SDN - Software Defined Networks by Thomas D. Nadeau & Ken Gray, O'Reilly, 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

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

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

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,
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| Students to choose one Elective course from the list of courses mentioned in the curriculum |

| **SUPPORTIVE COURSE** |   |   |   |   |
| 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** |   |   |   |   |
| 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

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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)

60 HRS

REFERENCE:
1. Adnan Ahmed Siddiqui - OpenStack Orchestration, PACKT Publishing 2015

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<th>MOBILE COMPUTING AND INTERNET OF THINGS</th>
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**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

**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

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, SMTPLibIoT 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
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.
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**


**UNIT II – FUNDAMENTALS OF SDN**


**UNIT III – SDN IN OTHER ENVIRONMENTS**

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

UNIT V – SDN IN OPTICAL NETWORKS AND MANAGEMENT  
9 hours

Total- 45 hrs

REFERENCES:
Students to choose one Elective course from the list of courses mentioned in the curriculum

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Students to choose one Elective course from the list of courses mentioned in the curriculum

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Students to choose one Elective course from the list of courses mentioned in the curriculum

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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.
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:

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<td>End semester</td>
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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.
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<th>COOPERATIVE COMMUNICATION SYSTEMS</th>
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**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

**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 CooperativeNetworks
UNIT-V CROSS-LAYER ISSUES IN COOPERATIVE NETWORKS
QoS in Cooperative Networks- Routing in Cooperative Networks- Security Issues in Cooperative Networks - Network lifetime maximization via cooperation

TOTAL- 45 HRS

REFERENCES
CS2171 SECURITY IN SOFTWARE DEFINED NETWORKING

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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

UNIT – II - Network Security 9 Hours

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

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
CS2172
SOFTWARE DEFINED RADIOS

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**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

**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
UNIT V: CASE STUDIES IN SOFTWARE RADIO DESIGNS

9 Hours


TOTAL- 45 HRS

REFERENCES

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

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

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

TOTAL -45 HRS

REFERENCES
CS2158 | SDN and NFV FOR IoT | L | T | P | C
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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

**UNIT II: SOFTWARE DEFINED NETWORKS**
9 Hours

**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

**UNIT V: SECURITY**
9 Hours

**TOTAL - 45 HRS**

**REFERENCES**
3. Paresh Shah, Syed Farrukh Hassan, Rajendra Chayaphat, “Network Function virtualization with a touch of sdn”
CS2162

CLOUD STORAGE AND COMPUTING

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Total Contact Hours – 45

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
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 I - INTRODUCTION TO EMBEDDED SYSTEMS 9 Hours

UNIT II - REAL-TIME ENVIRONMENT 9 Hours

UNIT III - REAL-TIME OPERATING SYSTEMS 9 Hours

UNIT IV - SYSTEM DESIGN 9 Hours

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

5. https://www.elsevier.com/books/embedded-systems-architecture/noergaard/978-0-12-382196-6#maincontent
### 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
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

### UNIT III – I/O VIRTUALIZATION
UNIT IV – VIRTUALIZED COMPUTING
9 hours

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
2. IEEE Computer special issue on virtualization technologies, Renato J. Figueiredo, Jose A. B. Fortes, Peter A. Dinda, Editors (May 2005
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
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
CS2175 APPLICATIONS OF SDN TO REAL NETWORKS

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Total Contact Hours - 45

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
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
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

UNIT IV SDN for Artificial Intelligence

UNIT V SDN for The 5G Networks

TOTAL-45 HRS
REFERENCES:
SUPPORTIVE COURSES

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<th>MA2013</th>
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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 (Sn and Dn) - 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
MA2010

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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

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
Tchebychev'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.
MA2011 STOCHASTIC PROCESSES AND QUEUEING THEORY

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**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

**UNIT V- QUEUING THEORY**
9 hours
Introduction – Characteristics of Markovian Single server and Multi server queuing models [(M/M/1) : (∞ / FIFO), (M/M/1) : (N / FIFO), (M/M/s) : (∞ /FIFO)] – M/G/1 Queuing System – Pollaczek Khinchin formula.
REFERENCES
SEMMESTER 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 – Pearson 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

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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 – Pearson 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

SEMESTER III
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**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**

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

**UNIT II – PRACTICE**

- Facilitating active learning
- Engaging learners

**UNIT III – ASSESSMENT**

- Assessing learner’s progress
- Assessing learner’s achievement

**UNIT IV – HANDS ON TRAINING**

- Group activities – designing learning session
- Designing teaching learning resources
- Designing assessment tools
- Mock teaching session
UNIT V – TEACHING IN ACTION

- 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

# AMENDMENTS

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