M. Tech. Computer Science and Engineering

CURRICULUM AND SYLLABI

(2018-2019)

M.Tech (CSE) - Specialization in Cloud Computing

VIT®

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

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VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

Transforming life through excellence in education and research.

MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

World class Education: Excellence in education, grounded in ethics and critical thinking, for improvement of life.

Cutting edge Research: An innovation ecosystem to extend knowledge and solve critical problems.

Impactful People: Happy, accountable, caring and effective workforce and students.

Rewarding Co-creations: Active collaboration with national & international industries & universities for productivity and economic development.

Service to Society: Service to the region and world through knowledge and compassion.

VISION STATEMENT OF THE SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

To be a world-renowned centre of education, research and service in computing and allied domains.

MISSION STATEMENT OF THE SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

- To offer computing education programs with the goal that the students become technically competent and develop lifelong learning skill.
- To undertake path-breaking research that creates new computing technologies and solutions for industry and society at large.
- To foster vibrant outreach programs for industry, research organizations, academia and society.

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School of Computer Science and Engineering

M.Tech (CSE) - Specialization in Cloud Computing

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Graduates will be engineering professionals who will engage in technology development and deployment with social awareness and responsibility.

2. Graduates will function as successful practicing engineer / researcher / teacher / entrepreneur in the chosen domain of study.

3. Graduates will have holistic approach addressing technological, societal, economic and sustainability dimensions of problems and contribute to economic growth of the country.

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M. Tech Computer Science and Engineering
Specialization in Cloud Computing

PROGRAMME OUTCOMES (POs)

PO_1 Having an ability to apply mathematics and science in engineering applications

PO_2 Having an ability to design a component or a product applying all the relevant standards and with realistic constraints

PO_3 Having an ability to design and conduct experiments, as well as to analyze and interpret data

PO_4 Having an ability to use techniques, skills and modern engineering tools necessary for engineering practice

PO_5 Having problem solving ability- solving social issues and engineering problems

PO_6 Having adaptive thinking and adaptability

PO_7 Having a clear understanding of professional and ethical responsibility

PO_8 Having a good cognitive load management [discriminate and filter the available data] skills

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School of Computer Science and Engineering

M.Tech (CSE) - Specialization in Cloud Computing

PROGRAMME SPECIFIC OUTCOMES (PSOs)

1. Ability to design and develop computer programs/computer-based systems in the advanced level of areas including algorithms design and analysis, networking, operating systems design, etc.

2. Ability to apply the advanced concepts of cloud infrastructure that pave the way to create a platform to gain skills which impacts setting up a cloud environment.

3. Ability to bring out the capabilities for research and development in contemporary issues and to exhibit the outcomes as technical report.

Category-wise Credit distribution

S.no	Category	Credits
1	University Core	27
2	University Elective	06
3	Programme Core	20
4	Programme Elective	17
Recommended Total Number of Credits		70
Minimum Total Number of Credits (As per Acad. Council)		70

UNIVERSITY CORE						
Course Code	**Course Title**	**L**	**T**	**P**	**J**	**C**
MAT5002	Mathematics for Computer Engineering	3	0	0	0	3
EFL5097/ENG5001	Scientific English / Foreign Language	1	0	2	0	2
STS5001	Soft Skills – I	0	0	0	0	1
STS5002	Soft Skills – II	0	0	0	0	1
SET5001	SET Project – I	0	0	0	0	2
SET5002	SET Project – II	0	0	0	0	2
CSE6099	Master's Thesis	0	0	0	0	16

PROGRAMME CORE						
Course Code	**Course Title**	**L**	**T**	**P**	**J**	**C**
CSE5001	Algorithms: Design and Implementations	2	0	2	0	3
CSE5002	Operating Systems and Virtualization	2	0	2	0	3
CSE5004	Computer Networks	2	0	2	0	3
CSE6004	Cloud Computing Eco-systems	2	0	2	4	4
CSE6010	Cloud Application Development and Management	2	0	2	4	4
CSE6003	Web services	2	0	2	0	3

PROGRAMME ELECTIVE						
Course Code	**Course Title**	**L**	**T**	**P**	**J**	**C**
CSE5006	Multicore Architectures	2	0	2	0	3
CSE6001	Bigdata Frameworks	2	0	2	4	4
CSE6005	Machine Learning	2	0	2	4	4
CSE6006	NoSQL Databases	2	0	2	4	4
CSE6026	IoT on Cloud	2	0	2	4	4
CSE6027	Mobile Cloud Computing	2	0	2	4	4
CSE6028	Cloud Security and Audit	2	0	0	4	3
CSE6029	Cloud Storage Technologies	2	0	2	4	4
CSE6030	Design Thinking	2	0	0	4	3
CSE6031	Cyberspace and Information Technology Laws	2	0	0	0	2
CSE6032	Cloud Computing Paradigm on software Engineering	2	0	0	4	3

UNIVERSITY ELECTIVE				
Course	**L**	**T**	**P**	**C**
University Elective-I	-	-	-	3
University Elective-II	-	-	-	3
Total	-	-	-	6

BREAKUP OF COURSES		
Sl.No.	**Category**	**Credits**
1	University Core	27
2	University Elective	06
3	Programme Core	20
4	Programme Elective	17
Recommended Total Number of Credits		70
Minimum Total Number of Credits (As per Acad. Council)		70

		L	T	P	J	C
	Mathematics for Computer Engineering	**3**	**0**	**0**	**0**	**3**

Pre-requisite	**Nil**	**Syllabus version**
Anti-requisite		v. 1.0

Course Objectives:

1. To introduce the basics of mathematical concepts like number theory, probability, statistics and queuing theory
2. To understand the applications of these mathmetical concepts in field of computer science

Expected Course Outcome:

1. Understand the relationship between mathematics and computer science
2. Ability to apply mathematics for designing computer system

Module:1	**Proof Techniques**	**6 Hours**

Implications, equivalences, converse, inverse, contrapositive, negation, contradiction, structure, direct proofs, disproofs, natural number induction, structural induction, weak/string induction, recursion, well orderings

Module:2	**Linear algebra**	**6 Hours**

Eigenvalues and eigenvectors-Gerschgorin Circles–Rutishauser method, Rotation and Reflection matrices- Face Recognition application

Module:3	**Number Theory**	**6 Hours**

Divisibility -division algorithm -Euclidean algorithm- Definitions and basic properties of congruences - Solving linear congruences and quadratic congruences, Applications of congruences: The Chinese remainder theorem, Euler's theorem aand Fermat's little theorem- Primarily checking,

Module:4	**Probability**	**6 Hours**

Introduction to random variable -Binomial and Poisson distributions – Normal distribution, Weibull, exponential and Gamma distributions Performance modeling application

Module:5	**Statistical Measures**	**6 Hours**
Correlation and regression- Covariance–partial and multiple correlation- multiple regression – Time Seriesdata Analysis application.		
Module:6	**Sampling Theory**	**8 Hours**
Small sample tests- student's t –test ,F-test, chi-square test, goodness of fit , independence of attributes, Basic principles of experimentation, Analysis of variance –application using Monte-Carlo methods and decision trees		
Module:7	**Queuing Theory**	**5 Hours**
Introduction-Markov Process-Poisson Process- Pure Berth Process-Death Process-Birth-death processes- Queue notation-Little's theorem-Queuing models M/M/1; M/M/c; M/M/∞		
Module:8	Expert Lecture: Modular arithmetic-Applications to cryptosystem	**2 Hours**
	Total Lecture hours:	**Hours: 45**

Reference Books

1.	Neal Koblitz, A course in number theory and cryptography, Springer reprint (2002).
2.	J. P. Tremblay and R Manohar Discrete Mathematical Structures with applications to Computer Science, Tata McGraw Hill (2001).
3.	Ronald E. Walpole , Raymond H. Myers Sharon L. Myers Keying E. Ye,Probability and Statistics for Engineers and Scientists (9th Edition),
4.	H. A .Taha Operations Research, 9 th Edition, PHI (2010).
5.	Narasingh Deo, Graph Theory, PHI, 23rd Indian reprint (2002).

Mode of Evaluation: Digital assignments, Continuous Assessment tests, Final Assessment Test

Recommended by Board of Studies	**09-03-2016**		
Approved by Academic Council	**No. 40**	**Date**	

		L	T	P	J	C
ENG5001	**Fundamentals of Communication Skills**	**0**	**0**	**2**	**0**	**2**
Pre-requisite	**Not cleared EPT (English Proficiency Test)**	**Syllabus version**				
Anti-requisite		v. 1.0				

Course Objectives:

To enable learners learn basic communication skills - Listening, Speaking, Reading and Writing and apply them for various purposes in academic and social contexts

Expected Course Outcome:

Ability to communicate effectively in social and academic contexts

Module:1	**Listening**	**8 hours**

Understanding Conversation

Listening to Speeches

Listening for Specific Information

Module:2	**Speaking**	**4 hours**

Exchanging Information

Describing Activities, Events and Quantity

Module:3	**Reading**	**6 hours**

Identifying Information

Inferring Meaning

Interpreting text

Module:4	**Writing: Sentence**	**8 hours**

Basic Sentence Structure

Connectives

Transformation of Sentences

Synthesis of Sentences

Module:5	Writing: Discourse	**4 hours**

Instructions Paragraph Transcoding			
	Total Practical hours:	**Hours: 30**	
List of Challenging Experiments (Indicative)			
1.	Familiarizing students to adjectives through brainstorming adjectives with all letters of the English alphabet and asking them to add an adjective that starts with the first letter of their name as a prefix.		2 hours
2.	Making students identify their peer who lack Pace, Clarity and Volume during presentation and respond using Symbols.		4 hours
3.	Using Picture as a tool to enhance learners speaking and writing skills		2 hours
4.	Using Music and Songs as tools to enhance pronunciation in the target language / Activities through VIT Community Radio		2 hours
5.	Making students upload their Self- introduction videos in Vimeo.com		4 hours
6.	Brainstorming idiomatic expressions and making them use those into their writings and day to day conversation		4 hours
7.	Making students Narrate events by adding more descriptive adjectives and add flavor to their language / Activities through VIT Community Radio		4 hours
8.	Identifying the root cause of stage fear in learners and providing remedies to make their presentation better		4 hours
9.	Identifying common Spelling & Sentence errors in Letter Writing and other day to day conversations		2 hours
10	Discussing FAQ's in interviews with answers so that the learner gets a better insight in to interviews / Activities through VIT Community Radio		2 hours
	Total Laboratory Hours		**30 hours**
1.	Redston, Chris, Theresa Clementson, and Gillie Cunningham. Face2face Upper Intermediate Student's Book. 2013, Cambridge University Press.		
Reference Books			
1.	Chris Juzwiak . Stepping Stones: A guided approach to writing sentences and Paragraphs (Second Edition), 2012, Library of Congress.		
2.	Clifford A Whitcomb & Leslie E Whitcomb, Effective Interpersonal and Team Communication Skills for Engineers, 2013, John Wiley & Sons, Inc., Hoboken: New Jersey.		

3.	Arun Patil, Henk Eijkman & Ena Bhattacharya, New Media Communication Skills for Engineers and IT Professionals,2012, IGI Global, Hershey PA.		
4.	Judi Brownell, Listening: Attitudes, Principles and Skills, 2016, 5 th Edition, Routledge:USA		
5.	John Langan, Ten Steps to Improving College Reading Skills, 2014, 6 th Edition, Townsend Press:USA		
6.	Redston, Chris, Theresa Clementson, and Gillie Cunningham. Face2face Upper Intermediate Teacher's Book. 2013, Cambridge University Press.		
Mode of Evaluation: Online Quizzes, Presentation, Role play, Group Discussions, Assignments, Mini Project			
Recommended by Board of Studies	22-07-2017		
Approved by Academic Council	No. 46	**Date**	24-08-2017

		L	T	P	J	C
STS5001	**Essentials of Business etiquettes**	**3**	**0**	**0**	**0**	**1**
Pre-requisite	**Nil**			**Syllabus version**		
Anti-requisite				v. 2.0		

Course Objectives:

Having Computational thinking (Ability to translate vast data into abstract concepts and to understand database reasoning)

Having problem solving ability- solving social issues and engineering problems

Expected Course Outcome:

Enabling students to use relevant aptitude and appropriate language to express themselves

To communicate the message to the target audience clearly

Module:1	**Business Etiquette: Social and Cultural Etiquette and Writing Company Blogs and Internal Communications and Planning and Writing press release and meeting notes**	**9 Hours**

Value, Manners, Customs, Language, Tradition, Building a blog, Developing brand message, FAQs', Assessing Competition, Open and objective Communication, Two way dialogue, Understanding the audience, Identifying, Gathering Information,. Analysis, Determining, Selecting plan, Progress check, Types of planning, Write a short, catchy headline, Get to the Point –summarize your subject in the first paragraph., Body – Make it relevant to your audience,

Module:2	**Study skills – Time management skills**	**3 Hours**

Prioritization, Procrastination, Scheduling, Multitasking, Monitoring, Working under pressure and adhering to deadlines

Module:3	**Presentation skills – Preparing presentation and Organizing materials and Maintaining and preparing visual aids and Dealing with questions**	**7 Hours**

10 Tips to prepare PowerPoint presentation, Outlining the content, Passing the Elevator Test, Blue sky thinking, Introduction, body and conclusion, Use of Font, Use of Color, Strategic presentation, Importance and types of visual aids, Animation to captivate your audience, Design of posters, Setting out the ground rules, Dealing with interruptions, Staying in control of the questions, Handling difficult questions

Module:4	**Quantitative Ability -L1 – Number properties and Averages and Progressions and Percentages and Ratios**	**11 Hours**
Number of factors, Factorials, Remainder Theorem, Unit digit position, Tens digit position, Averages, Weighted Average, Arithmetic Progression, Geometric Progression, Harmonic Progression, Increase & Decrease or successive increase, Types of ratios and proportions		
Module:5	**Reasoning Ability-L1 – Analytical Reasoning**	**8 Hours**
Data Arrangement(Linear and circular & Cross Variable Relationship), Blood Relations, Ordering/ranking/grouping, Puzzle test, Selection Decision table		
Module:6	**Verbal Ability-L1 – Vocabulary Building**	**7 Hours**
Synonyms & Antonyms, One word substitutes, Word Pairs, Spellings, Idioms, Sentence completion, Analogies		
	Total Lecture hours:	**Hours: 45**

Reference Book

1.	Kerry Patterson, Joseph Grenny, Ron McMillan, Al Switzler(2001) Crucial Conversations: Tools for Talking When Stakes are High. Bangalore. McGraw - Hill Contemporary
2.	Dale Carnegie,(1936) How to Win Friends and Influence People. New York. Gallery Books
3.	Scott Peck. M(1978) Road Less Travelled. New York City. M. Scott Peck.
4.	FACE(2016) Aptipedia Aptitude Encyclopedia. Delhi. Wiley publications
5.	ETHNUS(2013) Aptimithra. Bangalore. McGraw-Hill Education Pvt. Ltd.

Mode of Evaluation:FAT, Assignments, Projects, Case studies, Role plays, 3 Assessments with Term End FAT (Computer Based Test)

Recommended by Board of Studies	09/06/2017		
Approved by Academic Council	No 45	**Date**	15/06/2017

		L	T	P	J	C
CSE5001	**Algorithms: Design and Implementation**	**2**	**0**	**2**	**0**	**3**
Pre-requisite	**Nil**				**Syllabus version**	
Anti-requisite					v. 1.0	

Course Objectives:

1. To focus on the design of algorithms in various domains
2. To provide a foundation for designing efficient algorithms.
3. To provide familiarity with main thrusts of work in algorithms-sufficient to give some context for formulating and seeking known solutions to an algorithmic problem.

Expected Course Outcome:

1. Solve a problem using Algorithms and design techniques
2. Solve complexities of problems in various domain
3. Implement algorithm, compare their performance characteristics, and estimate their potential effectiveness in applications

Module:1	**Introduction**	**5 Hours**

Algorithm design techniques: Divide and Conquer, Brute force, Greedy, Dynamic Programming. Time complexity (asymptotic notation, recurrence relations)

Module:2	**Network Flows**	**6 Hours**

Maximum Flows, Min-cost Flows, Max-Flow Min-Cut Theorem, Cycle Cancelling Algorithms, Strongly Polynomial-time Analysis, Minimum Cuts without Flows

Module:3	**Tractable and Intractable Problems**	**3 Hours**

Class complexity: P, NP, NP-Hard, NP-Complete

Module:4	**Approximation Algorithms**	**3 Hours**

Limits to Approximability, Vertex Cover problem, Set cover problem, Euclidean TSP

Module:5	**Search Algorithms for Graphs and Trees**	**4 Hours**

Overview of fundamental algorithms, Dijkstra's algorithm, A* search algorithm		
Module:6	**Computational Geometry**	**4 Hours**
Line Segments, Convex hull finding algorithms		
Module:7	**Linear Programming**	**3 Hours**
Representing problems - shortest paths, maximum flow, and minimum-cost flow as linear programming problems. Simplex algorithm		
Module:8	**Recent Trends**	**2 Hours**
	Total Lecture hours:	**Hours: 45**
List of Challenging Experiments (Indicative)		

1.	Implementation of algorithms for problems that can be solved by one or more of the following strategies: Divide and Conquer, Brute force, Greedy, Dynamic Programming	4 hours
2.	Implementation of Ford Fulkerson method, Edmonds-Karp algorithm for finding maximum flow in a flow network and applying them for solving typical problems such as railway network flow, maximum bipartite matching	4 hours
3.	Implementation of Dinic's strongly polynomial algorithm for computing the maximum flow in a flow network and applying it for solving typical problems	2 hours
4.	Implementation of push-relabel algorithm of Goldberg and Tarjan for finding maximum flow in a flow network and applying it for solving typical problems	2 hours
5.	Applying linear programming for solving maximum flow problem	2 hours
6.	Applying network flow algorithms for baseball elimination and airline scheduling	2 hours
7.	Given a flow network G =(V , E, s, t) ,where V is the vertex set, E is the edge set , s and t are source and destination. An edge of the flow network is called critical if a decrease in the flow over that edge results in a decrease in the total flow of the flow network. An edge of the flow network is called a bottleneck edge if an increase in the flow over that edge results in an increase in the total flow of the flow	2 hours

	network. Assume that you are using to compute the maximum flow of the network. (a) Write a program (any language) to identify all the critical edges. (b) Write a program (any language) t o identify all bottleneck edges in the network.	
8.	Implementation of solution techniques for the minimum-cost flow problem	2 hours
9.	Design a polynomial time algorithm to compute the solution of a linear programming problem in two dimensions. Your algorithm should convert each constraint of the problem, into a planar region .Use that algorithm to compute the solution of the following problem. Implement your algorithm in any programming language. A manufacturer of furniture makes two products: chairs and tables. Processing of these products is done on two machines M1 and M2. A chair requires 2 hours on machine M1 and 6 hours on machine M2. A table requires 5 hours on machine M1 and no time on machine M2. There are 16 hours of time per day available on machine M1 and 30 hours on machine M2. Profits gained by manufacturer from a chair and a table are Rs.1 and Rs. 5 respectively. The problem is to maximize the profit for the manufacturer	2 hours
10.	Implementation of algorithms for the vertex cover problem, set cover problem, TSP	2 hours
11.	Implementation of search algorithms for graphs and trees: fundamental algorithms, Dijkstra's algorithm	2 hours
12.	Consider the problem of barricading n sleeping tigers by a fence of shortest length .Forest officials have tranquilized each tiger. Suggest an algorithm for the purpose. You are allowed to assume any information required for your algorithm. Implement your algorithm in any programming language(using convex hull)	2 hours
13.	A simple polygon is defined as a flat shape consisting of straight non-intersecting line segments or sides that are joined pair –wise to from a closed path. Let P = { p_1 , p_2 , p_3 ,.... p_n } be a set of points in the two dimensional plane. (a) Write a program to find the simple polygon of P . (b) Write a program (linear time) to convert that the simple polygon of P to a Convex Hull.	2 hours
Students a r e f r e e t o implement the algorithms using programming languages of their choice.		
	Total Laboratory Hours	**30 hours**

Reference Books	
1.	Cormen, Leiserson, Rivest and Stein, “Introduction to Algorithms”, 3 rd edition, McGraw-Hill, 2009.
2.	J.Kleinberg and E.Tardos. “Algorithm Design”, Pearson Education, 2009.
3.	E. Horowitz, S. Sahni, S.Rajasekaran,“Fundamentals of Computer Algorithms”, 2 nd edition, Universities Press, 2011.
4.	Ravindra K. Ahuja, Thomas L. Magnanti, and James B. Orlin, “Network Flows: Theory, Algorithms, and Applications”, Pearson Education, 2014.
5.	George T. Heineman, Gary Pollice, Stanley Selkow, “Algorithms in a nutshell”, O'Reilly Media, 2 nd edition, 2016.

Mode of Evaluation:

Theory : Digital Assignments, Continuous Assessment Tests and Final Assessment Test

Lab : Midterm test in lab, lab experiments submission and Final Assessment in lab

Recommended by Board of Studies	13.05.2016		
Approved by Academic Council	41	**Date**	17.06.2016

CSE5002	Operating systems and Virtualization	L	T	P	J	C
		2	0	2	0	3
Pre-requisite	**Nil**	**Syllabus version**				
Anti-requisite		v. 1.0				

Course Objectives:

1. This course introduces to virtualization, operating systems fundamental concepts and its technologies.

2. This course provides the skills to write programs that interact with operating systems components such as Processes, Thread, Memory during concurrent execution

3, This course provides the skills and knowledge necessary to implement, provisioning and administer server and desktop virtualization.

Expected Course Outcome:

1. Categorize the levels of abstraction in a computer system correspond to implementation layers in both hardware and software.
2. Apply and design the procedure used for concurrency and memory management.
3. Comprehend the basics of virtualization and to differentiate types of Virtualization.
4. Develop and provision server and desktop virtualization
5. Analyze the inner-working of a Virtual Machine and its Management

Module:1	**Computer System Architecture**	**2 Hours**

Computer system architecture a layered view with interfaces - Glenford Myer, Monolithic Linux & Hybrid Windows 10 kernels Layered architecture of operating system and core functionalities

Module:2	**Process**	**4 Hours**

Introduction, Process Operations, States, Context switching, Data Structures(Process Control Block (PCB), Process Scheduling: Multi-Level Feedback Queue, Multi-processor Scheduling, Deadlocks and its detection

Module:3	**Memory**	**4 Hours**

Introduction, Address Spaces, Memory API, Address Translation, Paging - Faster Translations (TLB), Smaller Tables. Virtual Memory System in x86

Module:4	Concurrency	4 Hours
Introduction, Thread Models, Thread API, Building & Evaluating a Lock, Test And Set, Two phase lock, Classical problems handling using semaphore Persistence - File Organization: The i-node, Crash Consistency & file security		
Module:5	**Virtual Machines**	**2 Hours**
Process and System VMs - Taxonomy of VMs		
Module:6	**Types of Virtualization**	**4 Hours**
Hardware Emulation, Full Virtualization with binary translation, Hardware assisted, Operating System Virtualization, OS assisted /Para virtualization		
Module:7	**Hypervisor and VM portability**	**5 Hours**
Hypervisor - Type 1, Type 2 Para-virtualization - Server Virtualization, Desktop Virtualization Overview VM portability Clones, Templates, Snapshots, OVF, Hot and Cold Cloning Protecting & Increasing Availability Light Weight Virtual machine: Container / Docker		
Module:8	**Recent Trends**	**2 Hours**
	Total Lecture hours:	**Hours: 45**
List of Challenging Experiments (Indicative)		**SLO 14, 17**
Each experiment should require the student to submit a system analysis & design document that describes the details of the experiment. The experiment may be submitted before the next lab if not completed within class hours. Collaboration and discussion with co-students on the experiments is encouraged. However plagiarism will be penalized severely as per University regulations.		

1.	Retrieval of System data file and its information	2 hours
2.	Write a program to simulate multi-level queue scheduling algorithm (ex) All the processes in the system are divided into two categories – system processes and user processes. System processes are to be given higher priority than user processes. Use FCFS scheduling for the processes in each queue.	4 hours
3.	Program to demonstrate Process Life Cycle	2 hours
4.	Process Synchronization using Binary and Counting Semaphore	2 hours

5.	Deadlock Avoidance Using Semaphores: Implement the deadlock-free solution to Dining Philosophers problem to illustrate the problem of deadlock and/or starvation that can occur when many synchronized threads are competing for limited resources.	6 hours
6.	Parallel Thread management using pthread library. Implement a data parallelism using multi-threading. Application should have Thread create, Thread synchronization, Thread termination. In the program, every thread must return the value and must be synchronized in the main function. Final consolidation should be done by main thread (main function)	2 hours
7.	Type II Hypervisor setup and configuration Create Virtual Machines (VM) Create Snapshot of all Virtual Machines Create clone of VM Configure Networking	2 hours
8.	Type I Hypervisor setup and configuration Virtual machines on Xen Migration of VMs Create a Virtual Network Switch Create Differencing Hard Disks for use by Virtual Machines	4 hours
Associate Hard Disks with Virtual Machines		
9.	VM migration and Backup and recovery virtual machines in type I	2 hours
10	Implementation of Server virtualization – multiple servers on single system	2 hours
11	Implementation of Desktop virtualization	2 hours
	Total Laboratory Hours	**30 hours**

Reference Books

1.	Thomas Anderson, Michael Dahlin , “Operating Systems: Principles and Practice” , Second Edition, Recursive Books,2014
2.	William Stallings,” Operating Systems: Internals and Design Principles”, 8th Edition, 2014.
3.	Remzi H. Arpaci-Dusseau and Andrea C, “Operating Systems: Three Easy Pieces”, . Arpaci-Dusseau , University of Wisconsin – Madison,2015

4.	A. Silberschatz and P. Galvin. “Operating System Concepts”. Eight Edition, John Wiley & Sons, 2008
5.	Matthew Portnoy, “Virtualization Essentials”, John Wiley & Sons Inc; 2nd Edition edition (8 September 2016)
6.	Smith, Nair, “Virtual Machines: Versatile Platforms for Systems and Processes”, Morgan Kaufmann Publishers (2005)

Mode of Evaluation:

Theory : Digital Assignments, Continuous Assessment Tests and Final Assessment Test

Lab : Midterm test in lab, lab experiments submission and Final Assessment in lab

Recommended by Board of Studies	13.05.2016		
Approved by Academic Council	41	**Date**	17.06.2016

		L	T	P	J	C
CSE5004	**COMPUTER NETWORKS**	**2**	**0**	**2**	**0**	**3**
Pre-requisite	**Nil**				**Syllabus version**	
Anti-requisite					v. 1.0	

Course Objectives:

1. Learn the division of network functionalities into layers.
2. Be familiar with the components required to build different types of networks and protocol
3. Understand the flow control and congestion control algorithms
4. Design the subnet and super net for particular organization

Expected Course Outcome:

1. Explore the basics of Computer Networks and Various Protocols.
2. Administrate a network and flow of information
3. Plan and design networks

Module:1	**INTRODUCTION**	**6 Hours**

Network models, Addressing: Classful and Classless, Routing Protocols : unicast, multicast, Congestion control, Host configuration: DHCP, DNS

Module:2	**NETWORK MANAGEMENT**	**4 Hours**

SNMP : Management Components, SMI, MIB, Configuration

Management – Fault management – Performance Management –

Accounting Management, Case studies

Module:3	**SOFTWARE DEFINED NETWORKS**	**5 Hours**

SDN Data plane, Control Plane, Application Plane. SDN security

attack vectors and SDN Harderning, Overlay model and network

model for cloud computing

Module:4	**Network Functions Virtualization**	**3 Hours**
Concepts, Benefits, requirements, Reference architecture, Management, Functionality and Infrastructure		
Module:5	**Network Virtualization**	**4 Hours**
Virtual LAN, Virtual Private Networks: IPSEC, MPLS, Network Virtualization Architecture and Benefits		
Module:6	**Security**	**2 Hours**
Security requirements, Threats to SDN, SDN security, NFV Security and its techniques		
Module:7	**Network Design Implications of QoS and QoE**	**4 Hours**
QoS Architectural Framework, SLA, IP Performance metrics, QoE: Strategies, Measurements, QoE/QoS Mapping models		
Module:8	**RECENT TRENDS**	**2 Hours**
	Total Lecture hours:	**Hours: 30**

List of Challenging Experiments (Indicative)		
1.	Study of different types of Network cables and Practically implement the cross-wired cable and straight through cable using crimping tool.	4 hours
Using commands and tools		
2.	Study of Network Devices in Detail.	4 hours
3.	Study of network IP.	2 hours
4.	Web NMS (SNMP based)	2 hours
5.	Network Simulators (Programs using NS3) .	2 hours
6.	Implementation of routing protocols in MANETs	4 hours
7.	Network trouble shooting	2 hours
8.	Programs using network packet tracers	2 hours
9.	SDN Applications and Use Cases (e.g. Multicasting)	4 hours

10	Network Virtualization and Slicing (e.g. FlowVisor)	2 hours
11	Network Function Virtualization (NFV)	2 hours
	Total Laboratory Hours	**30 hours**

Reference Books

1.	William Stallings, “Data and Computer Communication”, Sixth Edition, Pearson Education, 2000
2.	Behrouz A. Forouzan, ,“TCP/IP Protocol Suite”,Tata McGraw Hill edition, Fourth Edition. 2015.
3.	William Stallings, ”Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud" Pearson,2015
4.	James F. Kuross, Keith W. Ross, “Computer Networking, A Top-Down Approach Featuring the Internet”, Third Edition, Addison Wesley, 2004.
5.	Andrew S. Tanenbaum, “Computer Networks”, Fourth Edition, 2003.
6.	Forouzan, A. Behrouz. “Data Communications & Networking (sie)”. Tata McGraw-Hill Education, 2006.
7.	Peterson and Bruce S. Davie Larry L.,”Computer Networks – A Systems approach” -, Th Morgan Kaufmann Publishers, Elsevier, 5 edition, 2012.

Mode of Evaluation:

Theory : Digital Assignments, Continuous Assessment Tests and Final Assessment Test

Lab : Midterm test in lab, lab experiments submission and Final Assessment in lab

Recommended by Board of Studies	13.05.2016		
Approved by Academic Council	41	**Date**	17.06.2016

		L	T	P	J	C
CSE6004	**Cloud Computing Eco-Systems**	**2**	**0**	**2**	**4**	**4**
Pre-requisite	**Nil**				**Syllabus version**	
Anti-requisite					v. 1.0	

Course Objectives:

1. The fundamentals and essentials of Cloud Computing
2. The ability to adopt Cloud Computing tools and services for real life scenarios
3. An exposure to use commercial systems such as Google Apps, Microsoft Azure and Amazon Web Services etc.
4. To impart knowledge in applications of cloud computing

Expected Course Outcome:

1. Deploy real-world applications onto the cloud
2. Differentiate between Public, Private and hybrid clouds
3. Formulate devOps based design and development of cloud applications
4. Appreciate the requirements of various service paradigms in cloud computing
5. Describe Datacenter requirements for the cloud

Module:1	**Introduction to Cloud Computing**	**4 Hours**

Cloud Computing Overview: Characteristics – challenges, benefits, limitations, Evolution of Cloud Computing, Cloud computing architecture, Cloud Reference Model (NIST Architecutre), open group cloud ecosystem reference model

Module:2	**Cloud Service Models**	**4 Hours**

Service Models, Characteristics, Benefits, Enabling Technologies (IaaS/PaaS/SaaS)

Case Study : SaaS : Salesforce.com, Online Collaboration Serivces Iaas : AWS, OpenStack

PaaS : IBM Bluemix, GAE

Module:3	**Cloud Deployment Models and Resource Management**	**5 Hours**

Public/Private/Multi-cloud deployments, Shared Resources – Resource Pool – Usage and Administration Portal – Resource Management – Elastic Environment – Resilient Environment –

Security – Workload Distribution – Dynamic provisioning.		
Module:4	**Cloud Eco Systems**	**2 Hours**
The concept of a cloud ecosystem, Actors and Roles in the Cloud Eco System, Cloud adoption vision, Identifying your use cases, Developing your plan, Understanding the implications of Cloud Service Layers, Utilizing cloud to gain strategic advantage		
Module:5	**Introduction to DevOps**	**5 Hours**
Understanding the Business Needs for Devops, DevOps Culture, Process and Technology in DevOps,DevOps Myths, Path to DevOps Adoption, Plan and Measure, Develop and Test (collaborative and continuous), Release and Deploy Monitor and Optimize (Continuous and Customer Feedback)		
Module:6	**DevOps Capabilities**	**4 Hours**
Open stack Architecture, Open stack Compute, Network, Object storage in detail, Automation, Open stack installations.		
Module:7	**Cloud Data Centers**	**4 Hours**
Historical Perspective, Datacenter Components, Design Considerations, Power Calculations, Evolution of Data Centers		
Module:8	**Recent Trends**	**2 Hours**
	Total Lecture hours:	**Hours: 30**
List of Challenging Experiments (Indicative)		

1.	Cisco simulator – VLAN design, Routing, Sub netting, Gateway configuration	2 hours
2.	Virtual box based Webserver creation, Images/Snapshots access webpage from 2nd VM on another subnet work	2 hours
3.	EC2 AWS – S3 bucket based static webpages. Use this page as a start page vis EC2 webserver	4 hours
4.	AWS – Local balancing and auto scaling	2 hours
5.	DaaS – Deployment of a basic web app and add additional	4 hours

	functionality(Java scripts based)	
6.	PaaS – IOT – Mobile sensor based IOT application hosted via PaaS environment	2 hours
7.	SaaS – Deployment of any SaaS application for a online collaborative tool	2 hours
8.	Deployment of Open stack or Virtual box from the scratch	4 hours
9.	DevOps deployment of library automation etc. on the cloud platform with one complete upgrade of the application	4 hours
10	Automating Open stack deployment using Chef/Puppet configuration for 4 node/ 5 node/ HA clusters	4 hours
	Total Laboratory Hours	**30 hours**

Reference Books

1.	Kai Hwang , Geoffrey Fox, Jack J. Dongarra, Morgan Kaufmann, Distributed and Cloud Computing: From Parallel Processing to the Internet of Things, 1st Edition, 2011.
2.	Gautham Shroff, “Enterprise Cloud Computing: Technology, Architecture, Applications”, Cambridge press, 2010.
3.	Rajkumar Buyya, James Broberg, Andrzej Goscinski,” Cloud Computing Principles and Paradigms”, John Wiley & Sons, 2011.
4.	John Rhoton and Risto Haukiojal, “Cloud Computing Architectured : Solution Design Handbook”, Recursive Press, 2013.
5.	Dinkar Sitaram, Geetha Manjunathan, “ Moving to the Cloud: Developing Apps in the new world of Cloud Computing”, Syngress, 2012.
6.	Introduction to Cloud Eco Systems
7.	“DevOps for Dummies” by Sanjeev Sharma
8.	Mandis Walls, “Building a DevOps Culture”, O'relly
9.	“Handbook on Data Centers” Samee. U. Khan, Albert. Y. Zomaya, Springer
10.	https://www.cloudfoundry.org/
11.	https://puppet.com/blog/implement-a-message-queue-your-cloud-application
12.	www.cloudpatterns.org
13.	www.IBMCloud.com

Mode of Evaluation: **Theory :** Digital Assignments, Continuous Assessment Tests and Final Assessment Test **Lab :** Midterm test in lab, lab experiments submission and Final Assessment in lab			
Recommended by Board of Studies	13.05.2016		
Approved by Academic Council	41	**Date**	17.06.2016

CSE6010	Cloud Application Development and Management	L	T	P	J	C
		3	0	2	0	4
Pre-requisite	**Nil**	**Syllabus version**				
Anti-requisite		v. 1.0				

Course Objectives:

1. To enable student to develop and launch applications in the cloud environment
2. To understand the various frameworks and APIs that can be used for developing cloud based applications
3. To use Cloud application management and management tools are used to analyze digital service ecosystems and digital product life-cycles.

Expected Course Outcome:

1. Design, Develop & Deploy real-world applications in the cloud computing platforms they have learnt
2. Demonstrate the ability to access the various cloud platforms used.
3. Describe the standardization process of cloud platform and various API's
4. Describe the methods for managing the data in cloud and demonstrate the concepts of automation, provisioning using puppet tool.
5. Develop Applications in the cloud platform
6. Analyze and use of an appropriate framework and APIs for the task
7. Design dashboards for management across cloud based service

Module:1	Basic concepts & techniques	**4 Hours**

Business case for implementing cloud application, Requirements collection for cloud application development, Cloud service models and deployment models, Open challenges in Cloud Computing: Cloud inter-operability and standards, scalability and fault tolerance, security, trust and privacy.

Module:2	**Application development framework**	**6 Hours**

Accessing the clouds: Web application vs Cloud Application, Frameworks: Model View Controller (MVC), Struts, Spring. Cloud platforms in Industry – Google AppEngine, Microsoft Azure, Openshift, CloudFoundry

Module:3	**Cloud service delivery environment and API**	**5 Hours**

Storing objects in the Cloud, Session management, Working with third party APIs: Overview of

interconnectivity in Cloud ecosystems. Facebook API, Twitter API, Google API.		
Module:4	**Architecting for the Cloud : Best practices**	**3 Hours**
Best practices in architecture cloud applications in AWS cloud, Amazon Simple Queue Service (SQS), RabbitMQ		
Module:5	**Cloud applications**	**3 Hours**
Amazon Simple Notification Service (Amazon SNS), multi-player online game hosting on cloud resources, Building content delivery networks using clouds		
Module:6	**Managing the data in cloud**	**4 Hours**
Securing data in the cloud, ACL, OAuth, OpenID, XACML, securing data for transport in the cloud, scalability of applications and cloud services.		
Module:7	**Automation and provisioning tool**	**3 Hours**
Puppet and Chef – steps for automation: Introduction, files and packages, services and subscriptions, exec and notify, facts, conditional statements and logging.		
Module:8	**Recent Trends**	**2 Hours**
	Total Lecture hours:	**Hours: 45**

List of Challenging Experiments (Indicative)		
1.	**Software / API / Tools** JDK 1.7/1.8, Eclipse IDE, Dropbox API, Apache tomcat server 7.0/8.0, Google AppEngine API, Servlets, Struts, Spring framework. Design and Development of Web applications using MVC Framework.	4 hours
2.	Installing and Configuring required platform for Google App Engine	2 hours
3.	Studying the feature of GAE PaaS model.	2 hours
4.	Creating and running Web applications (Guest book, MVC) on local host and deploying the same in Google App Engine	2 hours
5.	Design and Development of Web applications using Struts.	2 hours

6.	Design and Development of Web applications using Spring framework.	2 hours
7.	Developing an ASP.NET based web application on Azure platform	4 hours
8.	Creating an application in Dropbox to store data securely. Develop a source code using Dropbox API for updating and retrieving files.	2 hours
9.	Installing Cloud Foundry in a local host and exploring CF commands.	2 hours
10	Cloud application development using IBM Bluemix Cloud.	2 hours
11	Installing and Configuring Dockers in local host and running multiple images on a Docker Platform.	4 hours
12	Configuring and deploying VMs/Dockers using Chef/Puppet Automation tool	2 hours
	Total Laboratory Hours	**30 hours**

Reference Books

1.	Rajkumar buyya, Christian vecchiola, S Thamarai Selvi , “Mastering cloud computing”, Tata McGraw Hill Education Private Limited, 2013
2.	2. Anthony T .Velte, Toby J. Velte, Robert Elsenpeter, “Cloud Computing a Practical Approach”, Tata McGraw-HILL, 2010 Edition.
3.	Barrie sosinsky, “Cloud computing bible, Wiley publishing
4.	James Loope, “Managing Infrastructure with puppet”, O’REILLY , June 2011
5.	https://cloud.google.com/appengine/docs
6.	https://www.chef.io/solutions/cloud-management/
7.	https://aws.amazon.com/documentation
8.	https://dev.twitter.com/overview/documentation
9.	https://developers.facebook.com/
10.	https://www.cloudfoundry.org/
11.	https://puppet.com/blog/implement-a-message-queue-your-cloud-application

Mode of Evaluation:

Theory : Digital Assignments, Continuous Assessment Tests and Final Assessment Test

Lab : Midterm test in lab, lab experiments submission and Final Assessment in lab

Recommended by Board of Studies	13.05.2016

Approved by Academic Council	41	**Date**	17.06.2016

		L	T	P	J	C
CSE6003	**Web Services**	**2**	**0**	**2**	**0**	**3**
Pre-requisite	**Nil**					**Syllabus version**
Anti-requisite						v. 1.0

Course Objectives:

1. To provide a basic conceptual understanding of web enterprise architectures.
2. To explore distributed remote communication.
3. To make understand the basic concepts of Service Oriented Architecture.
4. To explore XML, web services, web service security and its implementation.
5. To understand micro services and enterprise application patterns.

Expected Course Outcome:

1. Design, Develop & Demonstrate web services (U)
2. Recognize meaning of web enterprise architecture and SOA. (A)
3. Describe the micro services and enterprise application patterns.(F)

Module:1	**WEB APPLICATION ARCHITECTURE**	**3 Hours**

Web Architecture: MVC, middleware – Design considerations, Issuesin web application design: Security issues and interoperability issues (WS-I).

Module:2	**DISTRIBUTED REMOTE COMMUNICATION**	**5 Hours**

RPC, Java RMI, message queuing, Data Serialization –MQTT,RabbitMQ, JMS – JSON – AVRO, Thrift, protocol buffer.

Module:3	**SERVICE ORIENTED ARCHITECTURE**	**3 Hours**

Introducing SOA – SOA triangle, layered architecture of SOA, BPO – Business Process Outsourcing - Web service composition and coordination.

Module:4	**BUILDING SOA**	**6 Hours**

Web service creation and accessing - WSDL, SOAP, UDDI, XINS, JSON-RPC, JSON-WSP, REST-ful

web services, mashup		
Module:5	**SEMANTIC WEB Services**	**2 Hours**
RDF, RDFS, OWL, SPARQL		
Module:6	**MICROSERVICES**	**5 Hours**
Evolution, Modeling services, Integration, Deployment, Testing, Monitoring, Security. Implementation of microservices.		
Module:7	**ENTERPRISE APPLICATION PATTERNS**	**4 Hours**
Concurrency patterns, Session state patterns. Web service security – protocols.		
Module:8	**Recent Trends**	**2 Hours**
	Total Lecture hours:	**Hours: 30**

List of Challenging Experiments (Indicative) Software / API / Tools / IDE Netbeans Microsoft visual Studio 2010		
1.	Creation of .NET web service and consumed by .NET client (console, window and web).	2 hours
2.	Creation of Java web service consumed by Java client.	2 hours
3.	Interoperability in web services with java web service and .NET client.	2 hours
4.	Interoperability in web services with .NET web service and java client.	2 hours
5.	Creation of RESTful web services.	2 hours
6.	Consuming a realtime web service.	2 hours
7.	Creation and consuming .NET web service without IDE.	2 hours
8.	Web service composition using BPEL.	4 hours

9.	Web services with array methods.	2 hours
10	Web services with database connectivity methods.	2 hours
11	Application based on web service security	4 hours
12	Creation of ontology	2 hours
13	Application using SPARQL	2 hours
	Total Laboratory Hours	**30 hours**

Reference Books

1.	J.D.Meier,Alex Homer,"Web Application Architecture guide, Patterns and Practices", Microsoft 2008.
2.	Thomas Erl,"Service-Oriented Architecture: Concepts, Technology, and Design", Pearson Education, 2005.
3.	Andrew S. Tenenbaum, Marteen Van Steen,"Distributed Systems, Principles and Paradigms", Second Edition, Pearson, Prentice Hall, 2007.
4.	Sam Newman," Building Micro Services", O'Reilly, , 2015.
5.	Martin Fowler, David Rice, Matthew Foemmel, Edward Hieatt, Robert Mee, Randy Stafford,"Patterns of Enterprise Application Architecture", Addison Wesley, 2002.
6.	Heather Kreger," Web Services conceptual architecture", , IBM, 2001
7.	Sacha Krakowiak," Middleware Architecture with Patterns and Frameworks", 2009
8.	Leonard Richardson, Sam Ruby, "Restful Web Services", O'Reilly Media; First Edition edition (May 15, 2007)
9.	Ben Smith," Beginning JSON", Apress, 2015
10.	Mark O' Neill ,"Web services security" , McGraw Hill, 2003
11.	Kapil Pant," Business Process Orchestration for SOA using BPMN and BPEL", Packt publishing, 2008
12.	Gustavo Alonso, Fabio Casati, Harumi Kuno, Vijay Machiraju,"Web Services - Concepts, Architectures and Applications", Springer Verlag, 2004
13.	Fensel, D., Facca, F.M., Simperl, E., Toma, I., "Semantic Web Services", Springer, 2011
14.	Leon Shklar, Richard Rosen,"Web Application Architecture, Principles, Protocols and

	Practices", John Wiley and Sons, 2003.		
Mode of Evaluation: **Theory :** Digital Assignments, Continuous Assessment Tests and Final Assessment Test **Lab :** Midterm test in lab, lab experiments submission and Final Assessment in lab			
Recommended by Board of Studies	13.05.2016		
Approved by Academic Council	41	**Date**	17.06.2016

		L	T	P	J	C
CSE5006	**Multicore Architectures**	**2**	**0**	**2**	**0**	**3**
Pre-requisite	**Nil**				**Syllabus version**	
Anti-requisite					v. 1.0	

Course Objectives:

1. To provide knowledge on basics of Multicore architectures
2. To understand concepts of parallel computers and its programming models
3. To design and develop parallel programs
4. To practice parallel programming using OpenMP, CUDA parallel programming platforms
5. To apply program optimizations on parallel programs
6. To analyse the performance using profiling tools
7. To explore various contemporary tools and recent trends in field of multicore architectures

Expected Course Outcome:

Describe various parallel programming models

Design and develop High Performance Applications using CUDA Programming(Compute Unified Device Architecture) contemporary tools

Improve performance of applications through program optimizations

Analyse performance of parallel applications

Module:1	**Introduction to Multi-Core Architectures**	**2 Hours**

Evolution of multicores through Moor's Law, Comparisons of single core, multi-core, multi-processing and hyper threading

Module:2	**Parallel Computers and programming**	**5 Hours**

Threading Concepts, Communication Architectures and Communication Costs, Thread Level Parallelism(TLP), Instruction Level Parallelism(ILP), Comparisons, Cache Hierarchy and Memory-level Parallelism, Cache Coherence, Parallel programming models, Shared Memory and Message Passing, Vectorization

Module:3	**OpenMP programming (Open multi-processing)**	**5 Hours**
Introduction to OpenMP, Parallel constructs, Runtime Library routines, Work-sharing constructs, Scheduling clauses, Data environment clauses, atomic, master Nowait Clause, Barrier Construct		
Module:4	**CUDA Programming(Compute Unified Device Architecture)**	**6 Hours**
Introduction to GPU Computing, CUDA Programming Model, CUDA API, Simple Matrix, Multiplication in CUDA , CUDA Memory Model, Shared Memory Matrix Multiplication, Additional CUDA API Features		
Module:5	**Performance Analysers**	**4 Hours**
Trace analyzer and collector (ITAC), VTune Amplifier XE, Energy Efficient Performance, Integrated Performance Primitives (IPP)		
Module:6	**Contemporary tools**	**3 Hours**
MKL (Math Kernel Library), Threading Building Blocks, CUDA Tools		
Module:7	**HTC and MTC**	**3 Hours**
HTC (High Throughput Computing), MTC (Many Task Computing), 3 Top 500 Super computers in the world, Top 10 Super Computer architectural details, Exploring Linpack.		
Module:8	**Recent Trends**	**2 Hours**
	Total Lecture hours:	**Hours: 30**
Project **(**Projects may be given as group projects)		**60 [Non Contact hrs]**

	Design and development of High Performance applications through parallel programming platforms in the following areas	
1.	Network Security	
2.	Data Compression	

3.	Image Processing	
4.	Bio-Medical	
5.	Information retrieval	
6.	Natural Language Processing	
7.	Health care Applications	
	Total Laboratory Hours	**30 hours**

Reference Books

1.	Rob Farber, “CUDA Application Design and Development”, Morgan Kaufmann Publishers, 2013
2.	Shameem Akhter and Jason Roberts, “Multi-Core Programming”, 1st edition, Intel Press, 2012
3.	Cameron Hughes, Tracey Hughes, “Professional Multicore Programming Design and Implementation for C++ Developers”, Wiley, 2008
4.	Robert Oshana, “Multicore Software Development Techniques: Applications, Tips, and Tricks”, Newnes,1 edition, 2015
5.	David B. Kirk , Wen-mei W. Hwu, “Programming Massively Parallel Processors: A Hands-on Approach (Applications of GPU Computing Series)”, 1st edition, Morgan Kaufmann, 2010.

Mode of Evaluation:

Theory : Digital Assignments, Continuous Assessment Tests and Final Assessment Test

Lab : Midterm test in lab, lab experiments submission and Final Assessment in lab

Recommended by Board of Studies	13.05.2016		
Approved by Academic Council	41	**Date**	17.06.2016

		L	T	P	J	C
CSE6001	**Big Data Frameworks**	**2**	**0**	**2**	**4**	**4**
Pre-requisite	**Nil**				**Syllabus version**	
Anti-requisite					v. 1.0	

Course Objectives:

The course objective is to impart an understanding of the challenges in storing and processing big data and how to use different big data frameworks effectively to store and process big data.

Expected Course Outcome:

1. Discuss the challenges in Big Data.
2. Describe the need of different big data frameworks.
3. Write MapReduce programming in both Hadoop and Spark Framework.
4. Write programs in Spark Streaming, SPARK SQL and GraphX

Module:1	**INTRODUCTION TO BIG DATA**	**3 Hours**

Data Storage and Analysis - Characteristics of Big Data – Big Data Analytics - Typical Analytical Architecture – Requirement for new analytical architecture – Challenges in Big Data Analytics – Need of big data frameworks

Module:2	**Hadoop Framework**	**6 Hours**

Hadoop – Requirement of Hadoop Framework - Design principle of Hadoop –Comparison with other system - Hadoop Components – Hadoop 1 vs Hadoop 2 – Hadoop Daemon's – HDFS Commands – Map Reduce Programming: I/O formats, Map side join, Reduce Side Join, Secondary sorting, Pipelining MapReduce jobs

Module:3	**Hadoop Ecosystem**	**3 Hours**

Introduction to Hadoop ecosystem technologies: Serialization: AVRO, Co-ordination: Zookeeper, Databases: HBase, Hive, Scripting language: Pig, Streaming: Flink, Storm

Module:4	**Spark Framework**	**5 Hours**

Overview of Spark – Hadoop vs Spark – Cluster Design – Cluster Management – performance,Application Programming interface (API): Spark Context, Resilient Distributed Datasets,

Creating RDD, RDD Operations, Saving RDD - Lazy Operation – Spark Jobs		
Module:5	**Interactive Data Analysis with Spark Shell**	**3 Hours**
Writing Spark Application - Spark Programming in Scala, Python, R, Java - Application Execution		
Module:6	**Spark SQL and GraphX**	**5 Hours**
SQL Context – Importing and Saving data – Data frames – usingSQL – GraphX overview – Creating Graph – Graph Algorithms		
Module:7	**Spark Streaming**	**3 Hours**
Overview – Errors and Recovery – Streaming Source – Streaming live data with spark		
Module:8	**Recent Trends**	**2 Hours**
	Total Lecture hours:	**Hours: 30**

List of Challenging Experiments (Indicative)		
1.	HDFS Commends	2 hours
2.	MapReduce Program to show the need of Combiner	2 hours
3.	MapReduce I/O Formats –Text, key- value	2 hours
4.	MapReduce I/O Formats - NLine, Multiline Sequence file Input / Output Formats	4 hours
5.	Secondary sorting Distributed Cache & Map Side Join, Reduce side Join Building and Running a Spark Application	6 hours
6.	Wordcount in Hadoop and Spark	2 hours
7.	Manipulating RDD	2 hours
8.	Inverted Indexing in Spark	2 hours
9.	Sequence alignment problem in Spark	2 hours
10	Implementation of Matrix algorithms in Spark	2 hours
11	Spark Sql programming	2 hours

12	Building Spark Streaming application	4 hours
	Total Laboratory Hours	**30 hours**

Project# Generally ateamproject[5to10 members]60[NonContacthrs]17

Concepts studied inXXXX should have beenused

Down to earthapplication and innovative idea should havebeenattempted

ReportinDigital formatwithall drawings usingsoftware packagetobesubmitted.

Assessment ona continuous basis with a min of3 reviews.

Projects may be given as group projects

The following is the sample project that can be given to students tobe implemented:

1. Predicting forest cover

2. Anomaly detection

3. Text Analytics

4. Co-occurrence of terms in social networks using GraphX

5. HITS algorithm

6. Geospatial and Temporal data analytics

Reference Books

1.	Mike Frampton, “Mastering Apache Spark”, Packt Publishing, 2015.
2.	Tom White, “Hadoop: The Definitive Guide”, O’Reilly, 4 th Edition, 2015.
3.	Nick Pentreath, Machine Learning with Spark, Packt Publishing, 2015.
4.	Mohammed Guller, Big Data Analytics with Spark, Apress, 2015
5.	Donald Miner, Adam Shook, “MapReduce Design Pattern”, O’Reilly, 2012

Mode of Evaluation:

Theory : Digital Assignments, Continuous Assessment Tests and Final Assessment Test

Lab : Midterm test in lab, lab experiments submission and Final Assessment in lab

Recommended by Board of Studies	13.05.2016		
Approved by Academic Council	41	**Date**	17.06.2016

		L	T	P	J	C
CSE6005	**Machine Learning**	**2**	**0**	**2**	**4**	**4**
Pre-requisite	**Nil**					**Syllabus version**
Anti-requisite						v. 1.0

Course Objectives:

1. It introduces theoretical foundations, algorithms, methodologies, and applications of Machine
2. Learning and also provide practical knowledge for handling and analysing data sets covering a variety of real-world applications.

Expected Course Outcome:

1. Recognize the characteristics of machine learning that make it useful to solve real-world problems.
2. Identify real-world applications of machine learning.
3. Identify and apply appropriate machine learning algorithms for analyzing the data for variety of problems.
4. Implement different machine learning algorithms for analyzing the data
5. Design test procedures in order to evaluate a model
6. Combine several models in order to gain better results
7. Make choices for a model for new machine learning tasks based on reasoned argument

Module:1	**INTRODUCTION TO MACHINE LEARNING**	**3 Hours**

Introduction, Examples of Various Learning Paradigms, Perspectives and Issues, Version Spaces, Finite and Infinite Hypothesis Spaces, PAC Learning, VC Dimension.

Module:2	**Supervised Learning**	**9 Hours**

Decision Trees: ID3, Classification and Regression Trees,

Regression:Linear Regression, Multiple Linear Regression, Logistic Regression,

Neural Networks: Introduction, Perceptron, Multilayer Perceptron,

Support vector machines: Linear and Non-Linear, Kernel Functions, K-Nearest Neighbours

Module:3	Ensemble Learning	3 Hours
Model Combination Schemes, Voting, Error-Correcting Output Codes,Bagging: Random Forest Trees, Boosting: Adaboost, Stacking		
Module:4	**Unsupervised Learning**	**5 Hours**
Introduction to clustering, Hierarchical: AGNES, DIANA, Partitional: K-means clustering, K-Mode Clustering, Expectation Maximization, Gaussian Mixture Models		
Module:5	**Probabilistic Learning**	**3 Hours**
Bayesian Learning, Bayes Optimal Classifier, Naïve Bayes Classifier, Bayesian Belief Networks		
Module:6	**Learning Association Rules**	**3 Hours**
Mining Frequent Patterns - basic concepts -Apriori algorithm, FP- Growth algorithm, Association-based Decision Trees		
Module:7	**Machine Learning in Practice**	**2 Hours**
Design, Analysis and Evaluation of Machine Learning Experiments, Other Issues: Handling imbalanced data sets		
Module:8	**Recent Trends**	**2 Hours**
	Total Lecture hours:	**Hours: 30**

List of Challenging Experiments (Indicative)		
1.	Implement Decision Tree learning	2 hours
2.	Implement Logistic Regression	2 hours
3.	Implement classification using Multilayer perceptron	2 hours
4.	Implement classification using SVM	2 hours
5.	Implement Adaboost	2 hours
6.	Implement Bagging using Random Forests	2 hours
7.	Implement K – means Clustering to Find Natural Patterns in Data	2 hours

8.	Implement Hierarchical clustering	2 hours
9.	Implement K – mode clustering	2 hours
10	Implement Association Rule Mining using FP Growth	2 hours
11	Classification based on association rules	2 hours
12	Implement Gaussian Mixture Model Using the Expectation Maximization	2 hours
13	Evaluating ML algorithm with balanced and unbalanced datasets	2 hours
14	Comparison of Machine Learning algorithms	2 hours
15	Implement k – nearest neighbour algorithm	2 hours
	Total Laboratory Hours	**30 hours**
Project		**60 [Non Contact hrs]**
Projects may be given as group projects The following is the sample project that can be given to students to be implemented: 1. Solving Data Science problems from Kaggle website 2. Applying Machine Learning algorithms in the field of biometrics for reliable and robust identification of humans from their personal traits, mainly for security and authentication purposes 3. Applying Machine Learning for OCR, Video Analytics 4. Applying Machine Learning algorithms in the field of Natural Language Processing for document clustering and sentiment analysis 5. Applying Machine Learning for Fraud Detection, Customer segmentation etc. Note: Students can down load real time data sets for different Machine Learning Tasks from https://archive.ics.uci.edu/ml/datasets.html and http://sci2s.ugr.es/keel/datasets.php#sub1 and do the projects		
Reference Books		

1.	Ethem Alpaydin ," Introduction to Machine Learning ” , MIT Press, Prentice Hall of India, Third Edition 2014.
2.	Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar "Foundations of Machine Learning”, MIT Press, 2012.
3.	Tom Mitchell, “Machine Learning”, McGraw Hill, 3rd Edition,1997.
4.	Charu C. Aggarwal, “Data Classification Algorithms and Applications”, CRC Press, 2014.
5.	Charu C. Aggarwal, “DATA CLUSTERING Algorithms and Applications”, CRC Press, 2014.
6.	Kevin P. Murphy "Machine Learning: A Probabilistic Perspective", The MIT Press, 2012
7.	Jiawei Han and Micheline Kambers and Jian Pei, “Data Mining –Concepts and Techniques”, 3rd edition, Morgan Kaufman Publications, 2012

Mode of Evaluation:

Theory : Digital Assignments, Continuous Assessment Tests and Final Assessment Test

Lab : Midterm test in lab, lab experiments submission and Final Assessment in lab

Recommended by Board of Studies	13.05.2016		
Approved by Academic Council	41	**Date**	17.06.2016

		L	T	P	J	C
CSE6006	**NoSQL Databases**	**2**	**0**	**2**	**4**	**4**
Pre-requisite	**Nil**	**Syllabus version**				
Anti-requisite		v. 1.0				

Course Objectives:

1. This course will explore the origins of NoSQL databases and the characteristics that distinguish them from traditional relational database management systems.
2. This covers the architectures and common features of the main types of NoSQL databases (key-value stores, document databases, column-family stores, graph databases)
3. Finally, discuss the criteria that decision makers should consider when choosing between relational and non-relational databases and techniques for selecting the NoSQL database that best addresses specific use cases.

Expected Course Outcome:

1. Explain the detailed architecture, define objects, load data, query data and performance tune NoSQL databases
2. Define NoSQL, its characteristics, history and primary benefits using NoSQL Databases.
3. Define the major types of NoSQL databases including a primary use case and advantages/disadvantages of each type.
4. Analyze semi-structured data and choose an appropriate storage structure

Module:1	**INTRODUCTION TO NOSQL CONCEPTS**	**4 Hours**

Data base revolutions: First generation, second generation, third generation, Managing Transactions and Data Integrity, ACID and BASE for reliable database transactions, Speeding performance by strategic use of RAM, SSD, and disk, Achieving horizontal scalability with database sharding, Brewer's CAP theorem.

Module:2	**NOSQL DATA ARCHITECTURE PATTERNS**	**4 Hours**

NoSQL Data model: Aggregate Models- Document Data Model- Key-Value Data Model- Columnar Data Model, Graph Based Data Model – Graph Data Model, NoSQL system ways to handle big data problems, Moving Queries to data, not data to the query, hash rings to distribute the data on clusters, replication to scale reads, Database distributed queries to data nodes.

Module:3	**KEY –VALUE DATA STORES**	**5 Hours**

From array to key –value databases, Essential features of key – value Databases, Properties of keys,

Characteristics of Values, Key-Value Database Data Modeling Terms, Key-Value Architecture and implementation Terms, Designing Structured Values, Limitations of Key- Value Databases, Design Patterns for Key-Value Databases, Case Study: Key-Value Databases for Mobile Application Configuration		
Module:4	**DOCUMENT ORIENTED DATABASE**	**5 Hours**
Document, Collection, Naming, CRUD operation, querying, indexing, Replication, Sharding, Consistency Implementation: Distributed consistency, Eventual Consistency, Capped Collection, Case studies: document oriented database: MongoDB and/or Cassandra		
Module:5	**COLUMNAR DATA MODEL - I**	**3 Hours**
Data warehousing schemas: Comparison of columnar and row-oriented storage, Column-store Architectures: C-Store and Vector-Wise, Column-store internals and, Inserts/updates/deletes, Indexing, Adaptive Indexing and Database Cracking.		
Module:6	**COLUMNAR DATA MODEL - II**	**3 Hours**
Advanced techniques: Vectorized Processing, Compression, Write penalty, Operating Directly on Compressed Data Late Materialization Joins , Group-by, Aggregation and Arithmetic Operations, Case Studies		
Module:7	**DATA MODELING WITH GRAPH**	**4 Hours**
Comparison of Relational and Graph Modeling, Property Graph Model Graph Analytics: Link analysis algorithm- Web as a graph, PageRank- Markov chain, page rank computation, Topic specific page rank (Page Ranking Computation techniques: iterative processing, Random walk distribution Querying Graphs: Introduction to Cypher, case study: Building a Graph Database Application- community detection		
Module:8	**Recent Trends**	**2 Hours**
	Total Lecture hours:	**Hours: 30**
List of Challenging Experiments (Indicative)		
1.	Import the Hubway data into Neo4j and configure Neo4j. Then, answer the following questions using the Cypher Query Language: a) List top 10 stations with most outbound trips (Show station name and number of trips)	2 hours

	b) List top 10 stations with most inbound trips (Show station name and number of trips) c) List top 5 routes with most trips (Show starting station name, ending station name and number of trips) (4) List the hour number (for example 13 means 1pm -2pm) and number of trips which start from the station "B.U. Central" d) List the hour number (for example 13 means 1pm -2pm) and number f trips which end at the station "B.U. Central"	
2.	The flight data can be found at http://statomputing.org/dataexpo/2009/the-data.html . You need to download just one year and from there you can sample a subset of at least 10000 records. You can use the data from a full year if you want but we recommend using a smaller dataset for simplicity. Hint: If you need to unzip the data file, you can use the command: bzip2 –d datafile from a terminal. For example, for the 2008, you download the file and unzip it using: bzip2 -d 1987.csv.bz2. The airport data can be found at http://stat-computing.org/dataexpo/2009/supplemental-data.html . 1) Download the flight dataset and airport dataset. (2) Clean the dataset (for example: remove columns you do not need, remove records with missing information, remove duplicate records and so on). (3) Give the header to csv files (4) Import the data into Neo4j. (5) Write the queries to answer following questions: (5.1) List top 10 airports with most outbound flights. (5.2) List top 10 airports with most inbound flights. (5.3) List top 5 routes with most flights in weekdays. (5.4) List top 5 routes with most flights in weekends. List the hour number (for example 13 means 1pm -2pm) and number of flights, which depart from a specific airport in your data (e.g.,Boston Logan Airport). List the hour number (for example 13 means 1pm -2pm) and number of flights, which arrive at specific airport in your data (e.g., Boston Logan Airport).	2 hours

	In your report, you should answer the following questions: (a) List the year of the flights that you downloaded and prepared for this assignment. You can get a sample set from one-year data. However, the number of flights cannot be smaller than 10k. (b) Describe how you clean the data (Which columns you remove and why? Which rows you remove and why?). Hint: You can clean your data by writing a small program in Java, Python, C, Matlab or any kind of programming language. (c) Describe the header you give to the csv files. (d) Write down the command for importing data. (e) Write and execute the queries from step (5) above.	
3.	Download a zip code dataset at http://media.mongodb.org/zips.json. Use mongoimport to import the zip code dataset into MongoDB. After importing the data, answer the following questions by using aggregation pipelines: (1) Find all the states that have a city called "BOSTON". (2) Find all the states and cities whose names include the string "BOST". (3) Each city has several zip codes. Find the city in each state with the most number of zip codes and rank those cities along with the states using the city populations. (4) MongoDB can query on spatial information. Assume we have a spatial position as [-72, 42], and in the range of 2 (it can be [-71.5, 41.5] or [-72.5, 42.5] or somewhere else), there may exist a number of zip codes . Try to find the states in that range. You should return the total populations and the number of cities of each state in that range. Rank the states based on the number of cities. (5) Consider a certain rectangular area, in which the vertices are [-80 ,0] , [-90 ,30] , [-90 , 40] and [-80 , 40]. Find and report the top 10 largest cities (by population) in this area.	2 hours
4.	Create a database that stores road cars. Cars have a manufacturer, a type. Each car has a maximum performance and a maximum torque value. Use ifconfig to determine a machine's IP address. To check if Cassandra is running in the background, run: ps aux | grep cassandr[a] Do the following: Test Cassandra's replication schema and consistency models.	2 hours
5.	Network Partition without Replication	

6.	Network Partition with Replication and Weak Consistency	2 hours
7.	Network Partition with Replication and Quorum Consistency	2 hours
8.	Cars have different powertrains. Each type can be described with different parameters:	2 hours
9.	Internal combustion engine: fuel type, displacement, maximum torque, maximum power	2 hours
10	Electric motor: maximum torque, maximum power	2 hours
11	Both: all of the above and the combined maximum torque and power values	2 hours
12	The class hierarchy for different powertrain types	2 hours
13	Extend the cars column family to store the powertrain of each car.	2 hours
14	Write a query that collects the cars with an internal combustion engine.	2 hours
15	Write a query that collects the cars with an internal combustion engine or an electric motor.	2 hours
	Total Laboratory Hours	**30 hours**
Project		**60 Non Contact Hours**

Projects may be given as group projects

The following is the sample project that can be given to students to be implemented:

1. Analyzing and Visualizing social networks like Facebook and twitter using NoSQL Databases.

2. Using Sample datasets from http://www.rdatamining.com/resources/data,UCLA Repository, kaggle dataset etc., and analyzing those using NoSQL databases.

3. Twitter provides a fire hose of data. Automatically filtering, aggregating, analyzing such data can allow a way to harness the full value of the data,extracting valuable information. The idea of this project is investigating stream processing technology to operate on social streams.

4. Project on Combining Database management and Cloud storage system.

5. CarTel. In the CarTel project, we are building a system for collecting and managing data from automobiles. There are several possible CarTel related projects:

a) One of the features of CarTel is a GUI for browsing geo - spatial data collected from cars. We currently have a primitive interface for retrieving parts of the data that are of interest, but developing a

more sophisticated interface or query language for browsing and exploring this data would make a great project.

b) One of the dangers with building a system like CarTel is that it collects relatively sensitive personal information about user's location and driving habits.

Protecting this information from casual browsers, insurance companies, or other undesired users is important. However, it is also important to be able to combine different user's data together to do things like intelligent route planning or vehicle anomaly detection. The goal of this project would be to find a way to securely perform certain types of aggregate queries over CarTel data without exposing personally identifiable information.

Reference Books

1.	Guy Harrison, "Next Generation database: NoSQL New SQL and Big Data", Apress, I st Edition, 2015
2.	Daniel G. McCreary and Ann M. Kelly "Making Sense of NoSQL" Manning publisher, Edition illustrated, 2013
3.	Shanshak Tiwari, "Professional NoSQL", Wrox, I st Edition, 2011
4.	Christopher D. manning, Prabhakar Raghavan, Hinrich Schutze, "An introduction to Information Retrieval", Cambridge University Press, 2008
5.	Daniel Abadi, Peter Boncz, Stavros Harizopoulos, "The Design and Implementation of Modern Column-Oriented Database Systems", Now Publisher, 2013.
6.	Kristina Chodorow, "Mongo DB the Definitive Guide" O'Reilly Media, 2013.

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		L	T	P	J	C
CSE6026	**IoT on Cloud**	**2**	**0**	**2**	**4**	**4**
Pre-requisite	**Nil**					**Syllabus version**
Anti-requisite						v. 1.0

Course Objectives:

1. This course is to understand the working of Internet of Things.
2. It introduces students to technology that enables IoT, application of IoT, cloud support for IoT and access data using mobile computing devices.
3. This will serve as foundation for the cyber physical systems, Internet of services leading to Industry 4.0 changes.

Expected Course Outcome:

1. Introduction to fundamentals of IoT.
2. Application of IoT in various domain.
3. Hardware and software that enable IoT.
4. Upload data on cloud for further analysis and visualisation.
5. Access the IoT data from cloud using mobile
6. computing devices.
7. Learn to use of tools such as Apache servers, WebAPI,
8. Design product for automation various domain such as for Home, Industry.

Module:1	**Introduction to IoT**	**3 Hours**

Things in IoT, IoT protocols, IoT communication model, IoT communication APIs, IoT enabling Technologies.

Module:2	**Application of IoT**	**4 Hours**

Home, Cities, Environment, Energy, Retail, Logistics, Agriculture, Industry, Health, Life style, M2M – Machine to Machine, Difference between IoT and M2M. Industry 4.0 concepts - cyber physical system, Security aspects in IoT

Module:3	**IOT Supported hardware**	**5 Hours**

Introduction to wireless sensor network, RFID, Sensors, Overview of IoT supported Hardware platforms

(Any two hardware can be handled) Raspberry pi, Arduino and Intel Galileo boards, Beaglebone, ARM Cortex Processors.		
Module:4	**Communication in IOT**	**7 Hours**
Interface protocol , Serial, SPI, I2C, 6LoWPAN, 802.11wifi, 802.15 Bluetooth, 802.15.4 ZigBee, RTLS, GPS, CoAP – Constrained application protocol, RPL – routing protocol for lossy networks - MQTT.		
Module:5	**IOT Physical Servers and cloud**	**3 Hours**
Data retrieval from cloud – data storage to cloud – data dissemination from sensors of IoT – Cloud Access to Sensors with IBM Bluemix, Juju Framework, Google Cloud Engine – data visualization		
Module:6	**IoT on Cloud**	**3 Hours**
DevOps – Contained based software - Designing a RESTful Web API – PubNub API for IoT to cloud – mobile device as IoT – Mobile cloud access		
Module:7	**IoT Operating Systems**	**3 Hours**
Introduction to Contiki OS and RIOT OS – Proto threads – tasking – Simple IoT application with border router, implementation of CoAP in Contiki OS.		
Module:8	**Recent Trends**	**2 Hours**
	Total Lecture hours:	**Hours: 30**

List of Challenging Experiments (Indicative)		
1.	Installation of Raspbian OS or Ubuntu ARM OS on a Rasberry Pi Platform	2 hours
2.	Setting the networking parameters for Raspbian OS like Ethernet, WLAN, Bluetooth, etc	2 hours
3.	Enabling Security or SELinux in Raspbian OS or Ubuntu OS	2 hours
4.	Accessing IBM Bluemix from IoT Devices	2 hours
5.	Data dissemination from Sensor nodes (any make)	2 hours
6.	Data visualization using d3.js or any other tool	2 hours

7.	Contiki OS Installation and Simple IoT network configuration using Contiki	2 hours
8.	Border Router using Contiki OS	2 hours
9.	Implementation of CoAP protocol using Contiki OS	2 hours
10.	Energy, power, duty cycle calculation of IoT devices in Contiki OS	2 hours
11.	Simple application deployment in Google Cloud Engine or Juju framework	
12.	Simple application deployment with PubNub cloud services.	
	Total Laboratory Hours	**30 hours**
Project		**60 [Non Contact hrs]**

Sample project titles:

- Smart grid
- Vehicle charging using IOT
- Energy measurement and storage at cloud
- Water measurement and storage at cloud
- Analysis and presentation IOT data stored at cloud
- Smart Parking
- Flash flood prediction
- Real time monitoring of flood
- Remote Monitoring & Sensing
- Remote Controlling, Performance Analysis
- IOT industries and what they are doing, selling
- Healthcare application

Reference Books

1.	Arshdeep Bahga, Vijay Madisetti, Internet of Things: A hands-on Approach, University Press, 2015 (1 st edition)
2.	Adrian McEwen & Hakim Cassimally, Designing the Internet of Things by Nov 2013, (1st edition)
3.	Claire Rowland, Elizabeth Goodman, Martin Charlier, Ann Light, Algred Lui Designing Connected Products: UX for the consumer internet of things, O'Reilly, (1 st edition).

4.	Rethinking the Internet of things: A Scalable Approach to Connecting Learning Internet of Things by Peter Waher, Packt Publishing, 2015
5.	Designing the Internet of Things, by Adrian Mcewen, Hakin Cassimally, Wiley India Private Limited
6.	Cloud Computing, Thomas Erl, Pearson Education, 2014
7.	Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud, William Stallings, Addison-Wesley Professional; 1 edition

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		L	T	P	J	C
CSE6027	**Mobile Cloud Computing**	**2**	**0**	**2**	**4**	**4**
Pre-requisite	**Nil**				**Syllabus version**	
Anti-requisite					v. 1.0	

Course Objectives:

This Course provides a comprehensive overview of how to integrate cloud and mobile technology.

It is an emerging field and this course explores how distributed resources can be shared by mobile users in very different ways and issues arising there from

Expected Course Outcome:

1.Describe the usefulness of integrating cloud and mobile technologies.

2. Sketch the architecture and discuss the characteristics of mobile cloud computing.

3. Examine the issues of security and privacy due to user cooperation in mobile cloud.

4. Develop, Design and Deploy mobile Cloud Based Applications

Module:1	**Mobile clouds: Introduction and Background**	**5 Hours**

Introduction-Mobile vs Desktop devices -App Store, Google Play, Windows Store- Development environments- Phone GAP- Native vs. web applications – Mobile Connectivity Evolution: From Single to Multiple Air Interface Devices –Mobile cloud architecture and its need

Module:2	**Sharing Device Resources and allocation in Mobile Clouds**	**5 Hours**

Resource sharing - Loudspeakers, Microphones – Image Sensors, Displays, General Purpose Sensors, Keyboards, Data Pipes, Mobile Apps-Sharing Mass Memory-Sharing Processing Units, Sharing Batteries-Resource allocation strategy-Task scheduling, Middleware-Energy aware resource allocation

Module:3	**Integrating technologies for mobile clouds**	**4 Hours**

Wireless Communication Technologies – Cellular Communications Systems-Short-Combined Air Interface, User Cooperation in Mobile Clouds - Data Integrity in Mobile Cloud-warehousing and analysing social data using cloud- Social compute cloud

Module:4	**Mobile Cloud Formation and Maintenance**	**4 Hours**

Mobile Cloud Stages- Service Discovery for Mobile Clouds- Social Networks and Mobile Clouds- Mobile

Networks Supporting-Distributed Storage in Mobile Clouds Standards- Building mobile clouds		
Module:5	**Application deployment on mobile clouds**	**4 Hours**
Forced Cooperation – Overlay Network – Crowd sourced Information, Mobile Apps information backup-Direct Mobile Cloud-Technically enabled Cooperation–Bimetric application-vehicle monitoring application-Cooperative Access		
Module:6	**Green and Social aspects of mobile clouds**	**3 Hours**
Energy Consumption for the Sequential Local Exchange (SLE) - Energy Consumption for the Parallel Local Exchange (PLE) - Cooperative Streaming - Comparison of the Different Approaches SLE and PLE.		
Module:7	**Security in Mobile Cloud**	**3 Hours**
Security in mobile social cloud-Different level of security, Security issues. Trust in mobile computing:Trust properties, component of trust, type of trust, trust issues		
Module:8	**Recent Trends**	**2 Hours**
	Total Lecture hours:	**Hours: 30**
List of Challenging Experiments (Indicative)		SLO: 17

	Suggested Experiments:	
1	Using Eclipse Graphical Layout Builder to understand complete Lifecycle mobile Apps	2 hours
2	Tapping a Button displays a message and Controlling width & height of UI Widgets	2 hours
3	Combining Horizontal & Linear layouts and Capturing Text from an Edit Text Object	2 hours
4	Display the encrypted text back in the Text Field (so pressing enter should give you back the original text) Display the length of the entered text using the Label.	2 hours
5	Integrating Mobile to Cloud Environment & Sharing the resource into the cloud.	2 hours

6	Processing on Cloud Computing infrastructure: Hadoop/MapReduce.	2 hours
7	Scalable multimedia processing application with Amazon Web Services	2 hours
8	Event Data Collection and Processing by Crowdsourcing to Smartphones	2 hours
9	Collaborative Experiment using Mobile Cloud Computing	2 hours
10	Massive Processing Computation using Mobile Cloud Computing	2 hours
11	Mobile multimedia Cloud services on Android devices eg. Traffic Manament (or) Natural Disaster Alert System	2 hours
12	Mobile Application Performance and Energy Consumption Aspects through Hardware and Emulation.	2 hours
	Total Laboratory Hours	**30 hours**
Project		**60 [NonContacthrs]**

Suggested projects to gain subject knowledge: Google Ara-(xamarinframework) SLO - 14

1.Vehicle Tracking Using Driver Mobile Gps Tracking

2.Android Employee Tracker

3.Develop a MIDlet that has a Text Field and Label GUI components

Reference Books

1.	Mobile Cloud Computing: Architectures, Algorithms and Applications- Debashis De CRC press 2015
2.	Mobile Clouds Exploiting Distributed Resources in Wireless, Mobile and Social Networks- Frank H.P. Fitzek and Marcos D. Katz
3.	Valentino Lee, Heather Schneider, and Robbie Schell, Mobile Applications: Architecture, Design, and Development , Prentice Hall , 2004
4.	Brian Fling, Mobile Design and Development O'Reilly Media,2009
5.	Maximiliano Firtman Programming the Mobile Web , O'Reilly Media, 2010.
6.	Christian Crumlish and Erin Malone Designing Social Interfaces, O'Reilly Media , 2009

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		L	T	P	J	C
CSE6028	**Cloud Security and Audit**	**2**	**0**	**0**	**4**	**3**
Pre-requisite	**Nil**					**Syllabus version**
Anti-requisite						v. 1.0

Course Objectives:

1. Understanding of the security challenges in the cloud environment.
2. Understanding of the issues regarding privacy and manage risks associated with it.
3. Knowledge of security standards and the audit processes to follow and ensure better cloud security.

Expected Course Outcome:

1. State the security challenges of cloud infrastructure.
2. Illustrate the application security mechanisms.
3. Use the standards to define a management policy.
4. Design solutions for risk management and security threats.
5. Prepare a cloud security audit report.

Module:1	**Cloud Security Fundamentals**	**2 Hours**

Cloud computing security challenges – cloud computing security architecture – data security life-cycle - Security Patterns and architectural elements - Planning key Strategies for secure operation

Module:2	**Cloud Application Security**	**5 Hours**

Encryption techniques – homomorphic encryption - securing data Redaction - secure bitcoin – Public key infrastructure (PKI) – key management - open web application security project (OWASP) Cloud Top 10 Security Risks - Security as a service (SECaaS).

Module:3	**Cloud Infrastructure Security**	**5 Hours**

Virtualization security – securing hypervisor - securing virtual machines - designing virtual network for security - Network Security in the cloud - software-defined security - secure isolation strategy - anti-fragile cloud infrastructure - Failure as a service.

Module:4	**Security Management & Privacy**	**4 Hours**
Managed Security Service Provider(MSSP): Availability management – configuration management - vulnerability management - identity management. - Privacy: privacy, compliance and the cloud - privacy enhancing encryption		
Module:5	**Risk Management & Security Threats**	**3 Hours**
Risk management – principles - assessing the risk – strategies for managing risk – risk analysis framework – security threats - intrusion detection		
Module:6	**Cloud Standards and Compliance**	**4 Hours**
Cloud security alliance – cloud controls matrix - cloud security standards guidance – security compliance - NIST – PCI data security standards – SAS 70 - ISO 27001 – HIPAA – ITIL - FISMA - FIPS 140-2.		
Module:7	**Audit**	**5 Hours**
Cloud-Based IT Audit Process – System and Infrastructure lifecycle management for the cloud - goverance, risk management and compliance (GRC) – cloud audit assurance – auditing – record generation, reporting and management - tamper-proofing audit logs service level agreement (SLA) – legal safeguards - cloud morphing.		
Module:8	**Recent Trends**	**2 Hours**
	Total Lecture hours:	**Hours: 30**
Projects **(Suggested topics)**		**60[Non Contact hrs]**
1.Altor VF – security appliances		
2.Appgate security server – application layer firewall		
3.Biobeans – secure identification and authentication solutions		
4.Ciphercloud – data privacy		
5.Defensepro – intrusion protection system(IPS)		
6.Incapsula – DDoS protection, load balancing, fail-over services.		

7. Cloudbric – malicious attack	
Reference Books	
1	Tim Mather, Subra Kumaraswamy, Shahed Latif, Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance, O'Reilly Media Inc, 2009.
2	Dave Shackleford, Virtualization security:Protecting virtualized environments, John Wiley & sons, 2013.
3	Vic (J.R.) Winkler, Securing the Cloud: Cloud Computer Security Techniques and Tactics, Syngress; 1st edition (April 29, 2011).
4	Raghu Yeluri, Enrique castro-leon, Building the infrastructure for cloud security: A Solutions view, Apress, 2014.
5	Krutz, R.L. (2010), Cloud Security A Comprehensive Guide to Secure Cloud Computing, Wiley
6	Ben Halpert , "Auditing Cloud Computing: A Security and Privacy Guide: ", John Wiley & Sons, 2011.
7	Shao ying zhu, Richard Hill, Guide to security assurance for cloud computing, Springer 2015.
8	John Rittinghouse, James F.Ransome, Cloud computing implementation, Management, security, CRC Press, 2010.
9	Stefan Rass, Daniel Slamanig, Cryptography for security and Privacy in cloud computing, Artech House, 2014.
10	OWASP - https://www.owasp.org/images/4/47/Cloud-Top10-Security-Risks.pdf
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		L	T	P	J	C
CSE6029	**CLOUD STORAGE TECHNOLOGIES**	**2**	**0**	**2**	**4**	**4**
Pre-requisite	**Nil**				**Syllabus version**	
Anti-requisite					v. 1.0	

Course Objectives:

1. The objective of the course is to impart an understanding of the need of cloud storage, its architecture
2. the different cloud storage systems, their comparative merits and suitability to task specific deployment.
3. The course will discuss the various enabling technologies for cloud storage

Expected Course Outcome:

1.Propose a plan to store, maintain, and deliver the massive amounts of media, software, documents, and other digital objects.

2. Create a comparative report on how to Store/ access data using different cloud storage technologies for a range of applications.

3. Explain the various architectures of different cloud storage.

4. Describe approaches to virtualize and integrate multiple storage platforms.

5. Devise a plan to secure and manage the storage infrastructure.

Module:1	**Essentials of Storages**	**4 Hours**

Types of Storage - Data Processing: Local, Directly Attached, Remote - File Systems & Volume Management - Distributed/Clustered File Systems, Concatenation, Partitioning, etc. – RAIDs: Descriptions, Comparison - I/O & Capacity: Concatenation, Vertical Tier, Disk Splitting - Storage Taxonomy - Storage Levels: Block, File, Object - Backup - Snapshots, Disaster Recovery/Protection, Recovery Time – Caching – Replication

Module:2	**Storage Technology Devices**	**4 Hours**

Storage Network Adapters (HBAs, SNICs and HCAs) – NAS appliances, servers and gateways – Storage devices: JBOD and disk array subsystem, Modular subsystem, Frame storage subsystem, Solid state disks, memory disks, and SAN cache – Network Components: Hubs and concentrators – Switches and directors – Bridges, gateways and router devices – Intelligent switches, multifunction switches and storage domain controllers.

Module:3	**Fibre Channel Storage Area Networks & Intelligent Storage System**	**5 Hours**
Components of FC SAN – FC Connectivity – Switched fabric ports – Fibre channel architecture – Link services – Fabric services. Components of intelligent storage system: front-end, back-end and physical disk – Storage provisioning: traditional and virtual – Types of intelligent storage systems		
Module:4	**IP SAN, FcoE and Network Attached Storage**	**6 Hours**
Components of iSCSI, connectivity, topologies, protocol stack, PDU, discovery, names, sessions, command sequencing – FCIP protocol stack and topology – Components of FCoE, frame structure and enabling technologies - Converged Enhanced Ethernet (CEE), transmission selection, congestion notification. Components of NAS – NAS I/O operation – NAS implementation – NAS file sharing protocols		
Module:5	**Storage Virtualization**	**3 Hours**
Virtualization in I/O path, limitations and requirements – Storage virtualization definition – Implementation consideration – Storage virtualization on block and file level – Storage virtualization on various levels of storage network: server, storage devices and network		
Module:6	**Securing the Storage Infrastructure**	**3 Hours**
Information security framework – Risk triad – Storage security domains – Security implementation in storage networking – Securing storage infrastructure in virtualized and cloud environments		
Module:7	**Managing the Storage Infrastructure**	**3 Hours**
Monitoring the storage infrastructure - Storage infrastructure management activities - Storage infrastructure management challenges - Developing an ideal solution - Information lifecycle management - Storage Tiering		
Module:8	**Recent Trends**	**2 Hours**
	Total Lecture hours:	**Hours: 30**
List of Challenging Experiments (Indicative)		
	List of Laboratory Experiments (in the areas of)	2 hours

1.	Configuring network files system.	2 hours
2.	Adding virtual hard drives using VMware	2 hours
3.	Creating RAID Array using VMware.	2 hours
4.	Simulating Drive failures.	2 hours
5.	Creating the clusters	2 hours
6.	Replicating Data in Cloud	2 hours
7.	Encrypting and decrypting data in Cloud	4 hours
8.	Implementing Deduplication in cloud storage	2 hours
9.	Storage tiering	2 hours
10.	Storage backup exercise - Design and develop data backup utility that copies all files in one folder to another storage location specified by the user	4 hours
11.	Cloud storage platforms : Design and implementation of Intelligent storage system	4 hours
12.	Study of disk drive performance using DiskSim simulation (opensource) tool	2 hours
	Total Laboratory Hours	**30 hours**

Reference Books

1	Greg Schulz: Cloud and virtual data storage networking, ISBN-13: 978- 1439851739, Auerbach Publications, 2011.
2.	Hitachi Data Systems Academy: Storage Concepts: Storing and Managing Digital Data (Volume 1). ISBN-13: 978-0615656496, 2012.
3.	EMC education services. Information Storage and Management: Storing, Managing, and Protecting Digital Information in Classic, Virtualized, and Cloud Environments, ISBN-13: 978- 1118094839, Wiley, 2012.
4	Richard Barker, Paul Massiglia 2002, Storage area network essentials, Wiley New York
5	IBM Redbook “Introduction to Storage Area networks and System Networking” http://www.redbooks.ibm.com/redbooks/pdfs/sg245470.pdf

Mode of Evaluation:

Theory : Digital Assignments, Continuous Assessment Tests and Final Assessment Test

Lab : Midterm test in lab, lab experiments submission and Final Assessment in lab

Recommended by Board of Studies	13.05.2016

Approved by Academic Council	41	Date	17.06.2016

		L	T	P	J	C
CSE6030	Design Thinking	2	0	0	4	3

Pre-requisite	Nil	Syllabus version
Anti-requisite		v. 1.0

Course Objectives:

The intent of the course is to develop a creative thinking skill among students, which is a key to innovation. This includes the ability to gain deep insights about users of the product, to define and reframe problems, to generate alternative approaches and to finalize the solution for solving the problem.

Expected Course Outcome:

1. Identify the market needs and the potential stakeholders for the product.
2. Design a product prototype for the company satisfying company's and stakeholders' demands.
3. Perform a feasibility study and design a product that meets requirements.

Module:1	Introduction	6 Hours

Why Design thinking? – Standish group chaos report – Software crisis – Software failures - Key steps to Design Process – Design Ability – How to Design?

Module:2	Stakeholder Analysis	4 Hours

Converting Need to Demand – Identifying Stakeholders – Insight, Observation and Empathy – Mental Matrix

Module:3	Design	4 Hours

Principles of Good Design – Articulating Design – Design to think – Design to win – Design to please – Designing to use

Module:4	Meeting the Corporate Expectation	4 Hours

Storytelling – Modelling systems – Designing together – Impact of Human Psychology on Design – Design Activism – Design for tomorrow

Module:5	**New Social contract**	**4 Hours**
Product to customers – Usability test – Business canvas model – Applicability to cloud users – Economic feasibility		
Module:6	**Agile Software Development**	**3 Hours**
Lean and Design Thinking – People centric design – Pair Programming – Test Driven Development – Refactoring – Continuous Integration – Planning and Reviews – Clean code		
Module:7	**Branding**	**3 Hours**
Basics – Creation, Voice casting and Interpretation – Simulation and Evaluation		
Module:8	**Recent Trends**	**2 Hours**
	Total Lecture hours:	**Hours: 30**
Project		**60 [Non Contact hrs]**

Indicative Project Domains:

1. Healthcare
2. Agriculture
3. Cybercrime
4. Social media crime
5. Grocery shopping
6. Mobile marketing
7. Digital analytics
8. Digital marketing

Reference Books

1.	Nigel Cross, “Design thinking”, Berg Publishers, 2011.
2.	Roger L. Martin, “The Design of Business: Why Design Thinking is the Next Competitive Advantage”, Harvard Business Press, 2009.
3.	Robert C. Martin, “Agile Software Development, Principles, Patterns, and Practices”, Pearson

	Education publishers, 2003.
4.	Business canvas model : http://www.businessmodelgeneration.com/downloads/business_model_canvas_poster.pdf
5.	Standish survey: https://www.projectsmart.co.uk/white-papers/chaos-report.pdf
6.	Design Activism: http://theprotocity.com/designing-activism-an-interview-with-ann-thorpe/
7.	Principles of Design: http://www.archdaily.com/198583/dieter-rams-10-principles-of-%25e2%2580%259cgood-design%25e2%2580%259d
8.	Design Thinking http://ocw.mit.edu/courses/engineering-systems-division/esd-051j-engineering-innovation-and-design-fall-2012/lecture-notes-and-videos/
9.	Kristin Fontichiaro "Design Thinking", Cherry Lake Publishing, 2015

Mode of Evaluation:

Theory : Digital Assignments, Continuous Assessment Tests and Final Assessment Test

Recommended by Board of Studies	17.06.2016		
Approved by Academic Council	41	**Date**	13.05.2016

		L	T	P	J	C
CSE6031	**Cyber Space and Information Technology Laws**	**2**	**0**	**0**	**0**	**2**
Pre-requisite	**Nil**					**Syllabus version**
Anti-requisite						v. 1.0

Course Objectives:

1. To provide the basic understanding of the legal issues arising in the Cyber Space
2. To provide an insight into the myriad security and privacy issues in Cyberspace
3. To provide a comprehensive understanding about the laws applicable to the Cyber Space
4. To analyze the grey areas and the emerging trends in Cyber Space.

Expected Course Outcome:

1. List the basic issues arising in the cyber space
2. Discuss about the contemporary technologies that create unparalleled predicaments in cyber space
3. Outline the IT Laws that are applied to the cyber space

Module:1	**Basic concepts & Techniques**	**3 Hours**

Cyber Space – History Of Cyber Space – Information Technology Act, 2000 - Outline of the Act- Aims and Objectives of the Act- Applicability of the Act

Module:2	**Jurisdictional Issues**	**4 Hours**

Types of Jurisdiction – Jurisdiction for Internet cases –Territorial Jurisdiction and Cyber Space – Minimum Contacts theory and Purposeful Availment theory – French Yahoo case, Dow Jones case- IT Act on Jurisdiction

Module:3	**Digital Signatures**	**5 Hours**

Asymmetric Cryptography - Public and Private Key-Hash functions- Verification -Legality of the Digital Signature- Certifying Authorities- Digital Signature Certificates. Validity of expired and local certificates

Module:4	**eGovernance**	**4 Hours**

Legality of eGovernance - security issues and legislative control of eGovernance- Scope Of e Governance in India and other developed countries – Digital Evidence

Module:5	**eCommerce**	**5 Hours**

Online Contracts- Click wrap and Shrink wrap Contracts- Time and Delivery of the Contract- eCommerce websites- Online Payments- Indian law of electronic contracts

Module:6	Intellectual Property and Cyber Space	6 Hours
Copyright and the Internet – Linking – Inlining – Framing- peer to Peer networking, Commissioned work Trademark Issues- Domain Name – ICANN Policy – Uniform Dispute Resolution Policy- Dispute Resolution Procedure Patent-ability and Computer Software – Sui generis regime. Indian position on computer related patents, Copyright		
Module:7	**Security Issues and Cyber Crimes**	**1 Hours**
Cyber privacy –Crimes against property – Crimes against the Person- Crimes against the State- Crimes against the computer network- Financial Crimes- Cyber Security and safeguards		
Module:8	**Recent Trends** Online Dispute Resolution / eCourts	**2 Hours**
	Total Lecture hours:	**Hours: 30**

Reference Books

`1	S.K. Verma and Raman Mittal, “Legal Dimensions of Cyber Space”, Universal Law Publishing, 2004
2	Sachin Rastogi, “ Insights into E - Contracts in India”, LexisNexis, Ist Edition, 2013
3	Karnika Seth, “Computers, Internet and New Technology Laws”, LexisNexis, 2013
4	Kamath Nandan, “Law Relating to Computers Internet & E-commerce (A Guide to Cyber laws & the Information Technology Act, Rules, Regulations and Notifications along with Latest Case Laws)”, 2012, Universal Law Publishing, 2016
5	Christpher Millard, “Cloud Computing Law", OUP-UK, 2013
6	Chris Reed , “Computer Law”, Oxford University Press, 7th Edition, 2012

Mode of Evaluation:

Theory : Digital Assignments, Continuous Assessment Tests and Final Assessment Test

Recommended by Board of Studies	13.05.2016		
Approved by Academic Council	41	**Date**	17.06.2016

		L	T	P	J	C
CSE6032	**Cloud Computing Paradigm on Software Engineering**	**2**	**0**	**0**	**4**	**3**
Pre-requisite	**Nil**					**Syllabus version**
Anti-requisite						v. 1.0

Course Objectives:

1. To provide a basic understanding of core concepts of software engineering on the cloud platform
2. To familiarize with the state of the art software engineering approaches for developing cloud based applications
3. To provide the conceptual understanding of cloud-based application architecture
4. To understand the field of software engineering as relevant to the emerging new paradigm of cloud computing

Expected Course Outcome:

1. Creating cloud based application by using the appropriate software process model
2. Developing test plan to test the cloud application
3. Deploying enumerating techniques for cloud based applications
4. Enhancing and Maintaining the system in Cloud

Module:1	**Introduction and Impact of cloud paradigm on software engineering**	**3 Hours**

Introduction to cloud computing platform-traditional software engineering process-creating web services –Impact of cloud computing on software engineering- software process model for cloud platform

Module:2	**Cloud induced Transformations in software engineering**	**5 Hours**

Cloud-Sponsored Transformations for IT, Leveraging Clouds for Global Software Development (GSD), Combination of Agility and Cloud Infrastructure for Next-Generation Software Engineering, Convergence of Service and Cloud Paradigm

Module:3	**Software Development Life Cycle for Cloud Platform**	**4 Hours**

Impact of cloud services on software development life cycle, Cloud based development using classic life cycle model, Business Requirements Engineering for Developing Cloud Computing Services

Module:4	**Software Design Strategies for Cloud Adoption**	**4 Hours**
Feature-Driven Design of SaaS Architectures, Impact of Cloud Adoption on Agile Software Development, Technical Strategies and Architectural Patterns for Migrating Legacy Systems to the Cloud		
Module:5	**Software Reuse – Cloud**	**6 Hours**
Components and Frameworks in Cloud Era, Goal based requirements elicitation for service reuse in cloud computing. Reuse of Architecture - Reuse across multiple architectures Reuse Assets - Software Asset Re-Use : Migration of Data-Intensive Legacy system to the cloud computing. Reuse in Cloud Application - Reusing Transaction models for dependable cloud		
Module:6	**Performance of Cloud Based Software Applications**	**4 Hours**
Efficient Practices and Frameworks for Cloud-Based, Application Development, Methodology for Identifying the Relationships Between Performance Factors for Cloud Computing Applications		
Module:7	**Testing perspectives for cloud based applications**	**2 Hours**
Testing in the cloud : Strategies, risks and benefits		
Module:8	**Recent Trends**	**2 Hours**
	Total Lecture hours:	**Hours: 30**

List of Challenging Experiments (Indicative)		
1.	Agriculture Updates by SMS A Cloud Computing Approach	2 hours
2.	Cloud Computing for Agent-Based Urban Transportation Systems Project	2 hours
3.	A Hybrid Cloud Approach for Secure Authorized Deduplication	2 hours
4.	Privacy-Preserving Public Auditing for Shared Data in the Cloud	2 hours
5.	PACK: Prediction-Based Cloud Bandwidth and Cost Reduction System	2 hours
6.	Cloud-based Online Banking	2 hours
7.	Cloud File/Data storage	2 hours

8.	Performance evaluation of Cloud applications	2 hours
	Total Laboratory Hours	**30 hours**

Reference Books	
1	Software engineering frameworks for the cloud computing paradigm, by Zaigham Mahmood, Saqib Saeed, Springer London,2015
2	Software Reuse in the Emerging Cloud Computing Era, edited by Yang, Hongji, Harrisburg PA, United states,2012
3	Migrating Legacy Applications: Challenges in Service Oriented Architecture and Cloud Computing Environment , edited by Ionita, Anca Daniela, 2012

Mode of Evaluation:

Theory : Digital Assignments, Continuous Assessment Tests and Final Assessment Test

Lab : Midterm test in lab, lab experiments submission and Final Assessment in lab

Recommended by Board of Studies	13.05.2016		
Approved by Academic Council	41	**Date**	17.06.2016