

**BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI WORK INTEGRATED LEARNING PROGRAMMES**

**COURSE HANDOUT**

**Part A: Content Design**

|  |  |
| --- | --- |
| **Course Title** | Cloud Computing |
| **Course No(s)** | CSI ZG527 / SS ZG527 / SE ZG527 |
| **Credit Units** | 5  1-2-2, (total 5 units or credits) ie 1 unit for class room hours, 2 unit for lab hours, 2 units for student preparation.  Typically 1 unit translates to 32 hours |
| **Course Author** | Chandra Shekar RK / Nayan Khare |
| **Version No** | 1.5 |
| **Date** | 03/02/2020 |

**Course Objectives**

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| --- | --- |
| **No** | Objective |
| **CO1** | Students will learn the fundamental ideas behind Cloud Computing, the evolution of the paradigm, its applicability; benefits, as well as current and future challenges; |
| **CO2** | Students will learn the basic ideas and principles in data centre design and management |
| **CO3** | Students will learn about cloud components and technologies and relevant distributed file systems |
| **CO4** | Students will learn a variety of programming models and develop working experience |

**Text Book(s)**

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| --- | --- |
| T1 | Dinkar Sitaram and Geetha Manjunath. Moving to the Cloud. Syngress (Elsevier) Pub, 2011 |
| T2 | Rajkumar Buyya, James Broburg & Anderzej M.G, Cloud Computing – Principles and Paradigms. John Wiley Pub, 2011 |

**Reference Book(s) & other resources**

|  |  |
| --- | --- |
| R1 | Cloud Computing bible by Barrie Sosinsky, Wiley Publishers, 2010 |
| R2 | Virtualization A Beginner’s guide, Danielle Ruest, Nelson Ruest, TMH, 2009 |
| R3 | Cloud Computing bible by Barrie Sosinsky, Wiley Publishers, 2010 |
| R4 | Cloud security, a comprehensive guide to secure cloud computing, by Ronald L.Krutz et al, Wiley Publishers, 2010 |

**Modular Content Structure**

**1. Introduction to Cloud Computing**

1.1. Cloud Computing, services, deployment models

1.2. Introduction to Cloud Computing

1.3. Origins and Motivation

1.4. Types of Clouds and Services

1.5. Cloud Infrastructure and Deployment

**2. Virtualization Techniques and Types**

2.1. Introduction to Virtualization

2.2. Use & demerits of Virtualization

2.3. Types of Virtualization

2.4. x86 Hardware Virtualization

2.5. Manage the resources for the SaaS, PaaS and IaaS models

2.6. *Introduction to NFV – VNF*

3. **Infrastructure as a Service**

3.1. Introduction to IaaS

3.2. IaaS examples

3.3. Reference Model of AWS

3.4. Amazon cloud services - Compute, Database, Storage

3.5. Region Vs Availability zones

3.6. Case Study - Openstack

3.7. Managing Virtual Resources on the Cloud: Provisioning and Migration 3.7.1. Virtual Machine Provisioning and Manageability

3.7.2. VM Provisioning Process

3.7.3. Virtual Machine Migration Services

3.7.4. Migrations Techniques

3.7.5. VM Provisioning and Migration in action

**4. Containers (New)**

4.1.Linux Containers - LXC and LXD

4.2.Dockers - Elements, Images, Files, Containers

4.3.Cloud and *Container* orchestration technologies

**5. Platform as a Service and SaaS**

5.1. Introduction to PaaS

5.2. PaaS examples

5.3. Windows Azure

5.4. 5 Principles of UI Design - AWS PaaS

5.5. Introduction to SaaS

5.6. Pros and Cons of SaaS model and applications

**6. Capacity management and Scheduling in cloud computing** 6.1. Capacity management and Scheduling

6.2. Distributed management of virtual machines

6.3. Reservation-based provisioning of virtualized resource

6.4. Provisioning to meet SLA commitments

6.5. Stages of VM life cycle within OpenNebula

6.6. Network model for OpenNebula

**7. Issues and Challenges : Availability, Multi-Tenancy, Security and SLA**

7.1. Multi-Tenancy, 4 levels of multi tenancy

7.2. Multi-tenant models for cloud

7.3. Introduction to cloud security

7.4. Cloud security Issues

7.5. Threat Model

7.6. Top 5 cloud security threats

7.7. who is responsible for managing security

7.8. Service License Agreements: Lifecycle and Management

7.9. Traditional approaches to SLO management

7.10. SLA Management in Cloud

7.11. Automated Policy based management

7.12. Managing Clouds: Services and Infrastructure

**8. Distributed File System (DFS) and Hadoop**

8.1. Introduction to Distributed File System (DFS)

8.2. Case Study HDFS

8.3. Hadoop components and importance of MapReduce

8.4. Setting started - Amazon EMR

8.5. Amazon EMR - Plan and Configure clusters (# only for CSI)

8.6. AMazon EMC - Manage Clusters (# only for CSI)

8.7. Understanding MapReduce (\* Not for CSI)

8.8. Explore word count Java program (\* Not for CSI)

8.9. MapReduce Facts (\* Not for CSI)

**Learning Outcomes:**

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| **No** | **Learning Outcomes** |
| LO1 | **Explain** the core concepts of the cloud computing paradigm: how and why this paradigm shift came about, the characteristics, advantages and challenges brought about by the various models and services in cloud computing |
| LO2 | **Apply** the fundamental concepts in data-centres to understand the tradeoffs in power, efficiency and cost |
| LO3 | **Discuss** system virtualization and outline its role in enabling the cloud computing system model. |
| LO4 | **Illustrate** the fundamental concepts of cloud storage and demonstrate their use in storage systems such as Amazon S3 and HDFS |
| LO5 | **Analyze** various cloud programming models and apply them to solve problems on the cloud |

**Note to Faculty:**

**Some modules or topics are specific only to certain programmes. The faculty is instructed to choose the relevant topics/modules depending on the programme in which this course is being offered. Same needs to be reflected in the contact session plan.**

**# Specific to MTech, CSI (Computing Systems & Infrastructure)**

**\* Specific to MTech (SW Systems) and MTech (SW Engg)**

**Part B: Contact Session Plan**

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| **Academic Term** | First Semester 2020-2021 |
| **Course Title** | Cloud Computing |
| **Course No** | CSI ZG527 / SS ZG527 / SE ZG527 |
| **Lead Instructor** | D.V.N.SIVA KUMAR |

**Glossary of Terms**

1. Contact Hour (CH) stands for a hour long live session with students conducted either in a physical classroom or enabled through technology. In this model of instruction, instructor led sessions will be for 22 CH.

a. Pre CH = Self Learning done prior to a given contact hour

b. During CH = Content to be discussed during the contact hour by the course instructor c. Post CH = Self Learning done post the contact hour

2. Contact Hour (CS) stands for a two-hour long live session with students conducted either in a physical classroom or enabled through technology. In this model of instruction, instructor led sessions will be for 11 CS.

a. Pre CS = Self Learning done prior to a given contact session

b. During CS = Content to be discussed during the contact session by the course instructor c. Post CS = Self Learning done post the contact session

3. RL stands for Recorded Lecture or Recorded Lesson. It is presented to the student through an online portal. A given RL unfolds as a sequences of video segments interleaved with exercises 4. SS stands for Self-Study to be done as a study of relevant sections from textbooks and reference books. It could also include study of external resources.

5. LE stands for Lab Exercises

6. HW stands for Home Work.

7. M stands for module. Module is a standalone quantum of designed content. A typical course is delivered using a string of modules. M2 means module 2.

**Teaching Methodology (Flipped Learning Model)**

The pedagogy for this course is centered around flipped learning model in which the traditional class-room instruction is replaced with recorded lectures to be watched at home as per the student’s convenience and the erstwhile home-working or tutorials become the focus of classroom contact sessions. Students are expected to finish the home works on time.

**Contact Session Plan**

o Each Module (M#) covers an independent topic and module may encompass more than one Recorded Lecture (RL).

o Contact Sessions **(2hrs each week)** are scheduled alternate weeks after the student watches all Recorded Lectures (RLs) of the specified Modules (listed below) during the previous week o In the flipped learning model, Contact Sessions are meant for in-classroom discussions on cases, tutorials/exercises or responding to student’s questions/clarification--- may encompass more than one Module/RLs/CS topic.

o Contact Session topics listed in course structure (numbered CSx.y) may cover several RLs; and as

per the pace of instructor/students’ learning, the instructor may take up more than one CS topic during each of the below sessions.

**Detailed Structure**

**Introductory Video/Document:** *<< Introducing the faculty, overview of the course, structure and organization of topics, guidance for navigating the content, and expectations from students>>*

▪ Each of the sub-modules of **Recorded Lectures** (RLx.y ) shall delivered via **30 – 60mins videos** followed by:

▪ **Contact session** (CSx.y) of 2Hr each for illustrating the concepts discussed in the videos with exercises, tutorials and discussion on case-problems (wherever appropriate); contact sessions (CS) may cover more than one recorded-lecture (RL) videos.

**Course Contents**

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| --- | --- | --- | --- | --- |
| **Contact Session 1**  **M1: Introduction to Cloud Computing** | | | | |
| Time | Type | | Description | Text/Ref Book/external resource |
| Pre -CS | RL1.1 | Cloud Computing, services,  deployment  models | Motivation  Evolution of Web  Technology Advances  What is Cloud Computing? Drivers for the new Platform Cloud Summary | T1: Ch1  T2: Ch1 |
| RL1.2 | 3-4-5 Rule of CC | Cloud Computing: Definition 3-4-5 rule of Cloud  Computing  5-Characteristics of Cloud Computing  4-Deployment Models |
|  | RL1.3 | 3-4-5 Rule of CC Cloud Providers | 3 Cloud Service Models Software as a Service (SaaS) Platform as a Service  Infrastructure as a Service Cloud Infrastructures  Cloud Providers  Characteristics  Management of Virtualized Resources  Cloud OS |
| During CS | CS1.1 | Cloud Computing, services | Introduction to Cloud  Computing  Origins and Motivation | T1: Ch1  T2: Ch1 |
| CS 1.2 | Deployment  models | Types of Clouds and  Services  Cloud Infrastructure and Deployment |
| Post CS | LE1.1 |  |  |  |

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|  | SS1.1 |  | Merits and Demerits of CC |  |
|  | HW1.1 |  | Make a list of Public, Private, Hybrid clouds available in the IT space |  |
|  | QZ1.1 |  |  |  |
| Lab Reference |  |  |  |  |
| **Contact Session 2**  M2: **Virtualization Techniques and Types**  **Dockers** | | | |  |
| Time | Type | | Description | Text/Ref Book/external resource |
| Pre CS | RL2.1 | Virtualization | Importance of Virtualization in Cloud Computing  What is Virtualization  What does Virtualization do? Changes after Virtualization Virtualization Architecture | T1: Ch9 |
| RL2.2 | Hypervisor | Hypervisor  Hypervisor Design Goals How Hypervisor goals are achieved?  Monolithic versus  Microkernelized  CPU Sharing  Memory Sharing  IO Sharing |
| RL2.3 | Types of  Virtualization | Approaches for  Virtualization  Full Virtualization  ParaVirtualization  SKI Virtualization  x86 Hardware Virtualization Advantages of Virtualization Issues to be aware of  Virtualization  Applications of  Virtualization |
| RL\_2\_5 | Lab Demo | Check Virtualization  Support |  |
| RL\_2\_6 | Lab Demo | Oracle Virtual Box |  |
| RL\_2\_7 | Lab Demo | Hyper-V |  |
| During CS | CS2.1 | Virtualization  Types | Types of Virtualization  Advantages of Virtualization Issues to be aware of  Virtualization | T1: Ch9 |
| CS2.2 | Managing Virtual Resources on the Cloud  Introduction to NFV-VNF | Manage the resources for the SaaS, PaaS and IaaS models Dockers |

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| Post CS | LE2.1 |  | Go through RL 2.5, 2.6, 2.7 and solve exercise in Lab sheet 1 |  |
| SS2.1 |  | Study: KVM, Xen, Hyper-V, VirtualBox |  |
| HW2.1 |  | Exercise on Docker  Container |  |
| QZ2.1 |  |  |  |
| Lab Reference |  |  |  |  |
| **Contact Session 3, 4**  M3: **Infrastructure as a Service**  **Managing Virtual Resources on the Cloud** | | | |  |
| Time | Type | | Description | Text/Ref Book/external resource |
| Pre CS | RL3.1 | IaaS | Key concepts of IaaS  Two primary facets that make IaaS special  The value of IaaS | T1: Ch2 |
|  | RL3.2 | AWS | Amazon Web Services  AWS infrastructure services Amazon Elastic Compute Cloud (Amazon EC2)  Infrastructure Services |
|  | RL3.3 | Openstack -  CaseStudy | Openstack overview  Openstack Components Nova, Swift, Horizon,  Keystone, Cinder, Neutron, Glance  Conceptual Architecture | http://www.slashroot.in/open stack-tutorial-getting-started basics-building-your-own cloud  http://docs.openstack.org/ |
|  | RL3.4 | Virtual Machine Provisioning | Virtual Machine  Provisioning and  Manageability Life Cycle VM Provisioning Process VM Provisioning using templates  Examples - Vagrant,  Heat(Orchestration Tool of openstack) | T2: Ch5 |
|  | RL3.5 | Virtual Machine Migration | Virtual Machine Migration Services  Cold/regular migration  Live Migration Technique Live Migration Demo |
|  | RL3.6 | Lab Demo | AWS-InstanceCreation |  |
|  | RL3.7 | Lab Demo | AWS-S3-ObjStorage |  |
|  | RL3.8 | Lab Demo | OS-Openstack-Install-Setup |  |
|  | RL3.9 | Lab Demo | OS-InstanceCreation |  |
|  | RL3.10 | Lab Demo | OS-InstanceCreateWithVol |  |

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|  | RL3.11 | Lab Demo | OS-Swift-ObjStorage |  |
|  | RL3.12 | Lab Demo | OS-LoadBalancer-Manual |  |
|  | RL3.13 | Lab Demo | OS-InstanceCreate-Heat Provision |  |
|  | RL 3.14 | Lab Demo | OS-LoadBalancer-Heat Provision |  |
|  | RL3.15 | Lab Demo | Vagrant-Provision  WebServer |  |
|  | RL3.16 | Lab Demo | Part1-Proxmox-Cluster Provision-Migration |  |
|  | RL3.17 | Lab Demo | Part2-Proxmox-Cluster Provision-Migration |  |
| During CS | CS 3.1 | Infrastructure as a Service | Introduction to IaaS  IaaS examples  Reference Model of AWS Region Vs Availability zones | T1: Ch2 |
| CS 3.2 | AWS - Storage and Database  Services | Amazon S3, Amazon  Glacier, Amazon EBS, AWS Import/Export  Amazon RDS, Amazon DynamoDB, Amazon AWS Demo  Amazon Cloud Services - CloudFront, Elastic Load Balancer, Elastic Block Storage | T1: Ch2 |
| CS 3.3 | Openstack | Openstack overview and Components | http://docs.openstack.org/ |
| CS 3.4 | VM Provisioning and Migration | Virtual Machine  Provisioning Process  VM Provisioning using templates, Examples -  Vagrant  VM Migrations Techniques | T2: Ch5 |
| Post CS | LE3.1 |  | Install Openstack and carry out exercise on RL 3.9-3.17 |  |
| SS3.1 |  | RL 3.6 - 3.17, Try using Openstack -  http://trystack.org/ |  |
| HW3.1 |  | Compare Openstack vs AWS (Similarities and Differences) |  |
| QZ3.1 |  |  |  |
| Lab Reference |  |  |  |  |
| **Contact Session 5**  M4: **Containers** | | | |  |
| Time | Type | | Description | Text/Ref Book/external resource |

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| Pre CS | RL4.1 | SW Virtualization Dockers | How are Docker Containers different from a Virtual Machine?  Docker Container Lifecycle Dockerfile | https://docs.docker.com/get started/  **more focus on**  **1: Orientation**  **2: Containers**  **3. Services** |
| During CS | CS4.1 | Containers | Linux Containers - LXC and LXD | https://linuxcontainers.org/l xc/introduction/  https://access.redhat.com/doc umentation/en  us/red\_hat\_enterprise\_linux\_ atomic\_host/7/html/overview \_of\_containers\_in\_red\_hat\_s ystems/introduction\_to\_linux \_containers |
| CS4.2 | Cloud and  Container  orchestration | Cloud orchestration  technologies | https://www.ibm.com/develo perworks/cloud/library/cl cloud-orchestration  technologies-trs/index.html https://www.digitalocean.co m/community/tutorials/an introduction-to-kubernetes |
| Post CS | LE4.1 |  |  |  |
| SS4.1 |  |  |  |
| HW4.1 |  |  |  |
| QZ4.1 |  |  |  |
| Lab Reference |  |  |  |  |
| **Contact Session 6: Review**  **Contact Session 7**  M5: **Platform as a Service and SaaS** | | | |  |
| Time | Type | | Description | Text/Ref Book/external resource |
| Pre CH | RL5.1 |  | Dependency on IaaS and PaaS  Introduction to PaaS  Building blocks of PaaS Characteristics of PAAS Advantages and Risks | T1: Ch3 |
|  | RL5.2 |  | Paas Example: Windows Azure  Windows Azure Runtime Environment  Paas Vendors |
|  | RL5.3 | Introduction to SaaS | Dependency on IaaS and PaaS  What is SaaS?  Problems in traditional  Model |

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|  |  |  | SaaS – How is it delivered |  |
|  | RL5.4 | SaaS –  Architecture | SaaS – Architecture  SaaS Models  Business Model comparisons | T1: Ch4 |
|  | RL 5.5 | SaaS Advantages | SaaS Advantages  SaaS User and Vendor  Benefits (CS)  SaaS - Applicability |
|  | RL5.6 | Lab Demo | Get Azure Account |  |
|  | RL5.7 | Lab Demo | Running Azure app locally |  |
|  | RL5.8 | Lab Demo | Deploying the local app to Azure |  |
|  | RL5.9 | Lab Demo | Determine which instance gets serves the request |  |
| During CH | CS5.1 | Intro to PaaS | Introduction to PaaS  PaaS examples  5 Principles of UI Design - AWS PaaS | T1: Ch3 |
| CS5.2 | SaaS | Introduction to SaaS  Pros and Cons of SaaS model | T1: Ch4 |
| Post CH | LE5.1 |  | Try exercise on SS 5.1 |  |
| SS5.1 |  | RL 5.5, 5.6 |  |
| HW5.1 |  |  |  |
| QZ5.1 |  |  |  |
| Lab Reference |  |  |  |  |
| **Contact Session 8**  M6: **Capacity management and Scheduling in cloud computing** | | | |  |
| Time | Type | | Description | Text/Ref Book/external resource |
| Pre CH | RL 6.1 | Capacity  Management and Scheduling | Managing Cloud -  Introduction | T2: Ch6 |
|  | RL 6.2 | VIM | Why a Virtual Infrastructure Manager?  Extending the Benefits of Virtualization to Clusters Virtual Machine  Management Model |  |
|  | RL 6.3 | OpenNebula | What is OpenNebula?  The Benefits of OpenNebula Interoperability from the Cloud Provider perspective The Benefits for System Integrators (CS)  The main features of  OpenNebula  Comparison with Other | T2: Ch6 |

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|  |  |  | technologies (CS) |  |
|  | RL 6.4 | OpenNebula | OpenNebula Architecture Process separation  Constructing/Management of a private cloud  System Overview  Complex Storage behind OpenNebula  Networking for private  clouds  Users Management(CS) Preparing VMs for  OpenNebula  VM Description  VM States overview  Hybrid cloud  Making an Amazon EC2 hybrid |  |
| During CH | CS 6.1 | Capacity  Management | Capacity management  Distributed management of virtual machines | T2: Ch6 |
| CS 6.2 | Scheduling | Reservation -based  provisioning of virtualized resource  Provisioning to meet SLA commitments |
| Post CH | LE 6.1 |  |  |  |
| SS 6.1 |  | Documentation of  OpenNebula |  |
| HW 6.1 |  | Install OpenNebula, Create instances and cluster |  |
| QZ 6.1 |  |  |  |
| Lab Reference |  |  |  |  |
| **Contact Session 9**  M7: **Issues and Challenges : Availability, Multi-Tenancy, Security and SLA** | | | |  |
| Time | Type | | Description | Text/Ref Book/external resource |
| Pre CH | RL 7.1 | Availability | High Availability  Key aspects of SLA | T1: Ch6 |
| RL 7.2 | Multi-Tenancy | Multitenancy – What is it? Pros and Cons  Traditional Deployment Model  Multitenancy – Introduction Multi-tenants Deployment Modes for Application  Server  Multi-tenants Deployment Modes in Data Centers | T1: Ch6 |
| RL 7.3 | Security | Introduction to cloud security | T1: Ch 7 |

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|  |  |  | Cloud Security Issues  Loss of Control in the Cloud Multi-tenancy Issues in the Cloud  Taxonomy of Fear  Threat Model | T2: Ch 23 |
| During CH | CS 7.1 | Multi-Tenancy | Multi-Tenancy  4 levels of multi tenancy Top 5 cloud security threats | T1: Ch6 |
| CS 7.2 | Security and SLA | who is responsible for  managing security  Service License Agreements: Lifecycle and Management Traditional approaches to SLO management  Automated Policy based management  Managing Clouds: Services and Infrastructure | T1: Ch6  T1: Ch 7  T1: Ch8  T2: Ch 23  T2: Ch16 |
| Post CH | LE 7.1 |  |  |  |
| SS 7.1 |  | Study - NimSoft, Netchart |  |
| HW 7.1 |  |  |  |
| QZ 7.1 |  |  |  |
| Lab Reference |  |  |  |  |
| **Contact Session 10**  M8: **Distributed File System (DFS) and Hadoop** | | | |  |
| Time | Type | | Description | Text/Ref Book/external resource |
| Pre CH | RL 8.1 | Hadoop | Why Hadoop?  Introduction to BIG DATA Hadoop Features  Hadoop Framework Tools | https://hadoop.apache.org/d ocs/r1.2.1/hdfs\_design.html |
| RL 8.2 | Hadoop | Hadoop common Component MapReduce (Data Processing Framework)  MapReduce Processing flow Architecture Overview  Distributed Word Count Word Count Execution  MarketRatings example and Program demo  MapReduce Execution  Details  Fault Tolerance in  MapReduce  Challenges of Cloud  Environment |
| RL 8.3 | Lab Demo | HadoopMapReduce  MarketRating |  |
| RL 8.4 | Lab Demo | WordCountingwithApacheP |  |

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| During CH | CS 8.1 | DFS | Introduction to Distributed File System  Case Study HDFS  Setting started - Amazon EMR | https://hadoop.apache.org/d ocs/r1.2.1/hdfs\_design.html |
| CS 8.2 | Hadoop | Hadoop components and importance of MapReduce MapReduce Facts  Amazon EMR - Plan and Configure clusters (# only for CSI)  AMazon EMC - Manage Clusters (# only for CSI) | http://docs.aws.amazon.com/ emr/latest/ManagementGuide /emr-what-is-emr.html |
| Post CH | LE 8.1 |  | Install Hadoop and Carry out exercise on Word count and Market ratings |  |
| SS 8.1 |  | Study - Hive, PIG, HBase of Hadoop |  |
| HW 8.1 |  |  |  |
| QZ 8.1 |  |  |  |
| Lab Reference |  |  |  |  |

**Contact Session 11: Review**

**Lab Details**

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| **Lab No** | **Lab Objective** | **Lab**  **Sheet/Capsule Access URL** | **Content**  **Reference** |
| 1 | • Software(s) or Tool(s) required: Virtual Box, KVM on Ubuntu, Hyper V, Openstack, AWS, Salesforce,  Proxmox or ConVirt, Hadoop Harton Sandbox  • System Requirements: Any System with Processor better or equal to i3 intel. Min 4GB RAM (Recommended 8GB or more)  • Download url:  o https://www.virtualbox.org/wiki/Downloads  o www.devstack.org  o https://aws.amazon.com/console/  o https://www.proxmox.com/en/proxmox-ve  o https://www.convirture.com/products\_opensourc e.php  o http://hortonworks.com/products/hortonworks  sandbox/  • Mode of working (GUI based- Stand alone installer/ Client Server / Console based/ Browser based): All types • Open source/ Freeware/ Proprietary:  Opensource/Freeware  • Objective behind Labwork in this course: Understand and have hands on knowledge on technologies related to |  |  |

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|  | Cloud computing |  |  |

**Evaluation Scheme**

Legend: EC = Evaluation Component; AN = After Noon Session; FN = Fore Noon Session

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| **No** | **Name** | **Type** | **Duration** |  | **Weight Day, Date, Session, Time** |
| EC-1 | Quizzes / Assignments/ Paper Presentation | To be announced | | 15% | September 10-20, 2020 |
| EC-2 | Mid-Semester Test | Closed Book | 2 hours | 35% | Sunday, 11/10/2020 (AN) 2 PM – 4 PM |
| EC-3 | Comprehensive Exam | Open Book | 3 hours | 50% | Sunday, 29/11/2020 (AN) 2 PM – 5 PM |

***Note*** *- Evaluation components can be tailored depending on the proposed model.*

**Important Information**

Syllabus for Mid-Semester Test (Closed Book): Topics in Weeks 1-7

Syllabus for Comprehensive Exam (Open Book): All topics given in plan of study

Evaluation Guidelines:

1. EC-1 consists of either two Assignments or three Quizzes. Announcements regarding the same will be made in a timely manner.

2. For Closed Book tests: No books or reference material of any kind will be permitted. Laptops/Mobiles of any kind are not allowed. Exchange of any material is not allowed. 3. For Open Book exams: Use of prescribed and reference text books, in original (not photocopies) is permitted. Class notes/slides as reference material in filed or bound form is permitted. However, loose sheets of paper will not be allowed. Use of calculators is permitted in all exams. Laptops/Mobiles of any kind are not allowed. Exchange of any material is not allowed. 4. If a student is unable to appear for the Regular Test/Exam due to genuine exigencies, the student should follow the procedure to apply for the Make-Up Test/Exam. The genuineness of the reason for absence in the Regular Exam shall be assessed prior to giving permission to appear for the Make-up Exam. Make-Up Test/Exam will be conducted only at selected exam centres on the dates to be announced later.

It shall be the responsibility of the individual student to be regular in maintaining the self-study schedule as given in the course handout, attend the lectures, and take all the prescribed evaluation components such as Assignment/Quiz, Mid-Semester Test and Comprehensive Exam according to the evaluation scheme provided in the handout.

**Appendix**

**Course Plan**

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| **Contact hour** | **Pre-contact hour prep** | **During Contact hour** | **Post-contact hour** |
| 1 | RL 1.1 | CS 1.1 | SS 1.1 |
| 2 | RL 1.2, 1.3 | CS 1.2 | HW 1.1 |
| 3 | RL 2.1, 2.2 | CS 2.1 | SS 2.1, RL 2.5, 2.6, 2.7 |
| 4 | RL 2.3 | CS 2.2 | HW 2.1, LE 2.1 |
| 5 | RL 3.1, RL 3.2 | CS 3.1 | RL 3.8, SS 3.1 |
| 6 | RL 3.3 | CS 3.2 | RL 3.6, 3.7 |
| 7 | RL 3.4 | CS 3.3 | RL 3.9 - 3.15 |
| 8 | RL 3.5 | CS 3.4 | RL 3.16 , 3.17  LE 3.1 |
| 9 | RL 4.1 | CS 4.1 | SS 4.1 |
| 10 |  | CS 4.2 | LE 4.1 |
| 11 |  | Review |  |
| 12 |  | Review |  |
| 13 | RL 5.1, 5.2 | CS 5.1 | SS 5.1 |
| 14 | RL 5.3, 5.4, 5.5 | CS 5.2 | RL 5.6 - RL 5.9, LE 5.1 |
| 15 | RL 6.1, 6.2 | CS 6.1 | SS 6.1 |
| 16 | RL 6.3, 6.4 | CS 6.2 | HW 6.1 |
| 17 | RL 7.1, 7.2 | CS 7.1 |  |
| 18 | RL 7.3 | CS 7.2 | SS 7.1 |
| 19 | RL 8.1 | CS 8.1 | SS 8.1 |
| 20 | RL 8.2 | CS 8.2 | RL 8.3, 8.4, LE 8.1 |
| 21 |  | Review |  |
| 22 |  | Review |  |