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CLOUD COMPUTING **Course Code : 315325**

Programme Name/s	**: Computer Technology/ Computer Engineering/ Computer Science & Engineering/ Computer Hardware & Maintenance/ Computer Science & Information Technology/ Computer Science**
Programme Code	**: CM/ CO/ CW/ HA/ IH/ SE**
Semester	**: Fifth**
Course Title	**: CLOUD COMPUTING**
Course Code	**: 315325**

I. RATIONALE

Cloud computing has evolved as a very important computing model. It enables information, software, and other shared resources to be provisioned over the network as services in an on-demand manner. There are many aspects of cloud computing viz cloud types, storage in cloud, security in cloud, cloud monitoring and management. This course provides implementing virtualization, creation of cloud based storage, implementing security, and managing cloud services.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to attain following Industry Identified Competency through various Teaching Learning Experiences: Manage Cloud based services.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Use basic Cloud based applications.
- CO2 - Explain Virtualization in Cloud Computing.
- CO3 - Maintain storage system and services in Cloud.
- CO4 - Apply Security in Cloud Computing.
- CO5 - Use various Cloud Platforms.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
315325	CLOUD COMPUTING	CLC	DSE	4	-	2	-	6	2	3	30	70	100	40	25	10	25#	10	-	-	150

CLOUD COMPUTING **Course Code : 315325**

Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 10 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Explain characteristics of Cloud computing. TLO 1.2 Compare Cloud deployment models on the given services. TLO 1.3 Explain the given service offered by identified Cloud service model. TLO 1.4 Explain components of Cloud computing architecture.	**Unit - I Fundamentals of Cloud Computing** 1.1 Definition of Cloud Computing, Characteristics of Cloud computing 1.2 Cloud Deployment Models(Introduction, advantages and disadvantages) : Public Cloud, Private Cloud, Community Cloud, Hybrid Cloud 1.3 Cloud Service Models (Function, advantages, disadvantages) : IaaS, PaaS, SaaS 1.4 Cloud cost benefits 1.5 Architectural and Infrastructural components of Cloud Computing	Lecture Using Chalk-Board Presentations Flipped Classroom
2	TLO 2.1 Explain features of Virtualization. TLO 2.2 Compare characteristics of Virtualization types. TLO 2.3 Write the steps to build a virtual machine using VMWare on the given Operating System. TLO 2.4 Differentiate Virtual Machine Migration, Consolidation and Management. TLO 2.5 Explain advantages and disadvantages of Virtualization.	**Unit - II Virtualization** 2.1 Introduction, Virtualization Reference Model, Characteristics of virtualized environment 2.2 Differentiate various types of Virtualization : Storage, Network , Desktop , Application server 2.3 Technology Examples 2.3.1 VMWare: Full Virtualization Reference Model 2.3.2 Xen: Architecture and Guest Operating System Management 2.4 Definition and Life Cycle of Virtual Machine(VM), VM Migration: Concept and Techniques, VM Consolidation: Concepts, VM Management: Concepts 2.5 Advantages and Disadvantages of Virtualization	Flipped Classroom Presentations Lecture Using Chalk-Board Video Demonstrations

CLOUD COMPUTING **Course Code : 315325**

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 Explain Cloud storage system architecture. TLO 3.2 Write steps to design storage system for the given Cloud set-up. TLO 3.3 Compare GFS and HDFS. TLO 3.4 Describe the components of federated Cloud computing. TLO 3.5 Compare different types of Service Level Agreement (SLA). TLO 3.6 Describe the Cloud service life cycle.	**Unit - III Cloud Storage, Monitoring and Management** 3.1 Cloud Storage System Architecture 3.2 Virtualize Data Centre (VDC) Architecture, VDC Environment, Server, Storage, Networking, Desktop and Application Virtualization techniques and benefits 3.3 Cloud File Systems: Google File System (GFS) : Components, Features, Advantages and Disadvantages and Hadoop Distributed File System (HDFS) :Terminologies like Heartbeat, Balancing and Replication, Features and Limitations 3.4 Service Provider and users, An architecture of federated Cloud computing : Model and It's Explanation 3.5 Service Level Agreement (SLA) 3.5.1 SLA management: 5 Phases of SLA management like Feasibility, On-Boarding, Pre-production, Production and Termination 3.5.2 Types of SLA: Infrastructure SLA and Application SLA 3.5.3 Life cycle of SLA: 5 Phases like Contract Definition, Publishing and Discovery , Negotiation, Operationalization and De-commissioning 3.6 Cloud Service life cycle phases: Service planning, service creation, service operation and service termination	Presentations Lecture Using Chalk-Board Video Demonstrations Hands-on
4	TLO 4.1 Explain security and related risks in Cloud Computing. TLO 4.2 Explain key features of Data Security. TLO 4.3 Write steps to implement Cloud Data Security. TLO 4.4 Explain identity management and access facility of given Cloud set-up. TLO 4.5 Explain the features of Security-As-A-Cloud Service.	**Unit - IV Security in Cloud Computing** 4.1 Cloud Security Concepts: Multi-tenancy, Virtualization, Data Outsourcing and Trust Management, Metadata security 4.2 Cloud Risk: Concept, Types of Cloud Risks 4.2.1 Policy and Organizational Risks 4.2.2 Technical Risks 4.2.3 Legal Risks 4.3 Data security technologies, Data Security risks 4.4 Digital Identity and Access Management 4.5 Content level security: Pros and Cons, Features of Security-As-A-Cloud Service	Lecture Using Chalk-Board Presentations Video Demonstrations
5	TLO 5.1 Explain the characteristics of the enabling technology with the IoT. TLO 5.2 Select relevant Cloud platform or application for development. TLO 5.3 Describe the features of Cloud-based smart device. TLO 5.4 Compare features of various Cloud platforms.	**Unit - V Trends in Cloud** 5.1 Cloud trends in supporting Ubiquitous Computing 5.2 Enabling Technology in the Internet of Things(RFID, Sensor Networks and ZigBee Technologies, GPS) 5.3 Innovative Applications with the Internet of Things (Ex: Health care: ECG Analysis in Cloud and it's access, CRM and ERP: Business and Consumer Application) 5.4 Benefits of Cloud Platforms : Amazon EC2 and S3, CloudStack, Intercloud, Google App Engine, Open stack, Open Nebulla	Presentations Video Demonstrations Lecture Using Chalk-Board Model Demonstration

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

CLOUD COMPUTING **Course Code : 315325**

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Configure Cloud storage.	1	* Configure Cloud using JustCloud	2	CO1
LLO 2.1 Create document for given application.	2	Use Goggle Doc to make spreadsheet and notes	2	CO1
LLO 3.1 Create virtual environment.	3	* Create Virtual Machines using VMware (Private Cloud) and delete the created VM after completion	2	CO2
LLO 4.1 Implement storage service on Cloud.	4	* Implement Storage Service on Cloud using OpenStack	2	CO3
LLO 5.1 Create and Host Web Application.	5	* Create and Host Simple Web Application on Google cloud/Any cloud platform	2	CO3
LLO 6.1 Create a File system on Cloud.	6	Create a File System using HDFS	2	CO3
LLO 7.1 Create a workspace platform for development.	7	Work in Codenvy to show Provisioning and Scaling of a website	2	CO3
LLO 8.1 Implement Identity Management and Access Management using Cloud computing infrastructure.	8	* Implement Identity Management and Access Management using OpenStack	2	CO4
LLO 9.1 Configure server for security.	9	Configure Server using CFEngine or any other open source tool	2	CO4
LLO 10.1 Design IoT based application.	10	* Design an application based on IoT using Arduino or Raspberry Pi	2	CO5
LLO 11.1 Design Cloud based application.	11	Design any automated application using RFID	2	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Micro project

- A suggestive list of micro-projects is given here. Similar micro-projects could be added by concerned faculty:

a) Prepare the report on case study of Amazon Cloud Services.
b) Prepare the report on case study of Google App Engine.
c) Create infrastructure as service using OpenStack.
d) Develop Personal Cloud using Raspberry Pi or any equivalent platform.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

CLOUD COMPUTING **Course Code : 315325**

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Computer system - Hardware: Min 8GB RAM, 512 GB HDD, Gigabit Ethernet network equipment, Software Requirement: Apache Tomcat, Java, Python, Virtualization Software, Academic version of any public cloud service(Google/AWS)	All

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Fundamentals of Cloud Computing	CO1	6	4	6	0	10
2	II	Virtualization	CO2	8	4	4	8	16
3	III	Cloud Storage, Monitoring and Management	CO3	10	4	4	8	16
4	IV	Security in Cloud Computing	CO4	8	2	6	6	14
5	V	Trends in Cloud	CO5	8	0	6	8	14
Grand Total				**40**	**14**	**26**	**30**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Each practical will be assessed considering 60% weightage to process, 40% weightage to product.

For formative assessment of laboratory learning 25 marks.

Summative Assessment (Assessment of Learning)

- Two offline unit tests of 30 marks and average of two unit test marks will be considered for out of 30 marks.

End semester assessment is of 70 marks.
End semester summative assessment of 25 marks for laboratory learning.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	2	-	2	1	-	-	-			
CO2	2	2	2	2	1	1	1			
CO3	2	2	1	1	1	-	1			
CO4	1	2	-	2	1	1	1			
CO5	1	2	1	1	2	1	1			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

CLOUD COMPUTING **Course Code : 315325**

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Rajkumar Buyya, James Broberg, Andrzej Goscinski	Cloud Computing, Principals and Paradigms	A John Wilwy & Sons, Inc.,Publication, ISBN: 978-0-470-88799-8
2	Sharma Rishabh	Cloud Computing	Wiley Publication, ISBN: 978-81-265-5306-8
3	Christian Vecchiola, Rajkumar Buyya, and S.Thamarai Selvi	Mastering Cloud Computing	McGraw Hill Publication, ISBN 978-1-25-902995-0
4	Singh Shailendra	Cloud Computing	Oxford University Press, ISBN: 978-0199477388
5	Arshdeep Bahga, Vijay Madisetti	Cloud Computing: A Hands-On Approach	Self published, ISBN 1494435144, 9781494435141

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.techopedia.com/definition/2/cloud-computing	Cloud computing, How it works, Components and Types of Cloud Computing, Cloud Deployment Models
2	https://nptel.ac.in/courses/106105167	This course will introduce various aspects of cloud computing, including fundamentals, management issues, security challenges and future research trends. This will help students and researchers to use and explore the cloud computing platforms.
3	https://www.geeksforgeeks.org/service-level-agreements-in-cloud-computing/?ref=lbp	Service level agreements in Cloud computing
4	https://www.javatpoint.com/virtualization-in-cloud-computing	Virtualization in Cloud Computing
5	https://www.coursera.org/learn/cloud-security-on-aws/supplement/AcCam/course-overview	Learn AWS cloud security essentials: challenges, AWS services, advanced techniques, network security, encryption, breach response, compliance.
6	https://www.proquest.com/openview/53e8a5ed4ebc5ff06d57ebee9cba2a72/1?pq-origsite=gscholar&cbl=5444811	Research Paper on Current Development, Challenges, and Future Trends in Cloud Computing: A Survey

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students