GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester -VI

Course Title: Cloud and Data Center Technologies
(Course Code: 4361602)

Diploma programme in which this course is offered	Semester in which offered
Information Technology	6th semester

1.   RATIONALE

This course provides the knowledge necessary for cloud computing and data center technologies offer a range of benefits, including virtualization, security, and global reach. These factors make them essential components of modern IT infrastructure and enable businesses to adapt to rapidly evolving technological landscapes. After going through these course students will be able to understand cloud models, implement security, create a data center, implement virtualization, use cloud storage and Database service, and understand and implement emerging technologies with Cloud Computing.

2.   COMPETENCY
The purpose of this course is to help the student to attain the following skills with cloud technologies, as well as providing them with the core competencies to approach working in the Data Centre environment through various teaching learning experiences.

- **Develop and deploy Cloud Network with Data Center Technologies**

3.   COURSE OUTCOMES (COs)
The practical exercises, the underpinning knowledge, and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

The student will develop underpinning knowledge, adequate programming skills of competency for implementing various applications using cloud computing with data center Technologies to attain the following course outcomes.
   a) Understand the concept of Cloud architecture and its model.
   b) Apply the virtualization concept with its types.
   c) Understand Data Center Architecture.
   d) Learn and use Cloud Storage and Database Services.
   e) Explain Cloud Security and Compliance.
   f) Understand and implement emerging technologies with Cloud Computing.

4.   TEACHING AND EXAMINATION SCHEME

Teaching scheme In Hours			Total Credits(L+T/2 +P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	-	4	5	30	70	25	25	150

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for

the attainment of the COs.
Legends: L-*Lecture;* **T** *– Tutorial/Teacher Guided Theory Practice;* **P** *-Practical;* **C** *– Credit,*
CA *- Continuous Assessment;* **ESE** *-End Semester Examination.*

5.   SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the subcomponents of the COs. These PrOs need
to be attained to achieve the COs.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Sketch out and analyze the architecture of Openstack/ Eucalyptus/ OpenNebula/ KVM and identify different entities to understand the structure of it.	I	02
2	Create a Cloud Organization in AWS/Google Cloud/or any equivalent Open Source cloud softwares like Openstack/ Eucalyptus/ OpenNebula with Role-based access control.	I	04
3	Install Virtualbox/VMware/ Equivalent open source cloud Workstation with different platforms of Linux or Windows OS on top of windows 8 and above.	II	04
4	Install Python in the virtual machine created using VirtualBox/VMware and execute Simple Programs.	II	02
5	Create type 2 virtualization in VMWARE or any equivalent Open Source Tool. a. Starting and Stopping a virtual machine. b. Allocate memory and storage space as per requirement. c. Take snapshots of virtual machines d. Clone a virtual machine to create identical copies. e. Transfer the files from one virtual machine to another virtual machine	II	08
6	Create desktop Virtualization using Chrome Remote Desktop.	II	04
7	Setup your own virtual SDN lab using any of below given platform i) Virtualbox/Mininet Environment for SDN - http://mininet.org	III	10
8	A study and comparison on various cloud databases like Amazon RDS ,Google Cloud SQL,Microsoft Azure SQL Database, IBM Db2 on Cloud, Firebase Realtime Database (NoSQL), MongoDB Atlas (NoSQL),Oracle Cloud Autonomous Database	IV	06
9	A study and comparison on various cloud storage like Amazon S3,Google Cloud Storage, Microsoft Azure Blob Storage, IBM Cloud Object Storage for its performance and scalability	IV	04
10	Simulate resource management using cloudsim open source framework.	V	04

11	Simulate a secure file sharing using a cloudsim open source framework.	V	04
12	Creating and Executing Your First Container Using Docker platform.	VI	04
	Total		**56**

Note

i. _More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list._

ii. _The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.._

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Preparation of Experimental Setup	30
2	Setting and Operations	20
3	Observation and Recording	20
4	Interpretation of result and conclusion	10
5	Answer to sample questions	10
6	Submission of report in time	10
	Total	**100**

6.   MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to usher in uniformity of practical in all institutions across the state.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Computer system with operating system: Windows 7 or higher Ver., macOS, and Linux, with 4GB or higher RAM	All
2	Virtualbox/VMware , Cloudsim,NetBeans, Eclipse .	

7.   AFFECTIVE DOMAIN OUTCOMES

The following **sample** Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfill the development of this competency.

a) Work as a Cloud developer, Cloud architect or Cloud Engineer.
b) Follow ethical practices.

The ADOs are best developed through the laboratory/field based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

  i. 'Valuing Level' in 1st year
  ii. 'Organization Level' in 2nd year.
  iii. 'Characterization Level' in 3rd year.

8.   UNDERPINNING THEORY

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
Unit-1 Introduction to Cloud Computing	1a. Define Cloud computing 1b. Cloud Service models 1c. Types of Clouds	1.1 Defining Cloud Computing 1.2 Roots of Cloud Computing 1.2.1 Mainframes to cloud 1.2.2 Grid and Utility computing 1.2.3 Hardware virtualization 1.3 The Cloud Service Models 1.3.1 Cloud Architecture and Platforms 1.3.2 IaaS 1.3.3 Paas 1.3.4 SaaS 1.4 Layers and Types of Clouds 1.4.1 Deployment Model 1.4.2 Private cloud, Public cloud and Hybrid cloud 1.5 Desired Features of a Cloud 1.6 Pros and Cons of Cloud computing 1.7 Applications of cloud computing
Unit-2 Virtualization and Hypervisors	2a. Introduction to Cloud virtualization 2b. Types of virtualization 2c. Hypervisors and Virtual Machines	2.1 Introduction to Cloud virtualization 2.2 Characteristics of virtualization 2.3 Cloud Virtualization Basics 2.3.1 Hardware virtualization 2.3.2 Software Virtualization 2.3.3 Full virtualization 2.3.4 Para virtualization 2.3.5 Partial virtualization 2.3.6 Operating system level virtualization 2.4 Types of virtualization 2.4.1 Programming level 2.4.2 Application level 2.4.3 Storage 2.4.4 Network 2.2.5 Desktop 2.5 Hypervisors and Virtual Machines 2.5.1 Introduction to Hypervisors (Type 1 and Type2) 2.5.2 Creating and managing Virtual Machines 2.6 Virtualization of Clusters and data centers automation

Unit-3
Data Center Architecture
	3a. Data Center Fundamentals
	3b. Data Center Networking
	3c. Data Center Automation and Scaling
		3.1 Data Center Fundamentals
		   3.1.1 Historical perspective and evolution
		   3.1.2 Key components of a data center
		3.2 Data Center Networking
		   3.2.1 Data center network topologies
		   3.2.2 SDN (Software-Defined Networking) in data center
		3.3 Data Center Automation and Scaling
		   3.3.1 Automation in Data Centers
		   3.3.2 Infrastructure as Code (IaC) and automation tools
		   3.3.3 Scalability and elasticity in cloud data centers

Unit-4
Cloud Storage and Database Services
	4a. Cloud Storage Solutions
	4b. Cloud Databases
		4.1 Cloud Storage Solutions
		   4.1.1 Object storage, block storage, and file storage in the cloud
		   4.1.2 Data consistency and durability
		4.2 Cloud Databases
		   4.2.1 Types of cloud databases (SQL, NoSQL)
		   4.2.2 Data scaling and replication

Unit-5
Cloud Security and Compliance
	5a. Security in the Cloud
	5b. Data Security in Cloud
		5.1 Security in the Cloud
		   5.1.1 Cloud security challenges
		   5.1.2 Identity and access management
		   5.1.3 Access control and authentication in cloud computing
		5.2 Data Security in Cloud
		   5.2.1 Technologies for Data security in Cloud
		5.3 Securing Private and Public Cloud Architecture
		   5.3.1 Metrics for Service Level Agreements(SLAs)
		   5.3.2 DevSecOps

Unit-6 Emerging Technologies with Cloud Computing	6a. Introduction to Emerging Technologies in the Cloud	6.1 Serverless Computing 6.2 Edge and Fog Computing 6.3 AI and Machine Learning with Cloud Computing 6.4 Distributed Ledger Technology (DLT) with Cloud Computing 6.5 5G and Cloud-Native Networking 6.6 Kubernetes and Containers

Only the major Underpinning Theory is formulated as higher-level UOs of *Revised Bloom's taxonomy* in order development of the COs and competency is not missed out by the students and teachers. If required, more such higher-level UOs could be included by the course teacher to focus on the attainment of COs and competency.

Note: The UOs need to be formulated at the 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to Cloud Computing	04	02	02	02	06
II	Virtualization and Hypervisors	09	04	04	06	14
III	Data Center Architecture	09	04	04	06	14
IV	Cloud Storage and Database Services	09	04	04	06	14
V	Cloud Security and Compliance	05	02	06	02	10
VI	Emerging Technologies with Cloud Computing	06	04	06	02	12
Total		42				70

Legends: R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)
Note: This specification table provides general guidelines to assist students for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary slightly from the above table.

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student- related *co-curricular* activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:
- Explore different application development using different cloud domains.
- Undertake micro-projects in teams
- Give a seminar on any relevant topics.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)
These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:
- Massive open online courses (*MOOCs*) may be used to teach various topics/subtopics.
- Guide student(s) in undertaking micro-projects.
- *'L' in section No. 4* means different types of teaching methods that are to be employed by teachers to develop the outcomes.
- About *20% of the topics/sub-topics* which are relatively simpler or descriptive in nature is to be given to the students for *self-learning*, but to be assessed using different assessment methods.
- With respect to *section No.10*, teachers need to ensure to create opportunities and provisions for *co-curricular activities*.
- Guide students for various components of cloud platforms.

12.   SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be *individually* undertaken to build up the skill and confidence in every student to become problem solver so that he/she contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should *not exceed three.*

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain a dated work diary consisting of individual contributions in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than *16 (sixteen) student engagement hours* during the course. The student ought to submit a micro-project by the end of the semester to develop the industry- oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

- Host a static website using AWS or any other clouds.
- Create a cloud-based web/mobile application.
- Prepare the report on case study of Amazon Cloud Services/Google Cloud.

13.   SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Cloud computing, Principles and Paradigm	Rajkumar Buyya, J. Broberg, A. Goscinski	John Wiley & Sons, Inc. Publication, ISBN: 978-0-470-88799-8
2	Mastering Cloud Computing	Rajkumar Buyya, Christian Vecchiola, S Thamarai Selvi	McGraw Hill Publication ISBN: 978-1-25-902995-0
3	Cloud Computing Bible	Barrie Sosinsky	Wiley Publishing, Inc. ISBN: 978-0-470-90356-8
4	Cloud Data Centers and Cost Modeling A Complete Guide To Planning, Designing and Building a Cloud Data Center	Caesar Wu, Rajkumar Buyya	Elsevier Science ISBN: 978-0-12-801413-4
5	Cloud Computing: A Practical Approach	Anthony T.Velte, Toby J. Velte, Robert Elsenpeter	McGraw Hill Publication ISBN:978-0-07-068351-8

14.   SOFTWARE/LEARNING WEBSITES
a)   https://archive.nptel.ac.in/courses/106/105/106105167/
b)   https://www.openstack.org/
c)   https://www.virtualbox.org/
d)   https://www.vmware.com/in.html
e)   http://mininet.org
f)   https://cloudsimapp.com/
g)   https://www.docker.com/products/docker-scout/

h) Introduction to Docker Containers and Kubernetes -
https://www.youtube.com/watch?v=w1wNjVyv4r8

15. PO-COMPETENCY-CO MAPPING

Semester VI	Cloud and Data Center Technologies (Course Code: 4361601)						
	POs andPSOs						
Competency & Course Outcomes	PO 1 Basic & Discipline Specific Knowledge	PO 2 Problem Analysis	PO 3 Design/ Development of solutions	PO 4 Engineering Tools, Experimentation n & Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long Learning
Competency Develop a Develop and deploy Cloud Network with Data Center Technologies.							
Course Outcomes CO1 Understand the concept of Cloud architecture and its model.	3	2	3	1	-	2	2
CO2 Apply the virtualization concept with its types.	3	3	3	3	1	2	2
CO3 Understand Data Center Architecture.	3	3	3	3	1	2	2
CO4 Learn and use Cloud Storage and Database Services.	3	2	3	3	2	3	2
CO5 Explain Cloud Security and Compliance.	3	2	3	2	1	2	2
CO6 Understand and implement emerging technologies with Cloud Computing.	3	3	3	3	1	3	2

Legend: '**3**' for high, '**2**' for medium, '**1**' for low or '**-**' for the relevant correlation of each competency, CO, with PO/ PSO

16. COURSE CURRICULUM DEVELOPMENT

COMMITTEE GTU Resource Persons

Sr. No.	Name and Designation	Institute	Email
1	Ms. POOJA V. GARACH (LECTURER IN I.T.)	GGP, AHMEDABAD	pvgarach@gmail.com
2	Mr. PRADIPSINH K. CHAVDA (LECTURER IN I.T.)	LEC Poly. Morbi	pradipchavda.it@gmail.com
3	Dr .LATABEN J. GADHAVI (LECTURER IN I.T.)	Govt. Polytechnic Gandhinagar	latagpg@gmail.com