Pokhara University
Faculty of Science and Technology

Course No.: CMP424	Full marks: 100
Course Title: Cloud Computing and Virtualization (2-2-2)	Pass marks: 45
Nature of the course: Theory and Practical	Total Lectures: 30 hrs
Level: Bachelor	Program: BE

1. Course Description

This course is designed to provide on-demand access to shared computing resources, such as servers, storage, databases, and software applications, over the internet. The course objectives aim to provide students with a comprehensive understanding of cloud computing concepts, technologies, and practical skills needed to design, deploy, and manage cloud-based solutions effectively. The course provides the concept of advanced computing in the cloud. It also provides case studies on current cloud service providers of the industry. After completion of this course, students can design an architecture to rapidly scale computing resources up or down as needed, without having to make significant investments in on-premises infrastructure.

2. General Objectives

- To acquaint the students with basic concepts of basic cloud computing such as service model and deployment model.
- To acquaint the students with concepts of virtualization and virtual private cloud.
- To acquaint the students with the knowledge of services to breakdown monolithic applications into microservices.
- To develop the skills in students to choose the appropriate service model and architecture for a specified application..
- To familizes the students with the advanced computing in the cloud.

3. Methods of Instruction

Lecture, Discussion, Readings, Practical works and Project works.

4. Contents in Detail

Specific Objectives	Contents

• Understand the cloud architecture, cloud computing models and applications of Cloud .	**Unit 1: Introduction (8 hrs)** 1. Introduction of cloud computing 1.1. Need for Cloud Computing 1.2. NIST definition 1.3. Characteristics and Benefits 1.4. Application 2. Cloud reference model 2.1. NIST Architecture 2.2. Design principles of cloud architecture 2.3. InfrastructuralConstraints 3. Evolution of Cloud Computing 4. Cloud Service Model 4.1. Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS) 5. Cloud Deployment Model 5.1. Public, Private, Hybrid and Community 6. Jericho Cloud Cube model 7. Challenges and Ethical Issues
• Understand the concepts of different virtual machines their working • Understand the design and aspect of Virtual Private cloud, Subnets, Cloud service provide, internal gateway, Network monitoring and Security, Multihoming and Network cost optimization	**Unit 2: Virtualization (7 hrs)** 1. Introduction 1.1. Virtualization Technologies: Virtual machines, Hypervisors (Type 1 & Type 2) 1.2. overview of Containerization and Kubernetes 2. Virtual Machine (VM) 2.1. VM management and configuration 3. Virtualization Level 3.1. Hardware, Software, Operating System, Data and Networking 4. Virtual Private Cloud (VPC) 5. Virtual Private Network (VPN) 6. DNS service and Cloud Network 7. Multihoming

• To understand the various cloud storage models, redundancy and data durability, accessibility and availability, data management service and data security • Design relational and non relational database in cloud computing	**Unit 3: Storage in Cloud Computing (5 Hrs)** 1. Database as a Service 2. Storage model and file system 2.1. Parallel file system and Distributed file system 3. Cloud Storage Services 3.1. Object storage, file storage and block storage, Archive Storage 3.2. Elastic storage, Data redundancy 4. Databases 4.1. Relational: SQL, Non-relational: NoSQL and Graph Database
• Understand the concept of effective resource management in cloud computing, workload patterns, scaling strategies, ensuring load balancing, cloud monitoring tools and different service level agreements. • Design and implement the Billing management system,	**Unit 4: Resource Management in Cloud Computing (5 Hrs)** 1. Scaling 1.1. Scaling Strategies 1.2. Types 1.3. Load Balancing 2. Redundancy and High Availability 3. Cloud monitor mechanisms 3.1. Cloud Usage Monitor, Automated Scaling Listener, Load Balancing, Audit Monitor, Pay-Per-Use Monitor 4. Service Level Agreement and its Types 5. Billing Management System in cloud computing
• Understand the concept of robust security measures, leveraging encryption, secure protocols, security services and different disaster management tools in cloud computing	**Unit 7: Security in Cloud Computing (5 Hrs)** 1. Cloud Security 1.1. Cloud Security Threats 2. Security as a Service 3. Dimension of Cloud Security 4. Cloud Security Mechanism 4.1. SSO, IAM, Hashing and Digital Signatures 5. Disaster Management in cloud computing 6. Challenges of Cloud Security

5. Practical Works

Laboratory work of 30 hours per group of a maximum of 24 students should cover the implementation of Virtualization, Database, Auto-Scaling and Load Balancing, IAM, and VPC. Students should complete the following implementations in the laboratory:

SN	Implementation Description
1	Virtual machine creation and management in the cloud
2	Static web hosting on Linux Instances and server launching
3	Database (SQL and NoSQL) creation and management in the cloud
4	Dynamic web hosting and scaling in the cloud
5	Auto-scaling for resources based on demand in the cloud
6	Identity and access management (IAM) configuration and management in the cloud
7	Implementation of Virtual Private Cloud, VPC Peering Connection and Lunch a web server

Students should submit a project work that uses all the knowledge obtained from this course to solve any problem chosen by themselves. The marks for the practical evaluation must be based on the project work submitted by students.

6. List of Tutorials

The various tutorial activities that suit your course should cover all the content of the course to give students a space to engage more actively with the course content in the presence of the instructor. Students should submit tutorials as assignments or class works to the instructor for evaluation. The following tutorial activities of 15 hours per group of a maximum of 24 students should be conducted to cover the content of this course:

A. Discussion-based Tutorials: (3 hrs)
   a. Application of Cloud Computing on Healthcare, Education, Industry, and Transportation (Oral Presentation)
   b. Cloud Service model examples (Class discussion)

B. Problem-solving-based Tutorials: (6 hrs)
   a. Design an architecture for static and dynamic web hosting systems on Linux instances.
   b. Design an architecture to implement auto-scaling and load balance to distribute the workload.

C. Review and Question/Answer-based Tutorials: (6 hrs)
   a. Case study on Cloud Service Model: SaaS, PaaS, IaaS and Cloud Deployment Model: Public, Private, Community and Hybrid. (Oral Presentation in class).
   b. Real-world applications of cloud computing
   c. Students ask questions within the course content, assignments and review key course content in preparation for tests or exams.

7. Evaluation System and Students' Responsibilities

Evaluation System

The internal evaluation of a student may consist of assignments, attendance, internal assessment, lab reports, project works etc. The internal evaluation scheme for this course is as follows:

Internal Evaluation	**Weight**	**Marks**	**External Evaluation**	**Marks**
Theory		30	Semester-End examination	50
Attendance & Class Participation	10%			
Assignments	20%			
Presentations/Quizzes	10%			
Internal Assessment	60%			
Practical		20		
Attendance & Class Participation	10%			
Lab Report/Project Report	20%			
Practical Exam/Project Work	40%			
Viva	30%			
Total Internal		50		
Full Marks: 50 + 50 = 100				

Student Responsibilities

Each student must secure at least 45% marks separately in internal assessment and practical evaluation with 80% attendance in the class in order to appear in the Semester End Examination. Failing to get such a score will be given NOT QUALIFIED (NQ) to appear for the Semester-End Examinations. Students are advised to attend all the classes, formal exam, test, etc. and complete all the assignments within the specified time period. Students are required to complete all the requirements defined for the completion of the course.

8. Prescribed Books and References

Text Books

1. Arshdeep Bahga and Vijay Madisetti, *Cloud Computing: A Hands-On Approach*, Universities Press, 2014

2. Rajkumar Buyya and James Broberg, *Cloud Computing: Principles and Paradigms*, Wiley, 2011
3. Thomas Erl, Zaigham Mahmood, and Ricardo Puttini, *Cloud Computing Concepts, Technology & Architecture*, Prentice Hall, 2013

References

1. "Cloud Native DevOps with Kubernetes", Justin Domingus and John Arundel, O'Reilly, 2022
2. "Handbook of cloud computing", Borko Furht and Armando Escalante, Springer, 2010
3. "Cloud Application Architectures: Building Applications and Infrastructure in the Cloud", George Reese, O'Reilly, 2009