



# Shri Vaishnav Vidyapeeth Vishwavidyalaya

## B.Tech.(CSE-Big Data Analytics/Cloud and Mobile Computing-IBM)

### Choice Based Credit System (CBCS) 2017-18

### SEMESTER VI

COURSE CODE	CATEGORY	COURSE NAME	L	T	P	CREDITS	TEACHING & EVALUATION SCHEME				
							THEORY		PRACTICAL		
							END SEM University Exam	Two Term Exam	Teachers Assessment*	END SEM University Exam	Teachers Assessment*
<b>BTC501</b>	<b>UG</b>	<b>Theory of Computation</b>	3	1	0	4	60	20	20	0	0

**Legends:** L - Lecture; T - Tutorial/Teacher Guided Student Activity; P – Practical; C - Credit;

\***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

### Course Objectives:

The student will have ability to:

1. To introduce concepts in automata theory and theory of computation.
2. To identify different formal language classes and their relationships.
3. To design grammars and recognizers for different formal languages.

### Course Outcomes:

Upon completion of the subject, students will be able to:

1. Ability to relate practical problems to languages, automata, and computability.
2. Ability to demonstrate an increased level of mathematical sophistication.
3. Ability to apply mathematical and formal techniques for solving problems.

### Syllabus

#### UNIT-I

**Introduction:** Alphabets, Strings and Languages; Automata and Grammars, Deterministic finite Automata (DFA)-Formal Definition, Simplified notation: State transition graph, Transition table, Language of DFA, Nondeterministic finite Automata (NFA), NFA with epsilon transition, Language of NFA, Equivalence of NFA and DFA, Minimization of Finite Automata, Distinguishing one string from other, Myhill-Nerode Theorem.

#### UNIT-II

**Regular Expression (RE):** Definition, Operators of regular expression and their precedence, Algebraic laws for Regular expressions, Kleene's Theorem, Regular expression to FA, DFA to Regular expression, Arden's Theorem, Non Regular Languages, Pumping Lemma for regular Languages. Application of Pumping Lemma, Closure properties of Regular Languages, Decision properties of Regular Languages, FA with output: Moore and Mealy machine, Equivalence of Moore and Mealy Machine, Applications and Limitation of FA.

#### UNIT-III

**Context Free Grammar (CFG) and Context Free Languages (CFL):** Definition, Examples, Derivation, Derivation trees, Ambiguity in Grammar, Inherent ambiguity, Ambiguous to Unambiguous CFG, Useless symbols, Simplification of CFGs, Normal forms for CFGs: CNF and GNF, Closure properties of CFLs, Decision Properties of CFLs: Emptiness, Finiteness and Membership, Pumping lemma for CFLs.

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## B.Tech.(CSE-Big Data Analytics/Cloud and Mobile Computing-IBM)

### Choice Based Credit System (CBCS) 2017-18

### SEMESTER VI

#### UNIT-IV

**Push Down Automata (PDA):** Description and definition, Instantaneous Description, Language of PDA, Acceptance by Final state, Acceptance by empty stack, Deterministic PDA, Equivalence of PDA and CFG, CFG to PDA and PDA to CFG.

#### UNIT-V

**Turing machines (TM):** Basic model, definition and representation, Instantaneous Description, Language acceptance by TM, Variants of Turing Machine, TM as Computer of Integer functions, Universal TM, Church's Thesis, Recursive and recursively enumerable languages, Halting problem, Introduction to Decidability, Decidable problems about TMs. Post correspondence problem (PCP), Modified PCP, Introduction to recursive function theory.

#### Text Books:

1. Hopcroft and Ullman, "Introduction to Automata Theory, Languages and Computation", Pearson Education, 3rd edition, 2014

#### Reference Books:

1. Martin J. C., "Introduction to Languages and Theory of Computations", TMH, 4th edition, 2010.
2. Peter Linz, "An Introduction to Formal Language and Automata", NarosaPub.House, 2011.
3. Papadimitriou, C. and Lewis, C. L., "Elements of the Theory of Computation", PHI, 1997.
4. K.L.P Mishra & N.Chandrasekaran, "Theory of Computer Science", PHI Learning.

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<b>BTCS701</b>	<b>UG</b>	<b>Cloud Computing</b>	3	1	2	5	60	20	20	30	20

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#### Course Objectives:

The student will have ability to:

1. Analyze the SAAS, PAAS IAAS services of Cloud Computing to represent how engineering agility in an organization can be created.
2. Assess the exploitation of web services from cloud computing.
3. Configure essential infrastructural components used contained by the cloud.
4. Critically analyze dissimilar techniques for implementing Cloud.
5. Significantly study case studies to derive the most excellent practice model to be appropriate when deploying cloud based applications.

#### Course Outcomes:

Upon completion of the subject, students will be able to:

1. Investigate the trade-offs among deploying applications in the cloud and over the local infrastructure.
2. Compute the real-world problems using cloud computing through group collaboration.
3. Development and Deployment applications over commercial cloud computing infrastructures.
4. Analyze and investigation of application & hardware performance, scalability, and availability of the underlying cloud technologies and software.
5. Classify security and privacy issues in cloud computing.

#### Syllabus:

##### UNIT–I Overview of Cloud Computing

Advantages, History, and Characteristics of Cloud Computing, Service & Deployment Models, Infrastructure, and Consumer View, Functioning of Cloud Computing, Cloud Architecture, Cloud Storage, Cloud Services, Industrial Applications.

##### UNIT–II Dynamic Interactions and Computing Architectures

Overview , Service, Deployment, Scope, and Control ,SaaS Interaction Dynamics and Software Stack Control ,SaaS Benefits, Issues and Concerns, Suitability, and Recommendations ,PaaS Dynamics and Software Stack Control ,PaaS Benefits, Issues and Concerns, Suitability, and Recommendations , IaaS Abstract Interaction Dynamics and Software Stack Control Hardware and Infrastructure- Clients, Security, Network, Services. Software as a Service (SaaS)-

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## **B.Tech.(CSE-Big Data Analytics/Cloud and Mobile Computing-IBM)**

### **Choice Based Credit System (CBCS) 2017-18**

### **SEMESTER VI**

Understanding the Multitenant Nature of SaaS Solutions, Understanding SOA. Platform as a(PaaS)-IT Evolution Leading to the Cloud, Benefits of PaaS Solutions, Disadvantages ofPaaS Solutions. Infrastructure as a Service (IaaS)-Understanding IaaS, Improving Performancethrough Load Balancing, System and Storage Redundancy.

#### **UNIT–III Economics of Cloud Computing and Securing the Cloud**

Overview, Review of Service Models, SWOT Analysis and Value Proposition, General Cloud Computing Risks. Service Level Agreements and Monitoring- Support Services- Accounting Services, Resource Management- IT Security- Performance Management- Provisioning- Service Management, Untangling Software Dependencies.

#### **UNIT–IV Developing Applications and Migrating to the Cloud**

Technologies and the processes required when deploying web services; Deploying a web service from inside and outside a cloud architecture, advantages and disadvantages ,Analyzing the Services- Establishing a Baseline and Metrics- Tools, Best Practices- Finding the Right vendor- Phased-in Vs Flash-cut Approaches- Bringing in Creativity, How Cloud computing might evolve- Researcher Predictions- Responding to Changes- Getting ready.

#### **UNIT–V Designing Cloud Based Solutions and Coding Cloud Based Applications**

System Requirements, Design Is a Give-and-Take Process. Creating a Simple Yahoo Pipe,Amazon Web Services, Using Google App Engine and creating Windows Azure Applications.

#### **Text Books:**

1. Cloud Computing: A Practical Approach by Anthony T. Velte Toby J. Velte, RobertElsenpeter, 2010 by The McGraw-Hill.
2. Cloud Computing Theory And Practice Danc.MarinerCUS, Elsevier, 2013.
3. Cloud Computing: Principles and Paradigms, Editors: RajkumarBuyya, James Broberg, Andrzej M. Goscinski, Wile, 2011.
4. Buyya, Selvi ,” Mastering Cloud Computing “,TMH Pub.
5. Cloud Computing: Principles, Systems and Applications, Editors: Nikos Antonopoulos, Lee Gillam, Springer, 2012.

#### **Reference Books:**

1. Kumar Saurabh, “Cloud Computing” , Wiley Pub,2012.
2. Krutz , Vines, “Cloud Security “ , Wiley Pub,2013.
3. Sosinsky, “ Cloud Computing” , Wiley Pub,2012.
4. Murray Woodside ; John Chinneck ; Marin Litiou on “Adaptive Cloud Deployment Using Persistence Strategies and Application Awareness” IEEE Xplore, Year: 2017, Page(s):277 – 290.
5. ImanSadooghi ; Jesús Hernández Martin ; Tonglin Li on “Understanding the Performance and Potential of Cloud Computing for Scientific Applications” IEEE Xplore, ISSN: 2168-7161Page(s): 358 – 371.

#### **List of Practical:**

1. Service deployment & Usage over cloud using Virtual Box.
2. Performance evaluation of services over cloud using VMware tool.

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## **B.Tech.(CSE-Big Data Analytics/Cloud and Mobile Computing-IBM)**

### **Choice Based Credit System (CBCS) 2017-18**

### **SEMESTER VI**

3. Management of cloud resources using VMware tool.
4. Working on Aneka for Cloud application.
5. Working of Goggle Drive to make spread sheet.
6. Working and installation of Google App Engine.
7. Working and installation of Microsoft Azure.
8. Java Application deployment with Azure.
9. Installation and configuration of IBM Smart Cloud.
10. Installation and configuration of Hadoop.
11. Installation and configuration of Euceliptus.
12. Working & usage of Amazon Web Services.

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## B.Tech.(CSE-Big Data Analytics/Cloud and Mobile Computing-IBM)

### Choice Based Credit System (CBCS) 2017-18

#### SEMESTER VI

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<b>BTCS611</b>	<b>UG</b>	<b>Information Storage and Management</b>	3	1	2	5	60	20	20	30	20

**Legends:** L - Lecture; T - Tutorial/Teacher Guided Student Activity; P – Practical; C - Credit;

\***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

#### Course Objectives:

1. An ability to understand various storage architecture & technologies.
2. An ability to understand various technologies used to provide backup & recovery.
3. An ability to understand various techniques used to provide security.
4. Ability to identified information storage system requirements.
5. An ability to develop policy for information storage system.
6. An ability to develop policy for backup& recovery.

#### Course Outcomes:

On completion of the course students will be able to:

1. Describe & apply storage technologies.
2. Identified storage technologies that provide cost effective IT solution for medium to large scale businesses& data centers.
3. Manage Virtual Server & Storage between Remote locations.
4. Design analysis and manage clusters of resources.

#### Syllabus:

##### UNIT-I

**Introduction:** Digital data and its types, Information storage, Key characteristics of data centre, Evolution of computing platforms. Introduction to storage technology: Data Proliferation, evolution of various storage technologies, Overview of storage infrastructure components, Information life Cycle Management, Data categorization.

##### UNIT-II

**Storage System Architecture:** Intelligent disk subsystems overview, Contrast of integrands modular array, Component Architecture of Intelligent disk subsystems, Disk physical structure components, properties, performance, and specifications, RAID levels & parity algorithms, hot sparing, Front end to host storage provisioning, mapping and operation.

##### UNIT-III

**Introduction to network storage:** JBOD, DAS, NAS, SAN & CAS evolution and comparison, Applications, Elements, Connectivity, standards, management, security and limitations of DAS, NAS, CAS & SAN

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## B.Tech.(CSE-Big Data Analytics/Cloud and Mobile Computing-IBM)

### Choice Based Credit System (CBCS) 2017-18

### SEMESTER VI

#### UNIT-IV

**Hybrid storage solutions and virtualization:** memory, network, server, storage & appliances. Datacentre concepts & requirements, Backup and disaster recovery. Industry Management standards, standard framework applications, Key management metrics.

#### UNIT-V

**Information storage on clouds:** concept of cloud, cloud computing, storage on cloud, Cloud benefits, Cloud computing evolution. Application & services on cloud, cloud service providers, cloud deployment models, Essential characteristics of cloud computing.

#### Text Books:

1. G. Somasundaram&AlokShrivastava editors, ISM: Storing, Managing, and Protecting Digital Information; Wiley India

#### Reference Books:

1. Saurabh; Cloud Computing : Insight into New era Infrastructure; Wiley India.
2. Ulf Troppens, Wolfgang Mueller-Friedt, Rainer Erkens, Rainer Wolafka, Nils Haustein; Storage Network explained: Basic and application of fiber channels, SAN, NAS, ISES, INFINIBAND and FCOE, Wiley India.
3. Sosinsky, Cloud Computing Bible, Wiley India.

#### List of Practical:

1. Install The VNXE Simulator
2. Discover The Infrastructure
3. Navigate The Storage System
4. Create A Block Device
5. Create A File Device
6. Fc San Configuration
7. Fc San Trace
8. IP San Configuration
9. ISCSI San Trace

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### SEMESTER VI

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<b>BTCC505</b>	<b>UG</b>	<b>Mobile Adhoc Networks</b>	3	1	2	5	60	20	20	30	20

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#### **Course Objectives:**

The student will have ability to:

1. Understand the division of Ad-hoc network functionalities into layers.
2. Be familiar with the components required to build different types of networks
3. Be exposed to the required functionality at each layer
4. Learn the flow control, routing and congestion control algorithms.

#### **Course Outcomes:**

Upon completion of the subject, students will be able to:

1. Have an understanding of the principles of mobile ad hoc networks (MANETs) and what distinguishes them from infrastructure-based networks.
2. Understand how proactive routing protocols function and their implications on data transmission delay and bandwidth consumption.
3. To understand the routing algorithm used mobile adhoc network
4. To understand the Transport protocol of mobile adhoc network
5. To understand the security mechanism used in mobile adhoc network

#### **Syllabus:**

##### **UNIT-I**

##### **Introduction**

Introduction to adhoc networks – definition, characteristics features, applications. Characteristics of Wireless channel, Adhoc Mobility Models:- Indoor and outdoor models.

##### **UNIT-II**

##### **Medium Access Protocols**

MAC Protocols: design issues, goals and classification. Contention based protocols- with reservation, scheduling algorithms, protocols using directional antennas. IEEE standards: 802.11a, 802.11b, 802.11g, 802.15. HIPERLAN.

##### **UNIT-III**

##### **Network Protocols**

Routing Protocols: Design issues, goals and classification. Proactive Vs reactive routing, Unicast routing algorithms, Multicast routing algorithms, hybrid routing algorithm, Energy aware routing algorithm, Hierarchical Routing, QoS aware routing, AODV.

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## **B.Tech.(CSE-Big Data Analytics/Cloud and Mobile Computing-IBM)**

### **Choice Based Credit System (CBCS) 2017-18**

### **SEMESTER VI**

#### **UNIT-IV**

##### **End-End Delivery and Security**

Transport layer: Issues in designing- Transport layer classification, adhoc transport protocols.  
Security issues in adhoc networks: issues and challenges, network security attacks, secure routing protocols.

#### **UNIT-V**

##### **Cross Layer Design and Integration of Adhoc for 4G**

Cross layer Design: Need for cross layer design, cross layer optimization, parameter optimization techniques, Cross layer cautionary prespective. Intergration of adhoc with Mobile IP networks.

#### **Text Books:**

1. C.Siva Ram Murthy and B.S.Manoj, Ad hoc Wireless Networks Architectures and protocols, 2<sup>nd</sup> edition, Pearson Education, 2007.
2. Charles E. Perkins, Ad hoc Networking, Low Price Edition, Pearson Education, Addison, 2008.
3. C.K.Toh, "Ad Hoc Mobile Wireless Networks", 1<sup>st</sup> Edition, Pearson Education, 2007.
4. C.Siva Ram Murthy and B.S.Manoj, Ad hoc Wireless Networks Architectures and protocols, 2<sup>nd</sup> edition, Pearson Education, 2007.

#### **Reference Books:**

1. James F. Kurose, Keith W. Ross, "Computer Networking - A Top-Down Approach Featuring the Internet", 5<sup>th</sup> Edition, Pearson Education, 2010.
2. Nader. F. Mir, "Computer and Communication Networks", 2<sup>nd</sup> Edition, Pearson Prentice Hall Publishers, 2006.
3. Feng Zhao and Leonidas Guibas, "Wireless Sensor Networks", 1<sup>st</sup> Edition, Morgan Kaufmann Publishers, 2004.
4. Carlos De MoraesCordeiro, Dharma PrakashAgrawal "Ad Hoc & Sensor Networks: Theory and Applications", 2<sup>nd</sup> Edition, World Scientific Publishing Company, 2011.

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## B.Tech.(CSE-Big Data Analytics/Cloud and Mobile Computing-IBM)

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<b>BTIT513</b>	<b>UG</b>	<b>Management Information System</b>	3	1	2	5	60	20	20	30	20

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\***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

#### Course Objectives:

1. Understand types of MIS applications in organizations
2. Discuss the development of management information systems in organizations.
3. Select and design MIS systems appropriate to meet management requirements.
4. Critically evaluate MIS contributions to the strategic management of organizations

#### Course Outcomes:

1. To understand MIS in both the wider managerial context and in the narrower confines of the selection, support, design and development of computer applications
2. To focus on the concepts a manager needs to understand, in order to make effective use of, computerized information systems

#### Syllabus:

##### UNIT-I

**Organizations and Computing:** Introduction, Modern Organization-IT enabled- Networked- Dispersed- Knowledge Organization, Information Systems in Organizations- what are information systems?, Brief history of computing- ENIAC: Way to commercial computers- Advent of artificial intelligence- advent of personal computing-Free Software Movement- Advent of Internet, The role of internet- Internet and Web: they are different-the internet changes everything

##### UNIT-II

**Managing Information Systems in Organizations:** Introduction, Managing in the Internet Era, Managing Information Systems in Organization-the IT interaction model, Challenges for the manager- what information to build?-how much to spend on information systems?-what level of capabilities should be created with information systems?-how centralized should the services be?-what security levels are required?-what is technology road map for the organization?

##### UNIT-III

**Data and Information:** Introduction, data and information- measuring data, information as a resource, information in organizational functions, types of information technology, types of information systems- transaction processing systems-management information system.

##### UNIT-IV

**Decision making and communication:** Introduction, Decision making with MIS-Tactical

  
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## **B.Tech.(CSE-Big Data Analytics/Cloud and Mobile Computing-IBM)**

### **Choice Based Credit System (CBCS) 2017-18**

### **SEMESTER VI**

decisions-operational decisions-strategic decisions, communication in organizations- types of communication- examples of communications in organizations- decision making with communication technology

#### **UNIT-V**

**Strategy:** Introduction, Information goods-properties-technology lock-in and switching costs-network externalities-positive feedback-tippy markets, information systems and competitive strategy- value chain, the Role of CIO-information system's plan-vendor coordination-technology updates-return on investment on technology.

#### **Text Books:**

1. Kenneth C. Laudon & Jane P. Laudon, Essentials of Management Information Systems, Tenth Edition, Pearson Prentice, Hall, 2012
2. Terry Lucey, Management Information Systems, Ninth Edition, 2005, Thompson

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<b>BTCS612</b>	<b>UG</b>	<b>Simulation and Modeling</b>	3	1	2	5	60	20	20	30	20

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\***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

#### Course Objectives:

The student will have ability to:

1. Introduce students to the simulation and modelling techniques.
2. Provide a way for students with opportunities to develop basic simulation and modelling
3. Introduce concepts of modelling layers of society's & industrial real world problems.
4. Build tools to view and control simulations and their results.

#### Course Outcomes:

On completion of the subject, students will be able to:

1. Characterize a given engineering system in terms of its essential elements, that is, purpose, parameters, constraints, performance requirements, subsystems, interconnections and environmental context.
2. Develop a modeling strategy for a real world engineering system, which considers prediction and evaluation against design criteria, and integrates any required sub-system models.
3. Assess and select a model for an engineering system taking into consideration its suitability to facilitate engineering decision making and predicted advantages over alternative models.
4. Interpret the simulation results of an engineering system model, within the context of its capabilities and limitations, to address critical issues in an engineering project
5. Fundamentals and techniques for designing and using simulation, modeling, and optimization algorithms with applications in system performance modeling, business infrastructure modeling, and distributed and parallel computing. An introduction to advanced complex systems models.

#### Syllabus:

#### UNIT-I INTRODUCTION

Introduction to simulation & modeling, advantages and disadvantages of simulation, application areas in communication, computer and software design, systems and systems environment, components of a system, discrete and continuous systems, model of a system, types of models, discrete-event simulation, steps in a simulation study. Simulation Examples- Simulation of queueing systems, on-demand and inventory systems, simulation for reliability analysis, Introduction to GPSS.

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### **Choice Based Credit System (CBCS) 2017-18**

### **SEMESTER VI**

#### **UNIT-II COMPUTER BASED SYSTEM SIMULATION:**

Types of System Simulation, Monte Carlo Method, comparison of analytical and Simulation methods, Markov Model, Numerical Computation techniques for Continuous and Discrete Models, Distributed Lag Models, Cobweb Model. Continuous System models, Analog and Hybrid computers, Digital-Analog Simulators, Continuous system simulation languages, Hybrid simulation, Real Time simulations.

#### **UNIT-III INTRODUCTION TO QUEUING THEORY**

Characteristics of queuing system, Poisson's formula, birth-death system, equilibrium of queuing system, analysis of M/M/1 queues. Introduction to multiple server Queue models M/M/c Application of queuing theory in manufacturing and computer system, FSM, Petri-net Model.

#### **UNIT IV VERIFICATION AND VALIDATION**

Verification of Simulation Models, Calibration and Validation of Models, Validation of Model Assumptions, Validating Input & Output Transformations, Design of simulation experiments,

#### **UNIT-V SIMULATION TOOLS**

Simulation Tools – Model Input – High level computer system simulation – CPU – Memory, Simulation – Comparison of systems via simulation – Simulation Programming techniques, Development of Simulation models, General Purpose Simulation Package-MATLAB, ARENA, EXTEND, Study of SIMULA, DYNAMO

#### **Text Books:**

1. Gordon G., System simulation, PHI Learning
2. Singh V.P System Simulation and Modeling NEW AGE INTERNATIONAL, PUBLISHERS
3. Taha H, Operations Research; PHI.
4. Payer, T., Introduction to system simulation, McGraw Hill.
5. Spriet JA; Computer Aided Modelling and Simulation, Academic Press INC; USA

#### **Reference Books:**

1. J K Sharma, Operations Research Theory and Application, Pearson Education Pvt Ltd, 2 Edition Banks J; Hand book of Simulation; John Wiley.
2. Law AM and Kelton WD; Simulation Modeling and Analysis; TMH

#### **List of Practical:**

1. Simulate CPU scheduling algorithm using queueing system
2. Simulate multiplexer using queuing system
3. Simulate Network congestion control algorithms.
4. Simulate disk scheduling algorithms.
5. Simulate a Manufacturing shop and write a program in GPSS.
6. Simulate Telephone system model and write a program in SIMSCRIPT.
7. Graphical Simulation and Modelling using MATLAB.

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## B.Tech.(CSE-Big Data Analytics/Cloud and Mobile Computing-IBM)

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							THEORY		PRACTICAL		
							END SEM University Exam	Two Term Exam	Teachers Assessment#	END SEM University Exam	Teachers Assessment#
<b>BTIBM601</b>	<b>UG</b>	<b>Micro services Architecture &amp; Implementation</b>	3	0	2	4	60	20	20	30	20

**Legends:** L - Lecture; T - Tutorial/Teacher Guided Student Activity; P – Practical; C - Credit;

\***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

#### **Course Objectives:**

The student will have ability to:

1. Learn how Microservices have evolved over time.
2. Perform migration of monolithic application into microservices architecture.
3. Develop microservices using container technology like Docker.
4. Develop understanding of container orchestration like Kubernetes.
5. Deploy application on Kubernetes.

#### **Course Outcomes:**

After the successful completion of this course students will be able to:

1. Understand the need of micro services.
2. Understand the transformation journey from Monolithic application to micro services.
3. Develop understanding of connecting database using Mongo DB.
4. Develop understanding of Container and docker.
5. Develop understanding of Kubernetes.
6. Understanding cloud application Kubernetes architecture.
7. Deploying application on Kubernetes

#### **Syllabus:**

**UNIT I Introduction to Micro services:** Motivation for Micro services, What is monolithic application? Domain Driven Design, Edge Service, Dealing with complexity, Micro services Security, API management and gateways, the future of Micro services, Micro services Governance, Summary of Micro services.

**UNIT II Web App development using NodeJs:** Introduction to NodeJs, Getting Started with NodeJs, Project Structure, Basic Routing, File system, View templates Serving static content, Handling HTTP and HTTPS, Connecting to database, Mongo DB Installation and Database, Node Js Mongo driver, Performing CRUD operations, Connecting Pooling, Connecting Pooling using NodeJS mongo driver, Performing CRUD operations, Connecting Pooling, Connecting Pooling using NodeJS mongo driver.

**UNIT III Containers and Dockers:** Containers and Dockers, Basic Docker commands, Dev

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## B.Tech.(CSE-Big Data Analytics/Cloud and Mobile Computing-IBM)

### Choice Based Credit System (CBCS) 2017-18

### **SEMESTER VI**

versus Ops, The Twelve-Factor App, Docker mission, Docker Adoption, Docker basic concept, Docker architecture, Docker typical workflow, Docker shared and layered file systems technology, container ecosystem and orchestration.

**Unit IV Kubernetes:** what is kubernetes strength and architecture, Master & worker node component, kubernetes building blocks, Deploying Applications on kubernetes, Helm, Application center components, PoD health checking, Health check and kubectl example, Cloud application component architecture, Benefits of using Kubernetes with IBM container.

**Unit V: Case Study:** The Journey from Monolith Architecture to Micro services; Refactoring A Monolith application Into A Cloud-Native App.

#### **TEXT BOOKS:**

1. IBM Career Education – “*Microservices Architecture and Implementation*”
2. Sam Newman, “*Building Microservices*”, O’Reilly Publication.

#### **REFERENCES:**

1. NodeJS: <https://nodejs.org/documentation/>
2. Express: <http://express.com/4x/api/html>
3. MongoDB: <http://docs.mongodb.org/manual/contents/>
4. Microservices: [https://www.tutorialspoint.com/microservice\\_architecture/index.htm](https://www.tutorialspoint.com/microservice_architecture/index.htm)
5. Deploy a microservices app on IBM Cloud by using Kubernetes:  
<https://www.ibm.com/cloud/garage/tutorials/microservices-app-on-kubernetes/>

#### **LIST OF EXPERIMENTS:**

1. Study of Docker components- Docker image, Docker container, Docker hub and Docker engine.
2. Installation of Docker on windows OS.
3. Study and perform basic Docker commands.
4. Creating a Docker Image.
5. Pushing the Image to a Repository(Docker Hub).
6. Deploying the Image to a Docker host.
7. Study of Kubernetes architecture.
8. Deploying application on Kubernetes

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# Shri Vaishnav Vidyapeeth Vishwavidyalaya

## B.Tech.(CSE-Big Data Analytics/Cloud and Mobile Computing-IBM)

### Choice Based Credit System (CBCS) 2017-18

#### SEMESTER VI

COURSE CODE	CATEGORY	COURSE NAME	L	T	P	CREDITS	TEACHING & EVALUATION SCHEME				
							THEORY		PRACTICAL		
							END SEM University Exam	Two Term Exam	Teachers Assessment*	END SEM University Exam	Teachers Assessment*
<b>BTIBMB601</b>	<b>UG</b>	<b>Big Data Technologies</b>	3	0	2	4	60	20	20	30	20

**Legends:** L - Lecture; T - Tutorial/Teacher Guided Student Activity; P – Practical; C - Credit;

\***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

#### Course Objectives:

The objectives of this course are to make the students to:

1. Introduce students to Big Data Analysis using Hadoop
2. Introduce to Hadoop Eco System, HDFS, commands, management and map reduce.
3. Understating machine learning concept and Introduce JAQL, pig and HIVE
4. Data stream, partitioning, debugging and toolkits

#### Course Outcomes:

At the end of the course, students shall be able to:

1. Install Hadoop, configure HDFS, Install Zookeeper, Pig Installation, Sqoop Installation, Hbase Installation run commands
2. Use Zookeeper, Sqoop, Hbase, JAQL, PIG & HIVE
3. Use BigInsite, data streams, partitioning and other toolkits
4. Appreciate the influence of big data for business decisions and approach

#### Syllabus:

##### UNIT I

**Introduction to Big Data and Analytics:** Developing an understanding of the complete open-source Hadoop ecosystem and its near-term future directions, Comparing and evaluating the major Hadoop, distributions and their ecosystem components, both their strengths and their limitations, Gaining hands-on experience with key components of various big data ecosystem components and their roles in building a complete big data solution to common business problems, Learning the tools that will enable you to continue your big data education after the course, Describing the functions and features of HDP, Listing the IBM value-add components, Explaining what IBM Watson Studio is, Giving a brief description of the purpose of each of the value-add components, Exploring the lab environment.

##### UNIT II

**Apache Ambari:** Launching Apache Ambari, Starting a variety of services using Apache GUI, Exploring some of the directory structure on the Linux system, Understanding the purpose of Apache Ambari in the HDP stack, Understanding the overall architecture of Ambari, and Ambari's relation to other services and components of a Hadoop cluster, Listing the functions of

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**B.Tech.(CSE-Big Data Analytics/Cloud and Mobile Computing-IBM)**

**Choice Based Credit System (CBCS) 2017-18**

## **SEMESTER VI**

the main components of Ambari, Explaining how to start and stop services from Ambari Web Console, Managing Hadoop clusters with Apache Ambari oStart the Apache Ambari web console and perform basic start/stop services oExplore other aspects of the Ambari web server, Understanding the basic need for a big data strategy in terms of parallel reading of large data files and internode network speed in a cluster.

### **UNIT III**

**Hadoop and HDFS:** Describing the nature of the Hadoop Distributed File System (HDFS), Explaining the function of the NameNode and DataNodes in an Hadoop cluster, Explaining how files are stored and blocks ("splits") are replicated, Filing access and basic commands with HDFS, Describing the MapReduce model v1, Listing the limitations of Hadoop 1 and MapReduce 1, Reviewing the Java code required to handle the Mapper class, the Reducer class, and the program driver needed to access MapReduce, Describing the YARN model Comparing Hadoop 2/YARN with Hadoop 1, Run MapReduce and YARN jobs, Creating and code a simple MapReduce job, Understanding the nature and purpose of Apache Spark in the Hadoop ecosystem, Listing and describing the architecture and components of the Spark unified stack, Describing the role of a Resilient Distributed Dataset (RDD), Understanding the principles of Spark programming, Listing and describing the Spark libraries, Launching and using Spark's Scala and Python shells, Working with Spark RDD with Scala, Listing the characteristics of representative data file formats, including flat/text files, CSV, XML, JSON, and YAML, Listing the characteristics of the four types of NoSQL data stores, Describing the storage used by HBase in some detail, Describing and compare the open source programming languages, Pig and Hive, Listing the characteristics of programming languages typically used by •Data Scientists: R and Python, Understanding the challenges posed by distributed applications and how ZooKeeper is designed to handle them, Explaining the role of ZooKeeper within the Apache Hadoop infrastructure and the realm of Big Data management, Exploring generic use cases and some real-world scenarios for ZooKeeper, Defining the ZooKeeper services that are used to manage distributed systems, Exploring and use the ZooKeeper CLI to interact with ZooKeeper services, Understanding how Apache Slider works in conjunction with YARN to deploy distributed applications and to monitor them, Explaining how Apache Knox provides peripheral security services to a Hadoop cluster, Listing some of the load scenarios that are applicable to Hadoop, Understanding how to load data at rest, Understanding how to load data in motion, Understanding how to load data from common sources such as a data warehouse, relational database, web server, or database logs, Explaining what Sqoop is and how it works, Describing how Sqoop can be used to import data from relational systems into Hadoop and export data from Hadoop into relational systems, Briefing introduction to what Flume is and how it works, Moving data into HDFS with Sqoop, Explaining the need for data governance and the role of data security in this governance, Listing the Five Pillars of security and how they are implemented with HDP, Discussing the history of security with Hadoop, Identifying the need for and the methods used to secure Personal & Sensitive Information, Describing the function of the Hortonworks DataPlane Service (DPS), Defining streaming data, Describing IBM as a pioneer in streaming data - with System S IBM Streams, Explaining streaming data - concepts & terminology, Comparing and contrasting batch data vs streaming data, Listing and explaining streaming components & Streaming Data Engines (SDEs)

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## B.Tech.(CSE-Big Data Analytics/Cloud and Mobile Computing-IBM)

### Choice Based Credit System (CBCS) 2017-18

### SEMESTER VI

#### UNIT IV

**Understanding Data Science and Notebooks:** Have a better understanding of methodology “scientific approach” methods used & skills practiced by Data Scientists, Recognizing the iterative nature of a data science project, Outlining the benefits of using Data Science Notebooks, Describing the mechanisms and tools used with Data Science Notebooks, Comparing and contrasting the major Notebooks used by Data Scientists, Getting started with Jupyter Notebook, Data and notebooks in Jupyter, How notebooks help data scientists, Essential packages: NumPy, SciPy, Pandas, Scikit-learn, NLTK, BeautifulSoup, ... Data visualizations: matplotlib, ..., PixieDust Using Jupyter “Magic” commands: Start Jupyter - it will open in a web browser, Importing the lab file (all Jupyter files have a .ipynb suffix) into your default workspace This is now a copy of the provided lab file and you can do anything with it oIf you mess it up, you can re-import again later, Exploring the component panels - some are markdown, some are code, some are results of running the code (output data, visualizations,) Learning how to run single panels - and then the whole script you may need to adjust the provided script to locate the data files that accompany the Jupyter.ipynb file oAdd some additional panels, as described in the lab script.

#### UNIT V

**BigSQL and Watson Studio:** Overview of Big SQL, Understanding how Big SQL fits in the Hadoop architecture, Start and stop Big SQL using Ambari and command line, Connecting to Big SQL using command line, Connecting to Big SQL using IBM Data Server Manager, Configuring images, Starting Hadoop components, Start up the Big SQL and DSM services, Connecting to Big SQL using JSqsh, Executing basic Big SQL statements, Exploring Big SQL through Ambari using DSM, Describing and creating Big SQL schemas and tables, Describing and listing the Big SQL data types, Working with various Big SQL DDLs, Loading data into Big SQL tables using best practices, Creating and dropping simple Big SQL table, Creating sample tables, Moving data into HDFS, Loading data into Big SQL tables, Creating and working with views, Creating external tables, Describing Big SQL supported file formats, Query Big SQL tables using various DMLs, Connecting to Big SQL, Query data with Big SQL, Working with the ARRAY type, Working with Big SQL functions, Storing data in an alternate file format (Parquet), Configuring the Big SQL Server, Configuring the Big SQL Scheduler, Listing the registries for compiler and runtime performance improvement •Backup and restore Big SQL, Updating the database resource percentage for the Big SQL database instance, Inspecting the Big SQL scheduler configuration file, Viewing the registries for the compiler and runtime performance improvement, Configuring authentication for Big SQL, Managing security with Apache Ranger, Enabling SSL encryption, Configuring authorization of Big SQL objects, Configuring impersonation in Big SQL, Understanding the concept of Big SQL federation, Listing the supported data sources, Set up and configure a federation server to use different data sources, Configuring Fluid Query with Big SQL, What is Watson Studio? Setting up a project, Working with collaborators, Managing data assets, Sign up for a Watson Studio account, Creating a new project, Managing a project, Adding collaborators, Loading data, Managing the object storage, Overview of Jupyter notebooks ,Creating notebooks, Coding and running notebooks, Sharing and publishing notebooks, Creating a notebook, Using notebooks, working

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## **B.Tech.(CSE-Big Data Analytics/Cloud and Mobile Computing-IBM)**

### **Choice Based Credit System (CBCS) 2017-18**

### **SEMESTER VI**

with external data.

#### **TEXT BOOKS:**

1. Tom White,” Hadoop: The Definitive Guide Paperback – 2015” Shroff Publishers & Distributers Private Limited - Mumbai; Fourth edition (2015).
2. V. K. Jain (Author),” Big Data and Hadoop” Khanna Publishers; 1 edition (1 June 2015)
3. Jason Bell (Author) “Machine Learning for Big Data: Hands-On for Developers and Technical Professionals” Wiley (2014)
4. Big Data Technologies by IBM CE

#### **REFERENCES:**

1. Big data. Architettura, tecnologie e metodi per l'utilizzo di grandibasi di dati, A. Rezzani, Apogeo Education, 2013
2. Hadoop For Dummies, Dirk deRoos, For Dummies, 2014
3. Cohen et al.”MAD Skills: New Analysis Practices for Big Data”, 2009
4. Ullman, Rajaraman, Mining of Massive Datasets, Chapter 2
5. Stonebraker et al., “MapReduce and Parallel DBMS's: Friends or Foes?”, Communications of the ACM, January 2010.
6. Dean and Ghemawat, “MapReduce: A Flexible Data Processing Tool”, Communications of the ACM, January 2010.

#### **LIST OF PRACTICALS:**

1. Installing Hadoop, configure HDFS, Install Zookeeper , Pig Installation, Sqoop Installation, Hbase Installation
2. Configuring Hadoop
3. Running jobs on Hadoop
4. Working on HDFS
5. Hadoop streaming
6. Creating Mapper function using python.
7. Creating Reducer function using python
8. Python iterator and generators
9. Twitter data sentimental analysis using Flume and Hive
10. Business insights of User usage records of data cards
11. Wiki page ranking with hadoop
12. Health care Data Management using Apache Hadoop ecosystem

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## B.Tech.(CSE-Big Data Analytics/Cloud and Mobile Computing-IBM)

### Choice Based Credit System (CBCS) 2017-18

### SEMESTER VI

COURSE CODE	CATEGORY	COURSE NAME	L	T	P	CREDITS	TEACHING & EVALUATION SCHEME				
							THEORY		PRACTICAL		
							END SEM University Exam	Two Term Exam	Teachers Assessment*	END SEM University Exam	Teachers Assessment*
<b>BTBMC601</b>	<b>UG</b>	<b>Artificial Intelligence</b>	3	0	2	4	60	20	20	30	20

**Legends:** L - Lecture; T - Tutorial/Teacher Guided Student Activity; P – Practical; C - Credit;

\***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

### Course Objectives:

The student will have ability to:

1. Know how to build simple knowledge-based systems.
2. Know various AI search algorithms (uninformed, informed, heuristic, constraint satisfaction, genetic algorithms).
3. Ability to apply knowledge representation, reasoning, and machine learning techniques to real world problems.
4. An ability to use current techniques, skills, and tools necessary for computing practice

### Course Outcomes:

After the successful completion of this course students will be able to:

1. Describe the key components of the artificial intelligence (AI) field and its relation and role in Computer Science;
2. Identify and describe artificial intelligence techniques, including search heuristics, knowledge representation, automated planning and agent systems, machine learning, and probabilistic reasoning;
3. Identify and apply AI techniques to a wide range of problems, including complex problem solving via search, knowledge-base systems, machine learning, probabilistic models, agent decision making, etc.;
4. Design and implement appropriate AI solution techniques for such problems;
5. Analyze and understand the computational trade-offs involved in applying different AI techniques and models.
6. Communicate clearly and effectively using the technical language of the field correctly.

### Syllabus:

#### UNIT I

**Introduction to Artificial Intelligence:** Describing the eras of computing, Explaining the Difference between deterministic and probabilistic systems, describing the types of AI, Explaining what the main focus of AI is, listing of practical applications of AI.

#### UNIT II

**Introduction to Machine Learning:** Explaining what machine learning is, Describing the types of machine learning, Explaining what neural networks are and why they are important in today's AI's field, Explaining what domain adaptation is and its applications, Explaining

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## B.Tech.(CSE-Big Data Analytics/Cloud and Mobile Computing-IBM)

### Choice Based Credit System (CBCS) 2017-18

### **SEMESTER VI**

what NLP is, Describing different NLP processes, Listing tools and services for NLP, Identifying NLP use cases, Defining CV, Knowing the history of CV and its advancement with AI, Listing tools and services for CV, Identifying CV use cases, Explaining what cognitive computing is, Describing the characteristics of cognitive systems.

### **UNIT III**

**Artificial learning Foundation:** Explaining what IBM Watson is and how it works, Explaining how Watson technology is made available to developers and organizations, Describing how Watson technology is being applied to solve real world problems Explaining what the DeepQA architecture was, explaining why IBM decided to Commercialize Watson, Describing the evolution of Watson services from the original DeepQA architecture to the present, Recognizing the Watson services available today on the IBM Cloud, Listing the Watson services, explaining the capabilities of each Watson Service, describing the purpose of training the various Watson services to adapt them to a closed-domain, Listing the Watson services that can be trained , Listing the Watson services that cannot be trained, Describing what Watson Knowledge studio is, Listing the Watson services that can be trained with Watson Knowledge Studio.

### **Unit IV**

**Artificial Intelligence Analyst:** Explaining what NLP is, Describing different NLP processes, Listing tools and services for NLP, Identifying NLP use cases, Defining different components of NLP, Defining challenges within NLU, Explaining the NLP pipeline, Explaining the concepts of information extraction and sentiment analysis, Defining the capabilities of IBM Watson Natural Language Classifier (NLC), Describing how to train Watson NLC, Defining the capabilities of Watson Natural Language Understanding (NLU) service and its input and output, along with the discovery service, Explaining the capabilities of the Watson Tone Analyzer service and its input and output, Creating a collection, Adding content to a collection, Building queries, Using the Discovery API.

### **Unit V:**

**Introduction to ChatBot:** Explaining what a chatbot is, Describe common applications of chatbots, Identifying factors that drive the growing popularity of chatbots, Listing examples of tools and services that you can use to create chatbots, What a workspace is, What an intent is, What an entity is, What a dialog is, What dialog nodes are, How the nodes in a dialog are triggered, Conversation service instance, Creating a Conversation workspace, Adding intents, Building a dialog, Test in Slack, Defining CV, Know the history of CV and its advancement with AI, Listing tools and services for CV, Identifying CV use cases, defining the main pipeline within a CV application. Understanding how feature extraction works, Understanding how image classification and recognition works, Defining known techniques and classifiers that are used today for CV, Listing the features available with Watson Visual Recognition, Describing the output provided by the Watson Visual Recognition service, Explaining the capabilities of the default classifier, Explaining the difference between a default and a custom classifier, Describing how to train a custom classifier, and obtain the API key value, Using Visual Recognition API methods to: Classifying images, Detecting faces in an image, Recognizing text in an image, what is tensorflow, how to implement tensorflow, tensorflow <hello world>, features of tensorflow, history and version updates in tensorflow.

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## **B.Tech.(CSE-Big Data Analytics/Cloud and Mobile Computing-IBM)**

### **Choice Based Credit System (CBCS) 2017-18**

### **SEMESTER VI**

#### **TEXT BOOKS:**

1. Rich E and Knight K, Artificial Intelligence, TMH New Delhi.
2. Nelsson N.J., Principles of Artificial Intelligence, Springer Verlag, Berlin.
3. Kos Ko B, Neural Networks and Fuzzy system –PHI
4. IBM Text Book.

#### **REFERENCES:**

1. Neural Network, Fuzzy Logic, and Genetic Algorithms - Synthesis and Applications", by S. Rajasekaran and G.A. VijayalaksmiPai, (2005), Prentice Hall, Chapter 1-15, page 1-435.
2. "Artificial Intelligence: A Modern Approach" by Stuart Russell and Peter Norvig, (2002), Prentice Hall, Chapter 1-27, page 1-1057.
3. Waterman D.A., A guide to Expertsystem, Adision - Wesley, Reading
4. Artificial Intelligence Hand book, Vol. 1-2, ISA, Research Triangle Park.
5. Haykin S, Artificial Neural Networks-Comprehensive Foundation, Asea, Pearson.
6. Barr A, Fergenbaub E.A. and Cohen PR. Artificial Intelligence, Addison Wesley, Reading

#### **LIST OF EXPERIMENTS:**

1. Write a program to implement Tic-Tac-Toe game problem.
2. Write a program to implement BFS (for 8 puzzle problem or Water Jug problem or any AI search problem).
3. Write a program to implement DFS (for 8 puzzle problem or Water Jug problem or any AI search problem)
4. Write a program to implement Single Player Game (Using Heuristic Function)
5. Write a program to Implement A\* Algorithm.
6. Write a program to solve N-Queens problem.
7. Write a program to solve 8 puzzle problems.
8. Write a program to solve travelling salesman problem.

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# Shri Vaishnav Vidyapeeth Vishwavidyalaya

## B.Tech.(CSE-Big Data Analytics/Cloud and Mobile Computing-IBM)

### Choice Based Credit System (CBCS) 2017-18

### SEMESTER VI

COURSE CODE	CATEGORY	COURSE NAME	L	T	P	CREDITS	TEACHING & EVALUATION SCHEME				
							THEORY		PRACTICAL		
							END SEM University Exam	Two Term Exam	Teachers Assessment#	END SEM University Exam	Teachers Assessment#
<b>BTCS607</b>	<b>UG</b>	<b>Scripting Languages</b>	0	0	4	2	0	0	0	30	20

**Legends:** L - Lecture; T - Tutorial/Teacher Guided Student Activity; P – Practical; C - Credit;

\***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

### Course Objectives:

The student will have ability to:

1. To understand different types of scripting languages.
2. To gain knowledge about client side scripts and server side scripting.
3. To learn about PHP, PERL and Python languages and their usage in implementation.
4. To build web application project using scripting languages.

### Course Outcomes:

Upon completion of the subject, students will be able to:

1. Student will be Able to understand difference between scripting languages.
2. Student will be able to create programs using functions, control structures.
3. Student will learn implementation of scripting languages on different tools
4. Student can apply knowledge of scripting languages for creating a web application project using scripting languages implementation.

### Syllabus:

#### UNIT– I:

Introduction of scripting languages, need of scripting, characteristics of scripting languages, uses of scripting languages, Introduction of client side scripting languages like JavaScript, VBScript, HTML5 (Structure), CSS3 (Designing), AJAX, jQuery, Server side scripting languages like PHP, ASP.NET (C# OR Visual Basic), C++ , Java and JSP, Python, Ruby on Rails.

#### UNIT–II:

PHP basic features, Embedding php code in your web pages, outputting the data to the browser, data types, variables, constants, expressions, string interpolation, control structure, function, creating a function, function library, Arrays, String & regular expression, Web forms, Files, Authentication, Uploading file with PHP, sending email using PHP.

#### UNIT–III:

Python: Introduction to python languages, python syntax, statements, functions, build-in functions, methods, module in python, exception handling, integrated web application in python- Building small, efficient python web system, web application framework.

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## B.Tech.(CSE-Big Data Analytics/Cloud and Mobile Computing-IBM)

### Choice Based Credit System (CBCS) 2017-18

### **SEMESTER VI**

#### **UNIT-IV:**

Introduction to Perl and scripting, scripts, programs, Web scripting and PERL names , values, variable, scalar expression, control structures, arrays, list, hashes, strings, patterns, and regular expression, subroutine.

#### **UNIT-V:**

Introduction of Angular JS, Industrial usage of angular JS, benefits of Angular JS, Creation of Web application project using database, scripting, HTML, & CSS.

#### **Text Books:**

1. The World of Scripting Languages, David Barron, Wiley Publications.
2. Python Web Programming, Steve Holden and David Beazley, New Riders Publications.
3. Beginning PHP and MySQL, 3<sup>rd</sup> Edition, Jason Gilmore, Apress Publications (Dream tech.).

#### **Reference Books:**

1. Open Source Web Development with LAMP using Linux, Apache, MySQL, Pen and PHP, J.Lee and B.Ware(Addison Wesley) Pearson Education.
2. Programming Python,M.Lutz,SPD.
3. PHP 6 Fast and Easy Web Development, Julie Meloni and Matt Telles, Cengage Learning Publications.
4. PHP 5.1,I.Bayross and S.Shah, The X Team, SPD.
5. Core Python Programming, Chun, Pearson Education.
6. Guide to Programming with Python, M.Dawson, Cengage Learning.
7. Pen by Example, E.Quigley, Pearson Education.
8. Programming Perl,Larry Wall, T.Christiansen and J.Orwant,O'Reilly, SPD.
9. Tcl and the Tk Tool kit, Ousterhout, Pearson Education.
10. PHP and MySQL by Example, E.Quigley, Prentice Hall(Pearson).
11. Perl Power, J.RFlynt, Cengage Learning.
12. PHP Programming solutions, V.Vaswani, TMH.

#### **List of Practical:**

1. Javascript program to generate Fibonacci series and to look for motifs and patterns in sequences.
2. Javascript program to find out frequency of characters existing in nucleotide and protein sequences 6 Javascript's implementation to generate dynamic HTML pages.
3. Write PHP programs to do basic operations to deal with strings, and arrays, and to implement various mathematical functions.
4. Development of an PHP program to take set of sequences and find out conserved sequences.
5. Create a MySQL database tables and execute all SQL queries.
6. Write a PHP program to connect MySQL database and execute all SQL commands.
7. Construct a PHP interface for a given Web page and to produce its overall connectivity.
8. Implement database and server site connectivity all together to generate complete dynamic web based applications through PHP, HTML and MySQL.
9. Write programs in Perl to implement string handling and other functions to be implemented to deal with biological data management.

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# Shri Vaishnav Vidyapeeth Vishwavidyalaya

## B.Tech.(CSE-Big Data Analytics/Cloud and Mobile Computing-IBM)

### Choice Based Credit System (CBCS) 2017-18

### SEMESTER VI

COURSE CODE	CATEGORY	COURSE NAME	L	T	P	CREDITS	TEACHING & EVALUATION SCHEME				
							THEORY		PRACTICAL		
							END SEM University Exam	Two Term Exam	Teachers Assessment*	END SEM University Exam	Teachers Assessment*
<b>BTCS606</b>	<b>UG</b>	<b>Minor Project</b>	0	0	8	4	0	0	0	30	20

**Legends:** L - Lecture; T - Tutorial/Teacher Guided Student Activity; P – Practical; C - Credit;

\***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

#### Course Objectives:

This course is the masters by coursework Minor Project.

A Minor Project is a substantial work of supervised research or development, requiring the equivalent of about four to six months full-time work from start to finish. A Project involves identifying a task or problem, searching and reviewing relevant literature, a proposed, implemented, and critically analyzed solution to the task or problem, and a written report describing the problem, the relevant literature, the solution, and its relation to other work in the area.

**Note:** This course includes a work integrated learning experience in which your knowledge and skills will be applied and assessed in a real or simulated workplace context and where feedback from industry and/ or community is integral to your experience.

#### Course Outcomes:

Upon successful completion of this course you should be able to:

1. Identify a task or problem relevant to /or IT
2. Search and review of the relevant literature
3. Propose a solution to the task or problem
4. Develop a software and/or algorithmic solution to the task or problem
5. Implement solutions to meet high quality requirements developed by the supervisor
6. Carry out research under supervision
7. Present the research in a written form like that used for published papers
8. Present the research in an oral seminar.

#### Syllabus:

#### Overview of Learning Activities

A Minor project is a substantial work of supervised research or software development. You will choose an academic staff member as your supervisor to work on a research project. To successfully complete the course, you must demonstrate research skills: ability to undertake research under supervision, ability to analyze, develop, and present the research in a written form like that used for published papers, and ability to present the research in an oral seminar.

In this course, you are expected to carry out research activities including implementing a

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# **Shri Vaishnav Vidyapeeth Vishwavidyalaya**

## **B.Tech.(CSE-Big Data Analytics/Cloud and Mobile Computing-IBM)**

### **Choice Based Credit System (CBCS) 2017-18**

### **SEMESTER VI**

complete solution to the problems identified by the supervisor, critical analysis of results, and completing a written Project. The major deadline for this course is the delivery of the Minor Project by the end of the semester.

#### **Overview of Assessment**

You must satisfactorily complete each of the following assessment tasks for this course:

1. Research project comprising an implemented and critically analyzed solution to the task or problem
2. Written report (final Project) describing the problem, the relevant literature, the solution, and its relation to other work in the area
3. Seminar on your research (of 20 minutes) soon after your Project is submitted.

The Minor Project is assessed on its merits as a research publication. Each Project is examined by two academics, usually from within the Institute.

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