



# Shri Vaishnav Vidyapeeth Vishwavidyalaya

## B.Tech.(CSE-Big Data Analytics -IBM)

### Choice Based Credit System (CBCS) 2018-19

### 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>BTCS501</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, Kleen'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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## **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 undecidability, undecidable problems about TM, NP hard and NP complete problem, 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, 3<sup>rd</sup> edition, 2014
2. Peter Linz, "An Introduction to Formal Language and Automata", NarosaPub.House, 2011.
3. K.L.P Mishra & N.Chandrasekaran, "Theory of Computer Science", PHI Learning, 3<sup>rd</sup> edition, 2006

## **REFERENCES:**

1. Martin J. C., "Introduction to Languages and Theory of Computations", TMH, 4<sup>th</sup> edition, 2010.
2. Papadimitriou, C. and Lewis, C. L., "Elements of the Theory of Computation", PHI, 1997.
3. Michael Sipser, "Introduction to Theory of Computation", Cengage Learning, 3<sup>rd</sup> edition, 2013.



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							END SEM University Exam	Two Term Exam	Teachers Assessment*	END SEM University Exam	Teachers Assessment*
<b>BTIT604</b>	<b>UG</b>	<b>Object Oriented Analysis and Design</b>	2	0	2	3	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. To learn the concept of Object Oriented Software Development Process
2. To get acquainted with UML Diagrams
3. To understand Object Oriented Analysis Processes

#### Course Outcomes:

1. Understand Object Oriented Software Development Process
2. Gain exposure to Object Oriented Methodologies & UML Diagrams
3. To apply Object Oriented Analysis Processes for projects

#### SYLLABUS

##### UNIT-I

**Introduction:** About Object Oriented Technology, Development and OO Modeling History. Modeling Concepts: Modeling design Technique, Three models, Class Model, State model and Interaction model.

##### UNIT-II

**Class Modeling:** Object and class concepts, link and association, Generalization and Inheritance, Advanced class modeling- aggregation, Abstract class meta data, constraints. State Modeling: Event, state, Transition and conditions, state diagram, state diagram behavior, concurrency, Relation of Class and State models. Interaction Modeling: Use case Models, sequence models, activity models

##### UNIT-III

**Analysis and Design:** Development Life cycle, Development stages, Domain Analysis-Domain class model, domain state model, domain interaction model, Iterating and analysis. Application Interaction model, Application class model, Application state Model, Adding operation.

##### UNIT-IV

**System Design:** Estimating Performance, Making a reuse plan, breaking system into sub systems identifying concurrency, allocation of subsystems, management of data storage, Handling Global resources, choosing a software control strategy, Handling boundary condition, common Architectural style.

##### UNIT-V

**Class design:** Overview of class design, designing algorithms recursing downward, refactoring, design optimization, Adjustment of Inheritance, Rectification of Behavior.



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## **TEXT BOOKS:**

1. Michael Blaha and J. Rumbaugh, “Object oriented Modeling and design with UML”, Pearson Education

## **REFERENCES:**

1. Satzinger, Jackson and Burd, “Object oriented Analysis and design with the Unified Process”, CENGAGE Learning.
2. O’Docherty, “Object Oriented Analysis and Design Understanding, System Development with UML2.0”, Wiley India.

## **LIST OF EXPERIMENTS**

1. How to write a Problem Statement
2. Perform the system analysis: Requirement analysis, SRS.
3. Perform the function oriented diagram: DFD and Structured chart.
4. Perform the user’s view analysis: Use case diagram.
5. Draw the structural view diagram: Class diagram, object diagram.
6. Draw the behavioral view diagram: Sequence diagram, Collaboration diagram.
7. Draw the behavioral view diagram: State-chart diagram, Activity diagram.
8. Draw the implementation view diagram: Component diagram.
9. Draw the environmental view diagram: Deployment diagram.



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							THEORY		PRACTICAL		
							END SEM University Exam	Two Term Exam	Teachers Assessment*	END SEM University Exam	Teachers Assessment*
<b>BTCS612</b>	<b>UG</b>	<b>Simulation and Modeling</b>	2	1	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. Introduce students to the simulation and modeling techniques.
2. Provide a way for students with opportunities to develop basic simulation and modeling
3. Introduce concepts of modeling layers of society's&industrialreal 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 anddisadvantages of simulation, application areas in communication, computer and softwaredesign, systems and systems environment, components of a system, discrete and continuoussystem, model of a system, types of models, discrete-event simulation, steps in a simulationstudy. Simulation Examples- Simulation of queueing systems, on-demand and inventorysystems, simulation for reliability analysis, Introduction to GPSS.

### UNIT-II

#### COMPUTER BASED SYSTEM SIMULATION:



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#### **SEMESTER VI**

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 Modeling and Simulation, Academic Press INC; USA

##### **REFERENCES:**

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 EXPERIMENTS:**

1. Simulate CPU scheduling algorithm using queueing system.
2. Simulate multiplexer using queueing system.
3. Simulate Network congestion control algorithms using Petri-net Model.
4. Simulate disk scheduling algorithms Petri-net Model.
5. Verification and validation of Petri-net Model.
6. Simulate a Manufacturing shop and write a program in GPSS.
7. Simulate Telephone system model and write a program in SIMSCRIPT.
8. Graphical Simulation and Modeling using MATLAB.
9. Study of SIMULA.
10. Study of DYNAMO.



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							END SEM University Exam	Two Term Exam	Teachers Assessment*	END SEM University Exam	Teachers Assessment*
<b>BTCS613</b>	<b>UG</b>	<b>Software Testing and Quality Assurance</b>	2	1	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. Develop a skill in developing good quality in the software product.
2. Develop methods and procedures for software development that can scale up for large systems and that can be used to consistently produce high-quality software at low cost and with a small cycle time
3. Learn systematic approach to the operation, maintenance, and retirement of software.
4. Learn how to use available resources to develop software, reduce cost of software and how to maintain quality of software
5. Methods and tools of testing and maintenance of software

#### Course Outcomes:

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

1. Apply approach of Software Testing & QA concepts.
2. Apply modern software testing processes in relation to software development and project management.
3. Create test strategies and plans, design test cases prioritize and execute them.
4. Manage defects within a project.
5. Contribute to efficient delivery of software solutions and implement improvements in the software development processes.

### SYLLABUS

#### UNIT-I

**BASIC CONCEPTS:** Basic Testing Vocabulary, Quality Assurance versus Quality Control, The Cost of Quality, Software Quality Factors, Software Defect, The Multiple Roles of the Software Tester(People Relationships), Scope of Testing, Testing Constraints, Various software development Life cycles (SDLC), Independent Testing, QA Process, Levels of Testing, The “V” Concept of Testing.

#### UNIT-II

**WHITE BOX TESTING:** White box testing techniques - Statement coverage - Branch Coverage - Condition coverage - Decision/Condition coverage - Multiple condition coverage - Dataflow coverage - Mutation testing - Automated code coverage analysis.



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## **SEMESTER VI**

### **UNIT-III**

**BLACK BOX TESTING:** Black box testing techniques - Boundary value analysis - Robustness testing - Equivalence partitioning -Syntax testing - Finite state testing - Levels of testing – Unit testing- Integration Testing

### **UNIT-IV**

**SYSTEM TESTING** - Functional testing-non-Functional testing-acceptancetesting-performance testing –Factors and Methodology for Performance testing, Regression testing-Methodology for Regression-testing.Five Views of Software Quality, McCall’s Quality Factors and Criteria, Quality Factors, Quality Criteria, Relationship between Quality Factors and Criteria, Quality Metrics, Quality Characteristics, Software Quality Standard

### **UNIT-V**

**ADVANCE SOFTWARE TESTING METHOD (OBJECT ORIENTED TESTING):** Syntax testing - Finite State testing - Levels of testing - Unit, Integration and System Testing. Challenges - Differences from testing non-OO Software - Class testing strategies - State-based Testing Software quality Assurance: ISO 9000; CMM and Test Management Issues; Quality Assurance personnel Issues.

### **TEXT BOOKS:**

1. KshirasagarNaik&PriyadarshiTripathy, “Software Testing & Quality Assurance”, A JOHN WILEY & SONS, INC. Publication.
2. R S. Pressman ,”Software Engineering: A Practitioner's Approach”, Sixth edition 2006, McGraw-Hill.
3. Waman S.Jawadekar,”Software Enginerring”, TMH
4. Sommerville,”Software Enginerring”,Pearson Education.
5. 5.“IBM CE-Enablement Program- Essentials of Software Engineering (OOAD & SW Lifecycle)”, IBM Career Education

### **REFERENCES:**

1. KshirasagarNaik&PriyadarshiTripathy, “Software Testing & Quality Assurance”, A JOHN WILEY & SONS, INC. Publication.
2. R S. Pressman ,”Software Engineering: A Practitioner's Approach”, Sixth edition 2006, McGraw-Hill.
3. Waman S.Jawadekar,”Software Enginerring”, TMH
4. Sommerville,”Software Enginerring”,Pearson Education.
5. <http://www.softwaretestinghelp.com/online-software-testing-course-syllabus/>
6. <https://amizone.net/AdminAmizone/WebForms/Academics/NewSyllabus/1217201473127725.pdf>
7. <http://www.tutorialspoint.com/uml/>

### **LIST OF EXPERIMENTS:**

1. Design test cases using Boundary value analysis by taking quadratic equation problem.
2. Design test cases using Equivalence class partitioning taking triangle problem.
3. Design test cases using Decision table taking triangle problem.
4. Design independent paths by calculating cyclometer complexity using date problem.



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5. Design independent paths by taking DD path using date problem.
6. Design the test cases for login page of AMIZONE.
8. Manual Testing for PAN card verification.
9. Generate test case for ATM machine.
10. Overview of Testing process using Rational Robot.
11. Write a script to record verification point using Rational Robot (For GUI testing of single click on window OS).
12. Write a script to record verification point for Clip Board and alphanumeric values using Rational Robot.



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							THEORY		PRACTICAL		
							END SEM University Exam	Two Term Exam	Teachers Assessment*	END SEM University Exam	Teachers Assessment*
<b>BTCS617</b>	<b>UG</b>	<b>Robotics</b>	2	1	2	4	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 objective of this course is to impart knowledge about industrial robots for their control and design.

### Course Outcomes:

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

1. Perform kinematic and dynamic analyses with simulation.
2. Design control laws for a robot.
3. Integrate mechanical and electrical hardware for a real prototype of robotic device.
4. Select a robotic system for given application.

## SYLLABUS

### UNIT-I

**Introduction to Robotics:** Types and components of a robot, Classification of robots, closed-loop and open-loop control systems. Kinematics systems; Definition of mechanisms and manipulators, Social issues and safety.

### UNIT-II

**Robot Kinematics and Dynamics:** Kinematic Modelling: Translation and Rotation Representation, Coordinate transformation, DH parameters, Jacobian, Singularity, and Statics  
Dynamic Modelling: Equations of motion: Euler-Lagrange formulation

### UNIT-III

**Sensors and Vision System:** Sensor: Contact and Proximity, Position, Velocity, Force, Tactile etc. Introduction to Cameras, Camera calibration, Geometry of Image formation, Euclidean/Similarity /Affine/Projective transformations. Vision applications in robotics.

### UNIT-IV

**Robot Control:** Basics of control: Transfer functions, Control laws: P, PD, PID. Non-linear and advanced controls.

### UNIT-V

**Robot Actuation Systems:** Actuators: Electric, Hydraulic and Pneumatic; Transmission: Gears, Timing Belts and Bearings, Parameters for selection of actuators.

**Control Hardware and Interfacing:** Embedded systems: Architecture and integration with sensors, actuators, components, Programming for Robot Applications.



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#### **TEXT BOOKS:**

1. Saha, S.K., "Introduction to Robotics, 2nd Edition, McGraw-Hill Higher Education, New Delhi, 2014.
2. Ghosal, A., "Robotics", Oxford, New Delhi, 2006.
3. Niku Saeed B., "Introduction to Robotics: Analysis, Systems, Applications", PHI, New Delhi.
4. Mittal R.K. and Nagrath I.J., "Robotics and Control", Tata McGraw Hill.
5. Mukherjee S., "Robotics and Automation", Khanna Publishing House, Delhi.
6. Craig, J.J., "Introduction to Robotics: Mechanics and Control", Pearson, New Delhi, 2009
7. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, "Robot Modelling and Control", John Wiley and Sons Inc, 2005
8. Steve Heath, "Embedded System Design", 2nd Edition, Newnes, Burlington, 2003.
9. Merzouki R., Samantaray A.K., Phathak P.M. and Bouamama B. Ould, "Intelligent Mechatronic System: Modeling, Control and Diagnosis", Springer.

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

1. Study components of a real robot and its DH parameters.
2. Forward kinematics and validate using a software (Robo Analyser or any other free software tool).
3. Inverse kinematics of the real robot and validation using any software.
4. Use of open source computer vision programming tool openCV.
5. Image Processing using openCV.
6. Image Processing for color/shape detection.
7. Positioning and orientation of robot arm.
8. Control experiment using available hardware or software.
9. Integration of assorted sensors (IR, Potentiometer, strain gages etc.), micro controllers and ROS (Robot Operating System) in a robotic system.
10. Project work



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<b>BTCS618</b>	<b>UG</b>	<b>Block Chain</b>	2	1	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. Provide conceptual understanding of how block chain technology can be used to innovate and improve business processes.
2. Covers the technological underpinning of block Chain operations in both theoretical and practical implementation of solutions using block Chain technology.

#### Course Outcomes:

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

1. Understand block chain technology.
2. Develop block chain based solutions and write smart contract using Hyperledger Fabric and Ethereum frameworks.
3. Build and deploy block chain application for on premise and cloud based architecture.
4. Integrate ideas from various domains and implement them using block chain technology in different perspectives.

### SYLLABUS

#### UNIT-I

**Introduction:** Overview of Block chain, Public Ledgers, Bitcoin, Smart Contracts, Block in a Block chain, Transactions, Distributed Consensus, Public vs Private Block chain, Understanding Crypto currency to Block chain, Permissioned Model of Block chain, Overview of Security aspects of Block chain. Basic Crypto Primitives: Cryptographic Hash Function, Properties of a hash function, Hash pointer and Merkle tree, Digital Signature, Public Key Cryptography, A basic cryptocurrency.

#### UNIT-II

**Understanding Block chain with Crypto currency:** Bitcoin and Block chain: Creation of coins, Payments and double spending, Bitcoin Scripts, Bitcoin P2P Network, Transaction in Bitcoin Network, Block Mining, Block propagation and block relay. Working with Consensus in Bitcoin: Distributed consensus in open environments, Consensus in a Bitcoin network, Proof of Work (PoW) – basic introduction, Hashcash PoW, Bitcoin PoW, Attacks on PoW and the monopoly problem, Proof of Stake, Proof of Burn and Proof of Elapsed Time, The life of a Bitcoin Miner, Mining Difficulty, Mining Pool.



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### **UNIT-III**

**Understanding Block chain for Enterprises:** Permissioned Block chain: Permissioned model and use cases, Design issues for Permissioned block chains, Execute contracts, State machine replication, Overview of Consensus models for permissioned block chain- Distributed consensus in closed environment, Paxos, RAFT Consensus, Byzantine general problem, Byzantine fault tolerant system, Lamport-Shostak-Pease BFT Algorithm, BFT over Asynchronous systems.

### **UNIT-IV**

**Enterprise application of Block chain:** Cross border payments, Know Your Customer (KYC), Food Security, Mortgage over Block chain, Block chain enabled Trade, We Trade – Trade Finance Network, Supply Chain Financing, Identity on Block chain.

### **UNIT-V**

**Block chain application development:** Hyperledger Fabric- Architecture, Identities and Policies, Membership and Access Control, Channels, Transaction Validation, Writing smart contract using Hyperledger Fabric, Writing smart contract using Ethereum, Overview of Ripple and Corda.

### **TEXT BOOKS:**

1. Melanie Swan, “Block Chain: Blueprint for a New Economy”, O’Reilly, 2015
2. Josh Thompsons, “Block Chain: The Block Chain for Beginners- Guide to Block chain Technology and Leveraging Block Chain Programming”.
3. Daniel Drescher, “Block Chain Basics”, Apress; 1st edition, 2017.
4. Anshul Kaushik, “Block Chain and Crypto Currencies”, Khanna Publishing House, Delhi.
5. Imran Bashir, “Mastering Block Chain: Distributed Ledger Technology, Decentralization and Smart Contracts Explained”, Packt Publishing.
6. Ritesh Modi, “Solidity Programming Essentials: A Beginner’s Guide to Build Smart Contracts for Ethereum and Block Chain”, Packt Publishing.
7. Salman Baset, Luc Desrosiers, Nitin Gaur, Petr Novotny, Anthony O’Dowd, Venkatraman. Ramakrishna, “Hands-On Block Chain with Hyperledger: Building Decentralized Applications with Hyperledger Fabric and Composer”, Import, 2018

### **LIST OF PRACTICALS:**

1. Install and understand Docker container, Node.js, Java and Hyperledger Fabric, Ethereum and perform necessary software installation on local machine/create instance on Cloud to run.  
<https://github.com/hyperledger/https://docs.docker.com/getstarted/https://console.ng.bluemix.net/docs/services/block chain/index.html>  
[https://console.bluemix.net/docs/containers/container\\_index.html#container\\_index](https://console.bluemix.net/docs/containers/container_index.html#container_index)
2. Create and deploy a block chain network using Hyperledger Fabric SDK for Java Set up and initialize the channel, install and instantiate chaincode, and perform invoke and query on your block chain network  
<https://developer.ibm.com/patterns/create-and-deploy-block chain-network-using-fabric-sdk-java/>
3. Interact with a block chain network. Execute transactions and requests against a block chain network by creating an app to test the network and its rules.  
<https://developer.ibm.com/patterns/interacting-with-a-block chain-network/>
4. Deploy an asset-transfer app using block chain. Learn app development within a Hyperledger Fabric network.



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- [https://developer.ibm.com/patterns/deploy-an-asset-transfer-app-using-block chain/](https://developer.ibm.com/patterns/deploy-an-asset-transfer-app-using-block-chain/)
5. Use block chain to track fitness club rewards Build a web app that uses Hyperledger Fabric to track and trace member rewards.  
<https://developer.ibm.com/patterns/fitness-club-rewards-points-iot-and-retail-integration/>
6. Car auction network: A Hello World example with Hyperledger Fabric Node SDK and IBM Block chain Starter Plan. Use Hyperledger Fabric to invoke chaincode while storing results and data in the starter plan.  
<https://developer.ibm.com/patterns/car-auction-network-hyperledger-fabric-node-sdk-starter-plan/>
7. Develop an IoT asset tracking app using Block chain. Use an IoT asset tracking device to improve a supply chain by using Block chain, IoT devices, and Node-RED.  
[https://developer.ibm.com/patterns/develop-an-iot-asset-tracking-app-using-block chain/](https://developer.ibm.com/patterns/develop-an-iot-asset-tracking-app-using-block-chain/)
8. Secure art using block chain digital certificates. Node.js-based auction application can help democratize the art market  
[https://developer.ibm.com/patterns/securing-art-using-block chain-digital-certificates/](https://developer.ibm.com/patterns/securing-art-using-block-chain-digital-certificates/)
9. Mini projects such as :
- (i) Block chain for telecom roaming, fraud, and overage management. See how communication service providers use block chain to enhance their value chains.  
<https://developer.ibm.com/patterns/blockchain-for-telecom-roaming-fraud-and-overagemanagement/>
- (ii) Use IoT dashboards to analyze data sent from a Block chain network. Build an IoT app and IoT dashboards with Watson IoT Platform and Node-RED to analyze IoT data sent from a Block chain network.  
[https://developer.ibm.com/patterns/iot-dashboards-analyze-data-block chain-network/](https://developer.ibm.com/patterns/iot-dashboards-analyze-data-block-chain-network/)
- (iii) Create an Android app with Block chain integration. Build a Block chain enabled health and fitness app with Android and Kubernetes.  
[https://developer.ibm.com/patterns/create-an-android-app-with-block chain-integration/](https://developer.ibm.com/patterns/create-an-android-app-with-block-chain-integration/)
- (iv) Create a global finance block chain application with IBM Block chain Platform Extension for VS Code. Develop a Node.js smart contract and web app for a Global Finance with block chain use case  
[https://developer.ibm.com/patterns/global-financing-use-case-for-block chain/](https://developer.ibm.com/patterns/global-financing-use-case-for-block-chain/)
- (v) Develop a voting application using Hyperledger and Ethereum. Build a decentralized app that combines Ethereum's Web3 and Solidity smart contracts with Hyperledger's hosting Fabric and Chaincode EVM  
<https://developer.ibm.com/patterns/voting-app-hyperledger-ethereum/>
- (vi) Create a block chain app for loyalty points with Hyperledger Fabric Ethereum Virtual Machine. Deploy Fabric locally with EVM and create a proxy for interacting with a smart contract through a Node.js web app  
<https://developer.ibm.com/patterns/loyalty-points-fabric-vm/>



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## B.Tech.(CSE-Big Data Analytics -IBM)

### Choice Based Credit System (CBCS) 2018-19

### 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>BTIBM601</b>	<b>UG</b>	<b>Micro services Architecture and 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:

Students will acquire knowledge on:

- 1 Understand the importance of Microservices and describe its need as an Architecture Implementation.
- 2 Understand strengthen the understanding of basic concepts of Docker and Kubernetess.
- 3 Understand the Html and its Tags
- 4 Understand CSS and how we implement in html
- 5 Be able to Deploy application on docker and Access the Kubernetess

#### Course Outcomes:

At the end of the mobility period, students will be able to:

- 1 Make an application using nodejs
- 2 Run docker commands
- 3 Deploy container and pods on kubernetess.

#### Syllabus:

##### UNIT-I

##### css and JavaScript:

Understand JavaScript and DOM and BOM , Understand Server side Application, Understand NoSQL (MongoDb), Deployment of Nodejs application

##### UNIT-II

**Server side nodejs:-**Key features of NodeJS, Installation and Configuration, NodeJS Command Line, Sample Project using Node Express command prompt, Nodeclipse plugin, Sample Project using Nodeclipse, Performing CRUD Operations,Key features of MongoDB, Connection Pooling using NodeJS Mongo driver,Dockerarchitecture,Virtual machines versus containers, about containers.

##### UNIT-III

Docker: A shipping container for code, Benefits of using containers, Docker basic concepts, Docker shared and layered file systems technology. Deployment of container, Learn the concept of kubernetess, Learn how to run Docker command, Understand pods and cluster Container ecosystem,

##### UNIT-IV

Kubernetess, Container, orchestration, Kubernetess architecture, Master Node Components,



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#### **SEMESTER VI**

Worker Node Components, Kubernetes Building Blocks, Images, Immutability, Pod, Config Maps & Secrets, Deploying Applications on Kubernetes, Pod Health Checking, Kubectl Commands

#### **UNIT-V**

Cloud Application Component Architecture, Benefits of using Kubernetes with IBM Containers, About Microservices ,monolithic application, microservice security, api management and gateways, the future of microservices, microservices governance

#### **TEXT BOOKS:**

1. Sam Newman ,”Building Microservices”, O’Reilly Media
2. Ajay Sharma,“Microservices Architecture”, Kindle Edition
3. IBM Career education Microservices Architecture and Implementation

#### **REFERENCES:**

1. Eberhard Wolff ,“Microservices — A Practical Guide”, Korean translation
2. Martin Kleppmann ,“Designing Data-Intensive Applications”, O’Reilly Media

#### **Video Lectures**

1. [https://www.youtube.com/watch?v=dD2EISBDjWM&list=PLr6-GrHUIvf\\_ZNmuQSXdS197Oyr1L9sPB](https://www.youtube.com/watch?v=dD2EISBDjWM&list=PLr6-GrHUIvf_ZNmuQSXdS197Oyr1L9sPB)
2. <https://www.youtube.com/watch?v=0afZj1G0BIE&t=38s>
3. [https://www.youtube.com/watch?v=Ukg\\_U3CnJWI&t=15s](https://www.youtube.com/watch?v=Ukg_U3CnJWI&t=15s)
4. [https://www.youtube.com/watch?v=TlB\\_eWDSMt4](https://www.youtube.com/watch?v=TlB_eWDSMt4)
5. <https://www.youtube.com/watch?v=voDummz1gO0>
6. <https://www.youtube.com/watch?v=lktzQrHQcYU>
7. <https://www.youtube.com/watch?v=I4zWlW93-V4>

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

- 1 Design a static web application using html and CSS.
- 2 Wap program to define variable ,control structure in JavaScript
- 3 Define Function in JavaScript and understand message and link.
- 4 Wap for window in JavaScript and its objects. Create a gauge report and a pie chart repor
- 5 Design application using nodejs and configure node-eclipse.
- 6 Connectivity with mongo DB nodejs app
- 7 Docker Commands
  - a. Listing Running Containers
  - b. Restarting Stopped Containers
  - c. Retrieving Log Outputs
  - d. Container Isolation
  - e. Creating Docker Images
  - f. Building a Dockerfile
  - g. Copying Build Files
- 8 Kubernetes Cluster Demo
- 9 VM Creation in Google Cloud Platform – Demo
- 10 Minikube on local machine



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### Choice Based Credit System (CBCS) 2018-19

#### 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*
BTIBMB602	UG	Big Data Engineering - Spark & Scala	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

The student will have ability to:

1. Introduce students to Big Data Analysis
2. Introduce to Understanding Data Science and Notebooks.
3. Understating machine learning concept and Introduce JAQL, pig and HIVE
4. Managing the Big SQL, Data stream, Hortonworks Data Platform (HDP), Watson Studio

#### COURSE OUTCOMES

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

1. Read data from persistent storage and load it into Apache Spark,
2. Manipulate data with Spark and Scala,
3. Express algorithms for data analysis in a functional style,
4. Recognize how to avoid shuffles and recomputation in Spark,
5. Analyze data with Watson Studio

#### SYLLABUS

##### UNIT-I

##### Introduction to Big Data and Analytics

Introduction to big data, Big data overview, IBM 4'v, Describing the functions and features of HDP, Developing and understanding of the complete open-source Hadoop ecosystem, Understanding the purpose of Apache Ambari in the HDP stack, Exploring some of the directory structure on the Linux system, 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, Mapper class and Reducer class, Describing the YARN model, Comparing Hadoop 2/YARN with Hadoop 1, Run MapReduce and YARN jobs, Understanding the overall architecture of Ambari, Listing the functions of the main components of Ambari, Explaining how to start and stop services from Ambari Web Console, Managing Hadoop clusters with Apache Ambari to Start the Apache Ambari web console, Sqoop Introduction, Sqoop commands processing, Zookeeper introduction

##### UNIT-II

##### Apache Spark and Scala



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#### **SEMESTER VI**

Working with Spark RDD with Scala, Listing and describing the architecture and components of the Spark unified stack, Understanding the principles of Spark programming, Listing and describing the Spark libraries, Launching and using Spark's Scala and Python shells, 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

#### **UNIT-III**

##### **Understanding Data Science and Notebooks**

Data Scientists overview, 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, 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, Exploring the component panels

#### **UNIT-IV**

##### **BigSQL**

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, Starting Hadoop components, Executing basic Big SQL statements, 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, Backup and restore Big SQL, Configuring authentication for Big SQL, Managing security with Apache Ranger, Enabling SSL encryption, Configuring authorization of Big SQL objects, Configuring impersonation in Big SQL, Listing the supported data sources, Configuring Fluid Query with Big SQL

#### **UNIT-V**

##### **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 with external data.

#### **TEXT BOOKS:**

1. DT Editorial Services, “Big Data Black Book”, 2016
2. Subhashini Chellappan & Seema Acharya, “Big Data Analytics”, 2019
3. Radha Shankarmani & M. Vijaylakshmi, ” Big Data Analytics”, 2016



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**SEMESTER VI**

4. Vibrant Publishers “Hadoop Big Data”, 2017

**REFERENCES:**

1. IBM Study Material
2. IBM Ebook

**LIST OF EXPERIMENTS:**

1. Steps to run vmware or cloudera
3. Processing of all hadoop commands on terminal
4. Working with hdfs storage and retrieval of data
5. Mapper class implementation using java
6. Reducer class implementation using java
7. Yarn implementation
8. Sqoop command processing
9. Spark implementation
10. Scala implementation
11. Ambari console and start and stop process
12. Jupyter notebook implementation
13. Working with ddl, dml, dql, tcl, dcl commands in big sql
14. Working with big sql views, array, functions like query
15. Creating Watson studio project
16. Working with Watson datasets, collaborators etc.



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## 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>BTIT608</b>	<b>UG</b>	<b>IT Workshop-SciLab/MATLAB</b>	0	0	4	2	0	0	0	60	40

**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. Familiarization of the syntax, semantics, data-types and library functions of numerical computing languages such as MATLAB and/or SCILAB.
2. Learn application of MATLAB and/or SCILAB for implementation/simulation and visualization of basic mathematical functions relevant to electronics applications.

### Course Outcomes:

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

1. Understand the need for simulation/implementation for the verification of mathematical functions.
2. Understand the main features of the MATLAB/SCILAB program development environment to enable their usage in the higher learning.
3. Implement simple mathematical functions/equations in numerical computing environment such as MATLAB/SCILAB.
4. Interpret and visualize simple mathematical functions and operations thereon using plots/display.
5. Analyze the program for correctness and determine/estimate/predict the output and verify it under simulation environment using MATLAB/SCILAB tools.

## SYLLABUS

### UNIT-I

**INTRODUCTION TO SIMULATION SOFTWARE:** About SCILAB/MATLAB, SCILAB/MATLAB System, Starting and Quitting SCILAB/MATLAB.

**EXPRESSIONS:** Variables Numbers, Operators Functions, Expressions.

### UNIT-II

**FLOW CONTROL:** If, else, and else if, switch and case, for, while, continue, break try - catch, return.

**COMMAND WINDOW:** The format Function, Suppressing Output, Entering Long Statements, Command Line Editing.

### UNIT-III

**MATRICES AND ARRAYS:** Entering Matrices sum and transpose, subscripts, colon Operator, magic Function.



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## **SEMESTER VI**

**WORKING WITH MATRICES:** Generating Matrices, The load Function, M-Files, Concatenation, Deleting Rows and Columns, Linear Algebra, Arrays Multivariate Data, Scalar Expansion, Logical Subscripting, find Function.

### **UNIT-IV**

**SCRIPTS & FUNCTIONS:** Scripts, Functions, Global Variables, Passing String Arguments to Functions, eval Function, Function Handles, Vectorization, Pre allocation.

**OTHER DATA STRUCTURE:** Multidimensional Arrays, Cell Arrays, Characters and Text, Structures

### **UNIT-V**

**GRAPHICS:** Plotting Process, Editing Process, Preparing Graphs, Basic Plotting Functions, Mesh & Surface Plot, and Image Reading & Writing, Printing graphics. SIMULINK

### **TEXT BOOKS & REFERENCES:**

1. MATLAB and its Applications in Engineering, Rajkumar Bansal, Pearson Publishers, ISBN-10: 8131716813, 2009.
2. A Guide to MATLAB: For Beginners & Experienced Users By: Kevin R. Coombes, John E. Osborn, Garrett J. Stuck
3. SCILAB(a Free Software to Matlab), Er. HemaRamachandran and Dr. Achutsankar Nair, S. Chand Publishers, ISBN-10: 8121939704, 2011
4. Introduction to SCILAB by Rachna Verma and Arvind Verma
5. SCILAB—A Beginner's Approach by Anil Kumar Verma
6. <http://in.mathworks.com/>
7. <https://www.scilab.org/resources/documentation/tutorials>

### **LIST OF PRACTICALS:**

1. Addition, subtraction and multiplication of two matrices.
2. Verify whether the given matrix is singular or non-singular and compute its inverse if applicable.
3. Sorting of 1-D array and searching of an array/matrix. Also, list the set of numbers that obey a common condition in an array/matrix using *find()*.
4. Solve simultaneous equations (maximum of three) using Cramer's rule. [Simultaneous equations may be obtained by applying KCL or KVL for a circuit and they can be solved for voltages or currents, respectively]
5. a) Show that  $\log_{10}(A*B)=\log_{10} A + \log_{10} B$  and  $\log_{10}(A/B)=\log_{10} A - \log_{10} B$
1. b) Plot the voltage across capacitor during charging  $V_c=V_0[1-e^{-(t/RC)}]$
6. a) Plot a straight line for the given slope and intercept using different plot attributes.
1. b) Differentiate and integrate  $y=mx+c$ , separately, and display the results on the same plot.
7. Plot  $y_1=A*\sin(2\pi f_1 t)$ ,  $y_2=B*\cos(2\pi f_2 t)$  and  $y_3=A*\sin(2\pi f_1 t)+B*\cos(2\pi f_2 t)$ , in time and frequency (after computing DFT or FFT) domains as subplots and infer the results.
8. Integrate and differentiate  $\sin(x)$  and display the results on the same plot in different colors. Also display  $\sin(x)$  on the same plot.
9. Compute mean, median, standard deviation and variance of a set of data using formulae and verify using built-in functions.
10. Find all the even and prime numbers between two numbers (range).



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## **SEMESTER VI**

11. Demonstrate (a) reading and display image, (b) converting color image to gray and black-and-white and plotting their histograms, and (c) conversion of image file formats.
12. Compare the results of the built-in and user-defined function to compute  $\cos(x)$  [the series  $\cos(x)=1-(x^2/2!)+(x^4/4!)-(x^6/6!)+ \dots$  can be used]
13. Write a program to compute roots of a quadratic equation  $ax^2+bx+c=0$  given a, b and c.



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### 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	4	2	0	0	0	60	40

**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.

#### Objectives/Learning Outcomes/Capability Development

##### Program Learning Outcomes

This course contributes to the following program learning outcomes:

- **Enabling Knowledge:**

You will gain skills as you apply knowledge with creativity and initiative to new situations. In doing so, you will:

1. Demonstrate mastery of a body of knowledge that includes recent developments in Information Technology
2. Recognize and use research principles and methods applicable to Information Technology.

- **Critical Analysis:**

You will learn to accurately and objectively examine, and critically investigate Information Technology (IT) concepts, evidence, theories or situations, in particular to:

- analyze and model complex requirements and constraints for the purpose of designing and implementing software artifacts and IT systems
- Evaluate and compare designs of software artifacts and IT systems on the basis of organizational and user requirements.



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- **Problem Solving:**

Your capability to analyze complex problems and provide suitable solutions will be extended as you learn to: design and implement software solutions that accommodate specified requirements and constraints, based on analysis or modeling or requirements specification.

- **Communication:**

You will learn to communicate effectively with a variety of audiences through a range of modes and media, in particular to: interpret abstract theoretical propositions, choose methodologies, justify conclusions and defend professional decisions to both IT and non-IT personnel via technical reports of professional standard and technical presentations.

- **Responsibility:**

You will be required to accept responsibility for your own learning and make informed decisions about judging and adopting appropriate behaviour in professional and social situations. This includes accepting the responsibility for independent life-long learning and a high level of accountability. Specifically, you will learn to: effectively apply relevant standards, ethical considerations, and an understanding of legal and privacy issues to designing software applications and IT systems.

- **Research and Scholarship:**

You will have technical and communication skills to design, evaluate, implement, analyze and theorize about developments that contribute to professional practice or scholarship; specifically you will have cognitive skills:

To demonstrate mastery of theoretical knowledge and to reflect critically on theory and professional practice or scholarship

To plan and execute a substantial research-based project, capstone experience and/or piece of scholarship.

## **Course Learning 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.

## **Overview of Learning Activities**

A Minor project is a substantial work of supervised research or software development. You will



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## **SEMESTER VI**

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 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.