



AICTE Model Curriculum of Courses at UG Level in Emerging Areas



Developed by:

Curriculum Development Centre

**National Institute of Technical Teachers Training and
Research**

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- GENESIS -

Industry 4.0 demands smart systems integrated with intelligence to have a better human-machine interface. To cope up with the upcoming emerging industrial demands, the technical institutes are to be tuned to educate and train their students to meet the upcoming requirements of the industrial revolution. AICTE, as a polestar of the technical education system of the country, in the recent past has emerged as a guiding force to guide the technical institutions of the country to transform themselves with time. The curriculum design of these nine emerging subjects started with the visit of Prof MP Poonia, Vice-Chairman of All India Council for Technical Education (AICTE) to National Institute of Technical Teachers Training and Research (NITTTR), Chandigarh, where he brought out the discussion and asked the institute to take a lead in creating industry-accepted curriculum in these nine subjects.

The Vice-Chairman noticed that NITTTR, Chandigarh has already by that time initiated training programmes in the areas like Industry 4.0, Block Chain, Cyber Security, Robotics and Internet of Things (IoT). Realizing the strength and initiative of the institute, he addressed a formal meeting with the Director Prof SS Pattnaik and his team and set a target time of 10 days to prepare the industry-ready curriculum for the country in these nine areas.

Industry experts were contacted, R&D experts were invited and academicians from the institutes of national importance were requested to participate in the series of curriculum workshops conducted for the said purpose.

While discussing in these workshops, teams were advised to follow the principle of incorporating the contents needed by the industry. More emphasis was given on MOOCs and platform like SWAYAM to be used for meeting the pre-requisites rather than making it part of main course contents. The team with experts from industry, R&D and academia, in series of discussions, convinced themselves with the contents which are presented here as curriculum for the nine emerging subjects:

1. Artificial Intelligence (AI)
2. Internet of Things (IoT)
3. Block Chain
4. Robotics
5. Quantum Computing
6. Data Sciences
7. Cyber Security
8. 3D Printing and Design
9. Virtual Reality (VR)

This timely joint initiative of All India Council for Technical Education (AICTE) and National Institute of Technical Teachers Training and Research (NITTTR), Chandigarh, is expected to bring translational skills among the students of under-graduate programmes to meet the expectations of the industry.



Prof MP Poonia, Vice Chairman, AICTE in discussion with Prof SS Pattnaik, Director, NITTTR, Chandigarh



Vice Chairman in discussion with Director and Team of NITTTR, Chandigarh



Team in deliberations



CONTENTS

- 1. Artificial Intelligence**
- 2. Internet of Things (IoT)**
- 3. Blockchain**
- 4. Robotics**
- 5. Quantum Computing**
- 6. Data Sciences**
- 7. Cyber Security**
- 8. 3D Printing and Design**
- 9. Virtual Reality (VR)**

Code	ARTIFICIAL INTELLIGENCE	L	T	P	Credits
		3	-	2	4

PRE-REQUISITES

- Basic Programming in Python
- Data Structures

OBJECTIVES

Artificial Intelligence is a major step forward in how computer system adapts, evolves and learns. It has widespread application in almost every industry and is considered to be a big technological shift, similar in scale to past events such as the industrial revolution, the computer age, and the smart phone revolution.

This course will give an opportunity to gain expertise in one of the most fascinating and fastest growing areas of Computer Science through classroom program that covers fascinating and compelling topics related to human intelligence and its applications in industry, defence, healthcare, agriculture and many other areas. This course will give the students a rigorous, advanced and professional graduate-level foundation in Artificial Intelligence.

LEARNING OUTCOMES

After undergoing this course, the students will be able to:

- Build intelligent agents for search and games
- Solve AI problems through programming with Python
- Learning optimization and inference algorithms for model learning
- Design and develop programs for an agent to learn and act in a structured environment.

DETAIL CONTENTS

1. Introduction (3 Hours)

Concept of AI, history, current status, scope, agents, environments, Problem Formulations, Review of tree and graph structures, State space representation, Search graph and Search tree.

2. Search Algorithms (9 Hours)

Random search, Search with closed and open list, Depth first and Breadth first search, Heuristic search, Best first search, A* algorithm, Game Search.

3. Probabilistic Reasoning (12 Hours)

Probability, conditional probability, Bayes Rule, Bayesian Networks- representation, construction and inference, temporal model, hidden Markov model.

4. Markov Decision process (12 Hours)

MDP formulation, utility theory, utility functions, value iteration, policy iteration and partially observable MDPs.

5. Reinforcement Learning (9 Hours)

Passive reinforcement learning, direct utility estimation, adaptive dynamic programming, temporal difference learning, active reinforcement learning- Q learning.

LIST OF PRACTICALS

1. Write a programme to conduct uninformed and informed search.
2. Write a programme to conduct game search.
3. Write a programme to construct a Bayesian network from given data.
4. Write a programme to infer from the Bayesian network.
5. Write a programme to run value and policy iteration in a grid world.
6. Write a programme to do reinforcement learning in a grid world.
7. Mini Project work.

LIST OF SUGGESTED BOOKS

1. Stuart Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach" , 3rd Edition, Prentice Hall
2. Elaine Rich and Kevin Knight, "Artificial Intelligence", Tata McGraw Hill
3. Trivedi, M.C., "A Classical Approach to Artificial Intelligence", Khanna Publishing House, Delhi.
4. Saroj Kaushik, "Artificial Intelligence", Cengage Learning India, 2011

5. David Poole and Alan Mackworth, “Artificial Intelligence: Foundations for Computational Agents”, Cambridge University Press 2010.

WEBSITES FOR REFERENCE

<https://nptel.ac.in/courses/106105077>

<https://nptel.ac.in/courses/106106126>

<https://aima.cs.berkeley.edu>

https://ai.berkeley.edu/project_overview.html (for Practicals)

Code	INTERNET OF THINGS	L	T	P	Credits
		3	-	2	4

PRE-REQUISITES

- Sensors, System Integration
- Cloud and Network Security

OBJECTIVES

The objective of this course is to impart necessary and practical knowledge of components of Internet of Things and develop skills required to build real-life IoT based projects.

LEARNING OUTCOMES

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

- Understand internet of Things and its hardware and software components
- Interface I/O devices, sensors & communication modules
- Remotely monitor data and control devices
- Develop real life IoT based projects

DETAIL CONTENTS

1. Introduction to IoT (8 Hours)

Architectural Overview, Design principles and needed capabilities, IoT Applications, Sensing, Actuation, Basics of Networking, M2M and IoT Technology Fundamentals- Devices and gateways, Data management, Business processes in IoT, Everything as a Service(XaaS), Role of Cloud in IoT, Security aspects in IoT.

2. Elements of IoT (9 Hours)

Hardware Components- Computing (Arduino, Raspberry Pi), Communication, Sensing, Actuation, I/O interfaces.

Software Components- Programming API's (using Python/Node.js/Arduino) for Communication Protocols-MQTT, ZigBee, Bluetooth, CoAP, UDP, TCP.

3. IoT Application Development (18 Hours)

Solution framework for IoT applications- Implementation of Device integration, Data acquisition and integration, Device data storage- Unstructured data storage on cloud/local server, Authentication, authorization of devices.

4. IoT Case Studies (10 Hours)

IoT case studies and mini projects based on Industrial automation, Transportation, Agriculture, Healthcare, Home Automation

LIST OF PRACTICALS

1. Familiarization with Arduino/Raspberry Pi and perform necessary software installation.
2. To interface LED/Buzzer with Arduino/Raspberry Pi and write a program to turn ON LED for 1 sec after every 2 seconds.
3. To interface Push button/Digital sensor (IR/LDR) with Arduino/Raspberry Pi and write a program to turn ON LED when push button is pressed or at sensor detection.
4. To interface DHT11 sensor with Arduino/Raspberry Pi and write a program to print temperature and humidity readings.
5. To interface motor using relay with Arduino/Raspberry Pi and write a program to turn ON motor when push button is pressed.
6. To interface OLED with Arduino/Raspberry Pi and write a program to print temperature and humidity readings on it.
7. To interface Bluetooth with Arduino/Raspberry Pi and write a program to send sensor data to smartphone using Bluetooth.
8. To interface Bluetooth with Arduino/Raspberry Pi and write a program to turn LED ON/OFF when '1'/'0' is received from smartphone using Bluetooth.
9. Write a program on Arduino/Raspberry Pi to upload temperature and humidity data to thingspeak cloud.
10. Write a program on Arduino/Raspberry Pi to retrieve temperature and humidity data from thingspeak cloud.
11. To install MySQL database on Raspberry Pi and perform basic SQL queries.
12. Write a program on Arduino/Raspberry Pi to publish temperature data to MQTT broker.

13. Write a program on Arduino/Raspberry Pi to subscribe to MQTT broker for temperature data and print it.
14. Write a program to create TCP server on Arduino/Raspberry Pi and respond with humidity data to TCP client when requested.
15. Write a program to create UDP server on Arduino/Raspberry Pi and respond with humidity data to UDP client when requested.

LIST OF SUGGESTED BOOKS

1. Vijay Madiseti, Arshdeep Bahga, Internet of Things, “A Hands on Approach”, University Press
2. Dr. SRN Reddy, Rachit Thukral and Manasi Mishra, “Introduction to Internet of Things: A practical Approach”, ETI Labs
3. Pethuru Raj and Anupama C. Raman, “The Internet of Things: Enabling Technologies, Platforms, and Use Cases”, CRC Press
4. Jeeva Jose, “Internet of Things”, Khanna Publishing House, Delhi
5. Adrian McEwen, “Designing the Internet of Things”, Wiley
6. Raj Kamal, “Internet of Things: Architecture and Design”, McGraw Hill
7. Cuno Pfister, “Getting Started with the Internet of Things”, O Reilly Media

Code	BLOCK CHAIN	L	T	P	Credits
		3	-	2	4

PRE-REQUISITES

- Cryptography Techniques
- Data Structures and Algorithms
- Introduction to Programming

OBJECTIVES

The objective of this course is to provide conceptual understanding of how block chain technology can be used to innovate and improve business processes. The course covers the technological underpinning of block Chain operations in both theoretical and practical implementation of solutions using block Chain technology.

LEARNING OUTCOMES

At the end of this course, the students will be able to:

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

DETAIL CONTENTS

1. Introduction

(6 Hours)

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.

2. Understanding Block chain with Crypto currency

(9 Hours)

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.

3. Understanding Block chain for Enterprises

(12 Hours)

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.

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

4. Block chain application development

(18 Hours)

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

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/get-started/https://console.ng.bluemix.net/docs/services/blockchain/index.html>

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
(<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/>)
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/>)
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/block-chain-for-telecom-roaming-fraud-and-overage-management/>
 - (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/>
 - (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/>

- (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-ethereum/>

LIST OF SUGGESTED 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; 1stedition, 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

Code	ROBOTICS	L	T	P	Credits
		3	-	2	4

PRE REQUISITES

- Basic Engineering Mathematics
- Automation and Control

OBJECTIVE

The objective of this course is to impart knowledge about industrial robots for their control and design.

LEARNING OUTCOMES

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

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

DETAIL CONTENTS

1. Introduction to Robotics (3 Hours)
 - 1.1 Types and components of a robot, Classification of robots, closed-loop and open-loop control systems.
 - 1.2 Kinematics systems; Definition of mechanisms and manipulators, Social issues and safety.
2. Robot Kinematics and Dynamics (7 Hours)
 - 2.1 Kinematic Modelling: Translation and Rotation Representation, Coordinate transformation, DH parameters, Jacobian, Singularity, and Statics
 - 2.2 Dynamic Modelling: Equations of motion: Euler-Lagrange formulation
3. Sensors and Vision System (10 Hours)

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

4. Robot Control (12 Hours)

- 4.1 Basics of control: Transfer functions, Control laws: P, PD, PID
- 4.2 Non-linear and advanced controls

5. Robot Actuation Systems (3 Hours)

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

6. Control Hardware and Interfacing (10 Hours)

Embedded systems: Architecture and integration with sensors, actuators, components, Programming for Robot Applications

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

LIST OF SUGGESTED 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.

Code	QUANTUM COMPUTING	L	T	P	Credits
		3	-	2	4

PRE-REQUISITES

- Data Structure and Algorithm.
- Programming in Python/C#

OBJECTIVES

The objective of this course is to impart necessary knowledge to the learner so that he/she can develop and implement algorithm and write programs using these algorithm.

LEARNING OUTCOMES

At the end of this course, the students will be able to:

- Explain the working of a Quantum Computing program, its architecture and program model
- Develop quantum logic gate circuits
- Develop quantum algorithm
- Program quantum algorithm on major toolkits

DETAIL CONTENTS

1. Introduction to Quantum Computing (6 Hours)
 - 1.1 Motivation for studying Quantum Computing
 - 1.2 Major players in the industry (IBM, Microsoft, Rigetti, D-Wave etc.)
 - 1.3 Origin of Quantum Computing
 - 1.4 Overview of major concepts in Quantum Computing
 - Qubits and multi-qubits states, Bra-ket notation.
 - Bloch Sphere representation
 - Quantum Superposition
 - Quantum Entanglement
2. Math Foundation for Quantum Computing (9 Hours)

2.1 Matrix Algebra: basis vectors and orthogonality, inner product and Hilbert spaces, matrices and tensors, unitary operators and projectors, Dirac notation, Eigen values and Eigen vectors.

3. Building Blocks for Quantum Program (8 Hours)

3.1 Architecture of a Quantum Computing platform

3.2 Details of q-bit system of information representation:

- Bloch Sphere
- Multi-qubits States
- Quantum superposition of qubits (valid and invalid superposition)
- Quantum Entanglement
- Useful states from quantum algorithmic perspective e.g. Bell State
- Operation on qubits: Measuring and transforming using gates.
- Quantum Logic gates and Circuit: Pauli, Hadamard, phase shift, controlled gates, Ising, Deutsch, swap etc.

3.3 Programming model for a Quantum Computing Program

- Steps performed on classical computer
- Steps performed on Quantum Computer
- Moving data between bits and qubits.

4. Quantum Algorithms (22 Hours)

4.1 Basic techniques exploited by quantum algorithms.

- Amplitude amplification
- Quantum Fourier Transform
- Phase Kick-back
- Quantum Phase estimation
- Quantum Walks

4.2 Major Algorithms

- Shor's Algorithm
- Grover's Algorithm
- Deutsch's Algorithm
- Deutsch -Jozsa Algorithm

4.3 OSS Toolkits for implementing Quantum program

- IBM quantum experience

- Microsoft Q
- Rigetti PyQuil (QPU/QVM)

LIST OF PRACTICALS

1. Building Quantum dice
2. Building Quantum Random No. Generation
3. Composing simple quantum circuits with q-gates and measuring the output into classical bits.
4. Implementation of Shor's Algorithms
5. Implementation of Grover's Algorithm
6. Implementation of Deutsch's Algorithm
7. Implementation of Deutsch-Jozsa's Algorithm
8. Mini Project such as implementing an API for efficient search using Grover's Algorithms or Integer factorization using Shor's Algorithm

LIST OF SUGGESTED BOOKS

1. Michael A. Nielsen, "Quantum Computation and Quantum Information", Cambridge University Press.
2. David McMahon, "Quantum Computing Explained", Wiley
3. IBM Experience:
<https://quantumexperience.ng.bluemix.net>
4. Microsoft Quantum Development Kit
<https://www.microsoft.com/en-us/quantum/development-kit>
5. Forest SDK PyQuil:
<https://pyquil.readthedocs.io/en/stable/>

Code	DATA SCIENCES	L	T	P	Credits
		3	-	2	4

PRE-REQUISITES

- Introduction to Programming
- Probability

OBJECTIVES

The objective of this course is to impart necessary knowledge of the mathematical foundations needed for data science and develop programming skills required to build data science applications.

LEARNING OUTCOMES

At end of this course, the students will be able to:

- Demonstrate understanding of the mathematical foundations needed for data science.
- Collect, explore, clean, munge and manipulate data.
- Implement models such as k-nearest Neighbors, Naive Bayes, linear and logistic regression, decision trees, neural networks and clustering.
- Build data science applications using Python based toolkits.

DETAIL CONTENTS

1. Introduction to Data Science (4 Hours)

Concept of Data Science, Traits of Big data, Web Scraping, Analysis vs Reporting

2. Introduction to Programming Tools for Data Science (6 Hours)

- 2.1 Toolkits using Python: Matplotlib, NumPy, Scikit-learn, NLTK
- 2.2 Visualizing Data: Bar Charts, Line Charts, Scatterplots
- 2.3 Working with data: Reading Files, Scraping the Web, Using APIs (Example: Using the Twitter APIs), Cleaning and Munging, Manipulating Data, Rescaling, Dimensionality Reduction

3. Mathematical Foundations

(12 Hours)

- 3.1 Linear Algebra: Vectors, Matrices,
- 3.2 Statistics: Describing a Single Set of Data, Correlation, Simpson's Paradox, Correlation and Causation
- 3.3 Probability: Dependence and Independence, Conditional Probability, Bayes's Theorem, Random Variables, Continuous Distributions, The Normal Distribution, The Central Limit Theorem
- 3.4 Hypothesis and Inference: Statistical Hypothesis Testing, Confidence Intervals, P-hacking, Bayesian Inference

4. Machine Learning

(16 Hours)

Overview of Machine learning concepts – Over fitting and train/test splits, Types of Machine learning – Supervised, Unsupervised, Reinforced learning, Introduction to Bayes Theorem, Linear Regression- model assumptions, regularization (lasso, ridge, elastic net), Classification and Regression algorithms- Naïve Bayes, K-Nearest Neighbors, logistic regression, support vector machines (SVM), decision trees, and random forest, Classification Errors, Analysis of Time Series- Linear Systems Analysis, Nonlinear Dynamics, Rule Induction, Neural Networks- Learning And Generalization, Overview of Deep Learning.

5. Case Studies of Data Science Application

(6 Hours)

Weather forecasting, Stock market prediction, Object recognition, Real Time Sentiment Analysis.

LIST OF PRACTICALS

1. Write a programme in Python to predict the class of the flower based on available attributes.
2. Write a programme in Python to predict if a loan will get approved or not.
3. Write a programme in Python to predict the traffic on a new mode of transport.
4. Write a programme in Python to predict the class of user.
5. Write a programme in Python to indentify the tweets which are hate tweets and which are not.
6. Write a programme in Python to predict the age of the actors.
7. Mini project to predict the time taken to solve a problem given the current status of the user.

LIST OF SUGGESTED BOOKS

1. Joel Grus, "Data Science from Scratch: First Principles with Python", O'Reilly Media
2. Aurélien Géron, "Hands-On Machine Learning with Scikit-Learn and Tensor Flow: Concepts, Tools, and Techniques to Build Intelligent Systems", 1st Edition, O'Reilly Media
3. Jain V.K., "Data Sciences", Khanna Publishing House, Delhi.
4. Jain V.K., "Big Data and Hadoop", Khanna Publishing House, Delhi.
5. Jeeva Jose, "Machine Learning", Khanna Publishing House, Delhi.
6. Chopra Rajiv, "Machine Learning", Khanna Publishing House, Delhi.
7. Ian Goodfellow, Yoshua Bengio and Aaron Courville, "Deep Learning", MIT Press
<http://www.deeplearningbook.org>
8. Jiawei Han and Jian Pei, "Data Mining Concepts and Techniques", Third Edition, Morgan Kaufmann Publishers

Code	CYBER SECURITY	L	T	P	Credits
		3	-	2	4

PRE-REQUISITES

- Basic knowledge of Computers
- Basic knowledge of networking and Internet
- Hands on Windows operating system

OBJECTIVES

The course has been designed to give students an extensive overview of cyber security issues, tools and techniques that are critical in solving problems in cyber security domains. The course aims at providing students with concepts of computer security, cryptography, digital money, secure protocols, detection and other security techniques. The course will help students to gauge understanding in essential techniques in protecting Information Systems, IT infrastructure, analysing and monitoring potential threats and attacks, devising security architecture and implementing security solutions. The students will also have a wider perspective to information security from national security perspective from both technology and legal perspective.

LEARNING OUTCOMES

After completion of this course, the students should be able to:

- Understand, appreciate, employ, design and implement appropriate security technologies and policies to protect computers and digital information.
- Identify & Evaluate Information Security threats and vulnerabilities in Information Systems and apply security measures to real time scenarios
- Identify common trade-offs and compromises that are made in the design and development process of Information Systems
- Demonstrate the use of standards and cyber laws to enhance information security in the development process and infrastructure protection

DETAIL CONTENTS

1. Cyber Security Concepts

(2 Hours)

Essential Terminologies: CIA, Risks, Breaches, Threats, Attacks, Exploits. Information Gathering (Social Engineering, Foot Printing & Scanning).

Open Source/ Free/ Trial Tools: nmap, zenmap, Port Scanners, Network scanners.

2. Cryptography and Cryptanalysis (4 Hours)

Introduction to Cryptography, Symmetric key Cryptography, Asymmetric key Cryptography, Message Authentication, Digital Signatures, Applications of Cryptography. Overview of Firewalls- Types of Firewalls, User Management, VPN Security, Security Protocols: - security at the Application Layer- PGP and S/MIME, Security at Transport Layer- SSL and TLS, Security at Network Layer-IPSec.

Open Source/ Free/ Trial Tools: Implementation of Cryptographic techniques, OpenSSL, Hash Values Calculations MD5, SHA1, SHA256, SHA 512, Steganography (Stools)

3. Infrastructure and Network Security (6 Hours)

Introduction to System Security, Server Security, OS Security, Physical Security, Introduction to Networks, Network packet Sniffing, Network Design Simulation. DOS/ DDOS attacks. Asset Management and Audits, Vulnerabilities and Attacks. Intrusion detection and Prevention Techniques, Host based Intrusion prevention Systems, Security Information Management, Network Session Analysis, System Integrity Validation.

Open Source/ Free/ Trial Tools: DOS Attacks, DDOS attacks, Wireshark, Cain & abel, iptables/ Windows Firewall, snort, suricata, fail2ban

4. Cyber Security Vulnerabilities& Safe Guards (8 Hours)

Internet Security, Cloud Computing &Security, Social Network sites security, Cyber Security Vulnerabilities-Overview, vulnerabilities in software, System administration, Complex Network Architectures, Open Access to Organizational Data, Weak Authentication, Authorization, Unprotected Broadband communications, Poor Cyber Security Awareness. Cyber Security Safeguards- Overview, Access control, IT Audit, Authentication. Open Web Application Security Project (OWASP), Web Site Audit and Vulnerabilities assessment.

Open Source/ Free/ Trial Tools: WinAudit, Zap proxy (OWASP), burp suite, DVWA kit.

5. Malware (8 Hours)

Explanation of Malware, Types of Malware: Virus, Worms, Trojans, Rootkits, Robots, Adware's, Spywares, Ransom wares, Zombies etc., OS Hardening (Process Management, Memory Management, Task Management, Windows Registry/ services another configuration), Malware Analysis.

Open Source/ Free/ Trial Tools: Antivirus Protection, Anti Spywares, System tuning tools, Anti Phishing.

6. Security in Evolving Technology (8 Hours)

Biometrics, Mobile Computing and Hardening on android and ios, IOT Security, Web server configuration and Security. Introduction, Basic security for HTTP Applications and Services, Basic Security for Web Services like SOAP, REST etc., Identity Management and Web Services, Authorization Patterns, Security Considerations, Challenges.

Open Source/ Free/ Trial Tools: adb for android, xcode for ios, Implementation of REST/ SOAP web services and Security implementations.

7. Cyber Laws and Forensics (9 Hours)

Introduction, Cyber Security Regulations, Roles of International Law, the state and Private Sector in Cyberspace, Cyber Security Standards. The INDIAN Cyberspace, National Cyber Security Policy 2013. Introduction to Cyber Forensics, Need of Cyber Forensics, Cyber Evidence, Documentation and Management of Crime Scene, Image Capturing and its importance, Partial Volume Image, Web Attack Investigations, Denial of Service Investigations, Internet Crime Investigations, Internet Forensics, Steps for Investigating Internet Crime, Email Crime Investigations.

Open Source/ Free/ Trial Tools: Case Studies related to Cyber Law, Common Forensic Tools like dd, md5sum, sha1sum, Ram dump analysis, USB device

LIST OF PRACTICALS

1. Implementation to gather information from any PC's connected to the LAN using whois, port scanners, network scanning, Angry IP scanners etc.

2. Implementation of Symmetric and Asymmetric cryptography.
3. Implementation of Steganography.
4. Implementation of MITM- attack using wireshark/ network sniffers
5. Implementation of Windows security using firewall and other tools
6. Implementation to identify web vulnerabilities, using OWASP project
7. Implementation of IT Audit, malware analysis and Vulnerability assessment and generate the report.
8. Implementation of OS hardening and RAM dump analysis to collect the Artifacts and other information's.
9. Implementation of Mobile Audit and generate the report of the existing Artifacts.
10. Implementation of Cyber Forensics tools for Disk Imaging, Data acquisition, Data extraction and Data Analysis and recovery.

LIST OF SUGGESTED BOOKS

1. William Stallings, "Cryptography and Network Security", Pearson Education/PHI, 2006.
2. V.K. Jain, "Cryptography and Network Security", Khanna Publishing House.
3. Gupta Sarika, "Information and Cyber Security", Khanna Publishing House, Delhi.
4. Atul Kahate, "Cryptography and Network Security", McGraw Hill.
5. V.K. Pachghare, "Cryptography and Information Security", PHI Learning
6. Nina Godbole, "Information System Security", Wiley
7. Bothra Harsh, "Hacking", Khanna Publishing House, Delhi.

Reference Websites :

<http://www.ignou.ac.in/upload/Announcement/programmedetails.pdf>

Code	3D PRINTING AND DESIGN	L	T	P	Credits
		3	-	2	4

PRE-REQUISITES

- Computer Aided Design
- Engineering Materials

OBJECTIVES

The course is designed to impart knowledge and skills related to 3D printing technologies, selection of material and equipment and develop a product using this technique in Industry 4.0 environment.

LEARNING OUTCOMES

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

- Develop CAD models for 3D printing.
- Import and Export CAD data and generate .stl file.
- Select a specific material for the given application.
- Select a 3D printing process for an application.
- Produce a product using 3D Printing or Additive Manufacturing (AM).

DETAIL CONTENTS

1. 3D Printing (Additive Manufacturing) (3 Hours)

Introduction, Process, Classification, Advantages, Additive V/s Conventional Manufacturing processes, Applications.

2. CAD for Additive Manufacturing (4 Hours)

CAD Data formats, Data translation, Data loss, STL format.

3. Additive Manufacturing Techniques (12 Hours)

- 3.1 Stereo- Lithography, LOM, FDM, SLS, SLM, Binder Jet technology.

- 3.2 Process, Process parameter, Process Selection for various applications.
- 3.3 Additive Manufacturing Application Domains: Aerospace, Electronics, Health Care, Defence, Automotive, Construction, Food Processing, Machine Tools

- 4. Materials (8 Hours)
 - 4.1 Polymers, Metals, Non-Metals, Ceramics
 - 4.2 Various forms of raw material- Liquid, Solid, Wire, Powder; Powder Preparation and their desired properties, Polymers and their properties.
 - 4.3 Support Materials

- 5. Additive Manufacturing Equipment (10 Hours)
 - 5.1 Process Equipment- Design and process parameters
 - 5.2 Governing Bonding Mechanism
 - 5.3 Common faults and troubleshooting
 - 5.4 Process Design

- 6. Post Processing: Requirement and Techniques (4 Hours)

- 7. Product Quality (4 Hours)
 - 7.1 Inspection and testing
 - 7.2 Defects and their causes

LIST OF PRACTICALS

1. 3D Modelling of a single component.
2. Assembly of CAD modelled Components
3. Exercise on CAD Data Exchange.
4. Generation of .stl files.
5. Identification of a product for Additive Manufacturing and its AM process plan.
6. Printing of identified product on an available AM machine.
7. Post processing of additively manufactured product.
8. Inspection and defect analysis of the additively manufactured product.
9. Comparison of Additively manufactured product with conventional manufactured counterpart.

LIST OF SUGGESTED BOOKS

1. Lan Gibson, David W. Rosen and Brent Stucker, “Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing”, Springer, 2010.
2. Andreas Gebhardt, “Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing”, Hanser Publisher, 2011.
3. Khanna Editorial, “3D Printing and Design”, Khanna Publishing House, Delhi.
4. CK Chua, Kah Fai Leong, “3D Printing and Rapid Prototyping- Principles and Applications”, World Scientific, 2017.
5. J.D. Majumdar and I. Manna, “Laser-Assisted Fabrication of Materials”, Springer Series in Material Science, 2013.
6. L. Lu, J. Fuh and Y.S. Wong, “Laser-Induced Materials and Processes for Rapid Prototyping”, Kulwer Academic Press, 2001.
7. Zhiqiang Fan And Frank Liou, “Numerical Modelling of the Additive Manufacturing (AM) Processes of Titanium Alloy”, InTech, 2012.

Code	VIRTUAL REALITY	L	T	P	Credits
		3	-	2	4

PRE-REQUISITE

- Fundamentals of C++

OBJECTIVES

The objective of this course is to provide a detailed understanding of the concepts of Virtual Reality and its applications.

LEARNING OUTCOMES

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

- Understand geometric modelling and Virtual environment.
- Study about Virtual Hardware and Software
- Develop Virtual Reality applications.

DETAIL CONTENTS

1. Introduction to Virtual Reality (6 hours)

Virtual Reality and Virtual Environment: Introduction, Computer graphics, Real time computer graphics, Flight Simulation, Virtual environment requirement, benefits of virtual reality, Historical development of VR, Scientific Landmark

3D Computer Graphics: Introduction, The Virtual world space, positioning the virtual observer, the perspective projection, human vision, stereo perspective projection, 3D clipping, Colour theory, Simple 3D modelling, Illumination models, Reflection models, Shading algorithms, Radiosity, Hidden Surface Removal, Realism-Stereographic image.

2. Geometric Modelling (12 hours)

Geometric Modelling: Introduction, From 2D to 3D, 3D space curves, 3D boundary representation

Geometrical Transformations: Introduction, Frames of reference, Modelling transformations, Instances, Picking, Flying, Scaling the VE, Collision detection

Generic VR system: Introduction, Virtual environment, Computer environment, VR technology, Model of interaction, VR Systems.

3. Virtual Environment (10 hours)

Animating the Virtual Environment: Introduction, The dynamics of numbers, Linear and Non-linear interpolation, the animation of objects, linear and non-linear translation, shape & object inbetweening, free from deformation, particle system.

Physical Simulation: Introduction, Objects falling in a gravitational field, Rotating wheels, Elastic collisions, projectiles, simple pendulum, springs, Flight dynamics of an aircraft.

4. VR Hardware and Software (10 hours)

Human factors: Introduction, the eye, the ear, the somatic senses.

VR Hardware: Introduction, sensor hardware, Head-coupled displays, Acoustic hardware, Integrated VR systems.

VR Software: Introduction, Modelling virtual world, Physical simulation, VR toolkits, Introduction to VRML

5. VR Applications (7 hours)

Introduction, Engineering, Entertainment, Science, Training.

The Future: Virtual environment, modes of interaction

LIST OF PRACTICALS

1. Developing architecture of a house using Virtual Reality.
2. Perform CRO based experiment using Virtual Reality.
3. Undertaking qualitative analysis in Chemistry using Virtual Reality.
4. Carry out assembly/disassembly of an engine using Virtual Reality.
5. Explore human anatomy using Virtual Reality.
6. Simulation of circulation of blood in heart.
7. Simulation of Fight/Vehicle/Space Station.
8. Building Electronic circuit using Virtual Reality, given basic electronic components.
9. Developing concept of Virtual class room with multiplayer.

LIST OF SUGGESTED TEXT BOOKS

1. John Vince, “Virtual Reality Systems “, Pearson Education Asia, 2007.
2. Anand R., “Augmented and Virtual Reality”, Khanna Publishing House, Delhi.
3. Adams, “Visualizations of Virtual Reality”, Tata McGraw Hill, 2000.
4. Grigore C. Burdea, Philippe Coiffet , “Virtual Reality Technology”, Wiley Inter Science, 2nd Edition, 2006.
5. William R. Sherman, Alan B. Craig, “Understanding Virtual Reality: Interface, Application and Design”, Morgan Kaufmann, 2008.
6. www.vresources.org
7. www.vrac.iastate.edu
8. www.w3.org/Markup/VRM

MEET OUR TEAM

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