# AICTE PG Certificate Programme on Internet-of-things Curriculum

| Course code | Course Name | Credits | Resources |
|---|---|---|---|
| **IOT101** | **Introduction to computing** | **3-0-0:3** | **Physical and Hybrid mode** |
| **IOT102** | **Introduction to Internet of Things** | **2-1-1:4** | **Physical and Hybrid mode &NPTEL course** |
| **IOT103** | **Data Science for Engineers** | **2-1-1:4** | **Physical and Hybrid mode &NPTEL course** |
| **IOT104** | **Advanced Internet of Things** | **3-0-0:3** | **Physical and Hybrid mode** |
| **IOT 105** | **Project** | **4-0-0:4** | **Project** |

| Course Title | Course Code | Credits |
|---|---|---|
| **Introduction to computing** | **IOT 101** | **(3-0-0:3)** |

Course Objective: The aim of offering this course is to become proficient in Python programming fundamentals

The course will introduce learners to Python programming fundamentals, Data representation, Problem-Solving, Computational Thinking, Programming, and manipulation.

Course Outcomes: At the end of the course, the student will be able to:

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| CO1 | Define the basic components of a computer system and interpret commands to compile and execute basic Python programs on a collaborative platform. |
| CO2 | Understanding programming principles, including syntax, coding conventions, style, and best practices, and building programming skills to solve small-scale problems using Python libraries. |
| CO3 | Apply acquired knowledge to visualize data and solve real-world data analysis problems effectively. |

**Course Content**

| Si.No | Topic details | Mode of Execution |
|---|---|---|
| | Basic Python Programming | |
| 1 | Introduction to computer systems, hardware, application versus system software, information storing and retrieval | Hybrid or Physical mode |
| 2 | Binary numbers, memory components, files, peripheral devices, basic architecture of CPU, operating systems, high-level versus machine-level instructions,<br>overview of compiler, linker, loader, interpreter, etc. | Hybrid or Physical mode |
| 3 | Introduction to flowcharts and algorithms, some basic instructions, practice of developing flowcharts for problem-solving | Hybrid or Physical mode |
| 4 | Introduction to Google Colab, basic structure of a Python program, compiling and execution | Hybrid or Physical mode |
| 5 | Introduction to variables, reading input from the user, performing basic arithmetic instructions | Hybrid or Physical mode |
| 6 | Basic datatypes in Python, operations with different data types, exercises | Hybrid or Physical mode |
| 7 | Decision making and boolean logic: evaluation of boolean expressions, use of if-else, nested if-else, introduction loops | Hybrid or Physical mode |
| 8 | Revisit flowcharts for iteration, while loop, for loop, nested loops with related exercises | Hybrid or Physical mode |
| 9 | Meet sequences: strings, lists, and tuples | Hybrid or Physical mode |
| 10 | Manipulating lists and tuples: finding the length, min, max, sort, sum, etc., using library functions | Hybrid or Physical mode |
| 11 | Introduction to the dictionary and managing them through different operations | Hybrid or Physical mode |
| 12 | Define, create, and manage sets, and different operations on sets like union, intersection, freeze, aggregation, etc. | Hybrid or Physical mode |
| 13 | Definition and calling of functions, passing arguments to functions, local versus global variables, lambda functions | Hybrid or Physical mode |
| 14 | Functions contd.: keyword arguments, variable length arguments, return of values from functions, related exercises | Hybrid or Physical mode |
| 15 | Introduction to object-oriented programming, defining Python class, objects, use of inheritance | Hybrid or Physical mode |
| | Data representation, visualization and manipulation | |

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| 16 | Introduction to numpy libraries: The numpy ndarray, Data types, Array operations, indexing, slicing. | Hybrid or Physical mode |
| 17 | Pseudorandom number generation, mathematical and statistical methods, linear algebra operations. | Hybrid or Physical mode |
| 18 | File input and output with arrays | Hybrid or Physical mode |
| 19 | Introduction to pandas data structures-series and Dataframe | Hybrid or Physical mode |
| 20 | Essential functionality- indexing, selection-loc, and iloc, and filtering, dropping | Hybrid or Physical mode |
| 22 | Summarizing and computing descriptive statistics, unique values, value counts, and membership | Hybrid or Physical mode |
| 23 | Data loading, storage, and file formats. reading and writing data in text format (in brief) | Hybrid or Physical mode |
| 24 | Data cleaning and preparation: handling missing data, filtering missing data, and filling in missing data | Hybrid or Physical mode |
| 25 | Data transformation- removing duplicates, transforming data using a function or mapping, replacing values, and renaming axes | Hybrid or Physical mode |
| 26 | Discretization and binning, string functions in pandas | Hybrid or Physical mode |
| 27 | Categorical extension type in pandas | Hybrid or Physical mode |
| 28 | Data Wrangling: join, combine, and reshape | Hybrid or Physical mode |
| 29 | Data visualization: matplotlib introduction | Hybrid or Physical mode |
| 30 | Graphical representation and statistical plotting of data (scatter plots, line plots, bar charts, pie charts, box plots, density plots, histograms) | Hybrid or Physical mode |
| | Computational thinking and Problem-solving | Hybrid or Physical mode |
| 31-33 | Case study 1 (3 hours): Take a real-world problem, translate to a computational problem, draw a flowchart, develop an algorithm, optimize the algorithm, write a Python Program | Hybrid or Physical mode |
| 34-36 | Case study 2 (3 hours): Applying Pandas to real-world datasets, Exploratory Data Analysis (EDA), Solving common data analysis problems (titanic and bike sales datasets). | Hybrid or Physical mode |
| 37-39 | Case study 3 (3 hours): Take a real-world dataset and apply preprocessing and some supervised machine learning techniques using various libraries for predictive analysis | Hybrid or Physical mode |
| 40 | Open session, doubt clearing, feedback, additional topics | Hybrid or Physical mode |

**Assessment Process: As per AICTE Guidelines**
**50% based on a minimum of 2 quizzes (30-45 min each. class assignments (30), assignment and project submissions End- Semester Examination (50%): pen-and-paper based examination**

**Textbook & Reference Books:**


1. Allen B. Downey, "Think Python: How to Think Like a Computer Scientist", 2nd edition, Updated for Python 3, Shroff/O'Reilly Publishers, 2016
2. Guido van Rossum and Fred L. Drake Jr, "An Introduction to Python – Revised and updated for Python 3.2, Network Theory Ltd., 2011.
3. Charles Dierbach, "Introduction to Computer Science using Python: A Computational Problem-Solving Focus, Wiley India Edition, 2013.
4. John V Guttag, "Introduction to Computation and Programming Using Python", Revised and expanded Edition, MIT Press, 2013.

5. Kenneth A. Lambert, “Fundamentals of Python: First Programs”, CENGAGE Learning, 2012.
6. Paul Gries, Jennifer Campbell and Jason Montojo, “Practical Programming: An Introduction to Computer Science using Python 3”, Second edition, Pragmatic Programmers, LLC, 2013.
7. Robert Sedgewick, Kevin Wayne, Robert Dondero, “Introduction to Programming in Python: An Inter-disciplinary Approach, Pearson India Education Services Pvt. Ltd., 2016.
8. Timothy A. Budd, “Exploring Python”, Mc-Graw Hill Education (India) Private Ltd.,, 2015
9. Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython, by William McKinney
10. **online resources: https://nptel.ac.in/courses/106106145**

| Course Title | Course Code | Credits |
|---|---|---|
| **Introduction to IOT** | **IOT 102** | **(2-1-1:4)** |

Course Objective: The aim of offering this course is to become proficient in designing IoT systems

The course will introduce a basic understanding of embedded systems with communication and interface protocols for different sensors and actuators.

Course Outcomes: At the end of the course, the student will be able to:

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| CO1 | Design an IoT system with Raspberry Pi |
| CO2 | Design and interfacing various sensors and monitors through the cloud |
| CO3 | Understand and design various communication protocols and IoT Network Access Technologies |

**Course Content**

| Si.No | Topic details | |
|---|---|---|
| 1-3 | Introduction and understanding of IoT and Embedded Systems, IoT Technology and Application, Components and Features of IoT,, Configuration of IoT Platforms, | Physical mode of teaching |
| 2-4 | Introduction and understanding of IoT and Embedded Systems, IoT Technology and Application, | Physical mode of teaching |
| 5 | Components and Features of IoT,, Configuration of IoT Platforms, | Physical mode of teaching |
| 6-7 | IoT Sensing and Actuation, Protocols of sensor interfaces, Predecessors of IoT, Emergence of IoT | Physical mode of teaching |
| 7-8 | Demonstration of IoT with an Application | Physical mode of teaching |
| 8-9 | Hands-on IoT with an Application | Physical mode of teaching |
| 10-15 | Basic circuit and Raspberry Pi configuration, interacting with sensors and actuators, and programming with Raspberry Pi using Python. Design of system on Board applications.Concepts of RTOS, Node MCU | Physical mode of teaching |
| 16-17 | Basics of Raspberry Pi | Hybrid Mode of Teaching |
| 17-18 | Installing the Raspian and configuring the Raspberry Pi | Hybrid Mode of Teaching |
| 19 | Basics of Electronics Circuit, Components and connection Electronics Circuit wuth Audrino | Hybrid Mode of Teaching |
| 20 | Basics of Raspberry Pi | Hybrid Mode of Teaching |
| 21 | Characteristics and Types of Sensors, Interfacing of Sensors | Hybrid Mode of Teaching |

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| 22 | Characteristics and Types of Actuators | Hybrid Mode of Teaching |
| 23 | Interfacing of Actuators | Hybrid Mode of Teaching |
| 24-32 | Understanding IoT Network Access Technologies and protocols: WiFi, Zigbee, Zwave, Bluetooth, UWB, sub1GHz, LoRaWAN, NB-IoT, Topology and Security of IEEE 802.15.4, 802.15.4g, 802.15.4e, 1901.2a, 802.11ah and LoRaWAN, IoT application level protocols: MQTT, CoAP, XMPP, HTTP/Rest Services, WebSockets, -Socket Programming, Socket Programming Tutorial with Raspberry Pi User Raspberry Pi as DB Server, Node.js for IoT | Hybrid Mode of Teaching |
| 33-40 | 1. Raspberry Pi/Node MCU Configuration and GPIO Interfacing | |
| | 2. Raspberry Pi/Node MCU with Sensor Hub (I2C, SPI, UART) Interfacing and monitoring | |
| | 3. Raspberry Pi/Node MCU with Actuators Hub (Motors, Relay) Interfacing and Display through LCD, LED Display | |
| | 4. Raspberry Pi/Node MCU with Sensor and Actuator interfacing with Bluetooth and Android Application Development with Bylink | |
| | 5. Raspberry Pi/ Node MCU with Wifi interface and monitoring of sensors and actuators through Thing speak | |
| | 6. Implementation of MQTT and Node js in IoT Applications | |
| | 7. Design Experiment based on literature | |
| **Assessment Process: As per AICTE Guidelines**<br>**50% based on a minimum of 2 quizzes (30-45 min each. class assignments (30), assignment and project submissions End- Semester Examination (50%): pen-and-paper based examination** | | |
| | **Textbook & Reference Books:**<br>1. S. Misra, A. Mukherjee, and A. Roy, 2020. Introduction to IoT. Cambridge University Press.2022<br>2. Vijay Madisetti, Arshdeep Bahga, Adrian McEwen, Hakim Cassimally “Internet of Things: A Hands-on-Approach” Arshdeep Bahga & Vijay Madisetti, 2014<br>3. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, ―IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things, Cisco Press, 2017 | |

| Course Title | Course Code | Credits |
|---|---|---|
| **Data Science for Engineers** | **IOT 103** | **(3-1-0:4)** |

Course Objective: The aim of offering this course is to become a proficient data scientist and practitioner.

The course will introduce learners to the data scientist toolkit and the underlying core concepts. It will cover the full technical pipeline from data collection to processing, basic notions of statistical analysis, and data visualization techniques. By taking this course the students will be provided with the basic toolkit to work with data (CSV, R, Google Refine). To support these learning outcomes, the course will include exercises and a group project in which students will use existing open data sets and build their application

Course Outcomes: At the end of the course the student will be able to:

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| CO1 | Apply statistical methods to data for inferences. |
| CO2 | Analyze data using classification, Graphics, and computational methods. |
| CO3 | Understand Data Wrangling Approaches. |
| CO4 | Perform descriptive analytics over massive data. |
| CO5 | Demonstrate key concepts in Data Science, including tools, approaches, and application scenarios |
| CO6 | Describe a flow process for data science problems |

**Course Content**

| Si.No | Topic details | Mode of Execution |
|---|---|---|
| 1 | Introduction to Data Science. Structure and life cycle of Data Science project, Managing Data Analysis, Question types, characteristics of good questions, Overview of data science experiment | Hybrid Mode of Teaching |
| 2 | Exploratory Data Analysis | Hybrid Mode of Teaching |
| 3 | Statistical learning, Assessing Model Accuracy, Descriptive statistics, Dependent and independent events. (3 hours) | Hybrid Mode of Teaching |
| 4 | Data interpretation and use (visualization techniques, pitfalls, D3).<br>Data integration (fundamentals of Linked Data, Google Refine) | Hybrid Mode of Teaching |
| 5 | Graphical Analysis: Histograms and frequency polygons, box plots, Quartiles, Scatter Plots, Heat Maps | Hybrid Mode of Teaching |
| 6 | Sparse matrices and Interpolation by divided differences | Hybrid Mode of Teaching |
| 7 | Data Wrangling: Data Acquisition, Data Formats, Imputation, The split-apply-combine paradigm | Hybrid Mode of Teaching |
| 8 | Descriptive Analytics: Data Warehousing and OLAP, Data Summarization, Data de-duplication, Data Visualization using CUBEs and In-memory data analytics and Analytic functions in SQL. | Hybrid Mode of Teaching |
| 9 | Course Philosophy and Introduction to R | NPTEL |
| 10 | Linear algebra for data science | NPTEL |
| 11 | Algebraic view - vectors, matrices, a product of matrix & vector, rank, null space, solution of an overdetermined set of equations, and pseudo-inverse). Geometric view - vectors, distance, projections, eigenvalue decomposition | NPTEL |

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| 12 | Statistics (descriptive statistics, notion of probability, distributions, mean, variance, covariance, covariance matrix, understanding univariate and multivariate normal distributions, introduction to hypothesis testing, confidence interval for estimates) | NPTEL |
| 13 | Optimization and Typology of data science problems and a solution framework | NPTEL |
| 14 | Simple linear regression and verifying assumptions used in linear regression Multivariate linear regression, model assessment, assessing importance of different variables, subset selection | NPTEL |
| 15 | Classification using logistic regression. Classification using kNN and k-means clustering | NPTEL |
| **Assessment Process: As per AICTE Guidelines**<br>**50% based on a minimum of 2 quizzes (30-45 min each), assignments, and project Submissions. NPTEL Assignments (25), Quiz tests using Pickers (10); Laboratory Assessment (15), End-Semester Examination (50%).** | | |
| | **Textbook & Reference Books**<br>1. Data Science and Big Data Analytics, EMC Education Services, EMC2, Wiley Publication, 2015.<br>2. Foundation of Data Science, John Hopcroft and Ravindran Kannan, draft copy, 2013.<br>3. An Introduction to Statistical Learning with Applications in R, Gareth James Daniela Witten Trevor Hastie, Robert Tibshirani, February 11, 2013, web link: www.statlearning.com<br>4. Beginning R The Statistical Programming Language, Mark Gardener, Wiley, 2015.<br>5. Data Science for Engineers: NPTEL Videos - | |

Note: All students are required to use Moodle for accessing content and assignments related to theory as well as laboratory courses.

| Course Title | Course Code | Credits |
|---|---|---|
| **Advanced IoT Systems:** | **IOT 104** | **(3-0-0:3)** |

Course Objective: The aim of offering this course is to introduce the key IoT technologies from IoT devices programming, wireless network design and optimization, edge-cloud IoT platforms, deep/machine learning, as well as security and privacy-preserving mechanism

The course will introduce learners.

Course Outcomes: At the end of the course, the student will be able to:

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| CO1 | Understand the networking and cloud security essentials. |
| CO2 | Develop Cloud and Web services in the IoT platform |
| CO3 | Develop analytics and Machine learning on IoT |

**Course Content**

| Sino | Topic details | Mode of Execution |
|---|---|---|
| 1-4 | Basics of Networking, Network Security, | Hybrid Mode of Teaching |
| 5-8 | Cloud Computing, IoT Architectures and Cloud Computing basics, terminology, characteristics, services, Secure Communication and Cloud Security, Sensor-Cloud Fog Computing | Hybrid Mode of Teaching |
| 9-14 | Cloud deployment –public, and private environments, delivery models – IaaS, PaaS, and SaaS. | Hybrid Mode of Teaching |
| 15-18 | An open-source cloud: OpenStack, A commercial cloud: Amazon web services (AWS) and IBM Watson services. | Hybrid Mode of Teaching |
| 19-22 | Container Management, e.g., Docker, Platform Services for IOT Applications, | Hybrid Mode of Teaching |
| 23-28 | Introduction to Fog Computing and Its Applications, IoT Platform Data Visualization IoT Open Platform Mobius Installation Operation, OpenHAB Data Visualization | Hybrid Mode of Teaching |
| 29-32 | Introduction to SDN, SDN for IoT, Data Handling and Analytics | PhysicalMode of Teaching |
| 33-38 | Agricultural IoT, Vehicular IoT, Smart Grid, Industrial IoT, Industrial IoT Healthcare IoT Data Analytics and Applications of IoT case study. Machine learning, Selected Algorithms in ML, Performance Metrics for Evaluating ML Algorithms | Physical mode of Teaching |

**Assessment Process: As per AICTE Guidelines**
**Internal Assessment (50%): take-away and in-class assignments (30), quizzes (20), End- Semester Examination (50%): pen-and-paper based examination**

**Textbook & Reference Books**


1. S. Misra, A. Mukherjee, and A. Roy, 2020. Introduction to IoT. Cambridge University Press.2022
2. Gian Marco Iodice, TinyML Cookbook: Combine artificial intelligence and ultra-low- power embedded devices to make the world smarter
3. Idoko, J.B., Abiyev, R. (2023). Introduction to Machine Learning and IoT. In: Idoko, J.B., Abiyev, R. (eds) Machine Learning and the Internet of Things in Education. Studies in Computational Intelligence, vol 1115. Springer, Cham. https://doi.org/10.1007/978-3-031-42924-8_1
4. Nath, Shyam, Robert Stackowiak, and Carla Romano. Architecting the Industrial Internet. Packt Publishing Ltd, 2017.

| Course Title | Course Code | Credits |
|---|---|---|
| **Project** | **IOT 105** | **(4-0-0:4)** |
| Course Objective: The objective of the project is to perform a real-time project based on studied courses | | |
| **Assessment Process: As per AICTE Guidelines** | | |