

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:			
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, 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			

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: <ol style="list-style-type: none"> 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 Montoyo, “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:			
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

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 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: <ol style="list-style-type: none"> 1. S. Misra, A. Mukherjee, and A. Roy, 2020. Introduction to IoT. Cambridge University Press.2022 2. Vijay Madisetti, Arshdeep Bahga, Adrian McEwen, Hakim Cassimally “Internet of Things: A Hands-on-Approach” Arshdeep Bahga & Vijay Madisetti, 2014 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:			
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). 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

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 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 <ol style="list-style-type: none"> 1. Data Science and Big Data Analytics, EMC Education Services, EMC2, Wiley Publication, 2015. 2. Foundation of Data Science, John Hopcroft and Ravindran Kannan, draft copy, 2013. 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 4. Beginning R The Statistical Programming Language, Mark Gardener, Wiley, 2015. 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:			
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		PhysicalMod e 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		