

University of Mumbai



No. AAMS_UGS/ICC/2023-24/67

Sub: B.E. (Internet of Things) (Sem – V & VI).

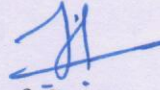
CIRCULAR:-

Attention of the Principals of the Affiliated Colleges and Directors of the Recognized Institutions in Faculty of Science & Technology is invited to this office Circular No. AAMS (UG)/116 of 2022-23 dated 20th October, 2022 relating to the B.E. (Internet of Things) (Sem – V & VI) (CBCS) (REV- 2019 'C' Scheme).

They are hereby informed that the recommendations made by the Board of Deans at its meeting held on 27th October, 2023 vide item No. 6.7 (N) have been accepted by the Academic Council at its meeting held on 01st November, 2023 vide item No. 6.7 (N) and that in accordance therewith, syllabus of **B.E. ((Internet of Things) (Sem – VII & VIII) (CBCS) (REV- 2019 'C' Scheme)** is introduced and the same has been brought into force with effect from the academic year 2023-24.

(The said circular is available on the University's website www.mu.ac.in).

MUMBAI – 400 032
24th November, 2023


(Prof. Sunil Bhirud)
I/c. REGISTRAR

To,

The Principals of the Affiliated Colleges and Directors of the Recognized Institutions in Faculty of Science & Technology.

A.C/6.7(N) /01/11/2023

Copy forwarded with Compliments for information to:-

- 1) The Chairman, Board of Deans,
- 2) The Dean, Faculty of Science & Technology,
- 3) The Chairman, Board of Studies,
- 4) The Director, Board of Examinations and Evaluation,
- 5) The Director, Department of Students Development,
- 6) The Director, Department of Information & Communication Technology,
- 7) The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari,
- 8) The Co-ordinator, MKCL.

Copy for information and necessary action :-

1. The Deputy Registrar, College Affiliations & Development Department (CAD),
2. College Teachers Approval Unit (CTA),
3. The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Department (AEM),
4. The Deputy Registrar, Academic Appointments & Quality Assurance (AAQA)
5. The Deputy Registrar, Research Administration & Promotion Cell (RAPC),
6. The Deputy Registrar, Executive Authorities Section (EA)
He is requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to the above circular.
7. The Deputy Registrar, PRO, Fort, (Publication Section),
8. The Deputy Registrar, Special Cell,
9. The Deputy Registrar, Fort Administration Department (FAD) Record Section,
10. The Deputy Registrar, Vidyanagari Administration Department (VAD),

Copy for information :-

1. The Director, Dept. of Information and Communication Technology (DICT), Vidyanagari,
He is requested to upload the Circular University Website
2. The Director of Department of Student Development (DSD),
3. The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari,
4. All Deputy Registrar, Examination House,
5. The Deputy Registrars, Finance & Accounts Section,
6. The Assistant Registrar, Administrative sub-Campus Thane,
7. The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan,
8. The Assistant Registrar, Ratnagiri sub-centre, Ratnagiri,
9. P.A to Hon'ble Vice-Chancellor,
10. P.A to Pro-Vice-Chancellor,
11. P.A to Registrar,
12. P.A to All Deans of all Faculties,
13. P.A to Finance & Account Officers, (F & A.O),
14. P.A to Director, Board of Examinations and Evaluation,
15. P.A to Director, Innovation, Incubation and Linkages,
16. P.A to Director, Department of Lifelong Learning and Extension (DLLE),
17. The Receptionist,
18. The Telephone Operator,

Copy with compliments for information to :-

19. The Secretary, MUASA
20. The Secretary, BUCTU.

University of Mumbai



Syllabus for B.E. (Internet of Things) Semester – VII & VIII

Choice Based Credit System

REV- 2019 'C' Scheme

(With effect from the academic year 2023-24)

University of Mumbai



Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of the Course	B.E. (Internet of Things)
2	Eligibility for Admission	After Passing Third Year Engineering as per the Ordinance 0.6243
3	Passing Marks	40%
4	Ordinances / Regulations (if any)	Ordinance 0.6243
5	No. of Years / Semesters	4 Years/ 8 semesters
6	Level	Under Graduation
7	Pattern	Semester
8	Status	New REV-2019 'C' Scheme
9	To be implemented from Academic Year	With effect from Academic Year: 2023-2024

Offg. Associate Dean
Faculty of Science and Technology

Offg. Dean
Faculty of Science and Technology

Preamble

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Science and Technology (in particular Engineering) of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty resolved that course objectives and course outcomes are to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. Choice based Credit and grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. Credit assignment for courses is based on 15 weeks teaching learning process, however content of courses is to be taught in 13 weeks and remaining 2 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

There was a concern that the earlier revised curriculum more focused on providing information and knowledge across various domains of the said program, which led to heavily loading of students in terms of direct contact hours. In this regard, faculty of science and technology resolved that to minimize the burden of contact hours, total credits of entire program will be of 170, wherein focus is not only on providing knowledge but also on building skills, attitude and self learning. Therefore in the present curriculum skill based laboratories and mini projects are made mandatory across all disciplines of engineering in second and third year of programs, which will definitely facilitate self learning of students. The overall credits and approach of curriculum proposed in the present revision is in line with AICTE model curriculum.

The present curriculum will be implemented for Second Year of Engineering from the academic year 2021-22. Subsequently this will be carried forward for Third Year and Final Year Engineering in the academic years 2022-23, 2023-24, respectively.

Incorporation and Implementation of Online Contents **from NPTEL/ Swayam Platform**

The curriculum revision is mainly focused on knowledge component, skill based activities and project based activities. Self-learning opportunities are provided to learners. In the revision process this time in particular Revised syllabus of 'C' scheme wherever possible additional resource links of platforms such as NPTEL, Swayam are appropriately provided. In an earlier revision of curriculum in the year 2012 and 2016 in Revised scheme 'A' and 'B' respectively, efforts were made to use online contents more appropriately as additional learning materials to enhance learning of students.

In the current revision based on the recommendation of AICTE model curriculum overall credits are reduced to 171, to provide opportunity of self-learning to learner. Learners are now getting sufficient time for self-learning either through online courses or additional projects for enhancing their knowledge and skill sets.

The Principals/ HoD's/ Faculties of all the institute are required to motivate and encourage learners to use additional online resources available on platforms such as NPTEL/ Swayam. Learners can be advised to take up online courses, on successful completion they are required to submit certification for the same. This will definitely help learners to facilitate their enhanced learning based on their interest.

Preface by Board of Studies Team

It is our honor and a privilege to present the Rev-2019 'C' scheme syllabus of the Bachelor of Engineering in the Internet of Thing - IoT(effective from the year 2021-22). AICTE has introduced IoT as one of the nine emerging technology and hence many colleges affiliated with the University of Mumbai has started four years UG program for IoT. As part of the policy decision from the University end, the Board of IT got an opportunity to work on designing the syllabus for this new branch. As the Internet of Things is comparatively a young branch among other emerging engineering disciplines in the University of Mumbai, and hence while designing the syllabus promotion of an interdisciplinary approach has been considered.

The branch also provides multi-faceted scope like better placement and promotion of entrepreneurship culture among students and increased Industry Institute Interactions. Industries' views are considered as stakeholders while the design of the syllabus. As per Industry views only 16 % of graduates are directly employable. One of the reasons is a syllabus that is not in line with the latest emerging technologies. Our team of faculties has tried to include all the latest emerging technologies in the Internet of Thing syllabus. Also the first time we are giving skill-based labs and Mini-project to students from the third semester onwards, which will help students to work on the latest Internet of Thing technologies. Also the first time we are giving the choice of elective from fifth semester such that students will be mastered in one of the Internet of Thing domain. The syllabus is peer-reviewed by experts from reputed industries and as per their suggestions, it covers future emerging trends in Internet of Thing technology and research opportunities available due to these trends. .

We would like to thank senior faculties of IT, Computer and Electronics Department, of all colleges affiliated to University of Mumbai for significant contribution in framing the syllabus. Also on behalf of all faculties we thank all the industry experts for their valuable feedback and suggestions. We sincerely hope that the revised syllabus will help all graduate engineers to face the future challenges in the field of Emerging Areas of Internet of Thing.

Program Specific Outcome for graduate Program in Internet of Thing

1. Apply Core Internet of Thing knowledge to develop stable and secure Internet of Things Application.
2. Identify, Design, Internet of Thing infrastructures for an enterprise using concepts and best Practices in the area Internet of Thing Domain.
3. Ability to work in multidisciplinary projects and make it Internet of Thing enabled Applications.

Program Structure for Fourth Year Engineering Semester VII & VIII

UNIVERSITY OF MUMBAI

(With Effect from 2023-24)

Semester VII

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned				
		Theory		Pract. Tut.	Theory		Pract.	Total	
IOTC701	Machine Learning & IoT	3		--	3		--	3	
IOTC702	Edge and Fog Computing	3		--	3			3	
IOTDO701X	Department Optional Course – 3	3		--	3		--	3	
IOTDO702X	Department Optional Course –4	3		--	3		--	3	
IOTIO701X	Institute Optional Course – 1	3		--	3		--	3	
IOTL701	ML & IoT Lab	--		2	--		1	1	
IOTL702	Edge and Fog Computing Lab	--		2	--		1	1	
IOTL703	DeVOPs Lab	--		2	--		1	1	
IOTL704	Linux administration Lab	--		2	--		1	1	
IOTP701	Major Project I	--		6#	--		3	3	
Total		15		14	15		7	22	
Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Prac/oral	Total
		Internal Assessment			End Sem Exam	Exam. Duration (in Hrs)			
		Test1	Test2	Avg					
IOTC701	Machine Learning & IoT	20	20	20	80	3	--	--	100
IOTC702	Fog Computing	20	20	20	80	3	--	--	100
IOTDO701X	Department Optional Course –3	20	20	20	80	3	--	--	100
IOTDO702X	Department Optional Course –4	20	20	20	80	3	--	--	100

IOTIO701X	Institute Optional Course – 1	20	20	20	80	3	--	--	100
IOTL701	ML & IoT Lab	--	--	--	--	--	25	25	50
IOTL702	Edge and Fog Computing Lab	--	--	--	--	--	25	25	50
IOTL703	DeVOPs Lab	--	--	--	--	--	25	25	50
IOTL704	Linux administration Lab	--	--	--	--	--	25	25	50
IOTP701	Major Project I	--	--	--	--	--	25	25	50
Total		--	--	100	400	--	125	125	750

indicates work load of Learner (Not Faculty), for Major Project

IOTDO701X	Department Optional Course –3
IOTDO7011	IoT for Healthcare Application
IOTDO7012	Wearable Computing & IoE
IOTDO7013	Privacy & Security
IOTDO7014	IoT for Smart Cities

IOTDO702X	Department Optional Course –4
IOTDO7021	SDN & NFV for IoT
IOTDO7022	Blockchain for IoT
IOTDO7023	Enterprise IoT Cyber Security
IOTDO7024	Software Engineering & Testing Methodology for IoT

Institute Level Optional Course (ILO)

Every student is required to take one Institute Elective Course for Semester VII, which is not closely allied to their disciplines. Different sets of courses will run in the both the semesters.

ILO701X	Institute Optional Course – 1 (Common for all branches will be notified)
ILO7011	Product Lifecycle Management
ILO7012	Reliability Engineering
ILO7013	Management Information System
ILO7014	Design of Experiments
ILO7015	Operation Research
ILO7016	Cyber Security and Laws
ILO7017	Disaster Management and Mitigation Measures
ILO7018	Energy Audit and Management
ILO7019	Development Engineering

Program Structure for Fourth Year Engineering Semester VII & VIII
UNIVERSITY OF MUMBAI
(With Effect from 2023-24)

Semester VIII

Course Code	Course Name	Teaching Scheme (Contact Hours)					Credits Assigned		
		Theory		Pract. Tut.	Theory		Pract.	Total	
IOTC801	Industrial IoT	3		--		3	--	3	
IOTDO801X	Department Optional Course – 5	3		--		3	--	3	
IOTDO802X	Department Optional Course – 6	3		--		3	--	3	
IOTIO801X	Institute Optional Course – 2	3		--		3	--	3	
IOTL801	IoT Automation Lab	--	2		--	1		1	
IOTL802	Cyber Security Lab	--	2		--	1		1	
IOTP801	Major Project II	--	12#		--	6		6	
Total		12	16		12	8		20	
Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Prac /oral	Total
		Internal Assessment			End Sem Exam	Exam. Duration (in Hrs)			
		Test1	Test2	Avg					
IOTC801	Industrial IoT	20	20	20	80	3	--	--	100
IOTDO801X	Department Optional Course – 5	20	20	20	80	3	--	--	100
IOTDO802X	Department Optional Course – 6	20	20	20	80	3	--	--	100
IOTIO801X	Institute Optional Course – 2	20	20	20	80	3	--	--	100
IOTL801	IoT Automation Lab	--	--	--	--	--	25	25	50
IOTL802	Cyber Security Lab	--	--	--	--	--	25	25	50
IOTP801	Major Project II	--	--	--	--	--	100	50	150
Total		--	--	80	320	--	150	100	650

indicates work load of Learner (Not Faculty), for Major Project

Students group and load of faculty per week.

Mini Project 1 and 2 :

Students can form groups with minimum 2 (Two) and not more than 4 (Four) Faculty Load : 1 hour per week per four groups

Major Project 1 and 2 :

Students can form groups with minimum 2 (Two) and not more than 4 (Four) Faculty Load : In Semester VII – ½ hour per week per project group
In Semester VIII – 1 hour per week per project group

IOTDO801X	Department Optional Course – 5
IOTDO8011	User Interface Design for IoT
IOTDO8012	Energy Harvesting and Power Management for IoT Devices
IOTDO8013	Information Retrieval System
IOTDO8014	Next Generation IoT

IOTDO802X	Department Optional Course –6
IOTDO8021	Business Process Management Cognitive IoT
IOTDO8022	RESTful Design for IoT Systems
IOTDO8023	Green IT
IOTDO8024	IoT for Smart Grids

Institute Level Optional Course (ILO)

Every student is required to take one Institute Elective Course for Semester VIII, which is not closely allied to their disciplines. Different sets of courses will run in the both the semesters.

ILO801X	Institute Optional Course – 2 (Common for all branches will be notified)
ILO8011	Project Management
ILO8012	Finance Management
ILO8013	Entrepreneurship Development and Management
ILO8014	Human Resource Management
ILO8015	Professional Ethics and CSR
ILO8016	Research Methodology
ILO8017	IPR and Patenting
ILO8018	Digital Business Management
ILO8019	Environmental Management

Subject Code	Subject Name	Theor y	Practical	Tutorial	Theory	Oral	Tutorial	Total
IOTC701	Machine learning and IoT	03	--	--	03	--	--	03

Subject Code	Subject Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		Test 1	Test 2	Avg. of 2 Tests					
IOTC701	Machine learning and IoT	20	20	20	80	--	--	--	100

Prerequisite: Engineering Mathematics, Data Structures, Algorithms

Course Objectives: The main objective of this course is to introduce the students to the basics of Machine Learning Concepts applicable with the Internet of Things.

- 1 To introduce the basic concepts and techniques of Machine Learning and Deep Learning.
- 2 To learn and understand Machine learning and Deep Learning methods for IoT applications
- 3 To be able to apply various Machine Learning techniques for combining Machine learning models.
- 4 To get acquainted with machine learning for IOT Data Analysis.
- 5 To design IoT applications using Machine Learning and Deep Learning methods.
- 6 To understand the social impact and benefits of IOT applications.

Course Outcomes: After the successful completion of course , learner should able to-

Sr. No.	Course Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		
1	To understand the fundamentals of Machine learning and IoT.	L2
2.	To acquire fundamental knowledge of developing Machine learning models.	L2
3.	To apply an appropriate Machine learning model for the IoT data.	L3
4.	To evaluate Machine learning techniques to combine predictions from different models.	L5
5.	To demonstrate various IoT applications using Machine learning and Deep learning techniques using IoT data analysis.	L3
6.	To comprehend the benefits of IoT and Machine learning for society.	L4

Module	Content	Hrs	Co mapping
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1		Introduction to Machine Learning and IoT	06	CO1
	1.1	Machine Learning, Types of Machine Learning, Issues in Machine Learning, Application of Machine Learning, Steps in developing a Machine Learning Application.		
	1.2	Introduction of IoT: Definition and characteristics of IoT, Technical Building blocks of IoT, Device, Communication Technologies, Data, Physical design of IoT, IoT enabling technologies, IoT Issues and Challenges- Planning, Costs and Quality, Security and Privacy, Risks		
	1.3	Introduction to Advanced ML - Deep Learning, Reinforcement Learning Self Learning topics: AI and IoT		
2		Learning with Regression and Trees	06	CO2
	2.1	Learning with Regression: Linear Regression, Multivariate Linear Regression, Logistic Regression.		
	2.2	Learning with Trees: Decision Trees, Constructing Decision Trees using Gini Index (Regression), Classification and Regression Trees (CART)		
	2.3	Performance Metrics: Confusion Matrix, [Kappa Statistics], Sensitivity, Specificity, Precision, Recall, F-measure, ROC curve Self Learning topic : Implementation of all above techniques		
3		Learning with Classification	07	CO3
	3.1	Support Vector Machine : Constrained Optimization, Optimal decision boundary, Margins and support vectors, SVM as constrained optimization problem, Quadratic Programming, SVM for linear and nonlinear classification, Basics of Kernel trick.		
4		Machine learning (ML) methods for IoT Application	08	CO4
	4.1	Support Vector Machines (SVMs), Bayesian theorem-based algorithms, kNearest neighbour (KNN), Random forest (RF), Association Rule (AR) algorithms, Ensemble learning (EL), k-Means clustering, Principal component analysis (PCA)		
5		Deep learning (DL) methods for IoT Applications	07	CO5
		Convolutional neural networks (CNNs), Recurrent neural networks (RNNs), Deep autoencoders (AEs), Restricted Boltzmann machines (RBMs), Deep belief networks (DBNs), Generative adversarial networks (GANs), Ensemble of DL networks (EDLNs) Self learning topic : NNFL and NP with IoT		
6		Applications of ML and IOT	05	CO6
		Case Studies: IOT for Agriculture, Remote Patient Monitoring, Smart City, Smart Transportation, IOT Security using ML. etc.		
		Total	39	

Text Books

1. Peter Harrington, —Machine Learning n Action||, DreamTech Press
2. Ethem Alpaydm, —Introduction to Machine Learning||, MIT Press
3. Tom M. Mitchell, —Machine Learning|| McGraw Hill

4. Stephen Marsland, —Machine Learning An Algorithmic Perspective, CRC Press
- 5 : Neeraj Kumar, Aaisha Makkar, “ MACHINE LEARNING IN COGNITIVE IOT”, <https://www.routledge.com/Machine-Learning-in-Cognitive-IoT/KumarMakkar/p/book/9780367359164> ISBN 9780367359164 Published June 1, 2020 by CRC Press

Reference Books

1. Puneet Mathur, “ IoT Machine Learning Applications in Telecom, Energy, and Agriculture, With Raspberry Pi and Arduino Using Python”, ISBN 978-1-4842-5549-0
2. Nicolas Modrzyk, “ Real-Time IoT Imaging with Deep Neural Networks - Using Java on the Raspberry Pi 4” , Apress Publication , Year: 2020, ISBN: 9781484257210, 978148425722
3. Han Kamber, —Data Mining Concepts and Techniques, Morgan Kaufmann Publishers
4. Margaret. H. Dunham, —Data Mining Introductory and Advanced Topics, Pearson Education
5. Kevin P. Murphy , Machine Learning — A Probabilistic Perspective
6. Samir Roy and Chakraborty, —Introduction to soft computing, Pearson Edition. 5 Richard Duda, Peter Hart, David G. Stork, —Pattern Classification, Second Edition, Wiley Publications.

Useful Digital Links

- 1 Data sets for Machine Learning algorithms:
[tps://www.kaggle.com/datasets](https://www.kaggle.com/datasets)
- 2 Machine Learning repository- <https://archive.ics.uci.edu/ml/index.php>
- 3 Machine Learning from Coursera
- 4 <https://towardsdatascience.com/machine-learning/home>
- 5 https://onlinecourses.nptel.ac.in/noc21_cs85/preview

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.
- **Question paper format:**
- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**.
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules).
- A total of **four questions** need to be answered.

Course Code	Course Name	Theory	Practical	Tutorial	Theory	Oral	Tutorial	Total
IoTCSBC702	Edge and Fog Computing	03	--	--	03	--	--	03

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		Test1	Test 2	Avg. of 2 Tests					
IoTCSBC702	Edge and Fog Computing	20	20	20	80	--	--	--	100

Course Objectives:

Sr. No.	Course Objectives:
The course aims:	
1	Understand the fundamentals of edge computing and its role in IoT systems.
2	Analyze and compare different edge computing architectures, platforms and frameworks.
3	Analyze and evaluate data processing at the edge and Edge analytics.
4	Understand the fundamentals of fog computing and its frameworks.
5	Demonstrate effective communication and collaboration skills in developing edge computing projects.

Course Outcomes:

Sr. No.	Course Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		
1	Understand the basic concepts of Edge Computing and its collaboration with Cloud Computing.	L2

2	Understand and identify edge computing architecture and various platforms and frameworks and Demonstrate knowledge of virtualization and containerization	L3
3	To apply data processing capabilities along with edge analytics and caching to process and extract insights from data at the edge	L3
4	To understand the fundamentals of Fog computing and its architecture.	L3
5	To develop programming for fog computing-based applications and frameworks.	L4
6	To develop edge computing solutions for specific IoT use cases or scenarios.	L6

Prerequisite: Linear algebra, Probability theory and Basic statistics

Sr. No.	Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic concepts of Cloud Computing and virtualization	02	--
I	Introduction to Edge Computing and IoT	Understanding Edge Computing: Evolution, Use cases, advantages, disadvantages, Overview of edge computing and its significance in IoT, Challenges and opportunities in edge computing. Self-Learning Topics: Edge devices and their capabilities	07	CO1
II	Edge Computing Infrastructure	Edge computing architectures and components: Requirements and views for Edge architecture, Edge Computing Reference Architecture, critical elements for Edge architecture, Challenges for Edge application Development. Setting up Edge computing environments: development tools, python libraries. Edge computing platforms and frameworks: AWS IoT Greengrass, Azure IoT Edge, Google Cloud IoT Edge, IBM Edge Application Manager, KubeEdge. Virtualization and containerization for edge computing: Introduction to Virtualization and containerization. Advantages of Virtualization and Containerization in Edge Computing. Resource Efficiency, Faster Time to Market. Self-Learning Topics: Apache Edgent, Eclipse ioFog.	09	CO2

III	Data Processing at the Edge	Data Acquisition and Processing: Data handling, python data handling, data storage and cloud connectivity, Data Aggregation, Data Timestamping and Synchronization, Data Security and Privacy. Edge analytics and machine learning at the edge: Introduction to Edge Analytics. Edge Machine Learning. Model Selection and Optimization. Collaborative Edge Learning. Resource management and task offloading strategies: Task Offloading, Edge-Cloud Collaboration, Dynamic Resource Provisioning. Edge caching and data synchronization: Introduction to Edge caching and data synchronization, Benefits of Edge Caching and Data Synchronization, Challenges in Edge Caching and Data Synchronization. Self-Learning Topics: Task Migration, Offline Operation, Bandwidth Optimization.	07	CO3
IV	Introduction to Fog Computing	Definition and basic concepts, Comparison with cloud computing and IoT, Data Management in Fog Computing. Comparison with cloud computing and edge computing. Fog Computing Architecture. Fog node and infrastructure components. Hierarchical and distributed models. Programming Models and Tools for Fog Computing Self-Learning Topics: Applications and integration of Fog Computing.	06	CO4
V	Fog computing programming languages and frameworks	Middleware and software platforms. Development and deployment considerations. Industrial Internet of Things (IIoT). Performance Evaluation and Metrics in Fog Computing. Simulation and modelling techniques. Applications and Use Cases of Fog Computing Self-Learning Topics: Development environments and Frameworks for programming in Fog Computing.	06	CO5
VI	Applications and Case Studies	High-Potential Use cases, Edge computing for smart cities. Industrial IoT and edge computing. Edge computing in Healthcare.	03	CO6

Text Books:

1. "Fog and Edge Computing" by Rajkumar Buyya, Satish Narayana Srirama, Wiley Publications
2. "Edge Computing: Models, Technologies, and Applications" by Mung Chiang, Bharath Balasubramanian, and H. Vincent Poor.
3. Edge Computing with Python: End-to-end Edge Applications, Python Tools and Techniques, Edge Architectures, and AI Benefit" by Abhinandan Bhadauria, BPB publications.
4. "Edge Computing: Simply in Depth" by Ajit Singh,

5. Edge Computing: Fundamentals, Advances and Applications (Advances in Industry 4.0 and Machine Learning) by K. Anitha Kumari, G. Sudha Sadasivam, D. Dharani, M. Niranjanamurthy, CRC Press.

References:

1. "Edge Computing for IoT: Architectures and Applications" by Bharat Bhargava, Sudip Misra, Valentina E. Balas, and Raghvendra Kumar
2. "Practical Industrial Internet of Things Security: A practitioner's guide to securing connected industries" by Sravani Bhattacharjee and Rajdeep Chowdhury
3. "Edge Computing: An Introduction to the Next Generation of Networked Systems" by Kiran Chitturi, Bharadwaj Veeravalli, and Satish Narayana Srirama
4. "Building the Web of Things: With examples in Node.js and Raspberry Pi" by Dominique D. Guinard and Vlad M. Trifa
5. "Internet of Things (IoT): Technologies, Applications, Challenges, and Solutions" edited by Balamuralidhar P., Bharadwaj Veeravalli, and V. Raghu
6. "Fog and Edge Computing: Principles and Paradigms" by Rajkumar Buyya, Satish Srirama, and Pradeep Kumar S.
7. "IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things" by David Hanes and Gonzalo Salgueiro
8. "Edge Analytics in IoT" by Shivashankar B. Nair, Siddhartha Bhattacharyya, and Thomas Edward Joshua
9. "Edge Computing: The Convergence of Big Data and Internet of Things" by Samee U. Khan, Albert Y. Zomaya, and Salman A. Baset

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

Question paper format

- Question Paper will comprise of a total of **six questions each carrying 20 marks**. Q.1 will be **compulsory** and should **cover maximum contents of the syllabus**.
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** needs to be answered.

Course code		Theory	Practical	Tutorial	Theory	Practical /Oral	Tutorial	Total
IOTDO701 1	IoT for Healthcare Application	03	--	--	03	--	--	03

Subject Code	Subject Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		Test 1	Test 2	Avg. of 2 Tests					
IOTDO701 1	IoT for Healthcare Application	20	20	20	80	--	--	--	100

Course Objectives: Six Course Objectives

1. To introduce basics of IoT in healthcare
2. To understand the IoT enabling technologies
3. To study various IoT in healthcare systems
4. To study various IoT supported medical products
5. To get familiarized with various security issues in healthcare IoT and the technologies used to overcome them
6. To learn various case studies for IoT in health care

Course Outcomes:

Sr. No.	Course Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		
1	To describe basics of IoT in healthcare	L1
2.	To describe the IoT enabling technologies	L2
3.	To analyze various IoT enabled healthcare systems	L3
4.	To compare various IoT supported medical products	L4
5.	To identify various security issues in healthcare IoT and the technologies to overcome them	L1
6.	To evaluate various case studies for IoT in healthcare	L4

Prerequisite: IoT Architecture, Protocols and Networking technologies, Wireless networks security, Basics of AI

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	CO Mapping
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0	Prerequisite	IoT Architecture, Protocols and Networking technologies, Wireless networks security, Basics of AI	2	-
I	Introduction	Challenges in healthcare, Classification of IoT applications in healthcare, Components of healthcare IoT, Advantages and Risks	4	CO1
II	Enabling IoT Technologies for Healthcare	Sensors for Healthcare, WBAN, Cloud and Fog Computing, Blockchain technology, AI for healthcare, Physically Unclonable Function (PUF) Devices, SDN for IoT in healthcare	8	CO2
III	IoT systems in Healthcare	Ambient Assisted Living, Wearable devices, Community-Based Healthcare Services, Cognitive Computing, Glucose Level Monitoring, Oxygen Saturation Monitoring, Asthma Monitoring, Mood Monitoring, Blood Pressure Monitoring, Medication Management, Wheelchair Management, Rehabilitation System, Telemedicine, Chronic Disease Detection and Prevention, Home and elderly healthcare	8	CO3
IV	IoT supported Medical Products	Best IoT applications in healthcare, Must-Have Apps for Healthcare Professionals, IoT Applications in the Connected Healthcare Space	6	CO4
V	IoT Security for Medical Sector	IoT security concerns, Key security issues, Security architecture in IoT, Security Issues of IoT in Medical Sector, Blockchain basics, Blockchain based security mechanisms for IoT systems in healthcare	6	CO5
VI	Case studies	PUF-based Authentication for E-healthcare, SDN Enabled E-healthcare, Blockchain Assisted Patient-Centric System, Wearable IoT enabled real time health monitoring system	5	CO6

Text Books:

1. Sudip Misra, Anandarup Mukherjee, Arijit Roy, Introduction to IoT, Cambridge University Press

References:

1. IoT and Cloud Computing-Based Healthcare Information Systems, Edited by - Anand Sharma, Hiren Kumar Deva Sarma, S. R. Biradar, CRC Press
2. Intelligent IoT Systems in Personalized Health Care, Edited by - Arun Kumar Sangaiah, Subhas Mukhopadhyay, Elsevier
3. IoT and ICT for Healthcare Applications (EAI/Springer Innovations in Communication and Computing) Edited by Nishu Gupta, Sara Paiva, 1st ed. 2020 Edition

Online References:

1. <https://www.techscience.com/csse/v35n6/40719>
2. <https://www.tandfonline.com/doi/full/10.1080/02564602.2021.1927863>
3. <https://www.hindawi.com/journals/jhe/2021/6632599/>
4. <https://easternpeak.com/blog/internet-of-medical-things-applications-in-healthcare/>
5. <https://connecteam.com/apps-for-healthcare-professionals/>
6. <https://screencloud.com/blog/healthcare/iot-applications-healthcare-space>
7. https://www.researchgate.net/publication/337910674_Security_Issues_of_Internet_of_Things_in_Health-Care_Sector_An_Analytical_Approach

8. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9003194/>
9. <https://www.tandfonline.com/doi/full/10.1080/02564602.2021.1927863>
10. https://www.researchgate.net/publication/329868510_Wearable_IoT_enabled_real-time_health_monitoring_system

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.
- **Question paper format:**
- Question Paper will comprise of a total of **six questions each carrying 20 marks** Q.1 will be **compulsory** and should **cover maximum contents of the syllabus**.
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules).
- A total of **four questions** need to be answered.

Subject Code	Subject Name	Theory	Practical	Tutorial	Theory	Oral	Tutorial	Total
IOTDO7012	Wearable Computing and IOE	03	--	--	03	--	--	03

Subject Code	Subject Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		Test 1	Test 2	Avg. of 2 Tests					
IOTDO7012	Wearable Computing and IOE	20	20	20	80	--	--	--	100

Course Objectives:

The course aims to,

1. Provide a basic understanding of evolution of IoE and its functional modules.
2. Understand advanced and emerging technologies in wearable computing.
3. Learn how to use software programs to perform varying and complex tasks.
4. Expand upon the knowledge learned and apply it to solve real world problems.

Course Outcomes:

On successful completion of the course students will be able to,

Sr. No.	Course Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		
1	To understands the basics of IoE	L1
2.	To Identify various wearable sensors and connecting technologies	L1
3.	To Design and develop IoE based wearable devices	L3
4.	To analyze wearable computing architecture for IoE devices	L3
5.	To analyze security and ethical issues related to Wearable devices	L3
6.	To identify the real world problem and provide IoE solutions through wearable technology.	L4

Prerequisite:

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Microcontroller and Embedded Systems, networking, wireless Technologies	02	-
I	Internet of Everything	What is IoE, How it is different than IoT, Industrial IoT, Industry 4.0	03	CO1
II	Introduction To Wearable Technologies	Fundamentals of Wearable Technologies, History of wearable Technologies, User Experience Design for IoE, Social Aspects of Wearability, Internet of Everything – Applications, Wearable Chemical and Biochemical Sensors, Technology of Connected Devices (ZigBee, Wi-fi, RFID, etc.)	07	CO2
III	Design consideration for Wearable Computing	Energy Expenditure and Energy Harvesting, Technology of Connected Devices, Energy Considerations, Flexible Electronics and Textiles for Wearable Technologies, Nano devices	06	CO2
IV	Wearable Computing Architecture	Wearable Algorithms, Web of Things, Architecture Standardization, Data Mining for Body Sensor Network, Embedded Device UX Design, Electronic Health Records	08	CO3
V	Security and Ethical Issues in wearable devices	Security challenges and privacy, vulnerability analysis, Security attacks on wearable systems, secure algorithms, Ethical issues	07	CO5
VI	Wearable Computing Case Studies	Wearable Sensors for Monitoring of Physical and Physiological Changes and for Early Detection of Diseases - Wearable and Non-Invasive Assistive Technologies. Real time applications of Wearable Technologies such as Medical Applications, Banking application etc.	06	CO6

Text Books:

1. Giacomo Veneri, Antonio Capasso - Hands-On Industrial Internet of Things_ Create a powerful Industrial IoT infrastructure using Industry 4.0-Packt Publishing (2018)
2. “Wearable Sensors” by Edward Sazonov Released August 2014 Publisher(s): Academic Press, O’Reilly Publication
3. “Fundamentals of IoT and Wearable Technology Design”, Haider Raad, ISBN:9781119617532 |Online ISBN:9781119617570 |DOI:10.1002/9781119617570

Reference Books:

1. “Internet of Things”, Hands-on-Approach, Harshdeep Bahga, Vijay Madiseti, University Press

Online References:

1. Wearables-a-new-opportunity-in-banking – Cisco
2. <https://codereality.net/wearable-computing/>
3. Mohd Javaid, Abid Haleem, Ravi Pratap Singh, Shanay Rab, Rajiv Suman, Internet of Behaviors (IoB) and its role in customer services, Sensors International, Volume 2, 2021, 100122, ISSN 2666-3511, <https://doi.org/10.1016/j.sintl.2021.100122>

MOOC Courses:

1. <https://www.mooc-list.com/tags/wearable-technology>

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.
- **Question paper format:**
- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**.
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules).
- A total of **four questions** need to be answered.

Subject Code	Subject Name	Theory	Practical	Tutorial	Theory	Practical/Oral	Tutorial	Total
IOTDO7013	Privacy & Security	03	--	--	03	--	--	03

Subject Code	Subject Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		Test1	Test 2	Avg. of 2 Tests					
IOTDO7013	Privacy & Security	20	20	20	80	--	--	--	100

Course Objectives:

1. To learn the fundamentals of the Internet of things and its applications.
2. To learn and illustrate the various Threats and Attacks associated with IOT.
3. To emphasis on the concept of Cryptographic Fundamentals for IoT.
4. To provide and maintain Trust and Authentication for IoT devices.
5. To discuss and learn various application areas of IOT in ensuring privacy of data.
6. To understand the concept of Cloud Security for IoT.

Course Outcomes:

On successful completion, of course, learner/student will be able to:

Sr. No.	Course Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		
1	Understand the fundamentals of the Internet of things and its applications.	L2
2.	Illustrate the various Threats and Attacks associated with IoT.	L3
3.	To Apply the concept of Cryptographic Fundamentals for IoT.	L3
4.	To Analyze Trust and Authentication for IoT devices.	L3
5.	Understand the various application areas of IoT in ensuring privacy of data.	L2
6.	To Analyze the concept of Cloud Security for IoT.	L3

Prerequisite:

Computer Networks, Basics of Cryptography, Operating Systems

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic concepts of Computer Network, Operating System	02	
I	Introduction: Security the Internet of Things	Security Requirements in IoT Architecture: Security in Enabling Technologies, Security Concerns in IoT Applications. Security Architecture in the Internet of Things: Security Requirements in IoT, Insufficient Authentication/Authorization, Insecure Access Control, Threats to Access Control, Privacy and Availability: Attacks Specific to IoT, The secure IoT system implementation lifecycle.	06	CO1
II	Threats and Attacks	Phases of IoT System, Internet of Things as Interconnections of Threats (IoT vs. IoT), Phase attacks, Attacks as per architecture: Wormhole Attack, Sinkhole Attack, Replay Attack, IP Spoof Attack, Centrality Attacks, Network Resilience, and Topological Defense Scheme, Sybil Attacks, Malware Schemes in IoT	07	CO2
III	Cryptographic Fundamentals for IoT	Cryptography and its role in securing the IoT , Types and uses of the cryptographic primitives in the IoT: Encryption and decryption, Hashing , Digital signatures, Random number generation, Cryptographic module principles , Cryptographic key management fundamentals	07	CO3
IV	Trust and Authentication	Trust and trust models for the IoT: Trust and security from a device perspective, Secure key storage, Trust and security from a network perspective, Trust Model Concepts, Preventing Unauthorized access to sensor data: Cooperative authentication, Cooperation incentive, Conflict balancing, Authentication in IoT- Fundament of Authentication	07	CO4
V	Privacy Preservation for IOT – Case Studies and Applications	Network model, Threat Model, Overview of a Smart Building Concept, Privacy Threats in Smart Buildings, Privacy-Preserving Approaches in Smart Buildings, Smart Meter Privacy-Preserving Approaches.	06	CO5
VI	Cloud Security for IoT	Cloud services and the IoT:, Cloud IoT security controls:, Tailoring an enterprise IoT cloud security architecture.	04	CO6

Text Books:

1. Shancang Li, Li Da “Securing the Internet of Things”, Syngress; 1st edition 2017.
2. Fei HU, “Security and Privacy in Internet of Things (IoTs): Models, Algorithms, and Implementations”, CRC Press Taylor and Francis Group ,2016
3. Russell, Brian and Drew Van Duren, “Practical Internet of Things Security”, PACKT Publishing, 2016.

References:

1. Brij B. Gupta, Aakanksha Tewari “A Beginner’s Guide to Internet of Things Security: Attacks, Applications, Authentication and Fundamentals”, CRC Press Taylor and Francis Group, 2020.
2. Ollie Whitehouse, “Security of Things: An Implementers’ Guide to Cyber-Security for Internet of Things Devices and Beyond”, NCC Group, 2014.
3. Tim Mather, Subra Kumaraswamy, and Shahed Latif ,” Cloud Security and Privacy”, Published by O’Reilly Media, 2009.

Online References:

1. <https://www.nptel.ac.in>
2. <https://swayam.gov.in>
3. <https://www.coursera.org/>

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.
- **Question paper format:**
- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**.
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules).
- A total of **four questions** need to be answered.

Subject Code	Subject Name	Theory	Practical	Tutorial	Theory	Practical /Oral	Tutorial	Total
IOTDO7014	IoT for Smart Cities	03	--	--	03	--	--	03

Subject Code	Subject Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		Test 1	Test 2	Avg. of 2 Tests					
IOTDO7014	IoT for Smart Cities	20	20	20	80	--	--	--	100

Course Objectives:

1. Understand the concept and significance of smart cities, and the various components and characteristics that define them.
2. Explore the transformation of conventional cities into smart cities, and the parameters used to measure their level of "smartness".
3. Understand the collaboration between drones and the Internet of Things (IoT) in smart cities, and the implications for privacy, security, energy efficiency, and public safety.
4. Develop an understanding of the system architecture design principles for IoT-based smart cities, including domain analysis, reference architecture design, and deployment view.
5. Examine the development of Smart Seoul, including its infrastructure, government/municipal-developed services, citizen-developed services, and smart city standardization.
6. Analyze real-world case studies of smart city applications in the areas of parking, weather monitoring, forest fire detection, and air pollution monitoring.

Course Outcomes:

After the course students will be able to

Sr. No.	Course Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		
1	Define the concept of smart cities and explain their importance in the modern world.	L1, L2
2.	Identify and describe the parameters used to measure the smartness of cities.	L2,L3
3.	Propose energy-efficient solutions using drones and IoT in smart cities.	L3,L4
4.	Evaluate the effectiveness of different architectural approaches for IoT-based smart cities.	L2,L3
5.	Generate ideas for innovative applications and solutions to improve smart city infrastructure and services based on the case study of Smart Seoul.	L1,L2
6.	Critically assess the impact and potential risks associated with the implementation of smart city solutions in various domains.	L2,L3

Prerequisites:

IoT Architecture and Protocols, RFID and Microcontrollers, Wireless Sensor Technologies

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	IoT architecture, protocols, design stages, applications.		
I	Introduction to smart cities	Introduction, Characteristics of Smart Cities, Smart Economy, Smart People Smart Governance Smart Mobility, Smart Environment, Smart Living. IoT-Based Solutions for Smart Cities , Smart Grid,Smart Home, Transport and Traffic Management,Smart Healthcare Challenges Ahead,Planning , Costs and Quality,Security and Privacy, Risks.	3	CO1
II	Journey from Conventional Cities to Smart Cities	Types of cities, Background of smart cities, Artificial intelligence for smart cities, Smart cities indexed parameters, Economy, Human capital, International outreach, Mobility and transport, Environment, Technology, Urban planning,Governance, Social cohesion, Infrastructure.	5	CO2
III	Collaborative drone and IoT for improving the	Overview of the collaboration between drones and the IoT, privacy and security issues, energy efficiency, data	5	CO3

	smartness of smart cities.	collection in smart cities, improving life quality, public safety in smart cities, disaster management.		
IV	System Architecture Design of IoT-Based Smart Cities	Domain Analysis, Reference Architecture Design, Architecture Framework and Viewpoint Selection, Decomposition View, Layered View, Deployment View. Case Study of Smart EV Charging.	8	CO4
V	Case study: Smart Cities Seoul	Smart Seoul, Smart Seoul Infrastructure, Government/Municipal-developed Services, Citizen-developed Services, NFC-based Mobile Payment, Virtual Store, Smart City Standardization. Artificial Intelligence Techniques for Smart City Applications : Machine Learning Algorithms for Smart Monitoring, Supervised Machine Learning Algorithms for Smart Monitoring, Unsupervised and Hybrid Machine Learning Algorithms for Smart Monitoring	7	CO5
VI	Case study on smart city applications	Smart Parking, Weather monitoring, Forest fire detection, Air pollution monitoring.	8	CO6

Text Books:

1. Internet of Things for Smart Cities: Technologies, Big Data and Security, WaleedEjaz, AlaganAnpalagan, Springer briefs in electrical and computer engineering
2. Smart Cities and Construction Technologies, Edited by Sara Shirowzhan and Kefeng Zhang, Intech open, Published in London, United Kingdom
3. Bahga, A. and Madiseti, V. (2015) Internet of Things: A Hands-On Approach., Universities Press.

References:

1. Green Internet of Things for Smart Cities, Concepts, Implications, and Challenges, Edited By Surjeet Dalal, Vivek Jaglan, Dac-Nhuong Le, CRC Press, 2021
2. Smart Cities: The Internet of Things, People and Systems, Schahram Dustdar , Stefan Nastić , Ognjen Šćekić, Springer, 2017.
3. IoT for Sustainable Smart Cities and Society, Edited By Joel J. P. C. Rodrigues, Parul Agarwal, Kavita Khanna, Springer, 2022.

Online References:

1. Survey on Collaborative Smart Drones and Internet of Things for Improving Smartness of Smart Cities, IEEE, <https://ieeexplore.ieee.org/document/8795473>

2. System Architecture Design of IoT-Based Smart Cities, MDPI, <https://www.mdpi.com/2076-3417/13/7/4173>
3. Smart Cities Seoul, International Telecommunication Union, https://www.itu.int/dms_pub/itu-t/oth/23/01/T23010000190001PDFE.pdf
4. Internet of Things for Smart Cities, IEEE INTERNET OF THINGS JOURNAL, VOL. 1, NO. 1, FEBRUARY 2014, <https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6740844>
5. Artificial Intelligence Techniques for Smart City Applications, Proceedings of the 18th International Conference on Computing in Civil and Building Engineering, 2021, Volume 98, ISBN : 978-3-030-51294-1

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.
- **Question paper format:**
- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**.
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules).
- A total of **four questions** need to be answered.

Subject Code	Subject Name	Theory	Practical	Tutorial	Theory	Practical /Oral	Tutorial	Total
IOTDO7021	SDN & NFV for IoT	03	--	--	03	--	--	03

Subject Code	Subject Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		Test1	Test 2	Avg. of 2 Tests					
IOTDO7021	SDN & NFV for IoT	20	20	20	80	--	--	--	100

Course Objectives:

Sr. No.	Course Objectives
The course aims:	
1	Understand the fundamentals of SDN and NFV.
2	Study the functionalities, and the protocols of SDN controllers.
3	Understand SDN/NFV integration to create agile and flexible network architectures.
4	Study the SDN/NFV deployment models.
5	Analyze the security challenges and solutions specific to SDN and NFV environments.
6	Investigate SDN/NFV use cases.

Course Outcomes: On successful completion of course, learners/students will be able to:

Sr. No.	Course Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		
1	Explain the concept of SDN with respect to its approach, differences and benefits over traditional network management.	L1
2.	Describe the relationship between SDN and NFV and their role in network infrastructure.	L2
3.	Explain the concept of NFV.	L3
4.	Analyze performance bottlenecks in virtualized network environments and propose optimizations.	L4
5.	Explain the security issues in SDN and NFV.	L2
6.	Create solutions to address complex challenges in SDN/NFV security, scalability, or performance.	L3

Prerequisite: Basic networking concepts, TCP/IP protocol. Basics of virtualization. OpenStack architecture.

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Networking fundamentals, Knowledge of OSI and TCP/IP model. Familiarity with virtualization concepts. Familiarity with cloud computing concepts.	02	
I	Basics of Modern Networking	Evolution of traditional networking architectures. Motivation and benefits of SDN and NFV. Relationship between SDN, NFV, and IoT. Introduction to cloud computing, Types of networks and Internet traffic. Requirements of Big Data, Cloud computing and Mobile traffic in terms of QoS, QoE, Routing and congestion control. Self-learning Topics: Introduction to Modern Networking Elements. Genesis of SDN and NFV.	04	CO1
II	Software Defined Networks	Problem of modern networks. Definition of Software Defined Networking (SDN). Flavors of SDN. SDN concepts and architecture. SDN controllers and switches. SDN-enabled IoT network design and deployment. OpenFlow protocol – Overview, Basic functionality, Messages, OpenFlow as fundamental protocol for SDN, OpenFlow limitations. Protocols competing with OpenFlow. Centralized and distributed controls and data planes. Architecture of NOX and POX. SDN in the data center. Self-learning Topics: Data center definition, Data center needs and demands, Tunneling and path technologies in data center, Real world implementations.	08	CO2

III	Virtualization	<p>NFV concepts and architecture. Virtualization technologies (e.g., hypervisors, containers). NFV-enabled IoT service provisioning and orchestration.</p> <p>NFV management and orchestration (MANO), NFV infrastructure (NFVI). Network programming – Network function virtualization, NetApp development, Network slicing.</p> <p>NFV systems- Ciena Agility, Intel, Cisco Evolved Services Platform (ESP), Open Platform for NFV (OPNFV), NFV specifications.</p> <p>Network management and orchestration frameworks (e.g., OpenStack, ONAP).</p> <p>Self-learning Topics: Service chaining and function composition in SDN/NFV-based IoT. Service lifecycle management and service assurance.</p>	08	CO3
IV	Components of Internet of Things	<p>Scope of IOT. IOT Enabled Things, IOT world forum reference model, IOTivity. CISCO -IoT systems, ioBridge. SDN and NFV over IoT deployment.</p> <p>SDN/NFV-enabled edge computing for IoT.</p> <p>Self-learning Topics: Edge computing concepts and architectures. Edge intelligence and analytics in SDN/NFV-based IoT.</p>	06	CO4
V	Security	<p>Security requirements – Introduction to security in SDN and NFV. ETSI security perspective. IOT security – The patching vulnerability. IOT security and privacy requirements.</p> <p>Introduction to ITU-T. The impact, advantages and disadvantages of SDN and NFV. IoT security challenges and threats.</p> <p>Self-learning Topics: SDN/NFV-based security solutions for IoT. Privacy considerations and data protection in IoT.</p>	06	CO5
VI	Applications and Use Cases	<p>Future of SDN and NFV - Standards bodies, Evolving standards, Novel applications. SDN applications. SDN Use Cases – The open network operating system. Real-world deployments of SDN/NFV in IoT.</p> <p>Self-learning Topics: Projects involving SDN/NFV for IoT. Research and emerging trends in SDN/NFV-based IoT.</p>	05	CO6

Text Books:

1. William Stallings, “Foundations of Modern Networking: SDN, NFV, QoE, IOT and Cloud” Addison-Wesley 2015.
2. Paul Goransson and Chuck Black, “SDN: A Comprehensive Approach”, Morgan Kaufmann 2014.
3. Siamak Azodolmolky, “SDN with OpenFlow” Packt Publishing.
4. Jim Doherty, “SDN and NFV Simplified: A Visual Guide to Understanding Software Defined Networks and Network Function Virtualization” 1st Edition.

References:

1. Rajendra Chayapathi, Syed Farrukh Hassan, Paresh Shah, “Network Functions Virtualization (NFV) with a Touch of SDN” Addison-Wesley.

2. Nick Feamster, Jennifer Rexford, Ellen Zegura, “The road to SDN: an intellectual history of programmable networks” ACM SIGCOMM Computer Communication Review Volume 44 Issue 208 April 2014 pp 87–98.
3. Rahamatullah Khondoker, “SDN and NFV Security”, Springer Publication.
4. Shao Ying Zhu, “Guide to Security in SDN and NFV: Challenges, Opportunities, and Applications”, Springer Publication.

Online References:

1. SDxCentral (<https://www.sdxcentral.com/>)
2. European Telecommunications Standards Institute (ETSI) NFV Portal (<https://www.etsi.org/technologies/nfv>)
3. VMware Learning Zone (<https://www.vmware.com/education-services/learning-zone/sdn-nfv.html>)
4. OpenStack (<https://www.openstack.org/>)
5. Open Networking Foundation (ONF) (<https://www.opennetworking.org/>)
6. Open Networking Foundation (ONF) (<https://www.youtube.com/user/OpenNetworking>)
7. Cisco DevNet (<https://www.youtube.com/c/CiscoDevNet>)
8. VMware (<https://www.youtube.com/user/vmwaretv>)

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.
- **Question paper format:**
 - Question Paper will comprise of a total of **six questions each carrying 20 marks** Q.1 will be **compulsory** and should **cover maximum contents of the syllabus**.
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 - A total of **four questions** need to be answered.

Subject Code	Subject Name	Theory	Practical	Tutorial	Theory	Practical/ Oral	Tutorial	Total
IOTDO7022	Blockchain for IoT	03	--	--	03	--	--	03

Subject Code	Subject Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		Test1	Test 2	Avg. of 2 Tests					
IOTDO7022	Blockchain for IoT	20	20	20	80	--	--	--	100

Course Objectives:

The course aims at:

1. To understand the fundamentals of blockchain, cryptocurrencies, their characteristics and examples.
2. To understand public blockchains, differentiate between Bitcoin and Ethereum.
3. To understand smart contracts and Solidity programming.
4. To understand private blockchains and Hyperledger.
5. To understand the architecture of an IoT-based ecosystem.
6. To understand the development of IOT solutions with blockchain.

Course Outcomes: On successful completion, of course, learner/student will be able to:

Sr. No.	Course Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		
1	Understand the fundamentals of blockchain, cryptocurrencies, their characteristics and examples.	L1
2.	Compare Bitcoin and Ethereum blockchains.	L2
3.	Execute smart contracts using Solidity.	L3
4.	Define private blockchains and Hyperledger.	L1
5.	Apply architecture of an IoT-based ecosystem	L3
6.	Design IOT solutions with blockchain.	L6

Prerequisite: Blockchain Technology, IoT

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Fundamentals of Distributed Systems, Cryptography, Hashing (SHA), Public and Private Keys, Digital Signatures	02	
I	Introduction to Blockchain	<p>Defining blockchain, Origin of blockchain (cryptographically secure hash functions), Blockchain architecture, Generic elements of a blockchain: Address, Transaction, Block - previous block hash (hash pointer), timestamp, and nonce, Merkle root, Blockchain functionality: Consensus, Types of blockchain: Distributed ledger, Shared ledger, Public, Private, and Consortium/Federated blockchain, Benefits and features of blockchain, Limitations of blockchain technology.</p> <p>Cryptocurrency :Introduction to cryptocurrency, Characteristics of cryptocurrency, Cryptocurrency wallets, Cryptocurrency usage, Fork and its types, Examples of cryptocurrencies: Bitcoin, Altcoin, and Tokens.</p> <p>Self-study: Blockchain Demo, Defi, Metaverse</p>	07	CO1
II	Public Blockchain: Bitcoin and Ethereum	<p>Bitcoin blockchain: Introduction to Bitcoin, Consensus mechanism in Bitcoin, Bitcoin PoW system, Double spending problem, difference between PoW, PoB, and PoS, PoET, UTXO model of Bitcoin, Life of a miner, Mining difficulty, Mining pool and its methods.</p> <p>Ethereum blockchain: Ethereum and its components, EVM, Mining in Ethereum, Transactions, Accounts, Architecture and Workflow</p> <p>Comparison between Bitcoin and Ethereum</p> <p>Self-study: Blockchain Explorer: Bitcoin Tracker, Etherscan.io</p>	07	CO2
III	Smart Contracts and Blockchain Programming using Solidity	<p>Introduction to smart contracts: Definition, properties, and real-world applications, Ricardian contracts, Smart contract templates/structure of a smart contract, smart contract approaches, limitations of smart contract, Oracles and its types, Decentralized autonomous organization.</p> <p>Solidity Programming: Basics, functions (fall back function), visibility (public, private, internal and external) and activity (constant, view, pure, and payable) qualifiers, address and address payable, data types in solidity, arrays (fixed and dynamic), special dynamically sized arrays, inheritance and its types, error handling (require, assert, revert)</p> <p>Self-study: Advances in smart contract technology (Solana Sealevel, Digital Asset Modeling Language)</p>	08	CO3
IV	Private Blockchain: Hyperledger	<p>Introduction to Private Blockchain, Key Characteristics, Need of a Private Blockchain, Smart contract in a Private Blockchain, Consensus mechanism (PAXOS and RAFT), Byzantine Faults: BFT and pBFT</p> <p>Hyperledger: Introduction to Hyperledger, Tools and Framework, Hyperledger Fabric Architecture, Components of Hyperledger Fabric: MSP, Chain Codes, Transaction Flow, Working of Hyperledger Fabric</p>	07	CO4

		Self-study: Case Study of Supply Chain Management using Hyperledger		
V	Convergence of Blockchain and IoT	IoT devices (sensors, actuators, chips) and their functionalities such as sensing, reacting, collecting, and communicating, Typical architecture of an IoT-based ecosystem, IoT layered model, Benefits of IoT and blockchain convergence, Layered blockchain-based IoT model, Implementing blockchain-based IoT. Role of blockchain in machine to machine communication. Self-study: Blockchain applications in government, finance, media, and healthcare, IOTA	04	CO5
VI	IoT Solutions with Blockchain	Creating a blockchain network: Concepts and enumerations, asset definitions, participants, manipulating assets via transactions, generating and exporting participant business cards, defining ACLs. Creating IOT Solution: hardware setup, firmware development, application development. End-to End Testing. Self Study: The IOT, Blockchain and Industry 4.0	06	CO6

Text Books:

1. Blockchain Technology, Chandramouli Subramanian, Asha A. George, Abhillash K. A and Meena Karthikeyen, Universities Press.
2. Mastering Blockchain by Imran Bashir (4th Edition) (2023)
3. Mastering Ethereum, Building Smart Contract and Dapps, Andreas M. Antonopoulos Dr. Gavin Wood, O'Reilly.
4. Mastering Bitcoin, Programming the Open Blockchain, 2nd Edition by Andreas M. Antonopoulos, June 2017, Publisher(s): O'Reilly Media, Inc. ISBN: 9781491954386.
5. Hyperledger Fabric In-Depth: Learn, Build and Deploy Blockchain Applications Using Hyperledger Fabric by Ashwani Kumar, BPB publications
6. Solidity Programming Essentials: A beginner's Guide to Build Smart Contracts for Ethereum and Blockchain by Ritesh Modi, Packt publication
7. Hands-On IoT Solutions with Blockchain by Maximiliano Santos, Enio Moura, Packt publication.

References:

1. Blockchain Technology: Concepts and Applications, Kumar Saurabh and Ashutosh Saxena, Wiley.
2. The Basics of Bitcoins and Blockchains: An Introduction to Cryptocurrencies and the Technology that Powers Them (Cryptography, Crypto Trading, Digital Assets, NFT) by Antony Lewis (2018)
3. Blockchain for Beginners, Yathish R and Tejaswini N, SPD
4. Blockchain Basics, A Non-technical Introduction in 25 Steps, Daniel Drescher, Apress.
5. Blockchain with Hyperledger Fabric, Luc Desrosiers, Nitin Gaur, Salman A. Baset, Venkatraman Ramakrishna, Packt Publishing

Online References:

1. Blockchain for Business, <https://www.ibm.com/downloads/cas/3EGWKGX7>.
2. NPTEL: https://onlinecourses.nptel.ac.in/noc19_cs63/preview
3. Hyperledger: <https://www.hyperledger.org/use/fabric>

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.
- **Question paper format:**
- Question Paper will comprise of a total of **six questions each carrying 20 marks** **Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**.
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules).
- A total of **four questions** need to be answered.

Subject Code	Subject Name	Theory	Practical	Tutorial	Theory	Oral	Tutorial	Total
IOTDO7023	Enterprise IoT Cyber Security	03	--	--	03	--	--	03

Subject Code	Subject Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		Test1	Test 2	Avg. of 2 Tests					
IOTDO 7023	Enterprise IoT Cyber Security	20	20	20	80	--	--	--	100

Course Objectives: The course aims:

1. To learn fundamentals of Enterprise IoT, vulnerabilities, attacks and countermeasures for IoT systems.
2. To gain knowledge in security engineering for IoT development and lifecycle.
3. To understand the cryptographic fundamentals for IoT security engineering.
4. To develop a comprehensive understanding of challenges and solutions in secured identity management.
5. To gain knowledge of the different privacy regulations and compliance requirements.
6. To analyze various case studies and applications for Enterprise IoT.

Course Outcomes: On successful completion of course, learner/student will be able to:

Sr. No.	Course Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		
1	Discuss fundamentals of Enterprise IoT, vulnerabilities, attacks and threats in IoT systems	L2
2.	Illustrate IoT security life cycle	L4
3.	Examine various cryptographic controls for IoT protocols.	L4
4.	Evaluate the identity and access management solution for IoT security.	L5
5.	Identify applicable privacy regulations and compliance requirements for data in IoT environments	L2
6.	Evaluate various case studies and applications for Enterprise IoT	L5

Prerequisite: Knowledge of IoT and Cryptography

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basics of IoT and cryptography	2	
I	INTRODUCTION TO ENTERPRISE IOT CYBER SECURITY	Fundamentals of IOT in Enterprise, IoT device lifecycle. Security Requirements in IoT Architecture, Security in Enabling Technologies. Primer on threats, vulnerability and risks (TVR), Primer on attacks and countermeasures. Today's IoT attacks. Self Learning Topics: Threat modeling an IoT System.	5	CO1
II	IOT SECURITY ENGINEERING AND DEVELOPMENT	Building security into design and development- Security in Agile developments Secure design- Safety and security design, Process and agreements, Technology selection – security products and services IoT security lifecycle – Implementation and integration, operations and maintenance, Dispose. Self Learning Topics: Cyber attack on Industrial control system, ransomware attack on healthcare enterprise “Wannacry” case study	7	CO2
III	CRYPTOGRAPHIC FUNDAMENTALS FOR IOT SECURITY	Cryptographic primitives and its role in securing the IoT. Cryptographic module principles, key management fundamentals. Cryptographic controls built into IoT communication and messaging protocols IoT Node Authentication Self Learning Topics: Future directions of IoT and Cryptography (Including blockchain for IoT security)	6	CO3
IV	IDENTITY & ACCESS MANAGEMENT SOLUTIONS FOR SECURE IOT	Identity lifecycle Authentication credentials – Passwords, Symmetric keys, Certificates, Biometrics IoT IAM infrastructure –802.1X, PKI for IoT Authorization and access control – OAuth 2.0, publish/subscribe protocols and communication protocols Self Learning Topics: Authentication and authorization framework of IIoT	6	CO4
V	MITIGATING IOT PRIVACY CONCERNS AND COMPLIANCE MONITORING	Privacy challenges introduced by the IoT, Performing an IoT Privacy Impact Assessment (PIA), Privacy by Design (PbD) principles, Privacy engineering recommendations IoT Compliance, challenges associated with IoT compliance, examining compliance standard support for IoT Self Learning Topics: Differential privacy in Industrial IoT	7	CO5
VI	ENTERPRISE IOT: CASE STUDIES AND APPLICATION	Cleaning Service Industry and Technology, Global Cold Chain Management, Intelligent Lot Tracking, Industrial Internet Consortium Testbeds	6	CO6

Text Books:

1. "Enterprise IoT: Strategies and Best Practices for Connected Products and Services" by Dirk Slama, Frank Puhlmann, Jim Morrish, and Rishi M. Bhatnagar, O'Reilly

2. "Practical Internet of Things Security" by Brian Russell, Drew Van Duren, and John Sammons, PACKT Publishing
3. "Securing the Internet of Things" by Shancang Li, Li Da Xu, and Liming Chen, SYNGRESS

References:

1. Security and Privacy in Internet of Things (IoTs) Models, Algorithms, and Implementations by FEI HU, CRC Press
2. Security, Privacy and Trust in the IoT Environment by Zaigham Mahmood, Springer, ISBN: 9783030180744, 2019.
3. Ollie Whitehouse, "Security of Things: An Implementers' Guide to Cyber-Security for Internet of Things Devices and Beyond", NCC Group, 2014
4. "Practical Industrial Internet of Things Security", By Sravani Bhattacharjee, PACKT Publishing.

Online References:

1. <https://www.coursera.org/learn/iot-cyber-security>
2. <https://www.edx.org/course/cybersecurity-and-privacy-in-the-iot>

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.
- **Question paper format:**
- Question Paper will comprise of a total of **six questions each carrying 20 marks** Q.1 will be **compulsory** and should **cover maximum contents of the syllabus**.
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules).
- A total of **four questions** need to be answered.

Course Code	Subject Name	Theory	Practical	Tutorial	Theory	Practical /Oral	Tutorial	Total
IOTDO7024	Software Engineering & Testing Methodology for IoT	03	--	--	03	--	--	03

Subject Code	Subject Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		Test1	Test 2	Avg. of 2 Tests					
IOTDO L7024	Software Engineering & Testing Methodology for IoT	20	20	20	80	--	--	--	100

Course Objectives:

1. To provide the knowledge of the new process models and trends for IoT based software engineering practices.
2. To acquire skills on web based IoT application development
3. To gain the ability to identify the challenges in IoT to automate the real-time problems.
4. To acquire knowledge about various software test planning and techniques for IoT.

Course Outcomes: On successful completion of course, learners will be able to:

Sr. No.	Course Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		
1	Apprehend new process models and trends for IoT based software engineering practices.	L1
2.	Design and model an IoT system using UML diagrams.	L3,L4
3.	Understand the challenges in IoT to automate the real-time problems.	L1, L2
4.	Understand IoT based testing concepts and challenges.	L1,L2
5.	Identify different IoT testing planning and strategies.	L1,L2
6.	Explore various IoT testing techniques.	L3,L4

Prerequisite:

Software Engineering , IoT Architecture and Protocols

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Process models in Software Engineering: Prescriptive, evolutionary, and agile process models, UML Diagrams, IoT devices and protocols.	2	
I	IoT Based Software Engineering	New process model for IoT based Software Engineering: Introduction, Layers of IoT, IoT based SDLC, Identifying Business needs through IoT, IoT in various domains. Introduction to trends in integrating IoT into Software Engineering practices: DevOps in IoT, DevSecOps in IoT, Integrating security into IoT, Machine Learning and AI in IoT of Software Engineering practices.	6	CO1
II	Modelling & Design of IoT System	Modeling of IoT system using UML diagrams: IoT Software Engineering, UML representations of IoT Systems: Use case diagram, class diagram, interaction diagrams, and physical diagrams, Architecture design of IoT system, Cryptographic approaches, Machine Learning approaches.	8	CO2
III	Web Based IoT Application Development	Introduction to web based IoT application development, IoT layered architecture for web application development, challenges of IoT application development, End-to-end complete IoT Solution.	5	CO3
IV	Introduction to IoT Testing	Challenges in IoT Testing, advanced IoT device challenges, IoT development-test-security-operation lifecycle, Verification & Validation testing concepts, factors and keys for IoT testing.	4	CO4
V	IoT Test Planning & Strategy	Basics of IoT Test Planning, IoT test planning & strategy for hardware & software, Agile/DevOps test lifecycle, Product and Development Lifecycle Impacts on Test Planning – DevOps and Agile, V & V activities, IoT test planning: Regression test cases, OTS hardware and software, Security and critical quality factors, IoT strategy.	8	CO5
VI	IoT Testing Techniques and Practices	Techniques, practices, levels and types of testing to apply to IoT, Functional test design techniques, Exploratory testing, structural testing, industrial test practices, IoT levels of testing related to lifecycle phases, test planning for Agile Team.	6	CO6

Text Books:

1. Jon Duncan Hagar, *IoT System Testing: An IoT Journey from Devices to Analytics and the Edge*, Apress 2022.
2. D. Jeya Mala, *Integrating the Internet of Things into Software Engineering Practices*, IGI Global 2019.

References:

1. Sudham Sudhakar, *Testing IoT: Build and Implement Test Automation and Performance Testing for IoT Systems*.
2. Aaron Guzman, Aditya Gupta, *IoT Penetration Testing Cookbook: Identify vulnerabilities and secure your smart devices* Paperback – Import, 29 November 2017.
3. Yogesh Singh, *Software Testing*, Cambridge University Press, 2012.
4. Mauro Pezze, Michal Young: *Software Testing and Analysis – Process, Principles and Techniques*, Wiley India, 2009.

Online References:

1. <https://bytebeam.io/blog/iot-software-testing-guide/>
2. www.omg.org/spec/UML/2.5.1/About-UML/
3. <https://www.softwaretestinghelp.com/internet-of-things-iot-testing/>
4. <https://www.techarcis.com/whitepapers/security-testing-in-iot/>
5. <https://dl.acm.org/doi/abs/10.1145/3356317.3356326>
6. <https://yalantis.com/blog/iot-testing-guide/>

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.
- **Question paper format:**
- Question Paper will comprise of a total of **six questions each carrying 20 marks** **Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**.
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules).
- A total of **four questions** need to be answered.

Course Code:	Course Title	Credit
IOTL701	Machine Learning and IOT Lab	

Lab Objectives: The course will help the students to:

1. To understand the concepts of ML and IOT.
2. To learn and apply ML techniques for IoT data sets.
3. To practice various ML platforms.
4. To analyze & illustrate various ML techniques.
5. To demonstrate the ML and IOT applications.
6. To familiarize with the MLops life cycle.

Lab Outcomes: Upon Completion of this course, the learner should be able to:

Sr. No.	Lab Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		
1	Understand the concepts Machine Learning and IOT	L2
2.	Explore with various data science platforms.	L2
3.	Demonstrate different ML libraries and tools.	L3
4.	Experiment Machine Learning Algorithms on given data sets.	L4
5.	Analyze the various ML techniques.	L4
6.	Apply MLops tools for ML application development.	L3

SR. NO	List of experiments:	Lab Outcome
1	Introduction to platforms such as Anaconda, COLAB	LO1
2	Study of Machine Learning Libraries and tools (Python library, tensorflow, keras,...)	LO2,LO3
3	Implementation of following algorithms for a given example data set : Linear Regression.	LO3,LO4, LO5
4	Implementation of following algorithms for a given example data set : Logistic Regression. -	LO3,LO4, LO5
5	Implementation of following algorithms for a given example data set :	LO3,LO4,

	Support Vector Machines	LO5
6	Implementation of following algorithms for a given example data set : Hebbian Learning	LO3,LO4, LO5
7	Implementation of following algorithms for a given example data set : Expectation -Maximization algorithm	LO3,LO4, LO5
8	Implementation of following algorithms for a given example data set : McCulloch Pitts Model. -	LO3,LO4, LO5
9	Implementation of following algorithms for a given example data set : Single Layer Perceptron Learning algorithm	LO3,LO4, LO5
10	Implementation of following algorithms for a given example data set : Error Backpropagation Perceptron Training Algorithm	LO3,LO4, LO5
11	First 4 phases of MLops life cycle- - ML Developments, - Model Training - Model Evaluation, - Model Deployment	LO6
12	5-7 phases of MLops – - Prediction Serving, - Model Monitoring, - Data and Model Management	LO6

Note : Data used for this lab should be collected with the help of different sensors (at least 5).

Text Books

1. Peter Harrington, —Machine Learning n Action||, DreamTech Press
2. Ethem Alpaydın, —Introduction to Machine Learning||, MIT Press
3. Tom M. Mitchell, —Machine Learning|| McGraw Hill
4. Stephen Marsland, —Machine Learning An Algorithmic Perspectivel, CRC Press
- 5 : Neeraj Kumar, Aaisha Makkar, “ MACHINE LEARNING IN COGNITIVE IOT”, <https://www.routledge.com/Machine-Learning-in-Cognitive-IoT/KumarMakkar/p/book/9780367359164> ISBN 9780367359164 Published June 1, 2020 by CRC Press

Reference Books

1. Puneet Mathur, “ IoT Machine Learning Applications in Telecom, Energy, and Agriculture, With Raspberry Pi and Arduino Using Python”, ISBN 978-1-4842-5549-0
2. Nicolas Modrzyk, “ Real-Time IoT Imaging with Deep Neural Networks - Using Java on the Raspberry Pi 4” , Apress Publication , Year: 2020, ISBN: 9781484257210, 978148425722
3. Han Kamber, —Data Mining Concepts and Techniques, Morgan Kaufmann Publishers
4. Margaret. H. Dunham, —Data Mining Introductory and Advanced Topics, Pearson Education
5. Kevin P. Murphy , Machine Learning — A Probabilistic Perspective
6. Samir Roy and Chakraborty, —Introduction to soft computing, Pearson Edition. 5 Richard Duda, Peter Hart, David G. Stork, —Pattern Classification, Second Edition, Wiley Publications.

References:

1. <https://www.packtpub/product/hands-on-artificial-intelligence-for-iot/9781788836067>
2. <https://it.mitindia.edu/PDF/books/ml1.pdf>
3. <https://www.perlego.com/book/1491982/machine-learning-and-iot-a-biological-perspective-pdf>
4. <https://media-exp1.licdn.com/dms/document/C4E1FAQE8SeLwleYzqA/feedshare-document-pdf-analyzed/0/1650189848484?e=2147483647&v=beta&t=OGnNH7tasNrvIEjV7h99wyWF3DY6QcaTTVg2-IdsJiE>

Term Work:

1. Term work should consist of 10 experiments
2. Journal must include at least 2 assignments based on Theory and Practical
3. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
4. Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)

Oral exam: Based on the entire syllabus of Machine Learning & IoT theory and lab

Subject Code	Subject Name	Theory	Practical	Tutorial	Theory	Practical & Oral	Tutorial	Total
IOTL703	DevOps Lab	--	2	--	--	--	--	01

Subject Code	Subject Name	Examination Scheme						
		Theory Marks				Term Work	Practical & Oral	Total
		Internal assessment			End Sem. Exam			
		Test1	Test 2	Avg. of 2 Tests				
IOTL703	DevOps Lab	--	--	--	--	25	25	50

Lab Objectives: The course will help the students to

- To understand the concept of distributed version control.
- To familiarize with Jenkins build & test software Applications & Continuous integration.
- To understand Docker to build, ship and run containerized images.
- To familiarize with the concept of Software Configuration Management & Continuous Monitoring.
- To understand the basics of Static Application security testing.
- To familiarize with the concept of Cloud and Infrastructure as a Code.

Lab Outcomes: Upon Completion of this course, the learner should be able to:

Sr. No.	Lab Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		
1	Understand the concepts of distributed version control using GIT and GITHUB	L1
2.	Apply Jenkins to Build, Deploy and Test the Software Applications	L3,L4
3.	Analyze & Illustrate the Containerization of OS images and deployment of applications over Docker	L2,L3
4.	Deploy and Examine the Software Configuration management using Ansible and Continuous monitoring using Nagios	L3
5.	Use Sonarqube to perform code quality checks.	L1,L2
6.	Implement Terraform scripts to manage VMs on a cloud.	L3,L4

Detailed Syllabus

Sr. No.	Module	Detailed Content	Hours	LO
	Prerequisite	Concept of DevOps with related technologies which are used to Code, Build, Test, Configure & Monitor the Software Applications.	02	
I	Version Control using GIT	<p>To Perform Version Control on documents/files websites/ Softwares using GIT & GITHUB that covers all GIT commands given in GIT cheat sheet</p> <ol style="list-style-type: none"> 1. To implement Version control for different files/directories using GIT 2. To implement version control using GITHUB to sync local GIT repositories and perform various related operations. 	04	LO 1
II	Working with Jenkins	<ol style="list-style-type: none"> 3. To deploy and test Java/web/Python application on jenkins server 4. To implement Jenkins pipeline using scripted/declarative pipeline 5. To use jenkins to deploy and run test cases for Java/Web application using Selenium/JUnit 6. To implement jenkins Master/Slave architecture 	06	LO 2

III	Containerization	7. To use docker to run containers of different applications and operating Systems 8. To create a custom docker image using Dockerfile and upload it to the docker hub.	04	LO 3
IV	Software Configuration Management and Continuous Monitoring	9. To implement continuous deployment using Ansible 10. To implement continuous monitoring using Splunk/Nagios	04	LO 4
V	Static Application Security Testing	11. To implement Static Application Security Testing using SonarQube	02	LO 5
VI	Cloud and Infrastructure as a code	12. To create and work with virtual machine on cloud (GCP / AWS / Azure) 13. To implement terraform script for deploying infrastructure on cloud platforms (GCP / AWS / Azure)	04	LO 6

Text Books:

1. Prem Kumar Ponuthurai, Jon Loeliger, Version Control with Git, 3rd Edition, O'Reilly Media.
2. John Ferguson Smart, "Jenkins, The Definitive Guide", O'Reilly Publication.
3. Karl Matthias & Sean P. Kane, Docker: Up and Running, O'Reilly Publication.
4. Russ McKendrick, Learn Ansible, Pakt Publication
5. Yevgeniy Brikman, Terraform: Up and Running, 3rd Edition, O'Reilly Publication.
6. G. Ann Campbell, SonarQube in Action, First Edition, Manning publication.

References:

1. Sanjeev Sharma and Bernie Coyne, "DevOps for Dummies", Wiley Publication
2. Httermann, Michael, "DevOps for Developers", Apress Publication.
3. Joakim Verona, "Practical DevOps", Pack publication

Term Work:

- 1 Term work should consist of experiments
- 2 Journal must include at least 2 assignments based on Theory and Practical

- 3 The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
- 4 Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)

Oral exam:

Based on the entire syllabus of DeVOPs Lab IOTL703

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Oral	Tutorial	Total
IoTCSBCL702	Edge and Fog Computing Lab	--	2	--	--	1	--	1

Subject Code	Subject Name	Examination Scheme						
		Theory Marks				Term Work	Oral	Total
		Internal assessment			End Sem. Exam			
		Test1	Test 2	Avg. of 2 Tests				
IoTCSBCL702	Edge and Fog Computing Lab	--	--	--	--	25	25	50

Lab Objectives:

Sr. No.	Lab Objectives
1	To study the concepts of virtual servers and AWS Edge platforms
2	To get acquainted with different Aws IoT Core Services.
3	To learn message passing between AWS IoT Core devices
4	To study different simulators and development of Edge Computing networks
5	To study different simulators and development of FogComputing networks

Lab Outcomes:

Sr. No.	Lab Outcomes	Cognitive Levels of Attainment as per Bloom's Taxonomy
On successful completion of the course students will be able to,		
1	Understand the concept of virtual servers deployed on AWS Edge platform	L1
2	Analyze the use of AWS IoT Core and related services.	L3
3	To examine the message passing techniques in AWS IoT Core devices and assess the security using VPC on AWS.	L3
4	Deploy Edge computing networks using Edge computing simulators	L4
5	Deploy Fog computing networks using Fog computing simulators	L5

Prerequisite: Cloud Computing and IoT concepts

Sr. No.	Suggested list of Assignments	LO
1	Create and deploy virtual servers on AWS / Azure.	LO1
2	To deploy Raspberry Pi on AWS IoT Core	LO2
3	To implement MQTT messaging between Raspberry Pi and AWS IoT Core	LO2
4	To implement virtual private cloud (VPC) on AWS for IoT services.	LO3
5	Study assignment on Edge and Fog Simulators	LO4
6	Design and deploy an edge computing architecture using edge simulators such as Mobius / EdgeCloudSim.	LO4
7	Develop and evaluate edge-based data analytics algorithms in an edge simulator.	LO5
8	Design and deploy a fog computing architecture using simulators such as iFogSim / CloudSim.	LO4
9	Explore collaboration between edge and fog nodes for IoT applications.	LO5

Text Books:

1. "Fog and Edge Computing" by Rajkumar Buyya, Satish Narayana Srirama, Wiley Publications

2. "Edge Computing: Models, Technologies, and Applications" by Mung Chiang, Bharath Balasubramanian, and H. Vincent Poor.
3. "Edge Computing with Python: End-to-end Edge Applications, Python Tools and Techniques, Edge Architectures, and AI Benefit" by Abhinandan Bhadauria, BPB publications.
4. "Edge Computing: Simply in Depth" by Ajit Singh,
5. "Edge Computing: Fundamentals, Advances and Applications (Advances in Industry 4.0 and Machine Learning)" by K. Anitha Kumari, G. Sudha Sadasivam, D. Dharani, M. Niranjana Murthy, CRC Press.

References:

1. "Edge Computing for IoT: Architectures and Applications" by Bharat Bhargava, Sudip Misra, Valentina E. Balas, and Raghvendra Kumar
2. "Practical Industrial Internet of Things Security: A practitioner's guide to securing connected industries" by Sravani Bhattacharjee and Rajdeep Chowdhury
3. "Edge Computing: An Introduction to the Next Generation of Networked Systems" by Kiran Chitturi, Bharadwaj Veeravalli, and Satish Narayana Srirama
4. "Building the Web of Things: With examples in Node.js and Raspberry Pi" by Dominique D. Guinard and Vlad M. Trifa
5. "Internet of Things (IoT): Technologies, Applications, Challenges, and Solutions" edited by Balamuralidhar P., Bharadwaj Veeravalli, and V. Raghunathan
6. "Fog and Edge Computing: Principles and Paradigms" by Rajkumar Buyya, Satish Srirama, and Pradeep Kumar S.
7. "IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things" by David Hanes and Gonzalo Salgueiro
8. "Edge Analytics in IoT" by Shivashankar B. Nair, Siddhartha Bhattacharyya, and Thomas Edward Joshua
9. "Edge Computing: The Convergence of Big Data and Internet of Things" by Samee U. Khan, Albert Y. Zomaya, and Salman A. Baset

Online References:

1. <http://www.steves-internet-guide.com/mqtt-protocol-messages-overview/>
2. <https://aws.amazon.com/iot-core/>

3. <https://github.com/CagataySonmez/EdgeCloudSim/wiki>
4. <https://www.cloudsimtutorials.online/ifogsim-project-structure-a-beginners-guide/>
5. <https://www.udemy.com/course/essential-ifogsim-tutorials/>
6. <https://slogix.in/source-code/ifog-computing-samples/how-to-create-fog-topology-in-ifogsim/>

Assessment:

Term Work: Term Work shall consist of at least 10 to 12 practicals based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Oral Exam: An Oral exam will be held based on the above syllabus / suggested list of Assignment.

		Teaching Scheme (Contact Hours)			Credits Assigned			
Course Code	Course Name	Theory	Practical	Tutorial	Theory	Prac	Tutorial	Total
IOTL704	Linux Administration Lab	--	02	--	--	1	--	1

Subject Code	Subject Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal Assessment			End Sem. Exam			
		Test 1	Test 2	Avg. of 2 Tests				
IOTL704	Linux Administration Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To effectively manage and maintain a Linux-based system infrastructure.
2. To develop and utilize shell programming and scripting skills in Linux systems.
3. To configure storage and manage networks in Linux systems.
4. To manage user accounts, groups, and permissions in Linux systems.
5. To administer and secure network infrastructure in Linux systems.
6. To configure and manage DNS, DHCP, and mail server services in Linux systems.

Lab Outcomes: After successful completion of the course, students will be able to

Sr. No.	Lab Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		
1	Understand the installation of Linux OS and apply different commands for Linux administration.	L1
2.	Develop shell scripts to perform tasks in a shell programming environment.	L2,L3
3.	Demonstrate the Linux storage configuration and network management.	L3
4.	Demonstrate the creation and management of user/group accounts in Linux.	L3
5.	Illustrate the use of iptables for Firewall setup.	L1,L2
6.	Demonstrate the configuration and management of different server services like DNS, DHCP, and Mail Server.	L3

Prerequisite: Operating Systems, Computer Networks

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	Basics of Operating System, Computer Networks	2	--
1	Introduction and Linux Administration Tasks	Introduction: History of Linux OS, Architecture of Linux OS, Linux Distributions, Installation of Linux OS, Administration Tasks: Introduction to terminal, Basic commands, File system, File handling commands, process and process management commands, VI editor.	4	LO1
2	Shell Programming	Introducing Bash Shell Scripting: Introduction, Elements of a Good Shell Script, Executing the Script, Working with Variables and Input, Understanding Variables, Variables, Subshells, and Sourcing, Working with Script Arguments, Asking for Input, Using Command Substitution, Substitution Operators, Changing Variable Content with Pattern Matching, Performing Calculations, Using Control Structures, Using if...then...else, Using case, Using while, Using until, Using for, Configuring booting with GRUB.	4	LO2
3	Storage Configuration, and Network Management	Configuring and Managing Storage: Types of storages, creating partitions using fdisk command, Logical volume management (LVM), Creating file system, mounting file system. Connecting to the Network: Understanding NetworkManager, Working with Services and Runlevels, Configuring the Network with NetworkManager, Working with system-config-network, NetworkManager Configuration Files, Network Service Scripts, Networking from the Command Line, Troubleshooting Networking, Setting Up IPv6, Configuring SSH, Enabling the SSH Server, Using the SSH Client.	4	LO3
4	User and Group Management	Working with Users, Groups, and Permissions: Managing Users and Groups, Commands for User Management, Managing Passwords, Modifying and Deleting User Accounts, Configuration Files, Creating Groups, Using Graphical Tools for User, and Group Management, Using External Authentication Sources, the Authentication Process, sssd, nsswitch, Pluggable Authentication Modules, Managing Permissions, the Role of Ownership, Basic Permissions: Read, Write, and Execute, Advanced Permissions, Working with Access Control Lists, Setting Default Permissions with umask, Working with Attributes	2	LO4
5	Network Configuration and File Sharing	Securing Server with iptables: Understanding Firewalls, Setting Up a Firewall with system-config-firewall, Allowing Services, Trusted Interfaces, Masquerading, Configuration Files, Setting Up a Firewall with iptables, Tables, Chains, and Rules, Composition of Rule, Configuration Example, Advanced iptables Configuration, Configuring Logging, The Limit Module, Configuring NAT, Configuring Virtual Network Computing (VNC) Server and Client. Configuring Server for File Sharing: What is NFS? Advantages and Disadvantages of NFS, Configuring NFS4, Setting Up NFSv4, Mounting an NFS Share, Making NFS Mounts Persistent, Configuring Automount, Configuring Samba, Setting Up a Samba File Server, Samba Advanced	4	LO5

		Authentication Options, Accessing Samba Shares, Offering FTP Services.		
6	Configuration of DNS, DHCP, and Mail Server	Configuring DNS and DHCP: Introduction to DNS, The DNS Hierarchy, DNS Server Types, The DNS Lookup Process, DNS Zone Types, Setting Up a DNS Server, Setting Up a Cache-Only Name Server, Setting Up a Primary Name Server, Setting Up a Secondary Name Server, Understanding DHCP, Setting Up a DHCP Server Setting Up a Mail Server: Using the Message Transfer Agent, the Mail Delivery Agent, and the Mail User Agent, Setting Up Postfix as an SMTP Server, Working with Mutt, Basic Configuration, Internet Configuration, Configuring Dovecot for POP and IMAP	4	LO6

List of Experiments:

Sr. No.	Name of the Experiment	LO Mapping
1	Installation of RHEL6.x and above/ CentOS/ Ubuntu/ Raspberry Pi OS on VirtualBox/ VMware.	LO1
2	Graphical User Interface, Command Line Interface, and Processes (a) Exploring the Graphical Desktop (b) The Command Line Interface (c) Process Management	LO1
3	Shell Programming – I (a) Write a menu-driven program for the following options <ul style="list-style-type: none"> List of files Processes of Users Today's Date Quit out of Linux (b) Write a shell program that accepts the name of a file from the standard input and then performs the following test on it. <ul style="list-style-type: none"> File Existence File Readable and Writable (c) Write a shell program to perform a simulated cp command. Proceed this program using positional parameter and the usage will be on the form of copy <s.file> <target file> and ensure that parameters are properly used. (d) Write a shell program to convert all lowercase letters in a file to uppercase letter. (e) Write a shell program for file containing several records where each record contains name and city, name of state, and name of country. How would you sort this file with country as the primary key and state as the secondary sort key?	LO2
4	Shell Programming – II (a) 2-3 C Programs (b) 2-3 Java Programs (c) 2-3 Python Programs	LO2
5	Storage Devices and Links, Backup, and Repository	LO3

	(a) Mounting and working with storage devices and links (b) Making a backup (c) Creating a Repository	
6	Working with RPMs, YUM, Storage, and Networking (a) Extracting Files from RPMs, YUM (b) Configuring and Managing Storage (c) Connecting to the Network	LO3
7	Working with Users, Groups, and Permissions (a) Creating a user (b) Creating a group (c) Assigning permissions to user and group (d) Access Control List (e) Login in multi-user mode. (f) Identify the current run level. (g) Identify the default run level of the system. (h) Change the default run level to 2. (i) Check the difference between run level 3 and single-user mode. (j) Create run control scripts and execute them at the time of system startup in the default run level.	LO3, LO4
8	(a) Firewall services to secure Server with iptables. (b) Configuring VNC Server and VNC Client.	LO5
9	Configuring Server for File Sharing (a) Configuring NFS Server and Client (b) Configuring FTP Server	LO5
10	Configuring DNS, DHCP, and Mail Server (a) Configuring DNS (b) Configuring DHCP (c) Setting up a Mail Server	LO6

Textbooks:

1. Wale Soyinka, "Linux Administration: A Beginner's Guide", McGraw Hill Publication, 6th Edition, 2012.
2. B.M. Harwani, "UNIX & Shell Programming", Oxford University Press, 2013.
3. W. Richard. Stevens, "Advanced Programming in the UNIX Environment", Pearson Education, 3rd Edition, 2013.

Reference Books:

1. Cristopher Negus, "Linux Bible", John Wiley & Sons, 10th Edition, 2020.
2. Ellen Siever, Stephen Figgins, Robert Love, Arnold Robbins, "Linux in a Nutshell", O'Reilly, 6th Edition, 2009.
3. Neil Mathew & Richard Stones, "Beginning Linux Programming", Wiley, 4th Edition, 2008.
4. W. Richard. Stevens, "Advanced Programming in the UNIX Environment", Pearson Education, 2013.

Online Resources:

1. <https://nptel.ac.in/courses/117106113>
2. https://www.tutorialspoint.com/linux_admin/index.htm
3. <https://linode.com/docs/tools-reference/linux-system-administrationbasics/>
4. opensourceforu.com/2016/07/introduction-linux-system-administration/

5. <https://www.linuxfoundation.org>
6. <https://www.classcentral.com/course/youtube-linux-full-course-of-rhcsa-ex200-in-hindi-rhel8-red-hat-linux-8-for-beginners-90420>

Term Work:

Term Work shall consist of at least 8 to 10 practicals based on the above list. Also, the Term Work Journal must include at least 2 assignments.

Term Work Marks:

25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Oral Exam: Oral exam will be held on the above syllabus for 25 Marks (Total marks).

Course Code:	Course Title	Credit
IOTP701	Major Project 1	3

Course Objectives:

- 1 To acquaint yourself with the process of identifying the needs and converting it into the problem.
- 2 To familiarize the process of solving the problem in a group.
- 3 To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems.
- 4 To inculcate the process of self-learning and research.

Course Outcomes:

- 1 Identify problems based on societal /research needs.
- 2 Apply Knowledge and skill to solve societal problems in a group
- 3 Draw the proper inferences from available results through theoretical/ experimental/simulations
- 4 Analyze the impact of solutions in societal and environmental context for sustainable development.
- 5 Demonstrate capabilities of self-learning in a group, which leads to lifelong learning.
- 6 Demonstrate project management principles during project work.

Guidelines:

1. Project Topic Selection and Allocation:

- Project topic selection Process to be defined and followed:
 - o Project orientation can be given at the end of sixth semester.
 - o Students should be informed about the domain and domain experts whose guidance can be taken before selecting projects.

- o Student's should be recommended to refer papers from reputed conferences/journals like IEEE, Elsevier, ACM etc. which are not more than 3 years old for review of literature.
 - o Dataset selected for the project should be COLLECTED from IOT devices (large and real time)
 - o Students can certainly take ideas from anywhere, but be sure that they should evolve them in the unique way to suit their project requirements. Students can be informed to refer to Digital India portal, SIH portal or any other hackathon portal for problem selection.
- Topics can be finalized with respect to following criterion:
- o **Topic Selection:** The topics selected should be novel in nature (Product based, Application based or Research based) or should work towards removing the lacuna in currently existing systems.
 - o **Technology Used:** Use of latest technology or modern tools can be encouraged. IoT, AI, ML, DL, NNFL, NLP based algorithms can be implemented
 - o Students should not repeat work done previously (work done in the last three years).
 - o Project work must be carried out by the group of at least 3 students and maximum 4.
 - o The project work can be undertaken in a research institute or organization/Industry/any business establishment. (out-house projects)
 - o The project proposal presentations can be scheduled according to the domains and should be judged by faculty who are expert in the domain.
 - o Head of department and senior staff along with project coordinators will take decision regarding final selection of projects.
 - o Guide allocation should be done and students have to submit weekly progress report to the internal guide.
 - o Internal guide has to keep track of the progress of the project and also has to maintain attendance report. This progress report can be used for awarding term work marks.
 - o In case of industry/ out-house projects, visit by internal guide will be preferred and external members can be called during the presentation at various levels

2. Project Report Format:

At the end of semester, each group needs to prepare a project report as per the guidelines issued by the University of Mumbai.

A project report should preferably contain following details:

- o Abstract
- o Introduction
- o Literature Survey/ Existing system
- o Limitation Existing system or research gap
- o Problem Statement and Objective
- o Proposed System
- o Analysis/Framework/ Algorithm
- o Design details
- o Methodology (your approach to solve the problem) Proposed System
- o Experimental Set up
- o Details of Database or details about input to systems or selected data
- o Performance Evaluation Parameters (for Validation)
- o Software and Hardware Setup
- o Implementation Plan for Next Semester

- o Timeline Chart for Term1 and Term-II (Project Management tools can be used.)
- o References

Desirable

Students can be asked to undergo some Certification course (for the technical skill set that will be useful and applicable for projects.)

3. Term Work:

Distribution of marks for term work shall be done based on following:

- o Weekly Log Report
- o Project Work Contribution
- o Project Report (Spiral Bound) (both side print)
- o Term End Presentation (Internal)

The final certification and acceptance of TW ensures the satisfactory performance on the above aspects.

4. Oral and Practical:

Oral and Practical examination (Final Project Evaluation) of Project 1 should be conducted by Internal and External examiners approved by University of Mumbai at the end of the semester.

Suggested quality evaluation parameters are as follows:

- o Quality of problem selected
- o Clarity of problem definition and feasibility of problem solution
- o Relevance to the specialization / industrial trends
- o Originality
- o Clarity of objective and scope
- o Quality of analysis and design
- o Quality of written and oral presentation
- o Individual as well as teamwork

Institute Level Optional Course (ILO)

Every student is required to take one Institute Elective Course for Semester VII, which is not closely allied to their disciplines. Different sets of courses will run in the both the semesters.

ILO701X	Institute Optional Course – 1 (Common for all branches will be notified)
ILO7011	Product Lifecycle Management
ILO7012	Reliability Engineering
ILO7013	Management Information System
ILO7014	Design of Experiments
ILO7015	Operation Research
ILO7016	Cyber Security and Laws
ILO7017	Disaster Management and Mitigation Measures
ILO7018	Energy Audit and Management
ILO7019	Development Engineering

Course Code	Course Name	Credits
ILO7011	Product Life Cycle Management	03

Course Objectives: Students will try :

1. To familiarize the students with the need, benefits and components of PLM
2. To acquaint students with Product Data Management & PLM strategies
3. To give insights into new product development program and guidelines for designing and developing a product
4. To familiarize the students with Virtual Product Development

Course Outcomes: Students will be able to :

1. Gain knowledge about phases of PLM, PLM strategies and methodology for PLM feasibility study and PDM implementation.
2. Illustrate various approaches and techniques for designing and developing products.
3. Apply product engineering guidelines / thumb rules in designing products for moulding, machining, sheet metal working etc.
4. Acquire knowledge in applying virtual product development tools for components, machining and manufacturing plant

Module	Detailed Contents	Hrs
01	<p>Introduction to Product Lifecycle Management (PLM):Product Lifecycle Management (PLM), Need for PLM, Product Lifecycle Phases, Opportunities of Globalization, Pre-PLM Environment, PLM Paradigm, Importance & Benefits of PLM, Widespread Impact of PLM, Focus and Application, A PLM Project, Starting the PLM Initiative, PLM Applications</p> <p>PLM Strategies:Industrial strategies, Strategy elements, its identification, selection and implementation, Developing PLM Vision and PLM Strategy , Change management for PLM</p>	10
02	<p>ProductDesign:Product Design and Development Process, Engineering Design, Organization and Decomposition in Product Design, Typologies of Design Process Models, Reference Model, Product Design in the Context of the Product Development Process, Relation with the Development Process Planning Phase, Relation with the Post design Planning Phase, Methodological Evolution in Product Design, Concurrent Engineering, Characteristic Features of Concurrent Engineering, Concurrent Engineering and Life Cycle Approach, New Product Development (NPD) and Strategies, Product Configuration and Variant Management, The Design for X System, Objective Properties and Design for X</p> <p>Tools, Choice of Design for X Tools and Their Use in the Design Process</p>	09

03	Product Data Management (PDM): Product and Product Data, PDM systems and importance, Components of PDM, Reason for implementing a PDM system, financial justification of PDM, barriers to PDM implementation	05
04	Virtual Product Development Tools: For components, machines, and manufacturing plants, 3D CAD systems and realistic rendering techniques,	05
	Digital mock-up, Model building, Model analysis, Modeling and simulations in Product Design, Examples/Case studies	
05	Integration of Environmental Aspects in Product Design: Sustainable Development, Design for Environment,Need for Life Cycle Environmental Strategies, Useful Life Extension Strategies, End-of-Life Strategies, Introduction of Environmental Strategies into the Design Process, Life Cycle Environmental Strategies and Considerations for Product Design	05
06	Life Cycle Assessment and Life Cycle Cost Analysis: Properties, and Framework of Life Cycle Assessment, Phases of LCA in ISO Standards, Fields of Application and Limitations of Life Cycle Assessment, Cost Analysis and the Life Cycle Approach, General Framework for LCCA, Evolution of Models for Product Life Cycle Cost Analysis	05

Assessment:

Internal:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papers of end semester examination. **In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.**

1. Question paper will comprise of total six question
2. All question carry equal marks
3. Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four question need to be solved.

REFERENCES:

1. John Stark, "Product Lifecycle Management: Paradigm for 21st Century Product Realisation", Springer-Verlag, 2004. ISBN: 1852338105
2. Fabio Giudice, Guido La Rosa, AntoninoRisitano, "Product Design for the environment-A life cycle approach", Taylor & Francis 2006, ISBN: 0849327229
3. SaaksvuoriAntti, ImmonenAnselmie, "Product Life Cycle Management", Springer, Dreamtech,

ISBN: 3540257314

4. Michael Grieve, "Product Lifecycle Management: Driving the next generation of lean thinking", Tata McGraw Hill, 2006, ISBN: 0070636265

Course Code	Course Name	Credits
ILO7012	Reliability Engineering	03

Objectives:

1. To familiarize the students with various aspects of probability theory
2. To acquaint the students with reliability and its concepts
3. To introduce the students to methods of estimating the system reliability of simple and complex systems
4. To understand the various aspects of Maintainability, Availability and FMEA procedure

Outcomes: Learner will be able to...

1. Understand and apply the concept of Probability to engineering problems
2. Apply various reliability concepts to calculate different reliability parameters
3. Estimate the system reliability of simple and complex systems
4. Carry out a Failure Mode Effect and Criticality Analysis

Module	Detailed Contents	Hrs
01	<p>Probability theory: Probability: Standard definitions and concepts; Conditional Probability, Baye's Theorem.</p> <p>Probability Distributions: Central tendency and Dispersion; Binomial, Normal, Poisson, Weibull, Exponential, relations between them and their significance.</p> <p>Measures of Dispersion: Mean, Median, Mode, Range, Mean Deviation, Standard Deviation, Variance, Skewness and Kurtosis.</p>	08
02	<p>Reliability Concepts: Reliability definitions, Importance of Reliability, Quality Assurance and Reliability, Bath Tub Curve.</p> <p>Failure Data Analysis: Hazard rate, failure density, Failure Rate, Mean Time To Failure (MTTF), MTBF, Reliability Functions.</p> <p>Reliability Hazard Models: Constant Failure Rate, Linearly increasing, Time Dependent Failure Rate, Weibull Model. Distribution functions and reliability analysis.</p>	08
03	<p>System Reliability: System Configurations: Series, parallel, mixed configuration, k out of n structure, Complex systems.</p>	05
04	<p>Reliability Improvement: Redundancy Techniques: Element redundancy, Unit redundancy, Standby redundancies. Markov analysis.</p> <p>System Reliability Analysis – Enumeration method, Cut-set method, Success Path method, Decomposition method.</p>	08
05	<p>Maintainability and Availability: System downtime, Design for Maintainability: Maintenance requirements, Design methods: Fault Isolation and self-diagnostics, Parts standardization and Interchangeability, Modularization and Accessibility, Repair Vs Replacement.</p> <p>Availability – qualitative aspects.</p>	05

06	Failure Mode, Effects and Criticality Analysis: Failure mode effects analysis, severity/criticality analysis, FMECA examples. Fault tree construction, basic symbols, development of functional reliability block diagram, Fault tree analysis and Event tree Analysis	05
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Assessment:

Internal:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papers of end semester examination. **In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.**

1. Question paper will comprise of total six question
2. All question carry equal marks
3. Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four question need to be solved.

REFERENCES:

1. L.S. Srinath, "Reliability Engineering", Affiliated East-West Press (P) Ltd., 1985.
2. Charles E. Ebeling, "Reliability and Maintainability Engineering", Tata McGraw Hill.
3. B.S. Dhillon, C. Singh, "Engineering Reliability", John Wiley & Sons, 1980.
4. P.D.T. Conon, "Practical Reliability Engg.", John Wiley & Sons, 1985.
5. K.C. Kapur, L.R. Lamberson, "Reliability in Engineering Design", John Wiley & Sons.
6. Murray R. Spiegel, "Probability and Statistics", Tata McGraw-Hill Publishing Co. Ltd.

Course Code	Course Name	Credits
ILO7013	Management Information System	03

Objectives:

1. The course is blend of Management and Technical field.
2. Discuss the roles played by information technology in today's business and define various technology architectures on which information systems are built
3. Define and analyze typical functional information systems and identify how they meet the needs of the firm to deliver efficiency and competitive advantage
4. Identify the basic steps in systems development

Outcomes: Learner will be able to...

1. Explain how information systems Transform Business
2. Identify the impact information systems have on an organization
3. Describe IT infrastructure and its components and its current trends
4. Understand the principal tools and technologies for accessing information from databases to improve business performance and decision making
5. Identify the types of systems used for enterprise-wide knowledge management and how they provide value for businesses

Module	Detailed Contents	Hrs
01	Introduction To Information Systems (IS): Computer Based Information Systems, Impact of IT on organizations, Importance of IS to Society. Organizational Strategy, Competitive Advantages and IS.	4
02	Data and Knowledge Management: Database Approach, Big Data, Data warehouse and Data Marts, Knowledge Management. Business intelligence (BI): Managers and Decision Making, BI for Data analysis and Presenting Results	7
03	Ethical issues and Privacy: Information Security. Threat to IS, and Security Controls	7
04	Social Computing (SC): Web 2.0 and 3.0, SC in business-shopping, Marketing, Operational and Analytic CRM, E-business and E-commerce – B2B B2C. Mobile commerce.	7
05	Computer Networks Wired and Wireless technology, Pervasive computing, Cloud computing model.	6
06	Information System within Organization: Transaction Processing Systems, Functional Area Information System, ERP and ERP support of Business Process. Acquiring Information Systems and Applications: Various System development life cycle models.	8

Assessment:

Internal:

Assessment consists of two tests out of which; one should be a compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papers of end semester examination. **In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.**

1. Question paper will comprise of total six question
2. All question carry equal marks
3. Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four question need to be solved.

REFERENCES:

1. Kelly Rainer, Brad Prince, Management Information Systems, Wiley
2. K.C. Laudon and J.P. Laudon, Management Information Systems: Managing the Digital Firm, 10th Ed., Prentice Hall, 2007.
3. D. Boddy, A. Boonstra, Managing Information Systems: Strategy and Organization, Prentice Hall, 2008

Course Code	Course Name	Credits
ILO7014	Design of Experiments	03

Objectives:

1. To understand the issues and principles of Design of Experiments (DOE)
2. To list the guidelines for designing experiments
3. To become familiar with methodologies that can be used in conjunction with experimental designs for robustness and optimization

Outcomes: Learner will be able to...

1. Plan data collection, to turn data into information and to make decisions that lead to appropriate action
2. Apply the methods taught to real life situations
3. Plan, analyze, and interpret the results of experiments

Module	Detailed Contents	Hrs
01	Introduction Strategy of Experimentation Typical Applications of Experimental Design Guidelines for Designing Experiments Response Surface Methodology	06
02	Fitting Regression Models Linear Regression Models Estimation of the Parameters in Linear Regression Models Hypothesis Testing in Multiple Regression Confidence Intervals in Multiple Regression Prediction of new response observation Regression model diagnostics Testing for lack of fit	08
03	Two-Level Factorial Designs The 2^2 Design The 2^3 Design The General 2^k Design A Single Replicate of the 2^k Design The Addition of Center Points to the 2^k Design, Blocking in the 2^k Factorial Design Split-Plot Designs	07

04	Two-Level Fractional Factorial Designs The One-Half Fraction of the 2^k Design The One-Quarter Fraction of the 2^k Design The General 2^{k-p} Fractional Factorial Design Resolution III Designs Resolution IV and V Designs Fractional Factorial Split-Plot Designs	07
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05	Response Surface Methods and Designs Introduction to Response Surface Methodology The Method of Steepest Ascent Analysis of a Second-Order Response Surface Experimental Designs for Fitting Response Surfaces	07
06	Taguchi Approach Crossed Array Designs and Signal-to-Noise Ratios Analysis Methods Robust design examples	04

Assessment:

Internal:

Assessment consists of two tests out of which; one should be a compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papers of end semester examination. **In question, paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.**

Question paper will comprise of total six question

All question carry equal marks

Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)

Only Four questions need to be solved.

REFERENCES:

1. Raymond H. Mayers, Douglas C. Montgomery, Christine M. Anderson-Cook, Response Surface Methodology: Process and Product Optimization using Designed Experiment, 3rd edition, John Wiley & Sons, New York, 2001
2. D.C. Montgomery, Design and Analysis of Experiments, 5th edition, John Wiley & Sons, New York, 2001
3. George E P Box, J Stuart Hunter, William G Hunter, Statistics for Experimenters: Design, Innovation and Discovery, 2nd Ed. Wiley
4. W J Dimond, Practical Experiment Designs for Engineers and Scientists, John Wiley and Sons Inc. ISBN: 0-471-39054-2
5. Design and Analysis of Experiments (Springer text in Statistics), Springer by A.M. Dean, and D. T.Voss

Course Code	Course Name	Credits
ILO7015	Operations Research	03

Objectives:

1. Formulate a real-world problem as a mathematical programming model.
2. Understand the mathematical tools that are needed to solve optimization problems.
3. Use mathematical software to solve the proposed models.

Outcomes: Learner will be able to...

1. Understand the theoretical workings of the simplex method, the relationship between a linear program and its dual, including strong duality and complementary slackness.
2. Perform sensitivity analysis to determine the direction and magnitude of change of a model's optimal solution as the data change.
3. Solve specialized linear programming problems like the transportation and assignment problems, solve network models like the shortest path, minimum spanning tree, and maximum flow problems.
4. Understand the applications of integer programming and a queuing model and compute important performance measures

Module	Detailed Contents	Hrs
01	<p>Introduction to Operations Research: Introduction, , Structure of the Mathematical Model, Limitations of Operations Research</p> <p>Linear Programming: Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Graphical method, Simplex Method Penalty Cost Method or Big M-method, Two Phase Method, Revised simplex method, Duality, Primal – Dual construction, Symmetric and Asymmetric Dual, Weak Duality Theorem, Complimentary Slackness Theorem, Main Duality Theorem, Dual Simplex Method, Sensitivity Analysis Transportation Problem: Formulation, solution, unbalanced Transportation problem. Finding basic feasible solutions – Northwest corner rule, least cost method and Vogel's approximation method. Optimality test: the stepping stone method and MODI method.</p> <p>Assignment Problem: Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Processing of n Jobs Through Two Machines and m Machines, Graphical Method of Two Jobs m Machines Problem Routing Problem, Travelling Salesman Problem</p> <p>Integer Programming Problem: Introduction, Types of Integer Programming Problems, Gomory's cutting plane Algorithm, Branch and Bound Technique. Introduction to Decomposition algorithms.</p>	14

02	Queuing models: queuing systems and structures, single server and multi-server models, Poisson input, exponential service, constant rate service, finite and infinite population	05
03	Simulation: Introduction, Methodology of Simulation, Basic Concepts,	05
	Simulation Procedure, Application of Simulation Monte-Carlo Method: Introduction, Monte-Carlo Simulation, Applications of Simulation, Advantages of Simulation, Limitations of Simulation	
04	Dynamic programming. Characteristics of dynamic programming. Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stage Coach/Shortest Path, cargo loading and Reliability problems.	05
05	Game Theory. Competitive games, rectangular game, saddle point, minimax (maximin) method of optimal strategies, value of the game. Solution of games with saddle points, dominance principle. Rectangular games without saddle point – mixed strategy for 2 X 2 games.	05
06	Inventory Models: Classical EOQ Models, EOQ Model with Price Breaks, EOQ with Shortage, Probabilistic EOQ Model,	05

Assessment:

Internal:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papers of end semester examination. **In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.**

1. Question paper will comprise of total six question
2. All question carry equal marks
3. Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four question need to be solved.

REFERENCES:

1. Taha, H.A. "Operations Research - An Introduction", Prentice Hall, (7th Edition), 2002.
2. Ravindran, A, Phillips, D. T and Solberg, J. J. "Operations Research: Principles and Practice", John Wiley and Sons, 2nd Edition, 2009.
3. Hiller, F. S. and Liebermann, G. J. "Introduction to Operations Research", Tata McGraw Hill, 2002.
4. Operations Research, S. D. Sharma, KedarNath Ram Nath-Meerut.
5. Operations Research, KantiSwarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons.

Course Code	Course Name	Credits
ILO7016	Cyber Security and Laws	03

Objectives:

1. To understand and identify different types cybercrime and cyber law
2. To recognized Indian IT Act 2008 and its latest amendments
3. To learn various types of security standards compliances

Outcomes: Learner will be able to...

1. Understand the concept of cybercrime and its effect on outside world
2. Interpret and apply IT law in various legal issues
3. Distinguish different aspects of cyber law
4. Apply Information Security Standards compliance during software design and development

Module	Detailed Contents	Hrs
01	Introduction to Cybercrime: Cybercrime definition and origins of the world, Cybercrime and information security, Classifications of cybercrime, Cybercrime and the Indian ITA 2000, A global Perspective on cybercrimes.	4
02	Cyber offenses & Cybercrime: How criminal plan the attacks, Social Engg, Cyber stalking, Cyber café and Cybercrimes, Bot nets, Attack vector, Cloud computing, Proliferation of Mobile and Wireless Devices, Trends in Mobility, Credit Card Frauds in Mobile and Wireless Computing Era, Security Challenges Posed by Mobile Devices, Registry Settings for Mobile Devices, Authentication Service Security, Attacks on Mobile/Cell Phones, Mobile Devices: Security Implications for Organizations, Organizational Measures for Handling Mobile, Devices-Related Security Issues, Organizational Security Policies and Measures in Mobile Computing Era, Laptops	9
03	Tools and Methods Used in Cyber line Phishing, Password Cracking, Key loggers and Spywares, Virus and Worms, Steganography, DoS and DDoS Attacks, SQL Injection, Buffer Over Flow, Attacks on Wireless Networks, Phishing, Identity Theft (ID Theft)	6
04	The Concept of Cyberspace E-Commerce , The Contract Aspects in Cyber Law ,The Security Aspect of Cyber Law ,The Intellectual Property Aspect in Cyber Law , The Evidence Aspect in Cyber Law , The Criminal Aspect in Cyber Law, Global Trends in Cyber Law , Legal Framework for Electronic Data Interchange Law Relating to Electronic Banking , The Need for an Indian Cyber Law	8

05	Indian IT Act. Cyber Crime and Criminal Justice : Penalties, Adjudication and Appeals Under the IT Act, 2000, IT Act. 2008 and its Amendments	6
06	Information Security Standard compliances SOX, GLBA, HIPAA, ISO, FISMA, NERC, PCI.	6

Assessment:

Internal:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papers of end semester examination.

In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

1. Question paper will comprise of total six question
2. All question carry equal marks
3. Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four question need to be solved.

REFERENCES:

1. Nina Godbole, Sunit Belapure, *Cyber Security*, Wiley India, New Delhi
2. The Indian Cyber Law by Suresh T. Vishwanathan; Bharat Law House New Delhi
3. The Information technology Act, 2000; Bare Act- Professional Book Publishers, New Delhi.
4. Cyber Law & Cyber Crimes By Advocate Prashant Mali; Snow White Publications, Mumbai
5. Nina Godbole, *Information Systems Security*, Wiley India, New Delhi
6. Kenneth J. Knapp, *Cyber Security & Global Information Assurance* Information Science Publishing.
7. William Stallings, *Cryptography and Network Security*, Pearson Publication
8. Websites for more information is available on : The Information Technology ACT, 2008- TIFR : <https://www.tifrh.res.in>
9. Website for more information , A Compliance Primer for IT professional : <https://www.sans.org/reading-room/whitepapers/compliance/compliance-primer-professionals-33538>

Course Code	Course Name	Credits
ILO7017	Disaster Management and Mitigation Measures	03

Objectives:

1. To understand physics and various types of disaster occurring around the world
2. To identify extent and damaging capacity of a disaster
3. To study and understand the means of losses and methods to overcome /minimize it.
4. To understand role of individual and various organization during and after disaster
5. To understand application of GIS in the field of disaster management
6. To understand the emergency government response structures before, during and after disaster

Outcomes: Learner will be able to...

1. Get to know natural as well as manmade disaster and their extent and possible effects on the economy.
2. Plan of national importance structures based upon the previous history.
3. Get acquainted with government policies, acts and various organizational structure associated with an emergency.
4. Get to know the simple do's and don'ts in such extreme events and act accordingly.

Module	Detailed Contents	Hrs
01	Introduction 1.1 Definition of Disaster, hazard, global and Indian scenario, general perspective, importance of study in human life, Direct and indirect effects of disasters, long term effects of disasters. Introduction to global warming and climate change.	03
02	Natural Disaster and Manmade disasters: Natural Disaster: Meaning and nature of natural disaster, Flood, Flash flood, drought, cloud burst, Earthquake, Landslides, Avalanches, Volcanic eruptions, Mudflow, Cyclone, Storm, Storm Surge, climate change, global warming, sea level rise, ozone depletion Manmade Disasters: Chemical, Industrial, Nuclear and Fire Hazards. Role of growing population and subsequent industrialization, urbanization and changing lifestyle of human beings in frequent occurrences of manmade disasters.	09
03	Disaster Management, Policy and Administration Disaster management: meaning, concept, importance, objective of disaster management policy, disaster risks in India, Paradigm shift in disaster management. Policy and administration: Importance and principles of disaster management policies, command and co-ordination of in disaster management, rescue operations-how to start with and how to proceed in due course of time, study of flowchart showing the entire process.	06

04	<p>Institutional Framework for Disaster Management in India:</p> <p>4.1 Importance of public awareness, Preparation and execution of emergency management programme.Scope and responsibilities of National Institute of Disaster Management (NIDM) and National disaster management authority (NDMA) in India.Methods and measures to avoid disasters, Management of</p>	06
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	casualties, set up of emergency facilities, importance of effective communication amongst different agencies in such situations. 4.2 Use of Internet and softwares for effective disaster management. Applications of GIS, Remote sensing and GPS in this regard.	
05	Financing Relief Measures: Ways to raise finance for relief expenditure, role of government agencies and NGO's in this process, Legal aspects related to finance raising as well as overall management of disasters. Various NGO's and the works they have carried out in the past on the occurrence of various disasters, Ways to approach these teams. International relief aid agencies and their role in extreme events.	09
06	Preventive and Mitigation Measures: Pre-disaster, during disaster and post-disaster measures in some events in general Structural mapping: Risk mapping, assessment and analysis, sea walls and embankments, Bio shield, shelters, early warning and communication Non Structural Mitigation: Community based disaster preparedness, risk transfer and risk financing, capacity development and training, awareness and education, contingency plans. Do's and don'ts in case of disasters and effective implementation of relief aids.	06

Assessment:

Internal:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papers of end semester examination. **In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.**

1. Question paper will comprise of total six question
2. All question carry equal marks
3. Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four question need to be solved.

REFERENCES:

1. 'Disaster Management' by Harsh K.Gupta, Universities Press Publications.
2. 'Disaster Management: An Appraisal of Institutional Mechanisms in India' by O.S.Dagur, published by Centre for land warfare studies, New Delhi, 2011.
3. 'Introduction to International Disaster Management' by Damon Copolla, Butterworth Heinemann Elseveir Publications.
4. 'Disaster Management Handbook' by Jack Pinkowski, CRC Press Taylor and Francis group.
5. 'Disaster management & rehabilitation' by Rajdeep Dasgupta, Mittal Publications, New Delhi.

6. 'Natural Hazards and Disaster Management, Vulnerability and Mitigation – R B Singh, Rawat Publications
7. Concepts and Techniques of GIS –C.P.Lo Albert, K.W. Yonng – Prentice Hall (India) Publications.
(Learners are expected to refer reports published at national and International level and updated information available on authentic web sites)

Course Code	Course Name	Credits
ILO7018	Energy Audit and Management	03

Objectives:

1. To understand the importance energy security for sustainable development and the fundamentals of energy conservation.
2. To introduce performance evaluation criteria of various electrical and thermal installations to facilitate the energy management
3. To relate the data collected during performance evaluation of systems for identification of energy saving opportunities.

Outcomes: Learner will be able to...

1. To identify and describe present state of energy security and its importance.
2. To identify and describe the basic principles and methodologies adopted in energy audit of an utility.
3. To describe the energy performance evaluation of some common electrical installations and identify the energy saving opportunities.
4. To describe the energy performance evaluation of some common thermal installations and identify the energy saving opportunities
5. To analyze the data collected during performance evaluation and recommend energy saving measures

Module	Detailed Contents	Hrs
01	Energy Scenario: Present Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy Security, Energy Conservation and its Importance, Energy Conservation Act- 2001 and its Features. Basics of Energy and its various forms, Material and Energy balance	04
02	Energy Audit Principles: Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution. Elements of monitoring& targeting; Energy audit Instruments; Data and information-analysis. Financial analysis techniques: Simple payback period, NPV, Return on investment (ROI), Internal rate of return (IRR)	08

03	Energy Management and Energy Conservation in Electrical System: Electricity billing, Electrical load management and maximum demand Control; Power factor improvement, Energy efficient equipments and appliances, star ratings. Energy efficiency measures in lighting system, Lighting control: Occupancy sensors, daylight integration, and use of intelligent controllers. Energy conservation opportunities in: water pumps, industrial drives, induction motors, motor retrofitting, soft starters, variable speed drives.	10
04	Energy Management and Energy Conservation in Thermal Systems: Review of different thermal loads; Energy conservation opportunities in: Steam distribution system, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system. General fuel economy measures in Boilers and furnaces, Waste heat recovery, use of insulation- types and application. HVAC system: Coefficient of performance, Capacity, factors affecting Refrigeration and Air Conditioning system performance and savings opportunities.	10
05	Energy Performance Assessment: On site Performance evaluation techniques, Case studies based on: Motors and variable speed drive, pumps, HVAC system calculations; Lighting System: Installed Load Efficacy Ratio (ILER) method, Financial Analysis.	04
06	Energy conservation in Buildings: Energy Conservation Building Codes (ECBC): Green Building, LEED rating, Application of Non-Conventional and Renewable Energy Sources	03

Assessment:

Internal:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papers of end semester examination. **In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.**

1. Question paper will comprise of total six question
2. All question carry equal marks
3. Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four question need to be solved.

REFERENCES:

1. Handbook of Electrical Installation Practice, Geofry Stokes, Blackwell Science
2. Designing with light: Lighting Handbook, By Anil Valia, Lighting System
3. Energy Management Handbook, By W.C. Turner, John Wiley and Sons

4. Handbook on Energy Audits and Management, edited by A. K. Tyagi, Tata Energy Research Institute (TERI).
5. Energy Management Principles, C.B.Smith, Pergamon Press
6. Energy Conservation Guidebook, Dale R. Patrick, S. Fardo, Ray E. Richardson, Fairmont Press
7. Handbook of Energy Audits, Albert Thumann, W. J. Younger, T. Niehus, CRC Press
8. www.energymanagertraining.com
9. www.bee-india.nic.in

Course Code	Course Name	Credits
ILO7019	Development Engineering	03

Objectives:

1. To familiarize the characteristics of rural Society and the Scope, Nature and Constraints of rural Development
2. To provide an exposure to implications of 73rdCAA on Planning, Development and Governance of Rural Areas
3. An exploration of human values, which go into making a ‘good’ human being, a ‘good’ professional, a ‘good’ society and a ‘good life’ in the context of work life and the personal life of modern Indian professionals
4. To familiarize the Nature and Type of Human Values relevant to Planning Institutions

Outcomes: Learner will be able to...

1. Demonstrate Understanding of knowledge for Rural Development.
2. Prepare solutions for Management Issues.
3. Take up Initiatives and design Strategies to complete the task
4. Develop acumen for higher education and research.
5. Demonstrate the art of working in group of different nature
6. Develop confidence to take up rural project activities independently

Module	Contents	Hrs
1	Introduction to Rural Development Meaning, nature and scope of development; Nature of rural society in India; Hierarchy of settlements; Social, economic and ecological constraints for rural development Roots of Rural Development in India Rural reconstruction and Sarvodaya programme before independence; Impact of voluntary effort and Sarvodaya Movement on rural development; Constitutional direction, directive principles; Panchayati Raj - beginning of planning and community development; National extension services.	08
2	Post-Independence rural Development Balwant Rai Mehta Committee - three tier system of rural local Government; Need and scope for people’s participation and Panchayati Raj; Ashok Mehta Committee - linkage between Panchayati Raj, participation and rural development.	06

3	Rural Development Initiatives in Five Year Plans Five Year Plans and Rural Development; Planning process at National, State, Regional and District levels; Planning, development, implementing and monitoring organizations and agencies; Urban and rural interface - integrated approach and local plans; Development initiatives and their convergence; Special component plan and sub-plan for the weaker section; Micro-eco zones; Data base for local planning; Need for decentralized planning; Sustainable rural development	07
4	Post 73rd Amendment Scenario 73rd Constitution Amendment Act, including - XI schedule, devolution of powers, functions and finance; Panchayati Raj institutions - organizational linkages; Recent changes in rural local planning; Gram Sabha - revitalized Panchayati Raj; Institutionalization; resource mapping, resource mobilization including social mobilization; Information Technology and rural planning; Need for further amendments.	04
5	Values and Science and Technology Material development and its values; the challenge of science and technology; Values in planning profession, research and education Types of Values Psychological values — integrated personality; mental health; Societal values — the modern search for a good society; justice, democracy, rule of law, values in the Indian constitution; Aesthetic values — perception and enjoyment of beauty; Moral and ethical values; nature of moral judgment; Spiritual values; different concepts; secular spirituality; Relative and absolute values; Human values— humanism and human values; human rights; human values as freedom, creativity, love and wisdom	10
6	Ethics Canons of ethics; ethics of virtue; ethics of duty; ethics of responsibility; Work ethics; Professional ethics; Ethics in planning profession, research and education	04

Assessment:

Internal Assessment for 20 marks:

Consisting Two Compulsory Class Tests

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions, each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**

Reference

1. ITPI, Village Planning and Rural Development, ITPI, New Delhi
2. Thooyavan, K.R. Human Settlements: A 2005 MA Publication, Chennai
3. GoI, Constitution (73rdGoI, New Delhi Amendment) Act, GoI, New Delhi
4. Planning Commission, Five Year Plans, Planning Commission
5. Planning Commission, Manual of Integrated District Planning, 2006, Planning Commission New Delhi
6. Planning Guide to Beginners
7. Weaver, R.C., The Urban Complex, Doubleday
8. Farmer, W.P. et al, Ethics in Planning, American Planning Association, Washington
9. How, E., Normative Ethics in Planning, Journal of Planning Literature, Vol.5, No.2, pp. 123-150
10. Watson, V. Conflicting Rationalities: -- Implications for Planning Theory and Ethics, Planning Theory and Practice, Vol. 4, No.4, pp.395 – 407

		Teaching Scheme (Contact Hours)			Credits Assigned			
Course Code	Course Name	Theory	Practical	Tutorial	Theory	Oral	Tutorial	Total
IOTC801	Industrial IoT	03	-	--	--	-	--	3

Subject Code	Subject Name	Examination Scheme						
		Theory Marks				Term Work	Oral	Total
		Internal assessment			End Sem. Exam			
		Test 1	Test 2	Avg. of 2 Tests				
IOTC801	Industrial IoT	20	20	20	80	-	-	100

Course Objectives: The course aims:

1. To understand the concepts of Industry 4.0 and IIOT.
2. To comprehend the Business models and reference architecture of IIoT.
3. To interpret Data Transmission and Data Acquisition systems for IIoT.
4. To explore middleware and WAN technologies.
5. To learn the security aspects in IIoT.
6. To understand real time applications of IIoT in various domains.

Course Outcomes: On successful completion, of course, learner/student will be able to:

Sr. No.	Course Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		
1	Describe the concepts of Industry 4.0 and IIOT.	L2
2.	Illustrate the Business models and reference architecture of IIOT.	L3
3.	Analyze Data Transmission and Data Acquisition systems for IIoT.	L4
4.	Discuss various middleware and WAN technologies in IIOT.	L2
5.	Explain security aspects in IIoT.	L2
6.	Analyze real time applications of IIoT in various domains.	L4

Prerequisite: IoT Architecture and Protocols, Wireless Sensor Technologies

Sr. No.	Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	IoT Architecture and Protocols, Wireless Sensing Technologies	02	
I	Introduction to Industry 4.0 and IIOT	Overview of Industry 4.0 and Industrial Internet of Things, Industry 4.0: Industrial Revolution: Phases of Development, Basics of CPS, CPS and IIOT, Design requirements of Industry 4.0, Drivers of Industry 4.0, Sustainability Assessment of industries, Smart Business Perspective, Cybersecurity, Impacts of Industry 4.0, Industrial Internet of Things: Basics, Industrial Internet Systems , Industrial Sensing, Industrial Processes. Self-learning Topics: Study real time IIoT challenges in industry.	6	CO1
II	Business Models and Reference Architecture of IIoT	Introduction, Definition of a business model, Business Models of IoT and IIoT, Reference Architecture of IIoT, Industrial Internet Reference Architecture(IIRA) , Key Performance Indicators for Occupational Safety and Health. Self-learning Topics: Study IoT Architecture.	6	CO2
III	Data Transmission and Acquisition for Industrial IoT	Introduction, (Features and Components of - Foundation Fieldbus, Profibus, HART,Interbus, Bitbus, CC-Link, Modbus, Batibus, DigitalSTROM, Controller Area Network, DeviceNet, LonWorks, ISA 100.11a, Wireless HART, LoRa and LoRaWAN) NB-IoT, IEEE 802.11AH, Distributed Control System, PLC, SCADA Self-learning Topics: Study SCADA, PLC in detail.	7	CO3
IV	IIOT Middleware and WAN Technologies	Examining Middleware Transport Protocols (TCP/IP, UDP, RTP, CoAP), Middleware Software Patterns (Publish Subscribe Pattern, Delay Tolerant Networks), Software Design Concepts – Application Programming Interface – A Technical Perspective, Web Services, IIOT Middleware Platforms – Middleware Architecture IIOT WAN Technologies and Protocols - IIoT Device Low-Power WAN Optimized Technologies for M2M, SigFox, LoRaWAN, nWave, Dash7 Protocol, Ingénue RPMA, Low Power Wi-Fi, LTE Category-M, Weightless, Millimeter Radio Self-learning Topics: Study different IIoT Middleware and WAN Technologies.	8	CO4
V	IIoT Security	Threats, Vulnerabilities and Risks in IIoT, IIoT Identity and Access Management: Identification, Authentication,	6	CO5

		<p>Authorization and Account Management, IAM in IIoT, Securing IIoT Edge, Fog, Cloud and Application, IIoT Security using Emerging Technologies: Blockchain to Secure IIoT Transactions, AI-based IIoT Security.</p> <p>Self-learning Topics: Case Studies on Vulnerability, Threat and Attacks and Possible Defense Mechanism in Different Application Scenarios.</p>		
VI	IIOT Applications	<p>Machine Learning and Data Science Applications in Industry, Health Care Applications in Industry, IIoT in Inventory Management and Quality Control, IIoT in Plant Safety and Security, Case Studies: Manufacturing Industry, Automotive Industry, Mining Industry.</p> <p>Self-learning Topics: Case Studies on Real-Time Applications</p>	6	CO6

Text Books:

1. “Industry 4.0: The Industrial Internet of Things”, by Alasdair Gilchrist (Apress)
2. “Introduction to Industrial Internet of Things and Industry 4.0”, by Sudip Misra, Chandana Roy And Anandarup Mukherjee, CRC Press (Taylor & Francis Group)
3. “Practical Industrial Internet of Things security”: A practitioner's guide to securing connected industries, by Bhattacharjee and Sravani, Packt Publishing Ltd, 2018.

Reference Books:

1. “Internet of Things Principles and Paradigms”, by Rajkumar Buyya, Amir Vahid Dastjerdi, ELSEVIER Inc.
2. “Practical Internet of Things Security”, by Brian Russell, Drew Van Duren (Packt Publishing)
3. “IoT Fundamentals – Networking Technologies, Protocols, and Use Cases for the Internet of Things”, David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton, Jerome Henry, 1st Edition, Published by Pearson Education, Inc, publishing as Cisco Press, 2017.

Online References:

1. https://onlinecourses.nptel.ac.in/noc23_cs51/preview
2. https://onlinecourses.nptel.ac.in/noc20_cs69/preview
3. https://onlinecourses.nptel.ac.in/noc22_me123/preview
4. [The Industrial Internet of Things \(IIOT\) - How to Build a Digitally Connected Enterprise |](#)

[Coursera](#)

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.
- **Question paper format:**
- Question Paper will comprise of a total of **six questions each carrying 20 marks** Q.1 will be **compulsory** and should **cover maximum contents of the syllabus**.
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules).
- A total of **four questions** need to be answered.

		Theory	Practical	Tutorial	Theory	Practical/ Oral	Tutorial	Total
IOTDO801 1	User Interface Design for IoT	03	--	--	03	--	--	03

Subject Code	Subject Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		Test 1	Test 2	Avg. of 2 Tests					
IOTDO801 1	User Interface Design for IoT	20	20	20	80	--	--	--	100

Course Objectives: Six Course Objectives

1. To understand the need for a good UI design in IoT
2. To orient students to the different data management technologies
3. To understand the need for web connectivity
4. To understand the importance of Cloud services in data collection and storage
5. To study and understand various software used for IoT Applications
6. Understanding various frontend and backend technologies used for designing IoT Applications

Course Outcomes: Six Course outcomes

Sr. No.	Course Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		
1	Understand Interaction Design Process and User Experience in IoT.	L1
2.	Design with the development of connected devices in various industries ensuring positive user experiences	L3
3.	Apply the knowledge of Web Connectivity in the UI design for IoT.	L3
4.	Illustrate Data Collection, Storage and Computing using a Cloud Platform.	L3
5.	Prototyping the Software for IoT Applications.	L1,L2
6.	Create websites using different web technologies for IoT applications.	L2,L3

Prerequisite: IoT Architecture and Protocols, Web X.0

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Software Engineering concepts, IoT basics and Cloud Computing basics.	02	NA
I	Introduction to Interaction Design	Good and Poor Design, What is Interaction Design, The User Experience, The Process of Interaction Design, Interaction Design and the User Experience, Necessity of UI/UX. Self-learning Topics: Study of Various interactive day to day IoT applications.	05	CO1
II	Design Principles for Connected Devices	Introduction, IoT/M2M Systems Layers and Design Standardisation, Communication Technologies, Data Enrichment, Data Consolidation and Device Management at gateway. Self-learning Topics: Understanding Security and Usability of the data.	05	CO2
III	Design Principles for Web Connectivity	Introduction, Web communication protocols for connected devices, Message Communication Protocols for connected devices, Web connectivity for connected devices network using gateway, SOAP, REST, HTTP RESTful and webSockets. Self-learning Topics: To build RESTful API.	08	CO3

IV	Data Collection, Storage and Computing Using a Cloud Platform	Introduction, Cloud Computing Paradigm for data collection, Storage and Computing, Everything as a Service and Cloud Service Models, IoT Cloud-based services using Xively, Nimbits and other platforms. Self-learning Topics: Study of tools like ThingSpeak, Ubidots, AWS cloud	08	CO4
V	Prototyping and Designing the Software for IoT Applications	Introduction, Prototyping Embedded Device Software, Devices, Gateways, Internet and Web/Cloud Services Software-Development, Prototyping Online Component APIs and Web APIs. Self-learning Topics: Study of online UI Tool like Figma	06	CO5
VI	Web Technologies used for User Interface Design for IoT applications	Front End Technologies: Responsive website design using HTML5, ReactJs, AngularJs etc. Back End Technologies: NodeJs, ExpressJs and MongoDB. Self-learning Topics: Use Case for Healthcare Monitoring System.	07	CO6

Text Books:

1. Interaction Design, by J. Preece, Y. Rogers and H. Sharp. ISBN 0-471-49278-7.
2. Wilbert O. Galitz, —The Essential Guide to User Interface Design, Wiley publication.
3. INTERNET OF THINGS: Architecture and Design Principles, Raj Kamal, McGraw Hill Education.

References:

1. Human-Computer Interaction, by ALAN DIX, JANET FINLAY, GREGORY D. ABOWD, RUSSELL BEALE, Pearson Education Limited, Edition 3
2. Internet of Things, by Vinayak Shinde, Yogesh Pingle, Anjali Yeole, Sybgen Learning
3. Internet of Things for Architects, Perry Lea, Packt

Online References:

1. Design & Implementation Of Human-Computer Interfaces
https://onlinecourses.nptel.ac.in/noc23_cs116/preview

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.
- **Question paper format:**
- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**.
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules).
- A total of **four questions** need to be answered.

Subject Code	Subject Name	Theory	Practical	Tutorial	Theory	Practical/Oral	Tutorial	Total
IOTDO8012	Energy Harvesting and Power Management for IoT devices	03	--	--	03	--	--	03

Subject Code	Subject Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		Test 1	Test 2	Avg. of 2 Tests					
IOTDO8012	Energy Harvesting and Power Management for IoT devices	20	20	20	80	--	--	--	100

Course Objectives:

1. To understand the energy sources and harvesting based sensor networks.
2. To learn Piezoelectric materials and energy harvesters.
3. To emphasize on Electromechanical Modeling of Cantilevered Piezoelectric Energy Harvesters for Persistent Base Motions.
4. To Learn principles of Electromagnetic Energy Harvesting and Non-linear Techniques.
5. To Understand the various Power sources for WSN.
6. To Learn the applications of Energy harvesting systems.

Course Outcomes:

Sr. No.	Course Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, the learner/student will be able to:		
1	Illustrate the knowledge of various energy sources, harvesting cell and the impact of factors influencing the efficiency.	L1, L2, L3
2	Analyze the properties of piezoelectric materials to convert the mechanical vibrations, and strains into electrical energy.	L1, L2, L3, L4
3	Develop mathematical models to analyse cantilevered piezoelectric energy harvesters' behaviour and dynamics.	L1, L2, L3, L4
4	Design electromagnetic energy harvesting devices and systems to explore non-linear techniques for improving energy harvesting efficiency.	L1, L2, L3, L4
5	Identify the different techniques of Energy Harvesting for Wireless Sensors and their appropriate applications.	L1, L2, L3
6	Summarize applications of Energy Harvesting Systems and apply them in relevant applications.	L1, L2, L3

Prerequisite:

IoTC601 IoT Architecture and Protocols, IoTC602 RFID and Microcontrollers, IoTC603 Wireless Sensor Technologies, CSDO701X IoT for Healthcare Application, CSDO701X IoT for Smart Cities

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hrs.	CO Mapping

0	Prerequisite	Basic knowledge of electrical circuits and electronics, Fundamentals of IoT, Analog and digital electronics, Energy and power fundamentals, Basic knowledge of sensors and actuators, Electrical power systems	03	
I	Energy Harvesting Electronic Systems	1.1 Available Energy Sources - Mechanical Energy, Thermal Gradients, Radio Frequency Electromagnetic Energy, Human Generation, Microbial Fuel Cells, Light. 1.2 Comparison of Harvestable Energy Sources 1.3 Energy Harvesting-Based Sensor Networks - Introduction, Energy Neutrality, Examples of WSN Powered by Harvested Energy 1.4 Photovoltaic Cell Technologies – Introduction - Concepts and Parameters Regarding PV Cells - Standard Illumination Conditions-Fill Factor-Efficiency-Peak Watt 1.5 Generation of Electric Power in Semiconductor PV Cells - Efficiency Limit According to Shockley and Queisser 1.6 Types of PV Cells - First-Generation PV Cells- Second Generation PV Cells-Third-Generation PV Cells- Comparison of the Different PV Technologies Self Learning Topics: Indoor Light Energy Availability Study- Light Power Intensity Measurements	06	CO1
II	Piezoelectric Energy Harvesting	2.1 Piezoelectric Materials- Piezoelectric Polycrystalline Ceramics - Piezoelectric Single Crystal Materials - Piezoelectric and Electrostrictive Polymers- Piezoelectric Thin Films 2.2 Piezoelectric Transducers 2.3 Meso-macro-scale Energy Harvesters- Mechanical Energy Harvester Using Laser Micromachining - Mechanical Energy Harvester Using Piezoelectric Fibers 2.4 Piezoelectric Microgenerator - Piezoelectric Microcantilevers 2.5 Energy Harvesting Circuits 2.6 Strategies for Enhancing the Performance of Energy Harvester - Multi-modal Energy Harvesting - Magnetoelectric Composites - Self-Tuning - Frequency Pumping - Wide-Bandwidth Transducers Self Learning Topics: Selected Applications - Border Security Sensors - Biomedical Applications	06	CO2
III	Electromechanical Modeling of Cantilevered	3.1 Amplitude-Wise Correction of the Lumped Parameter Model - Uncoupled Lumped Parameter Base	05	CO3

	Piezoelectric Energy Harvesters for Persistent Base Motions	<p>Excitation Model - Uncoupled Distributed Parameter Base Excitation Model</p> <p>3.2 Correction Factors for the Lumped Parameter Model - Correction Factor in the Piezoelectrically Coupled Lumped Parameter Equations</p> <p>3.3 Coupled Distributed Parameter Models and Closed-Form Solutions - Modeling Assumptions - Mathematical Background –</p> <p>3.4 Unimorph Configuration</p> <p>3.5 Bimorph Configurations</p> <p>Self Learning Topics: Single-Mode Electromechanical Equations, Experimental Validation</p>		
IV	Electromagnetic Energy Harvesting and Non-linear Techniques	<p>4.1 Basic Principles - Micro-Fabricated Coils - Magnetic Materials</p> <p>4.2 Scaling of Electromagnetic Vibration Generators - Scaling of Electromagnetic Damping -</p> <p>4.3 Maximizing Power from an EM Generator</p> <p>4.4 Microscale Implementations</p> <p>4.5 Macro-Scale Implementations</p> <p>4.6 Introduction to Nonlinear Techniques and their Application to Vibration Control - Principles</p> <p>4.7 Energy Harvesting Using Nonlinear Techniques in Steady-State Case - Principles - Analysis Without Induction of Vibration Damping</p> <p>Self Learning Topics: Energy Harvesting in Pulsed Operation, Energy Harvesting Techniques under Broadband Excitation</p>	07	CO4
V	Energy Harvesting Wireless Sensors	<p>5.1 Power Sources for Wireless Sensor Networks- Introduction - Primary Batteries</p> <p>5.2 Energy harvesting - Energy Harvesting versus Energy Scavenging - Photonic Methods - Vibrational Methods - Thermal Methods</p> <p>5.3 Alternative Methods - RF Power - Radioactive Sources - Power Conversion - Energy Storage - Examples - case studies.</p> <p>5.4 Harvesting Microelectronic Circuits - Harvesting Sources - Energy and Power - Energy Sources</p> <p>5.5 Power Conditioning - Microsystem - Linear DC–DC Converters - Switching DC–DC Converters - Switching AC–DC Converters - Comparison</p> <p>5.6 Power Losses - Conduction Losses - Switching Losses - Quiescent Losses - Losses Across Load</p> <p>Self Learning Topics: Tracking Helicopter Component Loads with Energy Harvesting Wireless Sensors, Monitoring Large Bridge Spans with Solar-Powered Wireless Sensors</p>	06	CO5

VI	Selected Applications of Energy Harvesting Systems	<p>6.1 Power Source for Implanted Medical Devices- Introduction- Generator Driven by Muscle Power - Selection of Mechanical-to-Electrical Conversion Method - Properties of Piezoelectric Material Relevant to the Generator System - Predicted Output Power of Generator - Steps Towards Reduction to Practice</p> <p>6.2 Piezoelectric Energy Harvesting for Bio-MEMS Applications - Introduction - General Expression for Harvesting Energy with Piezoelectric - Unimorph Diaphragm in Bending - Simply Supported Unimorph Diaphragm that is Partially Covered with Piezoelectric Material - Clamped Unimorph Diaphragm that is Partially Covered with Piezoelectric Material</p> <p>6.3 Energy Harvesting (EH) for Active RF Sensors and ID Tags - EH Technologies for RF sensors - EH Design Considerations - Energy Storage Technologies - Energy Requirements and Power Management Issues - Vibrational Energy Harvesting - Solar Energy Harvesting</p> <p>Self Learning Topics: Powering Wireless SHM Sensor Nodes through Energy Harvesting</p>	06	CO6

Text Books:

1. Shashank Priya, Daniel J. Inman, "Energy Harvesting Technologies", Springer New York, NY, ISBN: 978-0-387-76463-4, DOI- <https://doi.org/10.1007/978-0-387-76464-1>
2. Carlos Manuel Ferreira Carvalho, Nuno Filipe Silva Veríssimo Paulino (auth.), "CMOS Indoor Light Energy Harvesting System for Wireless Sensing Applications [1 ed.]" 978-3-319-21616-4, 978-3-319-21617-1, Springer International Publishing 2016.

References:

1. Danick Briand, Eric Yeatman, Shad Roundy (eds.), "Micro Energy Harvesting" , Advanced Micro and Nanosystems - Wiley-VCH, 2015.
2. Elena Blokhina, Abdelali El Aroudi, Eduard Alarcon, Dimitri Galayko (eds.), "Nonlinearity in Energy Harvesting Systems: Micro- and Nanoscale Applications", Springer International Publishing, 978-3-319-20354-6, 978-3-319-20355-3, 2016.

3. Bin Yang, Huicong Liu, Jingquan Liu, Chengkuo Lee, "Micro and Nano Energy Harvesting Technologies", Artech House; Illustrated edition (1 Dec. 2014), ISBN-13: 978-1608078141.

Online References:

Selection of Nanomaterials for Energy Harvesting and Storage Applications -
https://onlinecourses.nptel.ac.in/noc19_me73/preview

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.
- **Question paper format:**
- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**.
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules).
- A total of **four questions** need to be answered.

		Theory	Practical	Tutorial	Theory	Practical/ Oral	Tutorial	Total
IOTDO8013	Information Retrieval System	03	--	--	03	--	--	03

Subject Code	Subject Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		Test1	Test 2	Avg. of 2 Tests					
IOTDO8013	Information Retrieval System	20	20	20	80	--	--	--	100

Course Objectives: Six Course Objectives

1. To learn the fundamentals of the information retrieval system.
2. To classify various Information retrieval models.
3. To demonstrate the query processing techniques and operations
- 4.To compare the relevance of query languages for text and multimedia data
5. To analyse the significance of various multimedia information retrieval models.
6. To understand IoT data management and analytics.

Course Outcomes: Six Course outcomes

Sr. No.	Course Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		
1	Define the objectives of the basic concepts of the Information retrieval system.	L1,
2	Apply different information retrieval models to real time world problems.	L2, L3
3	Solve text and multimedia retrieval queries and their operations.	L3, L4

4	Apply text processing techniques and operations in the Information Retrieval system.	L3, L4
5	Analyze various multimedia Information Retrieval models.	L3
6	Apply different IoT data management techniques	L3

Prerequisite: Indexing and searching Algorithms, Internet of Things (IoT) Fundamentals

DETAILED SYLLABUS: t

Sr. No.	Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Indexing and searching Algorithms, Internet of Things (IoT) Fundamentals	02	
I	Introduction to Information Retrieval System	Motivation, Basic Concepts, The Retrieval Process, Information System: Components, parts and types on information system; Definition and objectives on information retrieval system, Information versus Data Retrieval. Search Engines and browsers Self-learning Topics: Search Engines , Search API	06	CO1
II	IR Models	Modeling: Taxonomy of Information Retrieval Models, Retrieval: Formal Characteristics of IR models, Classic Information Retrieval, Alternative Set Theoretic models, Probabilistic Models, Structured text retrieval Models, models for Browsing; Self-learning Topics: Terrier - IR Platform and similar IR Platforms	06	CO2
III	Query Processing and Operations	Query Languages: Keyword based Querying, Pattern Matching, Structural Queries, Query Protocols; Query Operations: User relevance feedback Self-learning Topics: Proximity Queries and Wildcard Queries	05	CO3
IV	Text Processing	Text and Multimedia languages and properties: Metadata, Markup Languages, Multimedia; Text Operations: Document Preprocessing, Document Clustering. Self-learning Topics: Digital Library : Greenstone	06	CO4

V	Multimedia IR models	Inverted files, Other indices for text, Boolean Queries, Sequential Searching, Pattern Matching, Structural Queries, Compression Multimedia IR models: Data Modeling Multimedia IR: Indexing and Searching:- A Generic Multimedia indexing approach, Automatic Feature extraction; Searching Web: Challenges, Characterizing the web, Search Engines. Browsing, Meta searches, Searching using Hyperlinks Self-learning Topics: Google Image Search Engine	08	CO5
VI	IoT Data Management and Analytics	IoT Evolution, IoT Architectures, Resource Management, IoT Data Management and Analytics, IoT Applications Self-learning Topics: ThingSpeak, Ubidots, AWS cloud platform	06	CO6

Text Books:

1. Modern Information Retrieval, Ricardo Baeza-Yates,berthier Ribeiro- Neto, ACM Press- Addison Wesley
2. Information Retrieval Systems: Theory and Implementation, Gerald Kowaski, Kluwer Academic Publisher
3. Internet of Things - Principles and Paradigms, Rajkumar Buyya and Amir V. Dastjerdi, Elsevier

References:

1. Information Retrieval Implementing and Evaluating search Engines by Stefan Butcher, Charles L.A. Clarke -The MIT Press Cambridge, Massachusetts London, England
2. Introduction to Information Retrieval By Christopher D. Manning and Prabhakar Raghavan, Cambridge University Press.
3. Introduction to Modern Information Retrieval. G.G. Chowdhury. NealSchuman.

Online References:

<https://nptel.ac.in/courses/106101007>

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.

➤ **Question paper format:**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**.
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules).
- A total of **four questions** need to be answered.

		Theory	Practical	Tutorial	Theory	Practical/Oral	Tutorial	Total
IOTDO8014	Next Generation IoT	03	--	--	03	--	--	03

Subject Code	Subject Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		Test1	Test 2	Avg. of 2 Tests					
IOTDO8014	Next Generation IoT	20	20	20	80	--	--	--	100

Course Objective

1. **Understand** the fundamental concepts and principles of IoT and its role in driving digital transformation in various sectors, including its impact on the economy and society.
2. **Explore** the strategic research and innovation trends in IoT, including next-generation IoT technologies, digitization, tactile IoT/IIoT, and digital twins for IoT applications.
3. Gain knowledge of the enabling technologies in IoT, such as edge computing, artificial intelligence, networks and communication, and distributed ledger technology/blockchain, and understand their significance in IoT systems.
4. **Examine** the future trends in IoT, including key technological advancements, interoperability challenges, and strategies to boost IoT innovation and deployment.
5. **Investigate** the implementation of IoT in smart environments and applications, including wearables, smart health, wellness and aging well, smart buildings and architecture, smart energy, and smart mobility and transport.
6. **Explore** real-world IoT implementations through the study of European large-scale pilot projects, focusing on integration, experimentation, testing, and user engagement in IoT initiatives.

Course Outcome

Sr. No.	Course Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy

On successful completion, of course, learner/student will be able to:		
1	Understand the impact of IoT on the economy and society, including its role as a major enabler for digitizing industries and its implications for projects, partnerships, and standardization.	L1
2	Analyze the European Union's IoT strategy, current state, and future perspectives, with a focus on research and innovation under Horizon 2020 and the deployment of IoT within the Next Generation Internet.	L2, L3
3	Identify future trends in IoT, including key technological game-changers, interoperability challenges, and strategies to boost IoT innovation and deployment.	L3
4	Explore the next generation IoT platforms, including the implementation process, working groups, state of play, and understanding the needs and priorities for the future IoT platform.	L3, L4
5	Evaluate emerging technologies and research trends in IoT, such as next-generation IoT, tactile IoT/IoT, digital twins, edge computing, artificial intelligence, networks and communication, and distributed ledger technology/blockchain	L2,L3
6	Examine IoT security technologies, including the identification of emerging security challenges and the exploration of solutions to ensure secure and trustworthy IoT systems.	L2,L3

SrNo		Topics	Hours
1		IoT Driving Digital Transformation	4
		IoT Driving Digital Transformation – Impact on Economy and Society	
	1.1	IoT as a Major Enabler for Digitizing Industry, Main Elements of the IoT Implementation Plan and Its First Pillar, The Second and the Third Pillar – Projects, Partnerships and Standardisation	
	1.2	IoT EU Strategy, State of Play and Future Perspectives	
		Research and Innovation under Horizon 2020, Deployment – IoT Focus Area and Focus Area on Digitization, IoT within the Next Generation Internet – Preparing the Next Framework Programme for Research and Innovation	
	1.3.	Future Trends in IoT	
		Key Technological Game Changers for IoT,Interoperability,Boosting IoT Innovation and Deployment	
	1.4	Next Generation IoT Platforms	
		DEI Implementation – Working Groups, DEI Implementation – Working Groups, IoT Platforms – State of Play, Needs and Priorities for the Next Generation IoT platform	
2		Internet of Things Cognitive Transformation Technology Research Trends and Applications	6

	2.1	Next Generation Internet of Things	
	2.2	Next Generation IoT Strategic Research and Innovation	
		Digitisation, Tactile IoT/IoT, Digital Twins for IoT	
	2.3	Future Internet of Things Enabling Technologies	
		Edge Computing, Artificial Intelligence, Networks and Communication, Distributed Ledger Technology/Blockchain Technology	
	2.4	Emerging IoT Security Technologies	
	2.5	IoT/IoT Technology Market Developments	
		Digital Business Model Innovation and IoT as a Driver, Business models and business model Innovation, The use of IoT for digital business development, The design and implementation processes of digital business development	
3	Internet of Things Cognitive Transformation Technology Research Trends and Applications		10
	3.1	Internet of Things Evolving Vision	
		IoT Common Definition, IoT Cognitive Transformation,	
		IoT Strategic Research and Innovation Directions , IoT Research Directions and Challenges	
		IoT Smart Environments and Applications	
		IoT Use Cases and Applications, Wearables, Smart Health, Wellness and Ageing Well, Smart Buildings and Architecture, Smart Energy, Smart Mobility and Transport	
	3.2	IoT and Related Future Internet Technologies	
		Edge Computing, Networks and Communication,	
		IoT Distributed Security – Blockchain Technology	
		Verification and Validation in Blockchain, IoT Blockchain Application in Healthcare, IoT Platforms	
	3.3	Internet of Robotic Things Concept, IoRT Platforms Architecture, IoRT Application	
4	IoT European Large-Scale Pilots – Integration, Experimentation and Testing		6
	4.1	ACTIVAGE – Activating Innovative IoT Smart Living Environments for Ageing Well, IoF2020 – Internet of Food and Farm 2020 , MONICA – Management of Networked IoT Wearables – Very Large Scale Demonstration of Cultural Societal Applications,	
	4.2	SynchroniCity: Delivering a Digital Single Market for IoT-enabled Urban Services in Europe and Beyond	

	4.3	AUTOPILOT – Automated Driving Progressed by Internet of Things , CREATE-IoT Cross Fertilisation through Alignment, Synchronisation and Exchanges for IoT	
	4.4	U4IoT – User Engagement for Large Scale Pilots in the Internet of Things	
5.	IoT European Security and Privacy Projects: Integration, Architectures and Interoperability		6
	5.1	BRAIN-IoT, Cognitive Heterogeneous Architecture for Industrial IoT – CHARIOT	
	5.2	ENACT: Development, Operation, and Quality Assurance of Trustworthy Smart IoT Systems, Search Engines for Browsing the Internet of Things – IoTcrawler	
	5.3	SecureIoT: Multi-Layer Architecture for Predictive End-to-End Internet-of- Things Security	
	5.4	SEMIoTICS, SerIoT, SOFIE	
6.	Future IoT technologies		7
	6.1	IoMT,IoAT,IoDT,IoUT	
	6.2	A Smart Tags Driven Service Platform for Enabling Ecosystems of Connected Objects	
	6.3	A Novel IoT Architecture based on 5G-IoT and Next Generation Technologies	

TextBook	
1	<i>Next Generation Internet of Things – Distributed Intelligence at the Edge and Human-Machine Interactions Vermesan, Ovidiu, Bacquet, Joël River Publishers,</i>
2	<i>Ovidiu Vermesan, Joël Bacquet, Cognitive Hyperconnected Digital Transformation, River Publishers</i>
3	Nishith Pathak Anurag Bhandari , IoT, AI, and Blockchain for .NET Building a Next-Generation Application from the Ground Up,apress
4.	Bob Familiar, Microservices, IoT, and Azure Leveraging DevOps and Microservice Architecture to Deliver SaaS Solutions, Apress
5	Anand Tamboli, Build Your Own IoT Platform Develop a Fully Flexible and Scalable Internet of Things Platform in 24 Hours,apress

Useful Links

IODT The Internet of Drones: Requirements, Taxonomy, Recent Advances, Internet of and Challenges of Research Trends <https://www.mdpi.com/1424-8220/21/17/5718>
Drone things

The Internet of Drone Things (IoDT): Future Envision of Smart Drones
https://link.springer.com/chapter/10.1007/978-981-15-0029-9_45

IoAT Applications of IoT in Agriculture - Making Agriculture Smarte
IoT of <https://www.biz4intellia.com/blog/5-applications-of-iot-in-agriculture/>
Agriculture Things

IOT IN AGRICULTURE:
9 TECHNOLOGY USE CASES FOR SMART FARMING
(AND CHALLENGES TO CONSIDER)
<http://ml6.in/ABKwx>
Smart Farming: Internet of Things (IoT)-Based Sustainable Agriculture
<https://www.mdpi.com/2077-0472/12/10/1745>

IoMT Internet of Medical Things (IoMT) - An overview
IoT Medical <https://ieeexplore.ieee.org/document/9075733>
things

Internet of Medical Things (IoMT): Overview, Emerging Technologies,

and Case Studies

<https://www.tandfonline.com/doi/full/10.1080/02564602.2021.1927863>

Internet of Medical Things (IoMT)- Based Smart Healthcare System: Trends and Progress <http://ml6.in/eteYj>

IoUT	An overview on IoUT and the performance of WiFi low-cost nodes for IoUT
Under ground and Under water	Applications https://ieeexplore.ieee.org/document/9348057 Internet of underwater things: Challenges and routing protocols https://ieeexplore.ieee.org/document/8394494 Batteryless IoT Sensor to be used underwater and in outer space https://www.onio.com/article/batteryless-io-sensor-underwater-and-outer-space.html Towards the internet of underwater things: a comprehensive survey https://www.researchgate.net/publication/359064835_ Towards_the_internet_of_underwater_things_a_comprehensive_survey

Papers

P1	Next Generation Internet of Things https://www.ngiot.eu/wp-content/uploads/sites/73/2020/03/NGIoT_D2.1_Revised.pdf https://www.ngiot.eu/wp-content/uploads/sites/73/2020/03/NGIoT_D2.1_Revised.pdf
P2	Blockchain-Driven Intelligent Scheme for IoT-Based Public Safety System beyond 5G Networks https://www.mdpi.com/1424-8220/23/2/969
P3	From IoT to 5G I-IoT: The Next Generation IoT-Based Intelligent Algorithms and 5G Technologies https://ieeexplore.ieee.org/document/8519960
P4	Next-Generation Internet of Things (IoT): Opportunities, Challenges, and Solutions https://www.mdpi.com/1424-8220/21/4/1174
P5	INTERNET OF THINGS (IOT) AND 5G BASED SMART ALGORITHM https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3878692

Assessment: Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.
- **Question paper format:**
- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**.

- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules).
- A total of **four questions** need to be answered.

		Theor y	Practical	Tutorial	Theory	Practical/ Oral	Tutorial	Total
IOTDO8021	Business Process Management & Cognitive IoT	03	--	--	03	--	--	03

Subject Code	Subject Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		T e s t 1	Test 2	Avg. of 2 Tests					
IOTDO8021	Business Process Management & Cognitive IoT	20	20	20	80	--	--	--	100

Course Objectives: The course aims at:

1. To understand the fundamental concepts, terminology and benefits of business process management(BPM).
2. To understand the fundamental concepts of the cognitive Internet of Things (IoT).
3. To identify the benefits using BPM concepts in the management of IoT applications, benefits of using IOT in BPM and the intersections/challenges in the two paradigms.
4. To understand cognitive enterprises, analyze existing processes of the system, and understand the opportunities to apply cognitive-IOT in them using the design principles of cognitive IOT.
5. To understand management of Cognitive IoT-enabled Business Processes.
6. To understand the use cases of cognitive-IOT.

Course Outcomes: On successful completion, of course, learner/student will be able to:

Sr. No.	Course Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		

1	Describe the fundamental concepts, terminology and benefits of business process management(BPM).	L2
2	Understand the fundamental concepts of the cognitive Internet of Things (IoT).	L2
3	Relate the benefits using BPM concepts in the management of IoT applications, benefits of using IOT in BPM and the intersections/challenges in the two paradigms.	L2
4	Design the application areas of cognitive-IOT in enterprise processes of the system using appropriate cognitive IOT design principles.	L6
5	Develop strategy for management of cognitive IoT-enabled Business Processes.	L6
6	RExamine the use cases of cognitive-IOT.	L4

Prerequisite: IoT Architecture and Protocols

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Sensors, Characteristics of IoT, Conceptual Framework of IoT, Physical and Logical design of IoT, Functional blocks of IoT, Communication models and APIs, Architecture and Protocols	02	CO1
I	Introduction to Business Process Management (BPM)	Defining BPM, BPM Lifecycle, Benefits and Importance of BPM in Organizations: Improved Efficiency, Enhanced Quality, Increased Agility, Cost Savings, Customer Satisfaction, Compliance and Risk Management, Continuous Improvement, Key Concepts and Terminologies in BPM: Process, Process Owner, Process Mapping, Process Analysis, Process Design, Process Automation, Key Performance Indicators (KPIs) Self-study: Drivers and triggers for BPM, approaches followed in BPM	05	CO1

II	Fundamentals of Cognitive IoT	<p>Introduction to Cognitive IoT, Need for Cognitive IoT, Key Components and Technologies in Cognitive IoT: Sensors and Actuators, Connectivity, Cloud Computing, Artificial Intelligence (AI), Edge Computing, Data Analytics. Current and Future trends of IoT, Cognitive computing and applications. Security in Cognitive IoT: Security issues in IoT, A hardware assisted approach for security, Architectural level overview for providing security, Security threats.</p> <p>Self-study: Data Analytics of Cognitive IoT, Cloud and Edge Computing in IoT</p>	08	CO2
III	Integrating Cognitive IoT with BPM	<p>Benefits of Cognitive IoT with BPM and vice versa, Factors to be considered for integrating Cognitive IoT with BPM such as placement of sensors, management of manually executed physical processes, connection of analytical processes with IoT, integrating IoT with process correctness checks, dealing with unstructured environments, segregating end-to-end processes, identifying new processes from data, etc.</p> <p>Self-study: Cognitive process transition and adoption phases</p>	08	CO3
IV	Designing Cognitive IoT-enabled Business Processes	<p>Introduction to Cognitive Enterprise, Building Cognitive Enterprise: Market-making Business Platforms, Intelligent Workflows, Enterprise Experience and Humanity</p> <p>Analyzing existing business processes, Identifying opportunities for automation and cognitive decision making</p> <p>Cognitive Design Principles: Context-awareness, data-driven decision making, event-driven triggers, human-machine collaboration, security and privacy, scalability and interoperability, and continuous improvement.</p> <p>Self-study: Design Principles for Industrial Cognitive Automation</p>	07	CO4
V	Managing Cognitive IoT-enabled Business Processes	<p>Strategic planning, operational execution, and continuous monitoring.</p> <p>Steps for managing cognitive IoT-enabled business processes: define clear business objectives, identify relevant use cases, design and architect cognitive</p>	06	CO5

		IoT solutions, deploy and implement solutions, monitor and optimize performance, ensure Security and privacy. Self-study: Role of BPM methodologies, frameworks, and tools in managing Cognitive IoT-enabled processes		
VI	Use Cases	Applications of Cognitive IoT: Smart Home Automation, Industrial Automation and Predictive Maintenance, Healthcare and Remote Patient Monitoring, Smart Agriculture, Supply Chain Optimization. Self-study: Energy Management, Intelligent Transportation Systems, Environmental Monitoring	03	CO6

Text Books:

1. Fundamentals of Business Process Management by Marlon Dumas, Marcello La Rosa, Jan Mendling Hajo A. Reijers, Springer.
2. The Process Improvement Handbook: A Blueprint for Managing Change and Increasing Organizational Performance by Marlon Dumas , Marcello La Rosa.
3. Business Process Management: Concepts, Languages, Architectures by Mathias Weske (2019)
4. Business Process Management Practical Guidelines to Successful Implementations by John Jeston (2022)
5. The Business of Things: Designing business models to win in the cognitive IoT by IBM Institute for Business Value.
6. Building the Cognitive Enterprise: Nine Action Areas by IBM Institute for Business Value
7. IoT Solutions in Microsoft's Azure IoT Suite: Data Acquisition and Analysis in the Real World by Scott Klein (2017)
8. IoT Fundamentals: Networking Technologies Protocols and Use Cases for the Internet of Things by Hanes David, Salgueiro Gonzalo, Grossetete Patrick, Barton Rob, Henry Jerome (2017)
9. The Internet-of-Things Meets Business Process Management: A Manifesto Christian Janiesch, Agnes Koschmider, Massimo Mecella, Barbara Weber, Andrea Burattin, Claudio Di Ciccio, Giancarlo Fortino, Avigdor Gal, Udo Kannengiesser, Francesco Leotta, Felix Mannhardt, Andrea Marrella, Jan Mendling, Andreas Oberweis, Manfred Reichert, Stefanie Rinderle-Ma, Estefania Serral Asensio, WenZhan Song, Jianwen Su, Victoria Torres, Matthias Weidlich, Mathias Weske, and Liang Zhang.

References:

1. Digital Transformation: Survive and Thrive in an Era of Mass Extinction by Thomas M. Siebel (2019)
2. How Cognitive Computing Unlocks Business Process Management's Performance-Enhancing Virtues
3. The design of things: Building in IoT connectivity - The Internet of Things in product design: A research collaboration between Deloitte and IBM
4. BPM Everywhere: Internet of Things, Process of Everything by Nathaniel Palmer, Scott Francis, Peter Whibley (2019)
5. Enabling Things to Talk: Designing IoT solutions with the IoT Architectural Reference Model by Alessandro Bassi, Martin Bauer, Martin Fiedler, Thorsten Kramp, Rob van Kranenburg, Sebastian Lange, Stefan Meissner (2013)
6. Building the Internet of Things: Implement New Business Models, Disrupt Competitors, Transform Your Industry by Maciej Kranz (2016)
7. Cognitive Internet of Things: A New Paradigm Beyond Connection Qihui Wu, Guoru Ding, Yuhua Xu, Shuo Feng, Zhiyong Du, Jinlong Wang, and Keping Long.
8. Cognitive Business Operations: Processes and decisions that sense, respond, and learn by IBM.

Online References:

1. Architectural Threats to Security and Privacy: A Challenge for Internet of Things (IoT) Applications (Link: <https://www.mdpi.com/2079-9292/12/1/88>)
2. Cognitive Automation in Industry – Design Principles and Case Study (Link: https://www.ripublication.com/ijaer18/ijaerv13n20_51.pdf)
3. IBM: BPM, Workflow, and Case (IBM Business Automation) (Link: <https://community.ibm.com/community/user/automation/communities/community-home?CommunityKey=810abde6-3916-441b-aac3-b9105bb37e3c>)
4. Cognitive IoT: Unleashing the future potential of IoT systems (Link: <https://www.iot-now.com/2023/04/13/129617-cognitive-iot-unleashing-the-future-potential-of-iot-systems/>)

Assessment: Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.
- **Question paper format:**
- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**.

- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules).
- A total of **four questions** need to be answered.

Course Code	Course Name	Theory	Practical	Tutorial	Theory	Practical /Oral	Tutorial	Total
IOTDO8022	RESTful Design for IoT Systems	03	--	--	03	--	--	03

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		Test 1	Test 2	Avg. of 2 Tests					
IOTDO8022	RESTful Design for IoT Systems	20	20	20	80	--	--	--	100

Course Objectives:

Sr. No.	Course Objectives
	The course aims:
1	To understand the concept of RESTful architecture.
2	To familiarize a standardized way of integrating Web-based applications.
3	To design the API to access the data of IOT components for secure communication.
4	To identify the issues and challenges associate with scalability in RESTful IoT systems.
5	To Explore and Analyze the concept of AI integration with RESTful APIs in IOT.
6	Enable the students to analyze real-world implementations of RESTful design for IoT systems.

Course Outcomes:

Sr. No.	Course Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
	On successful completion, of course, learner/student will be able to:	
1	Describe the Conceptual Framework and methods of RESTful architecture	L1,L2
2	Understand how web service enables the communication among various applications.	L1,L2,L3
3	Designing standard framework for connecting various IOT applications	L1,L2,L3
4	Identify the issues Associated With IoT Scalability.	L1,L2
5	Analyze different IOT protocols for integration with RESTful	L1,L2,L4

	APIs.	
6	Analyze and evaluate Real world RESTful design for various IoT systems	L1,L2,L3,L4

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	IoT concepts and principles,Basics of HTML,XML,CSS and Database Concepts, Knowledge of HTTP request and HTTP response	02	--
I	Introduction to RESTful Design	<p>RESTful architecture: RESTful relevance to IoT. Principles of Representational State Transfer (REST). HTTP methods (GET, POST, PUT, DELETE). Resource modeling and URI design for IoT devices and services. Benefits and challenges of using REST for IoT systems.</p> <p>Self-learning Topics: Case Study on allow the users to do the four methods of HTTP to create RESTful API</p>	04	CO1
II	Web Services	<p>Design XML Representations: XML Parsers. Design JSON Representations. JSON Parsers.Links in XML Representations. Links in JSON Representations.Assign Link Relation Types. Manage Application Flow.Clients Made Easy with WAD.</p> <p>Self-learning Topics: Case study on Writing Web services for Client Communication using Various languages HTTPs Library</p>	06	CO2
III	Designing RESTful APIs for IoT Systems	<p>API design principles and best practices: Creating resource representations for IoT devices and sensors. Implementing CRUD operations on IoT resources. Interacting with IoT Resources through RESTful APIs. Resource discovery and registration in IoT systems. Performing data retrieval, filtering, and aggregation. Security and Authentication in RESTful IoT Systems</p> <p>Self-learning Topics: Case Study on Design of RESTful APIs for M2M services</p>	06	CO3
IV	Managing scalability challenges in RESTful IoT systems	Caching strategies and content delivery networks (CDNs) for improved performance. Load balancing and horizontal scaling techniques. Integrating IoT with Cloud Services using RESTful APIs. Connecting IoT devices and services with cloud platforms. Using RESTful APIs to interact with	06	CO4

		cloud-based IoT platforms. Handling data storage, analytics, and visualization in the cloud Self-learning Topics: Case Study on Best Practices to manage the scalability and complexity of IoT infrastructure		
V	ML & AI Integration	Industry standards and protocols for IoT communication: Exploring emerging trends and technologies in RESTful IoT systems. Machine learning and AI integration with RESTful APIs in IoT. Traffic and Transportation Optimization, RESTful services to analyze sensor data for environmental monitoring. Edge computing and fog computing for improved IoT performance. Integration of standards like MQTT, CoAP, and WebSocket with RESTful APIs. Interoperability considerations in IoT systems Self-learning Topics: Case study on IoT communication protocols (bluetooth,wifi, LTE,etc)to and meet the specific functional requirement of an IoT system..	09	CO5
VI	Case Studies and Real-World Examples	Real-world implementations of RESTful design for IoT systems: Examining use cases across different industries (e.g., smart homes, industrial IoT, healthcare). Case studies on Twitter API, GitHub API, Amazon Web Services (AWS) API, Google Maps API, Stripes API. Analyzing challenges and lessons learned from deployed systems	06	CO6

Text Books:

1. "RESTful Web Services Cookbook" by Subbu Allamaraju
2. "RESTful Web Services"by Leonard Richardson.
3. "RESTful IoT with MQTT and Node-RED" by Colin Dow and Tim Pulver
4. "RESTful Java with JAX-RS 2.1: Designing and Developing Distributed Web Services" by Bill Burke
5. "Building the Web of Things: With examples in Node.js and Raspberry Pi" by Dominique D. Guinard and Vlad M. Trifa
6. "Designing Connected Products: UX for the Consumer Internet of Things" by Claire Rowland, Elizabeth Goodman, Martin Charlier, and Ann Light.

References:

1. "Designing the Internet of Things" by Adrian McEwen and Hakim Cassimally
2. "Internet Of Things: A Hands-On Approach Paperback", by Arsheep Bahga (Author), Vijay Madisetti, Universities Press, Reprint 2020
3. "IoT Fundamentals Networking Technologies, Protocols, and Use Cases for the Internet of Things CISCO" by David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert

Barton, Jerome Henry,

Online References:

1. <https://www.udemy.com/course/api-and-webservices/>
2. <https://restfulapi.net/rest-api-design-tutorial-with-example/>
3. <https://www.mygreatlearning.com/iot/free-courses>
4. https://www.researchgate.net/figure/RESTful-services-design-for-IoT-systems_fig3_339025795
5. <https://www.edureka.co/blog/what-is-rest-api/>

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➤ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks**
Q.1 will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered.

		Theory	Practical	Tutorial	Theory	Practical/Oral	Tutorial	Total
CSDO8023	Green IT	03	--	--	03	--	--	03

Subject Code	Subject Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		Test 1	Test 2	Avg. of 2 Tests					
CSDO8023	Green IT	20	20	20	80	--	--	--	100

Course Objectives:

1. To understand what Green IT is and How it can help improve environmental Sustainability.
2. To understand the principles and practices of Green IT.
3. To understand how Green IT is adopted or deployed in enterprises.
4. To understand how data centers, cloud computing, storage systems, software and networks can be made greener.
5. To measure the Maturity of a Sustainable ICT world.
6. To implement the concept of Green IT in Information Assurance in Communication and Social Media and all other commercial field.

Course Outcomes:

Course Outcome	Course Outcome Statement	Cognitive Levels of attainment as per Bloom's taxonomy

CO 1	Describe awareness among stakeholders and promote green agenda and green initiatives in their working environments leading to green movement.	L1
CO2	Identify IT Infrastructure Management and Green Data Center Metrics for software development	L1 L2
CO3	Recognize Objectives of Green Network Protocols for Data communication.	L1 L2
CO4	Apply Green IT Strategies and metrics for ICT development.	L1 L2 L3
CO5	Illustrate various green IT services and its roles	L1 L2
CO6	Demonstrate and use new career opportunities available in IT profession, audits and others with special skills such as energy efficiency, ethical IT assets disposal, carbon footprint estimation, reporting and development of green products, applications and services.	L1 L2 L3

Prerequisite: Environmental Studies

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Environmental Studies	2	
I	Introduction	Environmental Impacts of IT, Holistic Approach to Greening IT, Green IT Standards and Eco-Labeling, Enterprise Green IT Strategy, Green IT: Burden or Opportunity? Hardware: Life Cycle of a Device or Hardware, Reuse, Recycle and Dispose. Software: Introduction, Energy Saving Software Techniques, Evaluating and Measuring Software Impact to Platform Power. Self-Learning: Evaluating and Measuring software impact to platform power	6	CO1
II	Software development and data centers	Sustainable Software, Software Sustainability Attributes, Software Sustainability Metrics, Sustainable Software Methodology, Data Centers and Associated Energy Challenges, Data Centre IT Infrastructure, Data Centre Facility Infrastructure:	6	CO1 CO2

		Implications for Energy Efficiency, IT Infrastructure Management, Green Data Centre Metrics Self-learning Topics: Sustainable Software: A Case Study, Data Centre Management Strategies		
III	Data storage and communication	Storage Media Power Characteristics, Energy Management Techniques for Hard Disks, System-Level Energy Management, Objectives of Green Network Protocols, Green Network Protocols and Standards Self-learning Topics: System-Level Energy Management	6	CO1 CO3
IV	Information systems, green IT strategy and metrics	Approaching Green IT Strategies, Business Drivers of Green IT Strategy, Business Dimensions for Green IT Transformation, Multilevel Sustainable Information, Sustainability Hierarchy Models, Product Level Information, Individual Level Information, Functional Level Information, Organizational Level Information, Regional/City Level Information, Measuring the Maturity of Sustainable ICT. Self-learning Topics: Business Dimensions for Green IT transformation.	6	CO1 CO4
V	Green IT services and roles	Factors Driving the Development of Sustainable IT, Sustainable IT Services (SITS), SITS Strategic Framework, Sustainable IT Roadmap, Organizational and Enterprise Greening, Information Systems in Greening Enterprises, Greening the Enterprise: IT Usage and Hardware, Inter-organizational Enterprise Activities and Green Issues, Enablers and Making the Case for IT and the Green Enterprise. Self-learning Topics: Inter-organizational Enterprise Activities and Green Issues, Enablers and Making the Case for IT and the Green Enterprise.	6	CO1 CO4 CO5
VI	Managing and regulating green IT	Strategizing Green Initiatives, Implementation of Green IT, Information Assurance, Communication and Social Media, The Regulatory Environment and IT Manufacturers, Nonregulatory Government Initiatives, Industry Associations and Standards Bodies, Green Building Standards, Green Data Centers, Social Movements and Greenpeace. Case	7	CO1 CO5 CO6

		study on: Industry Sustainability with Green IT, Managing Green IT, The energy consumption in Torrent systems with malicious content, The use of thin client instead of desktop PC Self-learning Topics: Information Assurance, Green Data Centers		
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Text Books:

1. San Murugesan, G. R. Gangadharan, Harnessing Green IT, WILEY 1st Edition-2018
2. Mohammad Dastbaz Colin Pattinson Babak Akhgar, Green Information Technology A Sustainable Approach , Elsevier 2015
3. . Reinhold, Carol Baroudi, and Jeffrey Hill Green IT for Dummies, Wiley 2009

References:

1. Mark O'Neil, Green IT for Sustainable Business Practice: An ISEB Foundation Guide, BCS
2. Jae H. Kim, Myung J. Lee Green IT: Technologies and Applications, Springer, ISBN: 978-3-642- 22178-1
3. Elizabeth Rogers, Thomas M. Kostigen The Green Book: The Everyday Guide to Saving the Planet One Simple Step at a Time, Springer

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➤ Question paper format

- Question Paper will comprise of a total of **six questions each carrying 20 marks**
Q.1 will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered.

		Theory	Practical	Tutorial	Theory	Practical/ Oral	Tutorial	Total
CSDO8024	IoT for Smart Grids	03	--	--	03	--	--	03

Subject Code	Subject Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		Test 1	Test 2	Avg. of 2 Tests					
CSDO8024	IoT for Smart Grids	20	20	20	80	--	--	--	100

Course Objectives:

Sr. No.	Course Objectives
The course aims:	
1	To impart knowledge of futuristic power grid technology and the path on which development is taking place.
2	To elaborate the fundamentals of various technologies and tools which will play a vital role in formation of the Smart grids in near future.
3	To familiarize the students with distribution management systems in smart grid.
4	To expose students to various communication protocols used in smart grid.
5	To acquaint students with knowledge of smart meters and infrastructure in smart grid.
6	To understand different data management tools in a smart grid.

Course Outcomes:

Sr. No.	Course Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		
1	To identify the role and significance of smart in future power systems	L1, L2
2	To evaluate and compare applications of smart measurement and monitoring technologies.	L1, L2, L3, L4
3	To describe the role of a distribution management system in a smart grid.	L1, L2
4	To select and analyze different communication protocols for different applications	L1, L2, L3, L4

	in a smart grid.	
5	To illustrate the importance of advanced metering infrastructure in smart grids.	L1, L2, L3
6	To apply data management techniques and develop machine learning algorithms for smooth operation of smart grid.	L1, L2, L3, L4, L5

Prerequisite: IoTC601: IoT Architecture and Protocols, CSDO701X IoT for Smart Cities

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Fundamentals of Power Distribution System, Transmission and Distribution, Power system Operation and Control, Communication Networks	2	-
I	Smart Grid: Architecture and Design	1.1. Introduction, Smart Grid Drivers 1.2. Transformation of the Grid 1.3. Characteristics of a Smart Grid 1.4. Smart Grid Technology Framework 1.5. Benefits of Smart grid Self-Learning Topics: Smart grid architecture around the globe	5	CO1
II	Smart Grid Technology	2.1 Smart Energy Resources - Renewable energy generation 2.2 Energy storage 2.3 Electric vehicles 2.4 Energy Resources Integration Challenges, Solutions, and Benefit 2.5 Smart Substation - Protection, Monitoring, and Control Devices (IEDs) – Sensors – SCADA 2.6 IEC 61850-Based Substation Design 2.7 Energy Management Systems 2.8 Wide Area Monitoring, Protection and Control (WAMPAC) 2.9 Role of WAMPAC and Transmission Systems in a Smart Grid Self-Learning Topics: Microgrids versus smart grids	9	CO2
III	Smart Distribution Systems	3.1 Distribution Management Systems 3.2 Volt/VAr Control 3.3 Fault Detection, Isolation, and Service Restoration 3.4 Outage Management 3.5 Consumer Demand Management	5	CO3

		Self-Learning Topics: High-Efficiency Distribution Transformers		
IV	Communication Networks and Cyber Security	4.1 Communications Requirements for the Smart Grid 4.2 Communication layer- Home automation network, Building automation network, Neighbourhood area network, Local area network, Field area network, Wide area network 4.3 Wireless Network Solutions for Smart Grid- Cellular, RF Mesh 4.4 Communication Standards and Protocols- IEC 61850, DNP3 and IEC 60870-5 4.5 IEEE C37.118, IEC 61968-9 and MultiSpeak, ANSI 4.6 Communications Challenges in the Smart Grid 4.7 Cyber Security for Smart Grid. Self-Learning Topics: Probable attacks on smart grid.	8	CO4
V	Smart Meters and Advanced Metering Infrastructure (AMI)	5.1 Evolution of the Electric Meter, and Meter Reading 5.2 AMI Drivers and Benefits 5.3 AMI Protocols, Standards, and Initiatives 5.4 AMI Security 5.5 AMI Needs in the Smart Grid 5.6 Phasor Measurement Unit. Self-Learning Topics: Smart appliances	6	CO5
VI	Data Management and Forecasting	6.1 Smart Grid Data Management, Characterization of Smart Grid Data 6.2 Secure Information and Data Management Architecture 6.3 Secure Data Management, Applications of Smart Grid Data 6.4 Importance of machine learning in energy forecasting, Big data in smart grid. Self-Learning Topics: Renewable Energy Forecasting, Fault Detection and Predictive Maintenance, Data Visualization and Decision Support	4	CO6

Text Books:

1. James Momoh, "Smart Grid: Fundamentals of Design and Analysis", IEEE Press and Wiley Publications, 2015
2. K. Liyanage, Jianzhong Wu, A. Yokoyama, Nick Jenkins J.Ekanayake, "Smart Grid: Technology and Applications", Wiley Publications, 2015
3. Stuart Borlase, "Smart Grids: Infrastructure, Technology, and Solutions", CRC Press, 2012
4. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press

References:

1. Mini S. Thomas, John D McDonald, “Power System SCADA and Smart Grids”, CRC Press, 2015
2. Kenneth C.Budka, Jayant G. Deshpande, Marina Thottan, “Communication Networks for Smart Grids”, Springer, 2014.
3. H. T. Mouftah, and M. Erol-Kantarci, “Smart Grid: Networking, Data Management, and Business Models”, CRC Press, 2016
4. Yang Xiao, “Communication and Networking in Smart Grids”, CRC Press, 2012

Online References:

1. https://onlinecourses.nptel.ac.in/noc23_ee60/preview
2. https://onlinecourses.nptel.ac.in/noc21_ee68/preview

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➤ Question paper format

- Question Paper will comprise of a total of **six questions each carrying 20 marks**
Q.1 will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered.

		Teaching Scheme (Contact Hours)			Credits Assigned			
Subject Code	Subject Name	Theory	Practical	Tutorial	Theory	Oral	Tutorial	Total
IOTL801	IoT Automation Lab	-	02	--	--	-	--	2

Subject Code	Subject Name	Examination Scheme						
		Theory Marks				Term Work	Practical/Oral	Total
		Internal assessment			End Sem. Exam			
		Test1	Test 2	Avg. of 2 Tests				
IOTL801	IoT Automation Lab	-	-	-	-	25	25	50

Lab Objectives: The course will help the students to:

1. Understand the significance of the Internet of Things for real time applications.
2. Explore different protocols for communication used in IoT systems to other third-party Clouds.
3. Illustrate PLC programming with real time examples for industrial automation.
4. Study of database collection using controller boards in IoT systems.
5. Explore the relationship between IoT, cloud computing, and DevOps.
6. Examine real time applications using IoT systems in different environments.

Lab Outcomes:

Sr. No.	Lab Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		

1	Demonstrate the use of various IoT simulators in real time applications.	L3
2	Implement different protocols for Integrating IoT services to other third-party Clouds.	L3
3	Develop PLC programming with real time examples on industrial automation.	L6
4	Demonstrate the working of databases on controller boards for data analysis in IoT systems.	L3
5	Execute DevOps methodologies for continuous integration and continuous deployment of IoT applications.	L3
6	Develop real time applications using IoT systems in different environments.	L6

Prerequisite:

Basics of IoT Architecture and Protocols, Introduction to Embedded and Control systems.

Hardware Requirements	Software Requirements	Other Requirements
PC With Following Configuration 1. Intel PIV Processor 2. 4 GB RAM 3. 500 GB Hard disk 4. Network interface card 5. Sensors 6. IoT Kit (Raspberry Pi/NodeMCU/ESP32) 7. Actuators	1. Windows or Linux Desktop OS 2. Python 3. IoT Simulator/Emulator (open source) 4. Delta ISPSOft 5. DOPSOft 5. Devops	1. Internet Connection for installing additional packages if required

Suggested List of Experiments.

Sr. No	List of Experiments.	LO

1	To study and demonstrate use of IoT simulators (like Bevywise, COOJA, or Cupcarbon) on any real time application.	LO1
2	Real time data acquisition and transmission using NodeRed simulator.	LO1
3	To study and simulate CoAP protocol in Contiki OS.	LO1
3	To study and implement a program on ESP32/NodeMCU to push and retrieve the data from any cloud like Thingspeak, Thingsboard, AWS, Azure etc.	LO2
4	Connecting Raspberry Pi to AWS/Microsoft Iot Core : Setup and code Using Python and AWS IOT.	LO2
6	To study PLC basics, programming elements and their operation for Ladder Diagram in IIoT.	LO3
7	To develop PLC programming examples on industrial automation using Delta ISPsoft.	LO3
8	To design HMI for PLC programming examples using Delta ISPsoft and DOPSoft.	LO3
9	To install MySQL database on Raspberry Pi and perform basic SQL queries for analysis of data collected.	LO4
10	To study and implement Continuous Integration using Jenkins on IoT data and also perform interfacing of Raspberry Pi into Jenkins.	LO5
11	To study and implement Continuous Deployment (Infrastructure as a code) for IoT using Ansible.	LO5
12	<p>Select any one case study (in a group of 3-4) which will be a solution to a real problem and can be eased with the use of automation and IOT. The sample case studies can be as follows:</p> <ul style="list-style-type: none"> ● Smart agriculture System ● Smart Home Automation ● Smart Cities ● Smart Healthcare system, ● Smart Traffic Management System, etc. 	LO6

Text & Reference Books:

- “Hands-On Industrial Internet of Things” by Giacomo Veneri and Antonio Capasso (Packt)
- “IoT Fundamentals – Networking Technologies, Protocols, and Use Cases for the Internet of Things”, David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton, Jerome Henry, 1st Edition, Published by Pearson Education, Inc, publishing as Cisco Press, 2017.
- Honbo Zhou,” The internet of things in the cloud”, CRC press, Taylor and Francis group.
- “PLC Programming for Industrial Automation” Kevin Collins, Exposure Publishing, 2006.
- Joakim Verona,” Practical DevOps”, PACKT publishing, 2016.

Online Resources:

1. <http://www.contiki-os.org/>
2. <https://www.bevywise.com/iot-simulator/>
3. <https://mqtt.org/>
4. <https://shorturl.at/kwCV0>
5. <https://docs.aws.amazon.com/iot/latest/developerguide/connecting-to-existing-device.htm>
6. <https://shorturl.at/kzDJ1>
7. <https://shorturl.at/jor49>
8. <https://www.nsnam.com/2016/01/iot-coap-implementation-in-contiki-os.html>
9. <https://www.udemy.com/course/ispsoft-for-delta-plc-programming/>
10. <http://surl.li/hwxci>
11. <http://surl.li/hwxek>
12. <https://nodered.org/docs/tutorials/>

Term Work:

- 1 Term work should consist of 10 experiments
- 2 Journal must include at least 2 assignments based on Theory and Practical
- 3 The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
- 4 Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)

Oral exam:

Based on the entire syllabus of IOTC801 Industrial IoT and IOTL801 IoT Automation Lab

		Teaching Scheme (Contact Hours)			Credits Assigned			
Subject Code	Subject Name	Theory	Practical	Tutorial	Theory	Oral	Tutorial	Total
CSL802	Cyber Security Lab	--	4	--	--	2	--	2

Subject Code	Subject Name	Examination Scheme						
		Theory Marks				Term Work	Oral	Total
		Internal assessment			End Sem. Exam			
		Test1	Test 2	Avg. of 2 Tests				
CSL802	Cyber Security Lab	--	--	--	--	50	--	50

Lab Objectives:

- To detect the web application and browser vulnerabilities using various open-source tools
- To explore the network vulnerabilities using various open-source tools
- To conduct digital investigations that conform to accepted professional standards and are based on the investigative process, including the concept of the chain of evidence
- To identify, preserve, examine, analyze, and report the findings from digital forensics investigation
- To recover the digital evidences from various digital devices
- To Explore various forensics tools in Kali Linux and use them to acquire, duplicate and analyze data and recover deleted data

Lab Outcomes:

Sr. No.	Lab Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		

1	Gain hands-on experience in cracking passwords using various techniques and tools & develop skills in capturing and analyzing network traffic to identify security vulnerabilities and potential threats.	L1, L2
2	Understand the techniques used in phishing attacks and learn to recognize and mitigate such attacks & acquire skills in analyzing malware samples to understand their behavior and implement appropriate defenses.	L3, L4
3	Gain knowledge of firewall vulnerabilities and learn techniques to bypass them & understand the security vulnerabilities of wireless networks and implement measures to protect against attacks.	L2, L3
4	Develop skills in identifying and mitigating web application vulnerabilities to enhance security & understand the techniques used in social engineering attacks and develop awareness to prevent such attacks.	L2, L3
5	Gain practical experience in implementing and analyzing cryptographic algorithms & develop skills in responding to security incidents effectively and efficiently.	L2, L3
6	Understand various techniques used for data exfiltration and develop countermeasures to protect against them & acquire knowledge of IoT device vulnerabilities and learn techniques to secure them.	L1, L2, L3, L4

Prerequisite: Basic Networking Concepts, Programming languages, Cybersecurity fundamentals, Cryptography basics

Sr. No.	Experiment Details	LO Mapping
1	<p>Password Cracking:</p> <p>Tools: John the Ripper, Hashcat, Hydra</p> <p>Experiment: Use different password cracking techniques such as brute force attacks, dictionary attacks, or rainbow table attacks on password-protected files or accounts.</p>	LO1
2	<p>Network Sniffing:</p> <p>Tools: Wireshark, tcpdump</p> <p>Experiment: Capture network traffic and analyze it to understand the flow of data, identify potential security vulnerabilities, and observe any sensitive information being transmitted.</p>	LO1

3	<p>Phishing Attacks:</p> <p>Tools: GoPhish, Social-Engineer Toolkit (SET)</p> <p>Experiment: Set up a simulated phishing campaign to send deceptive emails and track the recipients' responses, measuring the success rate and effectiveness of the phishing attack.</p>	LO2
4	<p>Malware Analysis:</p> <p>Tools: IDA Pro, OllyDbg, VirusTotal</p> <p>Experiment: Analyze malware samples in a controlled environment, investigate their behavior, reverse-engineer their code, and understand their propagation methods.</p>	LO2
5	<p>Firewall Bypassing:</p> <p>Tools: Metasploit, Nmap, Netcat</p> <p>Experiment: Identify vulnerabilities in firewalls or network devices and attempt to bypass their security mechanisms to gain unauthorized access to a network or system.</p>	LO3
6	<p>Wireless Network Security:</p> <p>Tools: Aircrack-ng, Kismet, Reaver</p> <p>Experiment: Assess the security of wireless networks by cracking WEP or WPA/WPA2 encryption, implementing attacks like deauthentication attacks or capturing handshakes for offline cracking.</p>	LO3
7	<p>Web Application Security:</p> <p>Tools: Burp Suite, OWASP Zap, SQLMap</p> <p>Experiment: Test web applications for security vulnerabilities, such as injection attacks (e.g., SQL injection), cross-site scripting (XSS), or insecure direct object references.</p>	LO4
8	<p>Social Engineering:</p> <p>Tools: Maltego, SET, BeEF</p> <p>Experiment: Conduct a social engineering experiment to assess the susceptibility of individuals to manipulation, such as eliciting sensitive information over the phone, via email, or in person.</p>	LO4
9	<p>Cryptography:</p> <p>Tools: OpenSSL, Cryptool, HashCalc</p> <p>Experiment: Implement and analyze cryptographic algorithms, generate encryption keys, perform encryption/decryption, digital signatures, and hash calculations.</p>	LO5

10	<p>Incident Response:</p> <p>Tools: Volatility, Sleuth Kit, Wireshark</p> <p>Experiment: Simulate an incident response scenario by investigating a security breach, analyzing system logs, memory dumps, network traffic, and identifying the attack vector.</p>	LO5
11	<p>Data Exfiltration:</p> <p>Tools: Steghide, tcpflow, Dnscat2</p> <p>Experiment: Attempt to extract sensitive data from a target system using techniques like steganography (hiding data within files), covert channels, or exfiltration through DNS or ICMP.</p>	LO6
12	<p>IoT Security:</p> <p>Tools: Shodan, Wireshark, Firmware analysis tools</p> <p>Experiment: Assess the security of Internet of Things (IoT) devices by analyzing their firmware, identifying vulnerabilities, and demonstrating potential attacks like device takeover or unauthorized access.</p>	LO6

Text Books:

1. "The Web Application Hacker's Handbook: Finding and Exploiting Security Flaws" by Dafydd Stuttard and Marcus Pinto
2. "Metasploit: The Penetration Tester's Guide" by David Kennedy, Jim O'Gorman, Devon Kearns, and Mati Aharoni
3. "The Basics of Hacking and Penetration Testing" by Patrick Engebretson

References:

1. "Practical Malware Analysis: The Hands-On Guide to Dissecting Malicious Software" by Michael Sikorski and Andrew Honig
2. "Hacking Exposed" series by Stuart McClure, Joel Scambray, and George Kurtz
3. "The Incident Response Toolkit: Security Tools & Techniques" by Douglas Schweitzer

Resource Tools:

1. Wireshark: <https://www.wireshark.org/>

2. Kali Linux: <https://www.kali.org/>
3. Nessus: <https://www.tenable.com/products/nessus>
4. Metasploit Framework: <https://www.metasploit.com/>
5. Burp Suite: <https://portswigger.net/burp>
6. Snort: <https://www.snort.org/>
7. OWASP ZAP: <https://www.zaproxy.org/>
8. John the Ripper: <https://www.openwall.com/john/>
9. OSSEC: <https://www.ossec.net/>
10. GDB (GNU Debugger): <https://www.gnu.org/software/gdb/>

Term Work:

- 1 Term work should consist of 10 experiments
- 2 Journal must include at least 2 assignments based on Theory and Practical
- 3 The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
- 4 Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)

Oral exam:

Based on the entire syllabus of IOTL802 Cyber Security Lab

Course Code:	Course Title	Credit
CSP801	Major Project 2	6

Course Objectives:

- 1 To acquaint with the process of identifying the needs and converting it into the problem.
- 2 To familiarize the process of solving the problem in a group.
- 3 To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems.
- 4 To inculcate the process of self-learning and research.

Course Outcomes:

- 1 Identify problems based on societal /research needs.
- 2 Apply Knowledge and skill to solve societal problems in a group
- 3 Draw the proper inferences from available results through theoretical/ experimental/simulations
- 4 Analyse the impact of solutions in societal and environmental context for sustainable development.
- 5 Demonstrate capabilities of self-learning in a group, which leads to lifelong learning.
- 6 Demonstrate project management principles during project work.

Guidelines:

1. Internal guide has to keep track of the progress of the project and also has to maintain attendance report. This progress report can be used for awarding term work marks.

2. Project Report Format:

At the end of semester, each group needs to prepare a project report as per the guidelines issued by the University of Mumbai. Report should be submitted in hardcopy. Also, each group should submit softcopy of the report along with project documentation, implementation code, required utilities, software and user Manuals.

A project report should preferably contain at least following details:

- Abstract
- Introduction
- Literature Survey/ Existing system
- Limitation Existing system or research gap
- Problem Statement and Objective
- Proposed System
 - Analysis/Framework/ Algorithm
 - Design details
 - Methodology (your approach to solve the problem) Proposed System
- Experimental Set up

- Details of Database or details about input to systems or selected data
- Performance Evaluation Parameters (for Validation)
- Software and Hardware Setup
- Results and Discussion
- Conclusion and Future Work
- References
- Appendix – List of Publications or certificates

Desirable:

Students should be encouraged -

- to participate in various project competitions.
- to write minimum one technical paper & publish in a good journal.
- to participate in national / international conferences.

3. Term Work:

Distribution of marks for term work shall be done based on following:

- a. Weekly Log Report
- b. Completeness of the project and Project Work Contribution
- c. Project Report (Black Book) (both side print)
- d. Term End Presentation (Internal)

The final certification and acceptance of TW ensures the satisfactory performance on the above aspects.

4. Oral & Practical:

Oral & Practical examination (Final Project Evaluation) of Project 2 should be conducted by Internal and External examiners approved by University of Mumbai at the end of the semester.

Suggested quality evaluation parameters are as following:

- a. Relevance to the specialization / industrial trends
- b. Modern tools used
- c. Innovation
- d. Quality of work and completeness of the project
- e. Validation of results
- f. Impact and business value
- g. Quality of written and oral presentation
- h. Individual as well as teamwork

Institute Level Optional Course (ILO)

Every student is required to take one Institute Elective Course for Semester VII, which is not closely allied to their disciplines. Different sets of courses will run in the both the semesters.

ILO801X	Institute Optional Course – 2 (Common for all branches will be notified)
ILO8011	Project Management
ILO8012	Finance Management
ILO8013	Entrepreneurship Development and Management
ILO8014	Human Resource Management
ILO8015	Professional Ethics and CSR
ILO8016	Research Methodology
ILO8017	IPR and Patenting
ILO8018	Digital Business Management
ILO8019	Environmental Management

Course Code	Course Name	Credits
ILO8011	Project Management	03

Objectives:

1. To familiarize the students with the use of a structured methodology/approach for each and every unique project undertaken, including utilizing project management concepts, tools and techniques.
2. To appraise the students with the project management life cycle and make them knowledgeable about the various phases from project initiation through closure.

Outcomes: Learner will be able to...

1. Apply selection criteria and select an appropriate project from different options.
2. Write work break down structure for a project and develop a schedule based on it.
3. Identify opportunities and threats to the project and decide an approach to deal with them strategically.
4. Use Earned value technique and determine & predict status of the project.
5. Capture lessons learned during project phases and document them for future reference

a	Detailed Contents	Hrs
01	Project Management Foundation: Definition of a project, Project Vs Operations, Necessity of project management, Triple constraints, Project life cycles (typical & atypical) Project phases and stage gate process. Role of project manager. Negotiations and resolving conflicts. Project management in various organization structures. PM knowledge areas as per Project Management Institute (PMI).	5
02	Initiating Projects: How to get a project started, Selecting project strategically, Project selection models (Numeric /Scoring Models and Non-numeric models), Project portfolio process, Project sponsor and creating charter; Project proposal. Effective project team, Stages of team development & growth (forming, storming, norming & performing), team dynamics.	6
03	Project Planning and Scheduling: Work Breakdown structure (WBS) and linear responsibility chart, Interface Co-ordination and concurrent engineering, Project cost estimation and budgeting, Top down and bottoms up budgeting, Networking and Scheduling techniques. PERT, CPM, GANTT chart. Introduction to Project Management Information System (PMIS).	8

04	Planning Projects: Crashing project time, Resource loading and leveling, Goldratt's critical chain, Project Stakeholders and Communication plan. Risk Management in projects: Risk management planning, Risk identification and risk register. Qualitative and quantitative risk assessment, Probability and impact matrix. Risk response strategies for positive and negative risks	6
05	5.1 Executing Projects: Planning monitoring and controlling cycle. Information needs and reporting,	8

	engaging with all stakeholders of the projects. Team management, communication and project meetings. Monitoring and Controlling Projects: Earned Value Management techniques for measuring value of work completed; Using milestones for measurement; change requests and scope creep. Project audit. Project Contracting Project procurement management, contracting and outsourcing,	
06	Project Leadership and Ethics: Introduction to project leadership, ethics in projects. Multicultural and virtual projects. Closing the Project: Customer acceptance; Reasons of project termination, Various types of project terminations (Extinction, Addition, Integration, Starvation), Process of project termination, completing a final report; doing a lessons learned analysis; acknowledging successes and failures; Project management templates and other resources; Managing without authority; Areas of further study.	6

REFERENCES:

1. Jack Meredith & Samuel Mantel, Project Management: A managerial approach, Wiley India, 7thEd.
2. A Guide to the Project Management Body of Knowledge (PMBOK[®] Guide), 5th Ed, Project Management Institute PA, USA
3. Gido Clements, Project Management, Cengage Learning.
4. Gopalan, Project Management, , Wiley India
5. Dennis Lock, Project Management, Gower Publishing England, 9th Ed.

Assessment:

Internal:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papers of end semester examination. **In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.**

1. Question paper will comprise of total six question
2. All question carry equal marks
3. Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four question need to be solved.

Course Code	Course Name	Credits
ILO8012	Finance Management	03

Objectives:

1. Overview of Indian financial system, instruments and market
2. Basic concepts of value of money, returns and risks, corporate finance, working capital and its management
3. Knowledge about sources of finance, capital structure, dividend policy

Outcomes: Learner will be able to...

1. Understand Indian finance system and corporate finance
2. Take investment, finance as well as dividend decisions

Module	Detailed Contents	Hrs
01	<p>Overview of Indian Financial System: Characteristics, Components and Functions of Financial System.</p> <p>Financial Instruments: Meaning, Characteristics and Classification of Basic Financial Instruments — Equity Shares, Preference Shares, Bonds-Debentures, Certificates of Deposit, and Treasury Bills.</p> <p>Financial Markets: Meaning, Characteristics and Classification of Financial Markets — Capital Market, Money Market and Foreign Currency Market</p> <p>Financial Institutions: Meaning, Characteristics and Classification of Financial Institutions — Commercial Banks, Investment-Merchant Banks and Stock Exchanges</p>	06
02	<p>Concepts of Returns and Risks: Measurement of Historical Returns and Expected Returns of a Single Security and a Two-security Portfolio; Measurement of Historical Risk and Expected Risk of a Single Security and a Two-security Portfolio.</p> <p>Time Value of Money: Future Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Present Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Continuous Compounding and Continuous Discounting.</p>	06
03	<p>Overview of Corporate Finance: Objectives of Corporate Finance; Functions of Corporate Finance—Investment Decision, Financing Decision, and Dividend Decision.</p> <p>Financial Ratio Analysis: Overview of Financial Statements—Balance Sheet, Profit and Loss Account, and Cash Flow Statement; Purpose of Financial Ratio Analysis; Liquidity Ratios; Efficiency or Activity Ratios; Profitability Ratios; Capital Structure Ratios; Stock Market Ratios; Limitations of Ratio Analysis.</p>	09

04	Capital Budgeting: Meaning and Importance of Capital Budgeting; Inputs for Capital Budgeting Decisions; Investment Appraisal Criterion—Accounting Rate of Return, Payback Period, Discounted Payback Period, Net Present Value(NPV), Profitability Index, Internal Rate of Return (IRR), and Modified Internal Rate of Return (MIRR)	10
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	Working Capital Management: Concepts of Meaning Working Capital; Importance of Working Capital Management; Factors Affecting an Entity's Working Capital Needs; Estimation of Working Capital Requirements; Management of Inventories; Management of Receivables; and Management of Cash and Marketable Securities.	
05	Sources of Finance: Long Term Sources—Equity, Debt, and Hybrids; Mezzanine Finance; Sources of Short Term Finance—Trade Credit, Bank Finance, Commercial Paper; Project Finance. Capital Structure: Factors Affecting an Entity's Capital Structure; Overview of Capital Structure Theories and Approaches— Net Income Approach, Net Operating Income Approach; Traditional Approach, and Modigliani-Miller Approach. Relation between Capital Structure and Corporate Value; Concept of Optimal Capital Structure	05
06	Dividend Policy: Meaning and Importance of Dividend Policy; Factors Affecting an Entity's Dividend Decision; Overview of Dividend Policy Theories and Approaches—Gordon's Approach, Walter's Approach, and Modigliani-Miller Approach	03

REFERENCES:

1. Fundamentals of Financial Management, 13th Edition (2015) by Eugene F. Brigham and Joel F. Houston; Publisher: Cengage Publications, New Delhi.
2. Analysis for Financial Management, 10th Edition (2013) by Robert C. Higgins; Publishers: McGraw Hill Education, New Delhi.
3. Indian Financial System, 9th Edition (2015) by M. Y. Khan; Publisher: McGraw Hill Education, New Delhi.
4. Financial Management, 11th Edition (2015) by I. M. Pandey; Publisher: S. Chand (G/L) & Company Limited, New Delhi.

Assessment:

Internal:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papers of end semester examination. **In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.**

1. Question paper will comprise of total six question
2. All question carry equal marks
3. Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four question need to be solved.

Course Code	Course Name	Credits
ILO8013	Entrepreneurship Development and Management	03

Objectives:

1. To acquaint with entrepreneurship and management of business
2. Understand Indian environment for entrepreneurship
3. Idea of EDP, MSME

Outcomes: Learner will be able to...

1. Understand the concept of business plan and ownerships
2. Interpret key regulations and legal aspects of entrepreneurship in India
3. Understand government policies for entrepreneurs

Module	Detailed Contents	Hrs
01	Overview Of Entrepreneurship: Definitions, Roles and Functions/Values of Entrepreneurship, History of Entrepreneurship Development, Role of Entrepreneurship in the National Economy, Functions of an Entrepreneur, Entrepreneurship and Forms of Business Ownership Role of Money and Capital Markets in Entrepreneurial Development: Contribution of Government Agencies in Sourcing information for Entrepreneurship	04
02	Business Plans And Importance Of Capital To Entrepreneurship: Preliminary and Marketing Plans, Management and Personnel, Start-up Costs and Financing as well as Projected Financial Statements, Legal Section, Insurance, Suppliers and Risks, Assumptions and Conclusion, Capital and its Importance to the Entrepreneur Entrepreneurship And Business Development: Starting a New Business, Buying an Existing Business, New Product Development, Business Growth and the Entrepreneur Law and its Relevance to Business Operations	09
03	Women's Entrepreneurship Development, Social entrepreneurship-role and need, EDP cell, role of sustainability and sustainable development for SMEs, case studies, exercises	05
04	Indian Environment for Entrepreneurship: key regulations and legal aspects , MSMED Act 2006 and its implications, schemes and policies of the Ministry of MSME, role and responsibilities of various government organisations, departments, banks etc., Role of State governments in terms of infrastructure developments and support etc., Public private partnerships, National Skill development Mission, Credit Guarantee Fund, PMEGP, discussions, group exercises etc	08

05	Effective Management of Business: Issues and problems faced by micro and small enterprises and effective management of M and S enterprises (risk management, credit availability, technology innovation, supply chain management, linkage with large industries), exercises, e-Marketing	08
06	Achieving Success In The Small Business: Stages of the small business life cycle, four types of firm-level growth strategies, Options – harvesting or closing small business Critical Success factors of small business	05

REFERENCES:

1. Poornima Charantimath, Entrepreneurship development- Small Business Enterprise, Pearson
2. Education Robert D Hisrich, Michael P Peters, Dean A Shapherd, Entrepreneurship, latest edition, The McGrawHill Company
3. Dr TN Chhabra, Entrepreneurship Development, Sun India Publications, New Delhi
4. Dr CN Prasad, Small and Medium Enterprises in Global Perspective, New century Publications, New Delhi
5. Vasant Desai, Entrepreneurial development and management, Himalaya Publishing House
6. Maddhurima Lall, Shikah Sahai, Entrepreneurship, Excel Books
7. Rashmi Bansal, STAY hungry STAY foolish, CIIE, IIM Ahmedabad
8. Law and Practice relating to Micro, Small and Medium enterprises, Taxmann Publication Ltd.
9. Kurakto, Entrepreneurship- Principles and Practices, Thomson Publication
10. Laghu Udyog Samachar
11. www.msme.gov.in
12. www.dcmesme.gov.in
13. www.msmetraining.gov.in

Assessment:

Internal:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papers of end semester examination. **In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.**

1. Question paper will comprise of total six question
2. All question carry equal marks
3. Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four question need to be solved.

Course Code	Course Name	Credits
ILO8014	Human Resource Management	03

Objectives:

1. To introduce the students with basic concepts, techniques and practices of the human resource management.
2. To provide opportunity of learning Human resource management (HRM) processes, related with the functions, and challenges in the emerging perspective of today's organizations.
3. To familiarize the students about the latest developments, trends & different aspects of HRM.
4. To acquaint the student with the importance of inter-personal & inter-group behavioral skills in an organizational setting required for future stable engineers, leaders and managers.

Outcomes: Learner will be able to...

1. Understand the concepts, aspects, techniques and practices of the human resource management.
2. Understand the Human resource management (HRM) processes, functions, changes and challenges in today's emerging organizational perspective.
3. Gain knowledge about the latest developments and trends in HRM.
4. Apply the knowledge of behavioral skills learnt and integrate it with in inter personal and intergroup environment emerging as future stable engineers and managers.

Module	Detailed Contents	Hrs
01	Introduction to HR <ul style="list-style-type: none"> • Human Resource Management- Concept, Scope and Importance, Interdisciplinary Approach Relationship with other Sciences, Competencies of HR Manager, HRM functions. • Human resource development (HRD): changing role of HRM – Human resource Planning, Technological change, Restructuring and rightsizing, Empowerment, TQM, Managing ethical issues. 	5

02	Organizational Behavior (OB) <ul style="list-style-type: none"> ● Introduction to OB Origin, Nature and Scope of Organizational Behavior, Relevance to Organizational Effectiveness and Contemporary issues ● Personality: Meaning and Determinants of Personality, Personality development, Personality Types, Assessment of Personality Traits for Increasing Self Awareness ● Perception: Attitude and Value, Effect of perception on Individual Decision-making, Attitude and Behavior. ● Motivation: Theories of Motivation and their Applications for Behavioral Change (Maslow, Herzberg, McGregor); ● Group Behavior and Group Dynamics: Work groups formal and informal groups and stages of group development. Team Effectiveness: High performing teams, Team Roles, cross functional and self-directed team. ● Case study 	7
03	Organizational Structure & Design <ul style="list-style-type: none"> ● Structure, size, technology, Environment of organization; Organizational Roles & conflicts: Concept of roles; role dynamics; role conflicts and 	6

	<p>stress.</p> <ul style="list-style-type: none"> ● Leadership: Concepts and skills of leadership, Leadership and managerial roles, Leadership styles and contemporary issues in leadership. ● Power and Politics: Sources and uses of power; Politics at workplace, Tactics and strategies. 	
04	<p>Human resource Planning</p> <ul style="list-style-type: none"> ● Recruitment and Selection process, Job-enrichment, Empowerment - Job-Satisfaction, employee morale. ● Performance Appraisal Systems: Traditional & modern methods, Performance Counseling, Career Planning. ● Training & Development: Identification of Training Needs, Training Methods 	5
05	<p>Emerging Trends in HR</p> <ul style="list-style-type: none"> ● Organizational development; Business Process Re-engineering (BPR), BPR as a tool for organizational development , managing processes & transformation in HR. Organizational Change, Culture, Environment ● Cross Cultural Leadership and Decision Making: Cross Cultural Communication and diversity at work, Causes of diversity, managing diversity with special reference to handicapped, women and ageing people, intra company cultural difference in employee motivation. 	6
06	<p>HR & MIS Need, purpose, objective and role of information system in HR, Applications in HRD in various industries (e.g. manufacturing R&D, Public Transport, Hospitals, Hotels and service industries)</p> <p>Strategic HRM Role of Strategic HRM in the modern business world, Concept of Strategy, Strategic Management Process, Approaches to Strategic Decision Making; Strategic Intent – Corporate Mission, Vision, Objectives and Goals</p> <p>Labor Laws & Industrial Relations Evolution of IR, IR issues in organizations, Overview of Labor Laws in India; Industrial Disputes Act, Trade Unions Act, Shops and Establishments Act</p>	10

REFERENCES:

1. Stephen Robbins, Organizational Behavior, 16th Ed, 2013
2. V S P Rao, Human Resource Management, 3rd Ed, 2010, Excel publishing
3. Aswathapa, Human resource management: Text & cases, 6th edition, 2011
4. C. B. Mamoria and S V Gankar, Dynamics of Industrial Relations in India, 15th Ed, 2015, Himalaya Publishing, 15th edition, 2015
5. P. Subba Rao, Essentials of Human Resource management and Industrial relations, 5th Ed, 2013, Himalaya Publishing
6. Laurie Mullins, Management & Organizational Behavior, Latest Ed, 2016, Pearson Publications

Assessment:

Internal:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Theory Examination:

Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papers of end semester examination. **In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.**

1. Question paper will comprise of total six question
2. All question carry equal marks
3. Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four question need to be solved.

Course Code	Course Name	Credits
ILO8015	Professional Ethics and Corporate Social Responsibility (CSR)	03

Objectives:

1. To understand professional ethics in business
2. To recognize corporate social responsibility

Outcomes: Learner will be able to...

1. Understand rights and duties of business
2. Distinguish different aspects of corporate social responsibility
3. Demonstrate professional ethics
4. Understand legal aspects of corporate social responsibility

Module	Detailed Contents	Hrs
01	Professional Ethics and Business: The Nature of Business Ethics; Ethical Issues in Business; Moral Responsibility and Blame; Utilitarianism: Weighing Social Costs and Benefits; Rights and Duties of Business	04
02	Professional Ethics in the Marketplace: Perfect Competition; Monopoly Competition; Oligopolistic Competition; Oligopolies and Public Policy Professional Ethics and the Environment: Dimensions of Pollution and Resource Depletion; Ethics of Pollution Control; Ethics of Conserving Depletable Resources	08
03	Professional Ethics of Consumer Protection: Markets and Consumer Protection; Contract View of Business Firm's Duties to Consumers; Due Care Theory; Advertising Ethics; Consumer Privacy Professional Ethics of Job Discrimination: Nature of Job Discrimination; Extent of Discrimination; Reservation of Jobs.	06
04	Introduction to Corporate Social Responsibility: Potential Business Benefits—Triple bottom line, Human resources, Risk management, Supplier relations; Criticisms and concerns—Nature of business; Motives; Misdirection. Trajectory of Corporate Social Responsibility in India	05
05	Corporate Social Responsibility: Articulation of Gandhian Trusteeship Corporate Social Responsibility and Small and Medium Enterprises (SMEs) in India, Corporate Social Responsibility and Public-Private Partnership (PPP) in India	08

06	Corporate Social Responsibility in Globalizing India: Corporate Social Responsibility Voluntary Guidelines, 2009 issued by the Ministry of Corporate Affairs, Government of India, Legal Aspects of Corporate Social Responsibility—Companies Act, 2013.	08
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1. Business Ethics: Texts and Cases from the Indian Perspective (2013) by Ananda Das Gupta; Publisher: Springer.
2. Corporate Social Responsibility: Readings and Cases in a Global Context (2007) by Andrew Crane, Dirk Matten, Laura Spence; Publisher: Routledge.
3. Business Ethics: Concepts and Cases, 7th Edition (2011) by Manuel G. Velasquez; Publisher: Pearson, New Delhi.
4. Corporate Social Responsibility in India (2015) by BidyutChakrabarty, Routledge, New Delhi.

Assessment:

Internal:

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End Semester Theory Examination:

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3. Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four question need to be solved.

Course Code	Course Name	Credits
ILO8016	Research Methodology	03

Objectives:

1. To understand Research and Research Process
2. To acquaint students with identifying problems for research and develop research strategies
3. To familiarize students with the techniques of data collection, analysis of data and interpretation

Outcomes: Learner will be able to...

1. Prepare a preliminary research design for projects in their subject matter areas
2. Accurately collect, analyze and report data
3. Present complex data or situations clearly
4. Review and analyze research findings

Module	Detailed Contents	Hrs
01	Introduction and Basic Research Concepts Research – Definition; Concept of Construct, Postulate, Proposition, Thesis, Hypothesis, Law, Principle. Research methods vs Methodology Need of Research in Business and Social Sciences Objectives of Research Issues and Problems in Research Characteristics of Research: Systematic, Valid, Verifiable, Empirical and Critical	09
02	Types of Research Basic Research Applied Research Descriptive Research Analytical Research Empirical Research 2.6 Qualitative and Quantitative Approaches	07
03	Research Design and Sample Design Research Design – Meaning, Types and Significance Sample Design – Meaning and Significance Essentials of a good sampling Stages in Sample Design Sampling methods/techniques Sampling Errors	07

04	<p>Research Methodology</p> <p>4.1 Meaning of Research Methodology</p> <p>4.2. Stages in Scientific Research Process:</p> <p>a. Identification and Selection of Research Problem</p> <p>b. Formulation of Research Problem</p> <p>c. Review of Literature</p> <p>d. Formulation of Hypothesis</p> <p>e. Formulation of research Design</p> <p>f. Sample Design</p> <p>g. Data Collection</p> <p>h. Data Analysis</p> <p>i. Hypothesis testing and Interpretation of Data</p>	08
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	j. Preparation of Research Report	
05	Formulating Research Problem 5.1 Considerations: Relevance, Interest, Data Availability, Choice of data, Analysis of data, Generalization and Interpretation of analysis	04
06	Outcome of Research Preparation of the report on conclusion reached Validity Testing & Ethical Issues Suggestions and Recommendation	04

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1. Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS Publishers Distributors.
2. Kothari, C.R., 1985, Research Methodology-Methods and Techniques, New Delhi, Wiley Eastern Limited.
3. Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners, (2nded), Singapore, Pearson Education

Assessment:

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End Semester Theory Examination:

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4. Only Four question need to be solved.

Course Code	Course Name	Credits
ILO8017	IPR and Patenting	03

Objectives:

1. To understand intellectual property rights protection system
2. To promote the knowledge of Intellectual Property Laws of India as well as International treaty procedures
3. To get acquaintance with Patent search and patent filing procedure and applications

Outcomes: Learner will be able to...

1. understand Intellectual Property assets
2. assist individuals and organizations in capacity building
3. work for development, promotion, protection, compliance, and enforcement of Intellectual Property and Patenting

Module	Detailed Contents	Hr
01	<p>Introduction to Intellectual Property Rights (IPR): Meaning of IPR, Different category of IPR instruments - Patents, Trademarks, Copyrights, Industrial Designs, Plant variety protection, Geographical indications, Transfer of technology etc.</p> <p>Importance of IPR in Modern Global Economic Environment: Theories of IPR, Philosophical aspects of IPR laws, Need for IPR, IPR as an instrument of development</p>	05
02	<p>Enforcement of Intellectual Property Rights: Introduction, Magnitude of problem, Factors that create and sustain counterfeiting/piracy, International agreements, International organizations (e.g. WIPO, WTO) active in IPR enforcement</p> <p>Indian Scenario of IPR: Introduction, History of IPR in India, Overview of IP laws in India, Indian IPR, Administrative Machinery, Major international treaties signed by India, Procedure for submitting patent and Enforcement of IPR at national level etc.</p>	07
03	<p>Emerging Issues in IPR: Challenges for IP in digital economy, e-commerce, human genome, biodiversity and traditional knowledge etc.</p>	05
04	<p>Basics of Patents: Definition of Patents, Conditions of patentability, Patentable and non-patentable inventions, Types of patent applications (e.g. Patent of addition etc), Process Patent and Product Patent, Precautions while patenting, Patent specification Patent claims, Disclosures and non-disclosures, Patent rights and infringement, Method of getting a patent</p>	07
05	<p>Patent Rules: Indian patent act, European scenario, US scenario, Australia scenario, Japan scenario, Chinese scenario, Multilateral treaties where India is a member (TRIPS agreement, Paris convention etc.)</p>	08

06	Procedure for Filing a Patent (National and International): Legislation and Salient Features, Patent Search, Drafting and Filing Patent Applications, Processing of patent, Patent Litigation, Patent Publicationetc, Time frame and cost, Patent Licensing, Patent Infringement	07
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1. Rajkumar S. Adukia, 2007, A Handbook on Laws Relating to Intellectual Property Rights in India, The Institute of Chartered Accountants of India
2. Keayla B K, Patent system and related issues at a glance, Published by National Working Group on Patent Laws
3. T Sengupta, 2011, Intellectual Property Law in India, Kluwer Law International
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6. Lous Harns, 2012, The enforcement of Intellactual Property Rights: A Case Book, 3rd Edition, WIPO
7. Prabhuddha Ganguli, 2012, Intellectual Property Rights, 1st Edition, TMH
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10. Kompal Bansal and Praishit Bansal, 2012, Fundamentals of IPR for Engineers, 1st Edition, BS Publications
11. Entrepreneurship Development and IPR Unit, BITS Pilani, 2007, A Manual on Intellectual Property Rights,
12. Mathew Y Maa, 2009, Fundamentals of Patenting and Licensing for Scientists and Engineers, World Scientific Publishing Company
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14. Vivien Irish, 2005, Intellectual Property Rights for Engineers, IET
15. Howard B Rockman, 2004, Intellectual Property Law for Engineers and scientists, Wiley-IEEE Press

Assessment:

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End Semester Theory Examination:

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4. Only Four question need to be solved.

Course Code	Course Name	Credits
ILO8018	Digital Business Management	03

Objectives:

1. To familiarize with digital business concept
2. To acquaint with E-commerce
3. To give insights into E-business and its strategies

Outcomes: The learner will be able to

1. Identify drivers of digital business
2. Illustrate various approaches and techniques for E-business and management
3. Prepare E-business plan

Module	Detailed content	Hours
1	<p>Introduction to Digital Business-</p> <p>Introduction, Background and current status, E-market places, structures, mechanisms, economics and impacts</p> <p>Difference between physical economy and digital economy,</p> <p>Drivers of digital business- Big Data & Analytics, Mobile, Cloud Computing, Social media, BYOD, and Internet of Things(digitally intelligent machines/services)</p> <p>Opportunities and Challenges in Digital Business,</p>	09

2	<p>Overview of E-Commerce</p> <p>E-Commerce- Meaning, Retailing in e-commerce-products and services, consumer behavior, market research and advertisement</p> <p>B2B-E-commerce-selling and buying in private e-markets, public B2B exchanges and support services, e-supply chains, Collaborative Commerce, Intra business EC and Corporate portals</p> <p>Other E-C models and applications, innovative EC System-From E- government and learning to C2C, mobile commerce and pervasive computing</p> <p>EC Strategy and Implementation-EC strategy and global EC, Economics and Justification of EC, Using Affiliate marketing to promote your e- commerce business, Launching a successful online business and EC project, Legal, Ethics and Societal impacts of EC</p>	06
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3	Digital Business Support services: ERP as e –business backbone, knowledge Tope Apps, Information and referral system Application Development: Building Digital business Applications and Infrastructure	06
4	Managing E-Business- Managing Knowledge, Management skills for e-business, Managing Risks in e –business Security Threats to e-business -Security Overview, Electronic Commerce Threats, Encryption, Cryptography, Public Key and Private Key Cryptography, Digital Signatures, Digital Certificates, Security Protocols over Public Networks: HTTP, SSL, Firewall as Security Control, Public Key Infrastructure (PKI) for Security, Prominent Cryptographic Applications	06
5	E-Business Strategy- E-business Strategic formulation- Analysis of Company’s Internal and external environment, Selection of strategy, E-business strategy into Action, challenges and E-Transition (Process of Digital Transformation)	04
6	Materializing e-business: From Idea to Realization- Business plan preparation Case Studies and presentations	08

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2. E-commerce from vision to fulfilment, Elias M. Awad, PHI-Restricted, 2002
3. Digital Business and E-Commerce Management, 6th Ed, Dave Chaffey, Pearson, August 2014
4. Introduction to E-business-Management and Strategy, Colin Combe, ELSVIER, 2006
5. Digital Business Concepts and Strategy, Eloise Coupey, 2nd Edition, Pearson
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7. Digital Business Discourse Erika Darics, April 2015, Palgrave Macmillan
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10. Measuring Digital Economy-A new perspective -DOI:[10.1787/9789264221796-en](https://doi.org/10.1787/9789264221796-en) OECD Publishing

Assessment:

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Course Code	Course Name	Credits
ILO8019	Environmental Management	03

Objectives:

1. Understand and identify environmental issues relevant to India and global concerns
2. Learn concepts of ecology
3. Familiarise environment related legislations

Outcomes: Learner will be able to...

1. Understand the concept of environmental management
2. Understand ecosystem and interdependence, food chain etc.
3. Understand and interpret environment related legislations

Module	Detailed Contents	Hrs
01	Introduction and Definition of Environment: Significance of Environment Management for contemporary managers, Career opportunities. Environmental issues relevant to India, Sustainable Development, The Energy scenario.	10
02	Global Environmental concerns : Global Warming, Acid Rain, Ozone Depletion, Hazardous Wastes, Endangered life-species, Loss of Biodiversity, Industrial/Man-made disasters, Atomic/Biomedical hazards, etc.	06
03	Concepts of Ecology: Ecosystems and interdependence between living organisms, habitats, limiting factors, carrying capacity, food chain, etc.	05
04	Scope of Environment Management, Role & functions of Government as a planning and regulating agency. Environment Quality Management and Corporate Environmental Responsibility	10
05	Total Quality Environmental Management, ISO-14000, EMS certification.	05
06	General overview of major legislations like Environment Protection Act, Air (P & CP) Act, Water (P & CP) Act, Wildlife Protection Act, Forest Act, Factories Act, etc.	03

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1. Environmental Management: Principles and Practice, C J Barrow, Routledge Publishers London, 1999
2. A Handbook of Environmental Management Edited by Jon C. Lovett and David G. Ockwell, Edward Elgar Publishing

3. Environmental Management, **T V Ramachandra and Vijay Kulkarni**, TERI Press
4. Indian Standard Environmental Management Systems — Requirements With Guidance For Use, Bureau Of Indian Standards, February 2005
5. Environmental Management: An Indian Perspective, S N Chary and Vinod Vyasulu, Macmillan India, 2000

6. Introduction to Environmental Management, Mary K Theodore and Louise Theodore, CRC Press
7. Environment and Ecology, Majid Hussain, 3rd Ed. Access Publishing.2015

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