DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

Master of Technology in Electronics & Communication with specialization in Internet of Things

Effective from Academic Session – 2021-22

Detailed Course Structure & Curriculum

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

Approved in Academic Council Meeting held on 28 July, 2021

SEMESTER - I								
S. No.	**Course Code**	**Name of the Subjects**		**Course Hours**			**Total**	**Credits**
			C/E	**L**	**T**	**P**		
1	21M11EC112	Embedded Systems and Applications	C	3	0	0	3	3
2	21M11EC111	Sensor and Smart Instrumentation	C	3	0	0	3	3
3	21M11EC113	Object Oriented Programming	C	3	0	0	3	3
4		Departmental Elective - I	E	3	0	0	3	3
5		Departmental Elective - II	E	3	0	0	3	3
6		Departmental Elective - III	E	3	0	0	3	3
7	21M11EC171	Advanced IoT Lab - I	C	0	0	6	6	3
						Total	**24**	**21**
SEMESTER - II								
S.No.	**Course Code**	**Subject Names**		**Course Hours**			**Total**	**Credits**
			C/E	**L**	**T**	**P**		
1	21M11EC211	Digital System design using verilog HDL	C	3	0	0	3	3
2	21M11EC212	Artificial Intelligence and Expert Systems	C	3	0	0	3	3
3	21M11EC213	Network Security Protocols	C	3	0	0	3	3
4		Departmental Elective - IV	E	3	0	0	3	3
5		Departmental Elective - V	E	3	0	0	3	3
6		Open Elective	E	3	0	0	3	3
7	21M11EC271	Advanced IoT Lab - II	C	0	0	6	6	3
						Total	**24**	**21**
SEMESTER - III								
S. No.	**Course Code**	**Name of the Subjects**		**Course Hours**			**Total**	**Credits**
			C/E	**L**	**T**	**P**		
1	21M19EC391	Literature Review / Seminar	C	0	0	6	6	3
2	21M19EC392	Dissertation Part - I	C	0	0	28	28	14
						Total	**34**	**17**
SEMESTER - IV								
S.No.	**Course Code**	**Subject Names**		**Course Hours**			**Total**	**Credits**
			C/E	**L**	**T**	**P**		
1	21M19EC491	Seminar	C	0	0	6	6	3
2	21M19EC492	Dissertation Part - II	C	0	0	28	28	14
						Total	**34**	**17**

LIST OF ELECTIVES								
ELECTIVE - I								
S.No.	**Course Code**	**Subject Names**		**Course Hours**			**Total**	**Credits**
			C/E	**L**	**T**	**P**		
1	21M1WEC132	IoT Architecture and Protocols	E	3	0	0	3	3
2	21M1WEC131	Wireless Technologies for IoT	E	3	0	0	3	3
ELECTIVE – II								
S.No.	**Course Code**	**Subject Names**		**Course Hours**			**Total**	**Credits**
			C/E	**L**	**T**	**P**		
1	21M1WEC133	Industrial Automation and IIoT	E	3	0	0	3	3
2	21M1WEC134	Intelligent Robotics and Shared Autonomy	E	3	0	0	3	3
ELECTIVE – III								
S.No.	**Course Code**	**Subject Names**		**Course Hours**			**Total**	**Credits**
			C/E	**L**	**T**	**P**		
1	21M1WEC135	Signal Processing for IoT	E	3	0	0	3	3
2	21M1WEC136	Intelligent signal Processing	E	3	0	0	3	3
ELECTIVE – IV								
S.No.	**Course Code**	**Subject Names**		**Course Hours**			**Total**	**Credits**
			C/E	**L**	**T**	**P**		
1	21M1WEC231	Image Sensing and Realtime Processing	E	3	0	0	3	3
2	21M1WEC232	Medical Image Processing and Applications	E	3	0	0	3	3
3	21M1WEC233	Applied Machine Learning for IoT	E	3	0	0	3	3
ELECTIVE – V								
S.No.	**Course Code**	**Subject Names**		**Course Hours**			**Total**	**Credits**
			C/E	**L**	**T**	**P**		
1	21M1WEC234	Antennas for IoT	E	3	0	0	3	3
2	21M1WEC235	RF technology for 5G and IoT	E	3	0	0	3	3
3	21M1WEC236	Smart Internet of Things	E	3	0	0	3	3

M. TECH.

ELECTRONICS & COMMUNICATION ENGINEERING WITH SPECIALIZATION IN INTERNET OF THINGS (IoT)

COURSE CONTENTS

Approved in Academic Council Meeting held on 28 July, 2021

Embedded Systems and Applications

COURSE CODE: 21M11EC112

COURSE CREDITS: 3

CORE/ELECTIVE: CORE

L-T-P: 3-0-0

Prerequisite: None

Course Objectives:

To learn about the embedded system application areas, design challenges, embedded system processors and tools used for embedded system design.

Course Outcomes:

Sl. No.	Course Outcomes	Level of Attainment
1	Understand various components of embedded system, design challenges	Familiarity
2	Comprehend RISC architecture, programming of ARM and PIC microcontrollers	Usage
3	Know about embedded system design and development methodology, tools and languages used for embedded system design	Usage
4	Learn about Devices and Communication interface used in embedded system	Usage
5	Learn about Real Time Operating System used for embedded system application	Usage

Course Contents:

Unit	Contents	Lectures required
1	Introduction: Characteristics of Embedded System Computing, Concept of Real time Systems, Classification, Application areas, Design challenges – real-time execution, physical size, power consumption, multirate operation	6
2	Embedded system processors: ARM Processor Fundamentals and Architectures, ARM Instruction Set, PIC Microcontroller and its Architecture, Instruction Set	8
3	Embedded hardware units and devices in a System, Embedded software in a system, Embedded system-on-chip (SOC), Embedded system-on-module (SOM)	6
4	Devices and Communication interface: Serial communication devices, Parallel communication, Wireless Devices, Timer and Counting Devices, Watchdog timer, Real time clock, Parallel communication network using ISA, PCI, Serial bus communication protocols, SCI, CAN, I2C, USB	8
5	Real Time Operating System: Real-time Kernels, Polled Loops System, Co-routines, Interrupt-driven System, Multi-rate System, Processes and Threads,	8

	Context Switching, Scheduling, Inter-process Communication, Real-time Memory Management, I/O, VxWorks, RT-Linux	
6	Case Study: ARM Cortex-A5 Processor-based SOM, ATSAMA5D27-SOM1, Use of SAMA5D2 GPIO under Linux	6
Total lectures		**42**

Suggested Text Book(s):

1. Frank Vahid and Tony Givargis, "Embedded system design: A unified Hardware/Software introduction,"3rd Ed., Wiley 2014

2. Shibu K. V, "Introduction to Embedded Systems," 2nd Ed., McGraw Hill 2017

3. Embedded System: Architecture, Programming and Design by Rajkamal,2nd Ed., 2010, Tata McGraw Hill

Suggested Reference Book(s):

1. Steve Furber, "ARM System-on-Chip Architecture," 2nd Ed., Pearson, 2012

2. Tim Wilmshurst, "Designing Embedded Systems with PIC Microcontrollers: Principles and Applications," 2nd Ed., Newnes, 2009

3. Steven F Barrett and Daniel J Pack, "Embedded Systems Design and Applications with the 68HC12 and HCS12," 1st Ed., Pearson 2012

4. Kenneth Ayala, "The 8051 microcontroller," 3rd Ed., Thomson,2005

Other useful resource(s):

https://www.microchip.com/wwwproducts/en/ATSAMA5D27-SOM1

https://www.microchip.com/wwwappnotes/appnotes.aspx?appnote=en1000789

NPTEL ONLINE COURSES

1. Embedded Systems: https://nptel.ac.in/courses/108105057/
2. Embedded Systems: https://nptel.ac.in/courses/108102045/
3. Embedded Systems Design: https://nptel.ac.in/courses/106105159/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered up to T-1
2	T-2	25	1.5 Hours	Syllabus covered up to T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Sensors and Smart Instrumentation

COURSE CODE:21M11EC111

COURSE CREDITS: 3

CORE/ELECTIVE: CORE

L-T-P: 3-0-0

Prerequisite: None

Course Objectives:

To learn about various sensors and transducers and their integration in a smart instrumentation system

Course Outcomes:

Sl. No.	Course Outcomes	Level of Attainment
1	Knowledge of characteristics of sensors and measurement system, criteria for transducer selection	Familiarity
2	Learn about data acquisition systems, signal conditioners and signal converters	Usage
3	Knowledge about different basic sensors and transducers used for measurement of physical quantities	Usage
4	Knowledge about different measurement systems used in industry	Usage
5	Learn about characteristics and working of smart sensors and instruments	Assessment

Course Contents:

Unit	Contents	Lectures required
1	Introduction: Basics of measurement systems, sensors and transducers, General transducers characteristics, static and dynamic characteristics, Criteria for transducer selection, Calibration techniques, Classification of errors	6
2	Data acquisition system and its uses in intelligent Instrumentation systems, Signal conditioners, signal converters, sample and hold. Instrumentation amplifiers, Interference, grounding and shielding	8
3	Resistive Transducers: Potentiometers, strain gauges, Resistance Thermometer, Thermistors. Inductive Transducers, Capacitive Transducers: Principles of operation, construction, Piezoelectric transducer, fibre optic transducers for the measurement of force, temperature, flow and pressure, Elastic Transducers: Spring bellows, diaphragm, bourdon tube.	10

4	Pressure sensor, temperature measurement, flow measurement, level measurement, displacement, force, velocity, acceleration and torque measurement. Telemetry, multiplexing, modulation of data, transmission channels.	8
5	Smart instruments - comparison with conventional transducers - self diagnosis and remote calibration features - smart transmitter with HART communicator - Micro Electro Mechanical Systems - sensors, actuators - principles and applications, nonlinearity compensation. Cogent sensors, Soft sensors, self-validating sensors, temperature-compensating sensors, ANN-based sensors, ANN techniques for fault detection, linearization, and calibration	10
Total lectures		**42**

Suggested Text Book(s):

1. Doebelin EO, "Measurement Systems: Application and Design," Tata McGraw Hill, 7th Ed., 2019
2. Patranabis D, "Sensors and Transducers," Prentice Hall of India, 2nd Ed., 2003
3. Manabendra Bhuyan, "Intelligent Instrumentation: Principles and Applications", CRC Press, 2017

Suggested Reference Book(s):

1. Subhas Chandra Mukhopadhyay, "Intelligent Sensing, Instrumentation and Measurements (Smart Sensors, Measurement and Instrumentation Book 5)," Springer, 2013.
2. Bela G. Liptak, "Instrument Engineers' Handbook, Volume One: Process Measurement and Analysis," 4th Ed., CRC Press, 2003

Other useful resource(s):

NPTEL Course: https://nptel.ac.in/courses/108/105/108105064/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1.	T-1	15	1 Hour.	Syllabus covered up to T-1
2.	T-2	25	1.5 Hours	Syllabus covered up to T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Object Oriented Programming

COURSE CODE: 21M11EC113

COURSE CREDITS: 3

CORE/ELECTIVE: CORE

L-T-P: 3-0-0

Prerequisite: None Course Objectives:

To learn the concept of object oriented programming and to acquire programming skills in Python, C++ and JAVA

Course Outcomes:

object oriented

Sl. No.	Course Outcomes	Level of Attainment
1	Learn about object-oriented approach to programming and advantages of Object-oriented programming over other approaches	Familiarity
2	Understand the concepts of data abstraction, encapsulation, inheritance and polymorphism	Familiarity
3	Analyze and decompose problem specifications from Object Oriented Perspectives and represent the solution, using UML notation	Usage
4	Learn to do object oriented programming using Python	Usage
5	Learn to do object oriented programming using C++ and JAVA	Usage

Course Contents:

Unit	Contents	Lectures required
1	Introduction: procedural programming, structured programming, abstract data types, data encapsulation, object oriented programming paradigm	6
2	Abstract Data Types, Classes and Objects, Inheritance (Single, Multilevel, Multiple, Hierarchical, Hybrid). Super-classes (base classes) and sub-classes (derived classes). Specialisation vs. Generalisation. Abstract and Concrete Classes and Methods. Inheritance for Specialisation vs. Specification. Inter-class Relationships (isa, has-a, part-of, association, aggregation, composition). Class members: fields (data members, variables, attributes), and methods (member functions, procedures). Messages. Object State. Constructors (parameterised, copy, conversion, default) and destructors. Object and member scope. Polymorphism.	10

3	Unified Modelling Language (UML). Use case diagrams: actors, system boundary, <<uses>> and <<extends>>. Class diagrams: associations, aggregation, dependency, and inheritance. Object interaction diagrams, object state transition diagrams.	8
4	Object oriented programming using Python: Builtin classes in Python - data types. User defined class, Object, Method, Inheritance, Encapsulation, Polymorphism, Data Abstraction in Python. Exception handling.	8
5	Object oriented programming using C++ and JAVA: Objects, Classes, Methods, Constructors and destructors. Friend Functions, Static member functions, Inheritance, Multiple Inheritance, Polymorphism and Virtual Functions, Function and Operator overloading, Namespace and Templates in C++. Packages, Class path, Interfaces in JAVA. Exception Handling in C++ and JAVA	10
Total lectures		**42**

Suggested Text Book(s):

1. Robert Lafore, "Object-Oriented Programming in C++," 4th Ed., Sams, 2001
2. Herbert Schildt, "Java The Complete Reference - 11th Ed. McGraw Hill, 2020
3. Martin C. Brown, "Python: The Complete Reference", 4th Ed. McGraw Hill, 2018

Suggested Reference Book(s):

1. A Downey, "Learning with Python", Dreamtech Press, 2015
2. Bjarne Stroustrup, "The C++ Programming Language," 3rd Ed., Pearson, 2002
3. Matha, "Object - Oriented Analysis and Design Using UML: Introduction to Unified Process and Design Patterns", PHI, 2008

Other useful resource(s):

NPTEL Course: https://nptel.ac.in/courses/106/105/106105153/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1.	T-1	15	1 Hour.	Syllabus covered up to T-1
2.	T-2	25	1.5 Hours	Syllabus covered up to T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Approved in Academic Council Meeting held on 28 July, 2021

IoT Architecture and Protocols

COURSE CODE: 21M1WEC132

COURSE CREDITS: 3
CORE/ELECTIVE:
Elective L-T-P: 3-0-0

Pre-requisite: None

Course Objectives:

1. Understand the concepts of IoT Architecture Reference model.
2. Understand the different protocols employed for IoT.
3. Design IoT-based systems for real-world problems.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Comprehend the essentials of IoT and its applications	Familiarity
CO-2	Understand the concepts of IoT Architecture Reference model	Assessment
CO-3	Analyze various IoT Application layer Protocols.	Assessment
CO-4	Apply IP based protocols and Authentication Protocols for IoT	Usage
CO-5	Design IoT-based systems for real-world problems	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Introduction to IOT, Applications of IOT, Use cases of IOT** Introduction- The IOT Today & Progression to Tomorrow – Success Factors –Strategic Research & Innovation Directions.	7
2	IOT and Related Issues - IOT & Related Future Internet Technologies – Networks & Communication – Processes & Data Management - Security, Privacy & Trust - Protocol Convergence	7
3	An Architectural Overview, Reference Model and IOT Architecture - Architecture Reference Model – IOT Reference Architecture: Architecture, Functional, information, deployment and operation views; SOA based Architecture, API-based Architecture, OPEN IoT Architecture for IoT/Cloud Convergence.	10

4	IOT Smart Applications, Cloud Service Management and IOT - Connecting IOT to cloud – Cloud Storage for Iot – Data Analytics for IoT – Software & Management Tools for IOT. Application Protocols for IoT: UPnP, CoAP, MQTT, XMPP. SCADA, Web Socket; IP-based protocols: 6LoWPAN, RPL; Authentication Protocols; IEEE 802.15.4.	**10**
5	Case study 1: M2M To IOT -M2M Vs IOT – A vision from M2M to IOT – Case Study 2: Cloud-Based Smart-Facilities Management, Healthcare, Environment Monitoring System.	**8**
Total lectures		**42**

Suggested Text Book(s):

1. Ovidiu Vermesan, Peter Friess, "Internet of Things – From Research & Innovation to Market Deployment", River Publishers, 2014
2. Jan Holler ,VlasiosTsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Avesand, David Boyle, "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence", Elsevier Ltd, 2014.
3. Bassi, Alessandro, et al, "Enabling things to talk", Springer-Verlag Berlin An, 2016.
4. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry, "IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things", CISCO Press, 2017

Suggested Reference Book(s):

1. Arshdeep Bahga, Vijay Madisetti, "Internet of Things – A hands-on approach", Universities Press, 2015.
2. Manoel Carlos Ramon, "Intel® Galileo and Intel® Galileo Gen 2: API Features and Arduino Projects for Linux Programmers", Apress, 2014.
3. Hersent, Olivier, David Boswarthick, and Omar Elloumi. The internet of things: Key applications and protocols. John Wiley & Sons, 2011.
4. Buyya, Rajkumar, and Amir Vahid Dastjerdi, eds. Internet of Things: Principles and paradigms. Elsevier, 2016.

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programmed Outcomes (POs)

Course outcomes (IoT Architecture and Protocols)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	1	2	2	2	3	1	1	1	1	2	2	3	**1.75**
CO-2	3	3	2	2	2	2	2	1	2	2	1	2	**2**
CO-3	3	1	2	1	2	2	2	2	2	3	1	1	**1.83**
CO-4	3	3	2	2	2	2	1	2	1	2	2	1	**1.91**
Average	**2.5**	**2.25**	**2**	**1.75**	**2.25**	**1.75**	**1.5**	**1.5**	**1.5**	**2.25**	**1.5**	**1.75**	

Wireless Technologies for IoT

COURSE CODE:21MIWEC131

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: None

Course Objectives:

1. To understand the fundamentals of wireless networks.
2. Analyze the standards of IoT which employed for wireless networks.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	To understand the fundamentals of wireless networks	Familiarity
CO-2	Analyze the standards of IoT which employed for wireless networks	Assessment
CO-3	Explain the use of various wireless technologies in IoT	Assessment
CO-4	Design and develop various applications of IoT	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Cellular Standards:** Cellular carriers and Frequencies, Channel allocation, Cell coverage, Cell Splitting, Microcells, Picocells, Handoff, 1st, 2nd, 3rd and 4th Generation Cellular Systems (GSM, CDMA, GPRS, EDGE,UMTS), Mobile IP, WCDMA	8
2	**RF Basics: Radio Frequency (RF) Fundamentals:** Introduction to RF & Wireless Communications Systems, RF and Microwave Spectral Analysis, Communication Standards, Understanding RF & Microwave Specifications. Spectrum Analysis of RF Environment, Protocol Analysis of RF Environment, Units of RF measurements, Factors affecting network range and speed, Environment, Line-of-sight, Interference, Defining differences between physical layers- OFDM.	9

3	**WLAN: Wi-Fi Organizations and Standards:** IEEE, Wi-Fi Alliance, WLAN Connectivity, WLAN QoS & Power-Save, IEEE 802.11 Standards,802.11- 2007,802.11a/b/g, 802.11e/h/I,802.11n	**8**
4	**Wi-Fi Hardware & Software:** Access Points, WLAN Routers, WLAN Bridges, WLAN Repeaters, Direct-connect Aps, Distributed connect Aps, PoE Infrastructure, Endpoint, Client hardware and software, Wi-Fi Applications	**9**
5	**WSN & WPN:** Wireless Personal Area Networks, Bluetooth, Bluetooth Standards, BlueTooth Protocol Architecture, UWB, IEEE 802.15 standards, ZigBee, Sub1GHz, Sensor Networks, coexistence strategies in Sensor Networks, Routing protocols in Wireless Sensor Networks.	**8**
Total lectures		**42**

Suggested Text Book(s):

1. Wireless Communications – Principles and Practice; by Theodore S Rappaport, Pearson Education Pte. Ltd., Delhi
2. Wireless Communications and Networking; By: Stallings, William; Pearson Education Pte. Ltd., Delhi
3. Bluetooth Revealed; By: Miller, Brent A, Bisdikian, Chatschik; Addison Wesley Longman Pte Ltd., Delhi
4. Wilson , "Sensor Technology hand book," Elsevier publications 2005.
5. Andrea Goldsmith, "Wireless Communications," Cambridge University Press, 2005

Suggested Reference Book(s):

1. Mobile and Personal Communications Services and Systems; 1st Edition; By: Raj Pandya; PHI, New Delhi
2. Fundamentals of Wireless Communication by Tse David and Viswanath Pramod, Cambridge University press, Cambridge
3. Mobile Communications; By: Schiller, Jochen H; Addison Wesley Longman Pte Ltd., Delhi
4. 3G Networks: Architecture, protocols and procedures based on 3GPP specifications for UMTS WCDMA networks, By Kasera, Sumit, Narang, and Nishit, TATA MGH, New Delhi
5. Wireless Sensor Networks: information processing by approach, ZHAO, FENG, GUIBAS and LEONIDAS J, ELSEVIER, New Delhi

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programmed Outcomes (POs)

Course outcomes (Wireless Technologies for IoT)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	1	2	2	2	3	1	1	1	1	2	2	3	**1.75**
CO-2	3	3	2	2	2	2	2	1	2	2	1	2	**2**
CO-3	3	1	2	1	2	2	2	2	2	3	1	1	**1.83**
CO-4	3	3	2	2	2	2	1	2	1	2	2	1	**1.91**
Average	**2.5**	**2.25**	**2**	**1.75**	**2.25**	**1.75**	**1.5**	**1.5**	**1.5**	**2.25**	**1.5**	**1.75**	

Industrial Automation and IIoT

COURSE CODE: 21M1WEC133

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Prerequisite: None

Course Objectives:

To learn about industrial automation, and Industrial Internet of Things (IIoT) which is an application of IoT in industries to modify the various existing industrial systems.

Course Outcomes:

Sl. No.	Course Outcomes	Level of Attainment
1	Learn about history, architecture and advantages of Industrial automation	Familiarity
2	Knowledge about various components used for Industrial automation	Familiarity
3	Learn about PLC, SCADA and DCS used for automation	Usage
4	Study about Industrial Communication and Human Machine Interface	Assessment
5	Learn about Industrial IoT reference architecture, layers and application domains	Assessment

Course Contents:

Unit	Contents	Lectures required
1	Introduction: History of automation, Automation systems, Types of automation, Automation overview, Requirement of automation systems, Architecture of Industrial Automation system, Advantages and limitations of Automation, Industrial revolutions.	6
2	Automation components: Sensors and actuators, Electric, Hydraulic, Pneumatic, actuators, process control valves, Introduction of DC and AC servo drives for motion control. Controllers, Transmitters and Signal Conditioning: Need of transmitters, Standardization of signals, Current, Voltage and Pneumatic signal standards, 2-Wire & 3-Wire transmitters, Analog and Digital signal conditioning for sensors, Smart and Intelligent transmitters	8
3	Programmable logic controllers: Programmable controllers, Programmable logic controllers, Analog digital input and output modules, PLC programming, Ladder diagram, Sequential flow chart, PLC Communication and networking, PLC selection, PLC Installation, Advantage of using PLC for Industrial automation, Application of PLC to process control industries.	6
	SCADA & Distributed control system: Elements of SCADA, Features of SCADA,	

4	MTU, RTU Functions, Applications of SCADA, Communications in SCADA, Introduction to DCS, Architecture, Input and output modules, Specifications of DCS.	6
5	Industrial Communication and Human Machine Interface (HMI): Device network: CAN, PROFIBUS-PA, Control network: ControlNet, PROFIBUS-DP, Ethernet, Interfaces: RFID, Barcode, HMI: Block Diagram, Types, Advantages and industrial applications.	8
6	Industrial IoT: Business Model and Reference Architecture, Layers: IIoT Sensing, IIoT Processing, IIoT Communication , IIoT Networking. Industrial IoT-Application Domains: Healthcare, Power Plants, Inventory Management & Quality Control, Plant Safety and Security, Oil, chemical and pharmaceutical industry.	8
Total lectures		42

Suggested Text Book(s):

1. K. S. Singh, "Industrial Instrumentation and Control", 3rd Ed., The McGraw Hill, 2010
2. C.D. Johnson, "Process Control Instrumentation Technology", 8th Ed., PHI, 2015
3. Madhuchhanda Mitra, SamarjitSen Gupta, "Programmable Logic controllers and Industrial Automation", Penram International, 2008

Suggested Reference Book(s):

1. Gregory K. McMillan, P. Hunter Vegas, "Process / Industrial Instruments and Controls Handbook," 6th Ed., McGraw Hill, 2019
2. Bela G. Liptak, Kriszta Venczel, "Instrument and Automation Engineers' Handbook: Process Measurement and Analysis," 5th Ed., CRC Press, 2016
3. A. Suresh et. al., "Industrial IoT Application Architectures and Use Cases", 1st Ed., CRC Press, 2018
4. Giacomo Veneri Antonio Capasso, "Hands-On Industrial Internet of Things: Create a powerful Industrial IoT infrastructure using Industry 4.0", Ingram short title, 2018.

Other useful resource(s):

NPTEL Course:

https://nptel.ac.in/courses/108/105/108105088/

https://nptel.ac.in/courses/108/105/108105063/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1.	T-1	15	1 Hour.	Syllabus covered up to T-1

2.	T-2	25	1.5 Hours	Syllabus covered up to T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Intelligent Robotics and Shared Autonomy

COURSE CODE: 21M1WEC134

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Prerequisite: None

Course Objectives:

To learn about robotics, various elements, kinematics, dynamics and motion control of a robot and to get acquainted with intelligent robots working on shared autonomy.

Course Outcomes:

Sl. No.	Course Outcomes	Level of Attainment
1	Learn about history, classification and application of robots	Familiarity
2	Learn about elements of a robot, D-H parameters and homogeneous transformation	Usage
3	Knowledge about sensors and actuators used in robots	Assessment
4	Learn about robot kinematics, dynamics, motion planning and control	Usage
5	Study about intelligent robots and robot working on shared autonomy	Usage

Course Contents:

Unit	Contents	Lectures required
1	Introduction to Robotics: Introduction – brief history, types, classification and usage	4
2	Elements of Robots - joints, links, actuators, and sensors: Position and orientation of a rigid body, Homogeneous transformations, Representation of joints, link representation using D-H parameters, Examples of D-H parameters and link transforms	8
3	Actuators – stepper, DC servo and brushless motors, model of a DC servo motor, Types of transmissions, Purpose of sensors, internal and external sensors, common	8

	sensors – encoders, tachometers, strain gauge based force- torque sensors, proximity and distance measuring sensors, and vision.	
4	Robot Arm Kinematics and Dynamics: forward kinematics, Inverse kinematics, Lagrange formulation of dynamics	6
5	Motion Planning and Control: Joint and Cartesian space trajectory planning and generation, Classical control concepts using the example of control of a single link, Independent joint PID control, Control of a multi-link manipulator	8
6	Probability Based Approaches, Markov Decision Processes (MDPs), Partially Observable Markov Decision Processes, Navigation, Behaviour-Based Control. Adaptive approaches to robot control, Reinforcement learning for control, Model Based learning approaches to control, Evolutionary approaches, Interaction-aware control, intent inference, and shared autonomy	8
Total lectures		42

Suggested Text Book(s):

1. J. J. Craig, "Introduction to Robotics- Mechanics and Control", Pearson, 3rd Edition, 2009.
2. Spong and Vidyasagar, "Robot Dynamics and Control", Wiley Student Edition, John Wiley and Sons, 2013.
3. Roland Siegwart, "Introduction to Autonomous Mobile Robots," 2nd Ed. (Intelligent Robotics and Autonomous Agents series) MIT Press, 2011

Suggested Reference Book(s):

1. Sciavicco and Siciliano, "Modeling and Control of Robot Manipulators", Springer, 2nd Edition, 2002.
2. D.K. Pratihar, "Fundamentals of Robotics", Narosa Publishing House, 1st Edition, 2017.

Other useful resource(s):

1. Link to NPTEL course contents: https://nptel.ac.in/courses/112101099/

   https://nptel.ac.in/downloads/112101098/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1.	T-1	15	1 Hour.	Syllabus covered up to T-1
2.	T-2	25	1.5 Hours	Syllabus covered up to T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Signal Processing for IOT

COURSE CODE: 21M1WEC135

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE L-

T-P: 3-0-0

Pre-requisite: Digital signal processing, MATLAB Programming,

Course Objectives:

1. To provide the knowledge of the role of signal processing techniques for IOT applications.
2. To provide the practical implementation of signal processing techniques for IOT applications

Course Outcomes:

Course Outcomes ()		**Level of Attainment**
CO-1	Able to understand the sparse signal processing and its application in IOT.	Familiarity
CO-2	Able to understand the wavelet transform and its applicability in IOT	Familiarity
CO-3	Able to understand how signal processing provides an important role in energy efficiency, security and reliability for IOT.	Familiarity
CO-4	Able to understand the applicability of deep learning and TFA tools in IOT.	Assessment

Course Contents:

S. No.	**Contents**	**Contact Hours**
1	**Compressive sensing and sparse signal processing for IOT** Compressed Acquisition and Denoising Recovery of EMGdi Signal in WSNs and IoT, Compressed Sensing Signal and Data Acquisition in Wireless Sensor Networks and Internet of Things, Study on Secrecy Capacity of Wireless Sensor Networks in Internet of Things Based on the Amplify-and-Forward Compressed Sensing, Communication-Efficient Federated Learning Based on Compressed Sensing, Learning-based Sparse Data Reconstruction for Compressed Data Aggregation in IoT Networks, Sparse Signal Processing for Grant-Free Massive Connectivity: A Future Paradigm for Random Access Protocols in the Internet of Things, Compressed Sensing via Dictionary Learning and Approximate Message	14

	Passing for Multimedia Internet of Things, ECG Signal Reconstruction on the IoT-Gateway and Efficacy of Compressive Sensing Under Real-Time Constraints,	
2	**Wavelet transform for IOT** Insights Into IoT Data and an Innovative DWT-Based Technique to Denoise Sensor Signals, Industrial Pollution Areas Detection and Location via Satellite-Based IIoT, , RF Fingerprinting of IoT Devices Based on Transient Energy Spectrum, Learning Time-Frequency Analysis in Wireless Sensor Networks. IoMT-Based Association Rule Mining for the Prediction of Human Protein Complexes, Neuro-Detect: A Machine Learning-Based Fast and Accurate Seizure Detection System in the IoMT, An Efficient IoT-Based Platform for Remote Real-Time Cardiac Activity Monitoring Filtering and applications, An Adaptive Outlier Detection and Processing Approach Towards Time Series Sensor Data,	14
3	**Role of signal processing security and reliability** Signal processing techniques for energy efficiency, security, and reliability in the IoT domain, An Effective Data Privacy Protection Algorithm Based on Differential Privacy in Edge Computing, A Novel Image Steganography Method for Industrial Internet of Things Security, Robust Watermarking Algorithm for Medical Volume Data in Internet of Medical Things	08
4	**Signal processing and deep learning for IOT** Signal processing techniques for IoT-based structural health monitoring, Deep Learning for Fault Diagnosis based on short-time Fourier transform for IOT application,	06
	Total	**42**

Suggested Text Book(s):

1. Fornasier, Massimo, and Holger Rauhut. "Compressive Sensing." Handbook of mathematical methods in imaging 1 (2015): 187-229.
2. Baraniuk, R. G. (2007). Compressive sensing [lecture notes]. IEEE signal processing magazine, 24(4), 118-121.
3. J. G. Proakis and D. G. Manolakis, "Digital Signal Processing", 4th Edition, Prentice Hall, 2007.
4. Mallat S. A wavelet tour of signal processing. Elsevier; 1999 Sep 14.

Suggested Reference Book(s):

1. Zaknich, Anthony. Neural networks for intelligent signal processing. Vol. 4. World Scientific, 2003.
2. Swanson, David C. Signal processing for intelligent sensor systems with MATLAB. CRC Press, 2011.
3. Victor C. Chen, and Hao Ling, Time-frequency Transforms for Radar Imaging and Signal Analysis, Artech House Publishers, 2002

4. Karlheinz Gröchenig, Foundations of Time-Frequency Analysis, Birkhäuser publishers(Springer), 2001.
5. J. G. Proakis and D. G. Manolakis, “Digital Signal Processing”, 4th Edition, Prentice Hall, 2007.

Other useful resource(s):

Research papers:

1. F. Wu, K. Yang and Z. Yang, "Compressed Acquisition and Denoising Recovery of EMGdi Signal in WSNs and IoT," in IEEE Transactions on Industrial Informatics, vol. 14, no. 5, pp. 2210-2219, May 2018, doi: 10.1109/TII.2017.2759185.
2. S. Li, L. D. Xu and X. Wang, "Compressed Sensing Signal and Data Acquisition in Wireless Sensor Networks and Internet of Things," in IEEE Transactions on Industrial Informatics, vol. 9, no. 4, pp. 2177-2186, Nov. 2013, doi: 10.1109/TII.2012.2189222.
3. J. Guo et al., "Study on Secrecy Capacity of Wireless Sensor Networks in Internet of Things Based on the Amplify-and-Forward Compressed Sensing Scheme," in IEEE Access, vol. 7, pp. 185580-185589, 2019, doi: 10.1109/ACCESS.2019.2960603.
4. Vanus, J.; Fiedorova, K.; Kubicek, J.; Gorjani, O.M.; Augustynek, M. Wavelet-Based Filtration Procedure for Denoising the Predicted CO2 Waveforms in Smart Home within the Internet of Things. Sensors 2020, 20, 620. https://doi.org/10.3390/s20030620
5. Zhang, Chengwen, Jun Shi, Zheming Zhang, Yutao Liu, and Xudong Hu. "FRFT-based interference suppression for OFDM systems in IoT environment." IEEE Communications Letters 23, no. 11 (2019): 2068-2072.
6. Al-Shayea, Tamara K., et al. "A Novel Gaussian in Denoising Medical Images with Different Wavelets for Internet of Things Devices." GLOBECOM 2020-2020 IEEE Global Communications Conference. IEEE, 2020.
7. Tian, Qiao, Yun Lin, Xinghao Guo, Jinming Wen, Yi Fang, Jonathan Rodriguez, and Shahid Mumtaz. "New security mechanisms of high-reliability IoT communication based on radio frequency fingerprint." IEEE Internet of Things Journal 6, no. 5 (2019): 7980-7987.
8. M. Zhang, H. Zhang, D. Yuan and M. Zhang, "Learning-based Sparse Data Reconstruction for Compressed Data Aggregation in IoT Networks," in *IEEE Internet of Things Journal*, doi: 10.1109/JIOT.2021.3059735.
9. Djelouat, H.; Amira, A.; Bensaali, F. Compressive Sensing-Based IoT Applications: A Review. *J. Sens. Actuator Netw.* 2018, *7*, 45. https://doi.org/10.3390/jsan7040045
10. L. Liu, E. G. Larsson, W. Yu, P. Popovski, C. Stefanovic and E. de Carvalho, "Sparse Signal Processing for Grant-Free Massive Connectivity: A Future Paradigm for Random Access Protocols in the Internet of Things," in IEEE Signal Processing Magazine, vol. 35, no. 5, pp. 88-99, Sept. 2018, doi: 10.1109/MSP.2018.2844952.
11. Z. Li, H. Huang and S. Misra, "Compressed Sensing via Dictionary Learning and Approximate Message Passing for Multimedia Internet of Things," in IEEE Internet of

Things Journal, vol. 4, no. 2, pp. 505-512, April 2017, doi: 10.1109/JIOT.2016.2583465.
12. M. L. Lopes De Faria, C. E. Cugnasca and J. R. A. Amazonas, "Insights Into IoT Data and an Innovative DWT-Based Technique to Denoise Sensor Signals," in *IEEE Sensors Journal*, vol. 18, no. 1, pp. 237-247, 1 Jan.1, 2018, doi:10.1109/JSEN.2017.2767383.
13. J. Liu, J. Ma, J. Li, M. Huang, N. Sadiq and Y. Ai, "Robust Watermarking Algorithm for Medical Volume Data in Internet of Medical Things," in IEEE Access, vol. 8, pp. 93939-93961, 2020, doi: 10.1109/ACCESS.2020.2995015.
14. Y. Qiao et al., "An Effective Data Privacy Protection Algorithm Based on Differential Privacy in Edge Computing," in IEEE Access, vol. 7, pp. 136203-136213, 2019, doi: 10.1109/ACCESS.2019.2939015.
15. M. Hassaballah, M. A. Hameed, A. I. Awad and K. Muhammad, "A Novel Image Steganography Method for Industrial Internet of Things Security," in *IEEE Transactions on Industrial Informatics*, doi: 10.1109/TII.2021.3053595.
16. M. Zhang, X. Li and L. Wang, "An Adaptive Outlier Detection and Processing Approach Towards Time Series Sensor Data," in IEEE Access, vol. 7, pp. 175192-175212, 2019, doi: 10.1109/ACCESS.2019.2957602.
17. M. Zhang, X. Li and L. Wang, "An Adaptive Outlier Detection and Processing Approach Towards Time Series Sensor Data," in *IEEE Access*, vol. 7, pp. 175192-175212, 2019, doi: 10.1109/ACCESS.2019.2957602.
18. L. Wan, Y. Sun, I. Lee, W. Zhao and F. Xia, "Industrial Pollution Areas Detection and Location via Satellite-Based IIoT," in *IEEE Transactions on Industrial Informatics*, vol. 17, no. 3, pp. 1785-1794, March 2021, doi: 10.1109/TII.2020.2992658.
19. A. Ahmadi *et al*., "Toward Automatic Activity Classification and Movement Assessment During a Sports Training Session," in *IEEE Internet of Things Journal*, vol. 2, no. 1, pp. 23-32, Feb. 2015, doi: 10.1109/JIOT.2014.2377238.
20. S. Raj, "An Efficient IoT-Based Platform for Remote Real-Time Cardiac Activity Monitoring," in *IEEE Transactions on Consumer Electronics*, vol. 66, no. 2, pp. 106-114, May 2020, doi: 10.1109/TCE.2020.2981511.
21. M. Sikarndar, W. Anwar, A. Almogren, I. Ud Din and N. Guizani, "IoMT-Based Association Rule Mining for the Prediction of Human Protein Complexes," in *IEEE Access*, vol. 8, pp. 6226-6237, 2020, doi: 10.1109/ACCESS.2019.2963797.
22. H. Zou, Y. Zhou, R. Arghandeh and C. J. Spanos, "Multiple Kernel Semi-Representation Learning With Its Application to Device-Free Human Activity Recognition," in *IEEE Internet of Things Journal*, vol. 6, no. 5, pp. 7670-7680, Oct. 2019, doi: 10.1109/JIOT.2019.2901927.
23. M. Köse, S. Taşcioğlu and Z. Telatar, "RF Fingerprinting of IoT Devices Based on Transient Energy Spectrum," in *IEEE Access*, vol. 7, pp. 18715-18726, 2019, doi: 10.1109/ACCESS.2019.2896696.
24. Z. Sun, L. Zhou and W. Wang, "Learning Time-Frequency Analysis in Wireless Sensor Networks," in *IEEE Internet of Things Journal*, vol. 5, no. 5, pp. 3388-3396, Oct. 2018, doi: 10.1109/JIOT.2017.2771514.

25. M. A. Sayeed, S. P. Mohanty, E. Kougianos and H. P. Zaveri, "Neuro-Detect: A Machine Learning-Based Fast and Accurate Seizure Detection System in the IoMT," in *IEEE Transactions on Consumer Electronics*, vol. 65, no. 3, pp. 359-368, Aug. 2019, doi: 10.1109/TCE.2019.2917895.
26. T. BENKEDJOUH, N. ZERHOUNI and S. RECHAK, "Deep Learning for Fault Diagnosis based on short-time Fourier transform," *2018 International Conference on Smart Communications in Network Technologies (SaCoNeT)*, El Oued, Algeria, 2018, pp. 288-293, doi: 10.1109/SaCoNeT.2018.8585444.
27. M. Al Disi *et al*., "ECG Signal Reconstruction on the IoT-Gateway and Efficacy of Compressive Sensing Under Real-Time Constraints," in *IEEE Access*, vol. 6, pp. 69130-69140, 2018, doi: 10.1109/ACCESS.2018.2877679.
28. M. A. Mahmud, A. Abdelgawad, K. Yelamarthi and Y. A. Ismail, "Signal processing techniques for IoT-based structural health monitoring," *2017 29th International Conference on Microelectronics (ICM)*, Beirut, Lebanon, 2017, pp. 1-5, doi: 10.1109/ICM.2017.8268825.
29. Nawaz, Menaa, Jameel Ahmed, Ghulam Abbas, and Mujeeb Ur Rehman. "Signal Analysis and Anomaly Detection of IoT-Based Healthcare Framework." In 2020 Global Conference on Wireless and Optical Technologies (GCWOT), pp. 1-6. IEEE, 2020.
30. Fragkiadakis, Alexandros, Elias Tragos, Antonis Makrogiannakis, Stefanos Papadakis, Pavlos Charalampidis, and Manolis Surligas. "Signal processing techniques for energy efficiency, security, and reliability in the IoT domain." In Internet of Things (IoT) in 5G Mobile Technologies, pp. 419-447. Springer, Cham, 2016.

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1.	T-1	15	1 Hour.	Syllabus covered up to T-1
2.	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

COs/POs													**Average**
CO-1	3	3	2	2	2	3	3	2	3	3	3	3	2.666667
CO-2	3	3	3	3	3	3	3	3	3	3	3	3	3
CO-3	3	3	3	3	3	2	3	3	2	3	3	3	2.833333
CO-4	3	3	3	3	3	3	2	3	3	3	3	3	2.916667
Average	3	3	2.75	2.75	2.75	2.75	2.75	2.75	2.75	3	3	3	

Intelligent Signal Processing

COURSE CODE: 21M1WEC136

COURSE CREDITS: 3

CORE/ELECTIVE: Elective core

L-T-P: 3-0-0

Pre-requisite: Signals and Systems, MATLAB Programming,

Course Objectives:

To provide the knowledge of the concept of signal processing and neural networks.

To provide the basic knowledge of intelligent signal processing along with its practical implementation.

Course Outcomes:

Course Outcomes ()		**Level of Attainment**
CO-1	Able to understand the basic concept of spectral analysis	Familiarity
CO-2	Able to understand the concept of time-frequency analysis	Familiarity & Usage
CO-3	Able to understand the concept of wiener filtering and steepest descent algorithm	Familiarity & Usage
CO-4	Able to understand the role of neural network and deep neural network for signal processing applications	Familiarity & Usage
CO-5	Able to understand the overall concept of intelligent signal processing	Assessment

Course Contents:

S. No.	**Contents**	**Contact Hours**
1	Spectral Estimation, Parametric spectral methods, Non-Parametric Methods, Minimum Variance Spectrum Estimation, Maximum Entropy Method, Frequency Estimation Method, Parametric Methods, Principal Component Spectrum Estimation Method	10
2	Introduction of the Time-Frequency analysis methods, Non-stationary signals, Short time Fourier transform, spectrogram, continuous wavelet transform, scalogram, and DWT	10
3.	Wiener Filter Theory and its Application, Steepest Descent Algorithm, LMS Algorithm.	08
4	Basic neural network, deep neural network and their use in signal processing applications.	04
5	Applications of digital signal processing and neural networks in genomics data analysis, ECG analysis, EMG analysis, EEG analysis, respiratory sound analysis, lung sound analysis, vibration signal analysis, spectrum	10

	sensing, modulation analysis, and micro-Doppler signature analysis, Intelligent Radio Signal Processing: A Survey	
	Total	**42**

Suggested Text Book(s):

1. M. H. Hayes, Statistical Digital Signal Processing and Modelling, John Wiley & Sons, Student Edition, 2013.
2. Boualem Boashash, Time-frequency signal analysis and processing: A comprehensive reference, 2nd Edition, Academic Publishers (Elsevier), 2016.
3. Recently published research papers based on time-frequency analysis with machine learning or deep learning.

Suggested Reference Book(s):

1. Zaknich, Anthony. *Neural networks for intelligent signal processing*. Vol. 4. World Scientific, 2003.
2. Swanson, David C. *Signal processing for intelligent sensor systems with MATLAB*. CRC Press, 2011.
3. I. Goodfellow, Y, Bengio, A. Courville, Deep Learning", MIT Press, 2016.
4. Ruano, Antonio, and Annamária R. Várkonyi-Kóczy, eds. *New Advances in Intelligent Signal Processing*. Vol. 372. Springer Science & Business Media, 2011.
5. Simon Haykin, Bart Kosko, "Intelligent Signal Processing" IEEE xplore, 2001
6. Victor C. Chen, and Hao Ling, Time-frequency Transforms for Radar Imaging and Signal Analysis, Artech House Publishers, 2002
7. Karlheinz Gröchenig, Foundations of Time-Frequency Analysis, Birkhäuser publishers(Springer), 2001.
8. J. G. Proakis and D. G. Manolakis, "Digital Signal Processing", 4th Edition, Prentice Hall, 2007.

Other useful resource(s):

1. http://dsp.rice.edu/cs/
2. https://www.signalprocessingsociety.org/uploads/history/history.pdf
3. http://pfister.ee.duke.edu/courses/ece485/
4. https://www.wiley.com/en-in/Intelligent+Signal+Processing-p-9780780360105
5. https://ieeexplore.ieee.org/book/5265588
6. https://www.sciencedirect.com/science/article/abs/pii/S0266353802000088
7. https://www.ncl.ac.uk/engineering/research/electrical-electronic-engineering/intelligent-sensing-communication/signal-processing-ai/
8. https://www.ncl.ac.uk/postgraduate/modules/EEE8129/
9. https://www.youtube.com/watch?v=EErkgr1MWw0
10. https://www.youtube.com/watch?v=GZ3KUPqA1J M
11. https://www.coursera.org/learn/advanced-machine-learning-signal-processing

12. https://aims.asu.edu/signal-processing-for-st ructural-health-monitoring/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered up to T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

COs/POs													Average
CO-1	3	3	2	2	2	3	3	2	3	3	3	3	2.666667
CO-2	3	3	3	3	3	3	3	3	3	3	3	3	3
CO-3	3	3	3	3	3	2	3	3	2	3	3	3	2.833333
CO-4	3	3	3	3	3	3	2	3	3	3	3	3	2.916667
CO-5	3	3	3	3	3	3	3	3	3	3	3	3	3
Average	3	3	2.8	2.8	2.8	2.8	2.8	2.8	2.8	3	3	3	

Advanced IoT Lab – I

COURSE CODE: 21M11EC271

COURSE CREDITS: 6

CORE/ELECTIVE:

: 0-0-6

Pre-requisite:

Course Objectives:

This lab will include experiments on embedded systems and its interfacing with sensors.

- Experiments will be performed using ARM processor, PIC microcontroller, and 8051 microcontroller.
- Experiments based on Firebird-V Robotics Research Platform will be performed
- Experiments with virtual instrumentation with LabView will be performed in this Lab.
- Project work/Implementation of the research papers is also included in this lab.

Digital System Design Using Verilog HDL

COURSE CODE: 21M11EC211

COURSE CREDITS: 3

CORE/ELECTIVE: CORE

L-T-P: 3-0-0

Pre-requisite: Basic course in Digital Electronics & Logic Design

Course Objectives:

1. Designing digital circuits, behaviour and RTL modeling of digital circuits using verilog HDL, verifying these Models and synthesizing RTLmodels to standard cell libraries and FPGAs.

2. Students gain practical experience by designing, modeling, implementing and verifying several digital circuits.

Course Outcomes:

Sl. No.	Course Outcomes	Level of Attainment
1	To understand the constructs and conventions of the Verilog HDLprogramming.	Familiarity
2	To understand the structural, register-transfer level (RTL), and algorithmic levels of abstraction for modelling digital hardware systems.	Usage
3	To design and modelling of combinational and sequential digital systems (FiniteState Machines).	Usage, Assessment
4	To understand and apply the concept of test-benches to create testing behavioural environments for simulation based verification	Usage, Assessment

Course Contents:

Unit	Contents	Lectures required
1	Introduction to Logic circuits and implementation technology: Logic gates, Boolean algebra, design examples, CAD tools, introduction to verilog, Programmable Logic devices and types, Optimized implementation of Logic Functions	3
2	Verilog as HDL, Levels of design Description, Concurrency, Simulation and Synthesis, Functional verification, System Tasks, Programming Language Interface (PLI), Module, Simulation and Synthesis Tools, Test Benches	4
3	Introduction, Keywords, Identifiers, White Space Characters, Comments, Numbers, Strings, Logic Values,Strengths, Data Types, Scalars and Vectors, Parameters, Operators, AND Gate Primitive,Module Structure, Other Gate Primitives, Illustrative Examples, Tri-State gates, Array of Instances of Primitives, Design of Flip –Flops with gate primitives, Delays, Strengths and contention Resolution, Net Types, Design of BasicCircuits.MODELING AT DATA FLOW LEVEL: Introduction, Continuous Assignment Structures, Delays and Continuous Assignments, Assignment to vectors, Operators	7
4	BEHAVIORAL MODELING: Introduction, Operations and Assignments, Functional Bifurcation, Initial Construct, Always Construct, assignments with Delays, Wait Construct, Multiple Always Blocks, Designs at Behavioural Level, Blocking and Non-Blocking Assignments, The case statement, Simulation Flow if and if-else constructs, assign–design construct, repeat construct, for loop, the disable construct, while loop, forever loop, parallel	4

	blocks, force-release construct, Event.	
5	Arithmetic circuits: number representation review, arithmetic circuits (adders and multipliers using CAD, Combinational circuit building blocks: Multiplexers, decoders, encoders, using verilog HDL.	4
6	Flip-Flops, Registers, Counters and Simple Processor: Latches, Flip-flops. Registers, counters and types, Reset Synchronization, Using Storage Elements in verilog HDL, Design Examples and timing concepts	6
7	Synchronous Sequential Circuits with verilog: BasicDesign Steps, One hot encoding, Mealy State Model, Moore tupe FSM Design of FSM using verilog, Design Examples, FSM as arbitrator circuit, ASM	6
8	Asynchronous sequential circuits: Behaviour, Analysis and synthesis, State Reduction, State assignment, Hazards, a complete design example	4
9	Digital System Design: Building Block circuits, clock synchronization concepts, various design examples, Testing of Logic Circuits: Fault models, path sensitizing, testing of sequential circuits, Built in self test: boundary scan	4
Total lectures		**42**

Suggested Text Book(s):

1. Fundamentals of Digital Logic design with Verilog Design –Stephen Brown and Zvonko Vranesic, TMH, 2ndEdition,2010.

2. Advanced Digital Design with Verilog HDL –Michael D. Ciletti, PHI, 2005.

Suggested Reference Book(s):

Other useful resource(s):

1. T. R. Padmanabhan and B. Bala Tripura Sundari, Design through Verilog HDL – Wiley,2009.(T1) .Zainalabdien Navabi, Verilog Digital System Design, TMH, 2ndEdition

2. Verilog HDL –Samir Palnitkar, 2ndEdition, Pearson Education, 2009.

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered up to T-1
2	T-2	25	1.5 Hours	Syllabus covered up to T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course outcomes (Digital System Design Using Verilog HDL)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	3	3	2	2	3	3	2	3	3	3	2.75
CO-2	3	3	2	2	2	1	2	2	2	3	3	3	2.4
CO-3	3	3	3	2	2	1	2	3	2	3	3	3	2.5
CO-4	3	3	3	3	2	3	2	3	2	2	3	3	2.6
Average	3	3	2.75	2.5	2	1.75	2.25	2.75	2	2.75	3	3	

Artificial Intelligence and Expert Systems

COURSE CODE: 21M11EC212

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Prerequisites are good programming skills, basic data structures and algorithms, and some university level mathematics.

Course Objectives:

1. To understand the concept of designing expert systems which exhibit intell gent behavior.
2. To study and create expert systems which exhibit the capability to learn, demonstrate, explain and advise its users.
3. To learn artificial intelligent systems finding solutions to complex problems.
4. To design human-like machines in a computer friendly manner.
5. To study State of the Art algorithms with engineering applications.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	To analyze the need and foundation of Artificial Intelligence and expert systems	Familiarity
CO-2	Study the various types of expert systems that receive precepts from the environment and perform actions	Assessment
CO-3	Analysis of problem solving, knowledge and reasoning	Assessment
CO-4	Study of application domains of Artificial Intelligence	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Introduction to Artificial Intelligence:** What is Artificial Intelligence (AI), The foundations of AI, The birth of AI, Knowledge based Systems, The State of the Art techniques.	7
2	**Intelligent Agents:** Agents and Environments, The concept of Rationality, Performance Measures, The structure of Agents, Agent Programs, Simple reflex Agents, Model based reflex Agents, Goal based Agents, Utility based Agents, Learning Agents.	7
3	**Problem Solving:** Problem solving Agents, Formulating Problems, Searching for Solutions, Uninformed Search Strategies, Breadth first search, Depth first search, Depth limited Search, Bidirectional search, Informed Search Exploration, Constraint Satisfaction Problems	7

4	**Knowledge and Reasoning:** Knowledge based agents, Reasoning Patterns in Propositional Logic, Forward and Backward Chaining, Backtracking Algorithm, First Order Logic, Knowledge Representation, Uncertain Knowledge and Reasoning	**7**
5	**Learning:** Laning from Observations, Forms of Learning, Inductive Learning, Learning Decision Trees, Ensemble Learning, Knowledge in Learning, Statistical Learning, Reinforcement Learning	**7**
6	**Perception and Action:** Communication as Action, Fundamental of Language, Syntactic Analysis, Semantic Interpretation, Probabilistic Language Processing, Perceptual analysis, Robotic Hardware and software Architectures.	**7**
Total lectures		**42**

Suggested Text Book(s):

1. Stuart J. Russel and Peter Norvig, "Artificial Intelligence: A Modern Approach" Second Edition, Pearson Prentice Hall.
2. E. rich and K. Knight, "Artificial Intelligence and Applications" Third Edition, Tata Mcgraw Hill.

Suggested Reference Book(s):

1. P. Kulkarni and P. Joshi, "Artificial Intelligence", PHI Learning Private Limited, 2015.
2. P. H. Winston, Artificial Intelligence and Applications", PHI Learning Private Limited, 2017.

Other useful resource(s):

Link to topics related to course:

i. https://nptel.ac.in/courses/106105077/
ii. https://www.tutorialspoint.com/artificial_intelligence/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1.	T-1	15	1 Hour.	Syllabus covered upto T-1
2.	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10

				Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Artificial Intelligence and Expert Systems)													
CO-1	2	2	3	3	2	1	1	1	2	2	2	2	**2**
CO-2	2	3	3	3	2	1	1	1	2	2	1	2	**2**
CO-3	2	3	3	3	2	1	1	1	2	2	1	2	**2**
CO-4	2	3	3	3	2	1	1	1	2	3	2	2	**2**
Average	**2**	**3**	**3**	**3**	**2**	**1**	**1**	**1**	**2**	**2**	**3**	**2**	

Network Security Protocols

COURSE CODE: 21M11EC213

COURSE CREDITS: 3

CORE/ELECTIVE: CORE

L-T-P: 3-0-0

Pre-requisite: None

Course Objectives:

1. To understand the concept of network security.
2. Familiarization of various security protocols implemented at different layers.

Course Outcomes:

Sl. No.	Course Outcomes	Level of Attainment
CO-1	Understand the threats posed to network security and the more common attacks associated with those threats	Familiarity
CO-2	Understand the threats present in computer networks and counter measures for the same	Usage
CO-3	Analyzing the security protocols at different layers of the OSI model.	Usage
CO-4	Gain knowledge of authentication processes and security in the wireless networks.	Assessment

Course Contents:

Unit	Contents	Lectures required
1.	Introduction: Computer security concepts; OSI security architecture Security attacks, Security mechanisms, A model for network security, Standards	5
2.	Understanding network security: Network security: Physical security, Pseudo security, Hardware security, Software security; Security services: Access control, Authentication, Confidentiality, Integrity, Non-repudiation; Security standards, Elements of security. DoS Attacks, Firewall and Intrusion prevention systems	8
3.	Security threats to Computer Networks: Introduction; Sources of security threats; Security threat motives; Security threat management; Security threat correlation; Security threat awareness.	6
4.	Security protocols in network layer: Security at different layers: pros and cons; Internet protocol security (IPSec): IPSec security associations, IPSec protocols: AH and ESP, Tunnel versus transport mode, Incompatibility with	6

	NAT, Internet key exchange protocol.	
5.	Security protocols in transport layer: Secure socket layer (SSL) handshake protocol: Steps in handshake, Key design ideas; SSL record layer protocol, OpenSSL, Transport layer security (TLS).	6
6.	Security protocols in application layer: Pretty good privacy (PGP), Secure/multipurpose internet mail extension (S/MIME), Secure-HTTP (S-HTTP), Hypertext transfer protocol over secure socket layer (HTTPS), Secure electronic transactions (SET), Kerberos.	6
7	Security in wireless networks and devices: GSM (2G) security, Security in UMTS (3G), Wireless LAN security: authentication, confidentiality and integrity.	5
Total lectures		42

Suggested Text Book(s):

1. Cryptography and Network Security: principle and practices Wiliam Stallings.
2. Computer Network Security, Joseph Migga Kizza.
3. Cryptography, Network Security, and Cyber Laws / Bernard L. Menezes.

Suggested Reference Book(s):

Other useful resource(s):

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1.	T-1	15	1 Hour.	Syllabus covered up to T-1
2.	T-2	25	1.5 Hours	Syllabus covered up to T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programmed Outcomes (POs)

Course outcomes (Network security protocols)													
CO-1	1	2	2	2	3	1	1	1	1	2	2	3	**1.75**
CO-2	3	3	2	2	2	2	2	1	2	2	1	2	**2**
CO-3	3	1	2	1	2	2	2	2	2	3	1	1	**1.83**
CO-4	3	3	2	2	2	2	1	2	1	2	2	1	**1.91**
Average	**2.5**	**2.25**	**2**	**1.75**	**2.25**	**1.75**	**1.5**	**1.5**	**1.5**	**2.25**	**1.5**	**1.75**	

Image Sensing and Real Time Processing

COURSE CODE: 21M1WEC231

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Prerequisites image processing concepts. are good programming skills, basic signals and systems and

Course Objectives:

1. To understand the concept of designing image processing algorithms.
2. Study on various types of image sensing elements.
3. To study the implementation of image processing algorithms for real world problems.
4. To understand the mathematical concepts and principles behind the real time image processing techniques.
5. Application studies on image processing used in research and industry.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	To analyze the basic concepts of accessing and storing the image data	Familiarity
CO-2	Study and implement real world image processing algorithms used in research and industry.	Assessment
CO-3	Analysis of real world problems and their implementation issues.	Assessment
CO-4	Study of state-of-the-art image processing techniques.	Usage

Course Contents:

Unit	Contents	Lectures require d
1	**Introduction to Image Sensing:** Human visual system, Light and Electromagnetic Spectrum, Image Sensing Elements, Camera and Lenses, Accessing Image Data, Image sampling and Quantization, Simplified image processing models	7
2	**Fundamental of Imaging:** Types of image and image formats, Gray Level Transformations, Geometric Transformation, Histogram Processing, Averaging and edge detection, Image Compression and Interpolation, Morphology.	7
3	**Spatial Doman Filtering:** 2D and 3D Convolution, Smoothing by convolution with a Gaussian, Computing first order and second order derivatives, Non-linear filters, Grayscale Morphological Operators	7

4	**Frequency domain Filtering:** 2D Fourier Transform and its properties, 2D Discrete Fourier Transform and its properties, Frequency domain low pass, high pass and bandpass filtering, Homomorphic Filtering, Discrete Wavelet Transform.	**7**
5	**Color Image Processing :** Physics and Psychology of color, Trichromacy, Grassmann's Law, Color image coding, Color Spaces and Liner color Transformation.	**7**
6	**Real Time Image Processing:** Study and implementation of real time image processing algorithm such as Medical Imaging, Remote Sensing, Underwater Images, RADAR Images, Microscopic Images and Industrial Images.	**7**
Total lectures		**42**

Suggested Text Book(s):

1. Rafael C. Gonzales, Richard E. Woods, "Digital Image Processing", fourth Edition, Pearson Education, 2018.

Suggested Reference Book(s):

1. Anil K. Jain, "Fundamentals of Digital Image Processing", First Edition, PHI Learning Pvt. Ltd, 2015
2. Willliam K Pratt, "Digital Image Processing", Fourth Edition, John Willey, 2007.
3. S.Sridhar, "Digital Image Processing", Second Edition, Oxford University Press, 2016
4. Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, "Digital Image Processing Using MATLAB", Third Edition Tata Mc Graw Hill Pvt. Ltd., 2011.

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Artificial Image Sensing and Real Time Processing)													
CO-1	2	2	3	3	2	1	1	1	2	2	2	2	**2**
CO-2	2	3	3	3	2	1	1	1	2	2	1	2	**2**
CO-3	2	3	3	3	2	1	1	1	2	2	1	2	**2**
CO-4	2	3	3	3	2	1	1	1	2	3	2	2	**2**
Average	**2**	**3**	**3**	**3**	**2**	**1**	**1**	**1**	**2**	**2**	**3**	**2**	

Medical Image Processing and Applications

COURSE CODE:21M1WEC232

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: None

Course Objectives:

1. To introduce various medical imaging modalities.
2. To teach the requirement and development of different blocks of computer aided diagnosis for medical images.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Able to understand different types of medical imaging modalities and would be able to differentiate them with respect to their advantages and limitations.	Familiarity
CO-2	Acquire an ability to analyze and process medical images.	Usage
CO-3	Understand different feature extraction techniques and classifiers used for image classification.	Usage
CO-4	Understand the role of computer aided diagnosis for medical images.	Assessment

Course Contents:

Unit	Contents	Lectures required
1	**Introduction to Image Processing:**- Acquisition of Images, Image Sampling and quantization; Spatial and histogram based enhancement; Noise modeling, Image restoration. Image transformation.	**8**
2	**Edge Detection and Image Segmentation:** Gradient based edge detectors. Intensity thresholding based image segmentation; Region growing and region splitting algorithm; watershed segmentation.	**8**
3	**Medical Imaging Modalities:** Working principle, applications and limitations of Computed tomography , X-ray, Magnetic resonance imaging, Ultrasound imaging, and Positron emission tomography; Various Artifacts.	**6**

Approved in Academic Council Meeting held on 28 July, 2021

4	**Image Texture:** Types of texture parameters: Statistical analysis of texture (First order statistics and Second order statistics), Grey level co-occurrence matrix, grey-level run length matrix.	**8**
5	**Pattern classification:** Supervised and Unsupervised pattern classification, Neural Network classifier, Support Vector Machines.	**6**
6	**Case Studies:** Pre-processing, Segmentation, Feature extraction, and Classification of medical images.	**6**
Total lectures		**42**

Suggested Text Book(s):

1. Chris Solomon, Toby Breckon: Fundamental of Digital Image Processing, 1st Ed.,John Wiley & Sons, 2011.
2. Rangaraj M. Rangayyan: Biomedical Image Analysis, 1st Ed., CRC Press, New York, 2004.

Suggested Reference Book(s):

1. RC Gonzalez, RE Woods, Digital Image Processing, 3rd Ed., Pearson Publisher, 2008.
2. Kayvan Najarian, Robert Splinter: Biomedical Signal and Image Processing, 2nd Ed., CRC Press, 2012
3. Tamal Bose: Digital Signal and Image Processing, 1st Ed., John Wiley & Sons, 2003.

Other useful resource(s):

1. http://www.nptelvideos.in/2012/12/digital-image-processing.html (Prof P.K. Biswas, IIT Kharagpur)

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) -10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Medical Image Processing)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	3	3	3	3	2	3	1	2	1	2	**2.42**
CO-2	3	3	3	3	2	0	0	1	2	3	1	1	**1.83**
CO-3	3	3	3	3	3	1	1	1	1	2	1	1	**1.92**
CO-4	3	3	3	3	3	3	2	3	2	2	3	3	**2.75**
Average	**3.00**	**3.00**	**3.00**	**3.00**	**2.75**	**1.75**	**1.25**	**2.00**	**1.50**	**2.25**	**1.50**	**1.75**	

Applied Machine Learning for IoT

COURSE CODE: 21M1WEC233

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Artificial Intelligence, C Language, Python Language

Course Objectives:

1. To provide a broad survey of approaches and techniques in machine learning and IoT.
2. To develop the design and programming skills that will help you to build intelligent, adaptive artifacts.
3. To develop the basic skills necessary to pursue research in machine learning and IoT.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Understand the basic theory underlying machine learning.	Familiarity
CO-2	Understand general concepts of Internet of Things and recognize various devices, sensors and applications	Familiarity
CO-3	Apply machine learning algorithms to solve problems of moderate complexity.	Assessment
CO-4	Design, build and integrate IoT platforms, incorporating different types of sensors, actuators and machine learning methods.	Assessment
CO-5	Read current research papers and understand the issues raised by current research.	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Introduction to Machine Learning:** Definition of learning systems, Goals and applications of machine learning, Aspects of developing a learning system: training data, concept representation, Role of machine intelligence in IoT	5
2	**Machine Learning Models:** Bayesian classifiers, Nearest-neighbor classifiers, Linear and Polynomial classifiers, Random forests, Decision trees, Support vector machines, Dimensionality reduction methods, K-mean clustering, Artificial neural networks, Deep neural networks.	8
3	**Internet of Things:** Data Analytics, IoT analytics challenges, IoT data acquisition, Data Exploration and Pre-processing, IoT technologies, Architecture and Networking protocols, IoT Communication	8

	Technologies, Devices and Gateways,	
4	**Sensor & Actuators:** Overview of Sensors working, Analog and Digital Sensors, Interfacing of Temperature, Humidity, Motion, Light and Gas Sensor with Arduino, Interfacing of Actuators with Arduino, Interfacing of Relay Switch and Servo Motor with Arduino	**6**
5	**Computing framework:** Fog computing, Edge computing, Cloud computing, Characteristics of Cloud Computing, Driving factors towards cloud, Architecture, Role of Networks in Cloud computing, protocols used, Role of Web services, Service Models: IaaS, PaaS, SaaS, NaaS, Cloud Clients, Deployment Models: Public Clouds, Community Clouds, Hybrid Cloud, Private Cloud, Issues in Cloud Computing, Applications, Distributed computing.	**7**
6	**Applications of Machine learning in smart cities:** Use cases - Smart energy, Smart mobility, Smart citizens, Urban planning, Smart city data characteristics, Applied machine learning algorithms to Internet of Things use cases.	**8**
Total lectures		**42**

Suggested Text Book(s):

1. Vijay Madisetti, Arshdeep Bahga, "Internet of Things: A Hands-on Approach", University Press, 2014.
2. C.M. Bishop, Pattern Recognition and Machine Learning, Springer (2006)
3. J. Watt, R. Borhani and A. K. Katsaggelos: Machine Learning Refined: Foundations, Algorithms and Applications, Cambridge University Press, 1st ed., 2016.
4. Andrew Minteer: Analytics for the Internet of Things (IoT) Intelligent Analytics for Your Intelligent Devices, Packt Publishing, 2017

Suggested Reference Book(s):

1. D. Barber, Bayesian Reasoning and Machine Learning, Cambridge University Press (2012)
2. Michael Stanley and Jongmin Lee: Sensor Analysis for the Internet of Things, Morgan & Claypool Publishers, 2018.
3. Raj Kamal, "Internet of Things: Architecture and Design", McGraw Hill, 2017.
4. Cuno Pfister, "Getting Started with the Internet of Things", Oreilly Media, 2011.

Other useful resource(s):

1. H. Daume: A course in Machine Leaning, 2015. http://ciml.info/
2. Link to NPTEL course contents: Introduction to Machine Learning https://onlinecourses.nptel.ac.in/noc17_cs26/preview
3. Link to MITOPENCOURESEWARE: Machine Learning https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-867-machine-learning-

fall-2006/
4. Link to NPTEL course contents: Internet ofThings https://nptel.ac.in/courses/106/105/106105166/
5. Link to NPTEL course contents: Internet ofThings https://nptel.ac.in/courses/106105077
6. M. S. Mahdavinejad et al., "Machine learning for Internet of Things data analysis: A survey," Digit. Commun. Netw., vol. 4, no. 3, pp. 161–175, Aug. 2018. https://www.sciencedirect.com/science/article/pii/S235286481730247X
7. J. Jagannath, N. Polosky, A. Jagannath, F. Restuccia, and T. Melodia, "Machine learning for wireless communications in the Internet of Things: A comprehensive survey," Ad Hoc Netw., vol. 93, 2019. https://arxiv.org/abs/1901.07947

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (3) - 10 Quizzes (3) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Applied Machine Learning for IoT)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	2	2	2	2	2	1	1	2	3	3	**2.17**
CO-2	3	3	3	2	3	2	2	1	1	2	3	3	**2.33**
CO-3	3	3	3	3	3	3	3	1	3	3	3	3	**2.83**
CO-4	3	3	3	3	3	3	3	1	3	3	3	3	**2.83**
CO-5	3	3	3	3	3	3	3	1	3	3	3	3	**2.83**
Average	**3.00**	**3.00**	**2.80**	**2.60**	**2.80**	**2.60**	**2.60**	**1.00**	**2.20**	**2.60**	**3.00**	**3.00**	

Antennas for IoT

COURSE CODE: 21MIWEC234

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Transmission lines and E.M waves.

Course Objectives:

The main objective of the course is to

1. Learn the mechanism of antenna, antenna performance parameters.
2. Design and analysis of various antennas for different applications.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Understand key benefits of smart antenna technology, wide band smart antennas, Propagation Channels..	Familiarity
CO-2	To do analysis of Multiple Input - Multiple Output (MIMO) Communications Systems	Familiarity
CO-3	To analyze the channel models for antenna systems for IoT Applications.	Usage
CO-4	To study the environmental parameters for signal processing of smart antenna systems	Usage
CO-5	To evaluate the requirements for the design and implementation of smart antenna systems.	Assessment

Course Contents:

Unit	Contents	Lectures required
1.	**Introduction:** Antenna Basics, Phased array antenna, power pattern, beam steering, degree of freedom, adaptive antennas, smart antennas – key benefits of smart antenna technology, wide band smart antennas, Propagation Channels	6
2.	**Smart Antennas For Wireless Communications:** Spatial Processing for Wireless Systems, Key Benefits of Smart Antenna Technology, The Vector Channel Impulse Response and the Spatial Signature, Spatial Processing Receivers, Fixed Beam forming Networks, Switched Beam Systems, Adaptive Antenna Systems, Wideband Smart Antennas, Diversity Techniques, Multiple Input - Multiple Output (MIMO) Communications Systems, MIMO for frequency selective scenarios	6
	Adaptive Processing: Sample matrix inversion algorithm, unconstrained LMS algorithm, normalized LMS algorithm, Constrained LMS algorithm, Perturbation algorithms, neural network approach, Adaptive beam space processing, and Implementation issues.	

3.		6
4.	**Direction of Arrival Estimation (DOA) Methods:** Spectral estimation methods, linear prediction method, Maximum entropy method, Maximum likelihood method, Eigen structure methods, MUSIC algorithm – root music and cyclic music algorithm, the ESPRIT algorithm.	5
5.	**Implementation of Smart Antenna System:** DOA based beam former design using simulation and hardware. Adaptive beam forming implementation using Altera Stratix series FPGA, QRD RLS Algorithm. CORDIC algorithm.	7
6.	**Microstrip Antennas Rectangular patch antenna**: cavity and transmission line models, Circular patch antenna Coupling mechanisms, circular polarization, Microstrip arrays, Broadband and Multi band microstrip antennas, Compact Microstrip Antennas, Wearable microstrip antennas for 5G, medical, and IoT applications	7
7.	**Dielectric Resonator Antennas:** Introduction, radiation mechanism, advantages of DRA, types of DRA, feeding techniques, design method, modes, Wearable Metamaterial antennas for 5G, IoT, and medical applications	5
Total lectures		**42**

Suggested Text Book(s):

1. Constantine A. Balanis: Antenna Theory Analysis and Desin, John Wiley, 3rd Edition, 2009.
2. Antennas for All Applications, J. D. Kraus and R. J. Marhefka, McGraw-Hill, Inc, 3rd Ed., 2007.
3. T. S. Rappaport, Smart antennas: Adaptive arrays, algorithms and wireless position location, IEEE Press, 1998.
4. Frank Gross, Smart antennas for wireless communications, McGra-Hill, 2006.
5. S. Chandran, Adaptive antenna arrays, trends and applications, Springer, 2009.

Suggested Reference Book(s):

1. Antennas and Radio wave Propagation, R. E. Collin, McGraw-Hill, Inc, 3rd Ed, 2005.
2. Modern Antenna Design, T. A. Milligan, John Wiley & Sons, 2nd Ed., 2005.
3. Antenna Arrays, R. L. Haupt, John Wiley & Sons, Inc., 1st Ed., 2010.
4. Antenna Theory and Microstrip Antennas, D. G. Fang, CRC Press, 1st Ed., 2009.

Other useful resource(s):

Link to NPTEL course contents

1. **https://nptel.ac.in/courses/108101092/**

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered up to T-1
2	T-2	25	1.5 Hours	Syllabus covered up to T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) -10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Antennas for IoT)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	3	3	3	2	1	1	1	2	2	2	**2.2**
CO-2	2	3	3	3	2	2	1	1	2	1	1	2	**1.9**
CO-3	2	2	2	3	2	2	1	1	1	2	1	3	**1.8**
CO-4	2	2	3	3	2	1	1	2	2	2	2	2	**2**
CO-5	2	2	3	3	3	2	1	1	2	2	1	2	**2**
Average	**2.2**	**2.4**	**2.8**	**3**	**2.4**	**1.8**	**1**	**1.2**	**1.6**	**1.6**	**1.4**	**2.2**	

RF technology for 5G and IoT

COURSE CODE: 21M1WEC235

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Digital communications, Mobile Communications / Wireless Communications

Course Objectives:

The main objective of the course is to

1. To gather the latest developments in the domain of wireless communication technology leading to 5G air interface.

2. To learn about technology changes that are expected to be engines of 5G air interface/ radio access technology.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	To learn about new waveforms (termed as 5G NR, the new radio)	Familiarity
CO-2	To understand the millimeter wave technology.	Familiarity
CO-3	To analyze massive multiple antenna technologies.	Usage
CO-4	To understand non orthogonal multiple access and heterogeneous networks such as small cells and device to device communications	Usage
CO-5	To get acquitted with energy savings in radio access network and ubiquitous quality of service.	Assessment

Course Contents:

Unit	Contents	Lectures required
1.	Introduction to RF technology for 5G and IoT, Overview of 5G communication technology, (operating scenarios, mm wave technology, propagation models), ITU-R recommendations, GSM, IMT-2000, requirements of IMT Advanced, Evolution of wireless Communication, Evolution of wireless Communication Standards From 2G to 5G.	6
2.	Requirements and operating scenarios of 5G, 5G scenarios, Ultra reliable low latency communication, Minimum requirements towards IMT-2020,Designing 5G new radio	8
3.	Basic Signal Model, Fundamental Framework for waveform analysis, Waveform Design Aspects of 2G, Waveforms in 3G, Waveform in 4G and 5G (OFDM),	7

	Waveform in 4G and 5G (OFDMA, SCFDMA, SCFDE),	
4.	Waveform in 5G, Waveform in 5G Numerology, Frame Structure in 5G NR, Numerology in 5G and adaptive subcarrier bandwidth, Waveforms beyond 5G, Waveform beyond 5G (Precoded GFDM)	7
5.	Comparison of waveforms, Channel models for performance evaluation, MIMO Signal Processing (Receive Diversity), MIMO Signal Processing (Capacity), MIMO Signal Processing (Capacity & Massive MIMO)	7
6.	Introduction to 5G Sub-6 GHz Bands, Distribution of arrival time of clusters, power angular spectrum, K-factor, the rician k-factor expression for modified Saleh-Valenzuela channels, Spatial Co-relation in 3GPP MIMO Systems,3GPP Clustering Environment, Challenges with massive MIMO, Analog Beam forming, Digital Beam forming, Hybrid beamforming (mm Wave)	7
Total lectures		**42**

Suggested Text Book(s):

1. Wei Xiang, Kan Zheng, Xuemin (Sherman) Shen: 5G Mobile Communications, Springer,1st Edition, 2017.
2. Yang, Y., Xu, J., Shi, G., Wang, C.-X.: 5G Wireless Systems, Springer, 1st Edition, 2018.

Suggested Reference Book(s):

1. Howard Huang, Constantinos B. Papadias, Sivarama Venkatesan: MIMO Communication for Cellular Networks, Springer, 1st Edition, 2012.
2. Robert W. Heath Jr.: Foundations of MIMO Communication, Cambridge University Press, 1st Edition, 2018.

Other useful resource(s):

Link to NPTEL course contents

2. **https://nptel.ac.in/courses/108/105/108105134/**

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered up to T-1
2	T-2	25	1.5 Hours	Syllabus covered up to T-2
3.	T-3	35	2 Hours	Entire Syllabus

4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) -10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (RF technology for 5G and IoT)	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**	**PO-9**	**PO-10**	**PO-11**	**PO-12**	**Average**
CO-1	3	3	3	3	3	2	1	1	1	2	2	2	**2.2**
CO-2	2	3	3	3	2	2	1	1	2	1	1	2	**1.9**
CO-3	2	2	2	3	2	2	1	1	1	2	1	3	**1.8**
CO-4	2	2	3	3	2	1	1	2	2	2	2	2	**2**
CO-5	2	2	3	3	3	2	1	1	2	2	1	2	**2**
Average	**2.2**	**2.4**	**2.8**	**3**	**2.4**	**1.8**	**1**	**1.2**	**1.6**	**1.6**	**1.4**	**2.2**	

Smart Internet of Things

COURSE CODE: 21M1WEC236

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: C programming, Python, Data Analytics, Cloud Computing

Course Objectives:

1. To understand the application areas of Internet of things.
2. To examine the potential business opportunities that IoT can uncover.
3. To develop the basic skills necessary to pursue research in the field of Internet ofthings.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Recognize various devices, sensors and applications of IoT	Familiarity
CO-2	Apply design concept to IoT solutions.	Usage
CO-3	Create IoT solutions using sensors, actuators and Devices	Assessment
CO-4	Read current research papers and understand the issues raised by current research.	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Introduction:** Relevance of IOT for the future, IOT in everyday life, Internet of Everything, IOT and Individual Privacy, Challenges in IOT implementation, Big Data Management, Connectivity challenges, Mission critical applications.	**4**
2	**Sensors & Microcontrollers:** Types of sensors, 8051 Microcontroller, ARM processor, Implementation of IoT with Arduino and Raspberry Pi, Intel Galileo,	**6**
3	**IoT Real Time Operating Systems:** Introduction Real time Operating Systems, GPOS vs. RTOS, Characteristics of RTOS, Application of RTOS, Internet of Things Real time Operating Systems: Contiki/FreeRTOS/RIOT/TinyOS, Application development using IoT RTOS	**7**
4	**IoT for Smart Appliances:** Understanding smart appliances, Operation, Monitoring, Energy saving, Maintenance, Smart Appliances use-cases: Smart refrigerator, Smart Oven, Smart Washer and Dryer	**6**
5	**IoT for Smart Home:** Automating the home, Steps to a smart home,	**6**

	Components for smart home, Smart home use-cases: Smart Furniture, Smart Lighting, Smart Security Systems, Smart Monitors.	

6	**IoT for Transportation:** Transportation and transports, Challenges, IoT architecture for transportation, IoT use-case for transportation: Connected cars, Connected fleet, Infrastructure and mass transit,	**6**
7	**IOT for smart cities:** IoT strategy for smart cities, Smart city IoT architecture, Smart city Security architecture, Smart city use-case examples: Connected street lighting, Smart Parking, Smart traffic control, Smart water management, Connected environment.	**7**
Total lectures		**42**

Suggested Text Book(s):

1. Michael Miller, "The Internet of Things: How Smart TVs, Smart Cars, Smart Homes, and Smart Cities Are Changing the World", QUE, 2015.
2. Shriram K Vasudevan, Abhishek S Nagarajan and RMD Sundaram, "Internet of Things", Wiley, Ist Edition, 2019.
3. David Hanes, Gonzalo Salgueiro, "IoT fundamentals: Networking technologies, Protocols, and use cases for the Internet of Things", Pearson, 2018

Suggested Reference Book(s):

1. Andrew Minteer: Analytics for the Internet of Things (IoT) Intelligent Analytics for Your Intelligent Devices, Packt Publishing, 2017
2. Michael Stanley and Jongmin Lee: Sensor Analysis for the Internet of Things, Morgan & Claypool Publishers, 2018.
3. Vijay Madisetti, Arshdeep Bahga, "Internet of Things: A Hands-on Approach", University Press, 2014.

Other useful resource(s):

1. Link to NPTEL course contents: Internet of Things https://nptel.ac.in/courses/106/105/106105166/
2. Link to NPTEL course contents: Internet of Things https://nptel.ac.in/courses/106105077

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (3) - 10 Quizzes (3) - 10

				Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Smart Internet of Things)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	2	2	2	2	2	1	1	2	3	3	**2.17**
CO-2	3	3	3	2	3	2	2	1	1	2	3	3	**2.33**
CO-3	3	3	3	3	3	3	3	1	3	3	3	3	**2.83**
CO-4	3	3	3	3	3	3	3	1	3	3	3	3	**2.83**
Average	**3.00**	**3.00**	**2.75**	**2.50**	**2.75**	**2.50**	**2.50**	**1.00**	**2.00**	**2.50**	**3.00**	**3.00**	

Advanced IoT Lab – II

COURSE CODE: 21M11EC271

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

This lab will include experiments based on the following topics:

- Communication networking systems for IoT.
- Development of complete IoT system for different applications
- Project work/Implementation of the research papers is also included in this lab.