# CURRICULUM AND DETAILED SYLLABI

FOR

## M. TECH DEGREE PROGRAMME

IN

## IoT and Sensor Systems

## 2022 SCHEME

## (AUTONOMOUS)


**MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY**

(Approved by AICTE, Autonomous Institution Affiliated to APJ Abdul Kalam Technological University)
MAR IVANIOS VIDYANAGAR, NALANCHIRA, THIRUVANANTHAPURAM – 695015, KERALA.Phone: 0471 2545866

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Passed in BoS Meetings held on 11/08/2022 Approved in AC Meetings held on 29/08/2022, 21/11/2022

**MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY**

***DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING***

# M. TECH DEGREE PROGRAMME

IN

# IoT and Sensor Systems

## CURRICULUM AND DETAILED SYLLABI

| Items | Board of Studies (BoS) | Academic Council (AC) |
|---|---|---|
| Date of Approval | 11.08.2022 | 29.08.2022 |
| | | 21.11.2022 |

Sd/-

***Head of Department***

**Chairman, Board of Studies**

Sd/-

***Principal***

**Chairman, Academic Council**

## MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

### Vision and Mission of the Institution

***Vision:***

To be an Institution moulding globally competent professionals as epitomes of Noble Values.

***Mission:***

To transform the Youth as technically competent, ethically sound and socially committedprofessionals, by providing a vibrant learning ambience for the welfare of humanity.

## DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

### Vision and Mission of the Department

***Vision:***

To be a Centre of Excellence in Electronics and Communication Engineering Education and Research for the service of humanity.

***Mission:***

To provide quality Engineering Education and to carry out Research in the field of Electronics and Communication Engineering addressing the challenges faced by the society.

## CURRICULUM

### Semester I (M1)

| Slot | Course Type | Course | Marks | | Hours L - T - P | Credits |
|---|---|---|---|---|---|---|
| | | | CIA | ESE | | |
| A | DCC | Random Process and Applications | 40 | 60 | 3 – 0 - 0 | 3 |
| B | PCC | IoT Fundamentals and Architecture | 40 | 60 | 3 – 0 - 0 | 3 |
| C | PCC | Signal Processing and Data Analytics | 40 | 60 | 3 – 0 - 0 | 3 |
| D | PEC | Program Elective 1 | 40 | 60 | 3/2 – 0/0– 0/2 | 3 |
| E | PEC | Program Elective 2 | 40 | 60 | 3/2 – 0/0– 0/2 | 3 |
| S | RM | Research Methodology & IPR | 40 | 60 | 2 – 0 - 0 | 2 |
| T | LBC | IoT Data Acquisition and Analysis Lab | 100 | - | 0 – 0 - 2 | 1 |
| **Total** | | | **340** | **360** | **19** | **18** |

**Teaching Assistance: 6 hours**

Passed in BoS Meetings held on 11/08/2022 Approved in AC Meetings held on 29/08/2022,21/11/2022

## Semester II (M2)

| Slot | Course Type | Course | Marks | | Hours | Credits |
|---|---|---|---|---|---|---|
| | | | CIA | ESE | L - T - P | |
| A | DCC | Estimation and Detection Theory | 40 | 60 | 3 – 0 - 0 | 3 |
| B | PCC | Microcontrollers for IoT | 40 | 60 | 3 – 0 - 0 | 3 |
| C | PEC | Program Elective 3 | 40 | 60 | 3/2 – 0/0– 0/2 | 3 |
| D | PEC | Program Elective 4 | 40 | 60 | 3/2 – 0/0 – 0/2 | 3 |
| E | IEC | Industry/Interdisciplinary Elective | 40 | 60 | 3 – 0 - 0 | 3 |
| S | PR | Mini project | 100 | - | 0 – 0 - 4 | 2 |
| T | LBC | IoT and Sensor Systems Lab | 100 | - | 0 – 0 - 2 | 1 |
| **Total** | | | **400** | **300** | **21** | **18** |

**Teaching Assistance: 6 hours**

**Semester III (M3)**

| Slot | Course Type | Course | Marks | | Hours L - T - P | Credits |
|---|---|---|---|---|---|---|
| | | | CIA | ESE | | |
| **TRACK 1** | | | | | | |
| A* | MOOC | MOOC | To be successfully completed | | - | 2 |
| B | AC | Audit Course | 40 | 60 | 3 – 0 - 0 | - |
| C | PR | Internship | 50 | 50 | - | 3 |
| D | PR | Dissertation Phase I | 100 | - | 0 – 0 - 17 | 11 |
| **TRACK 2** | | | | | | |
| A* | MOOC | MOOC | To be successfully completed | | - | 2 |
| B | AC | Audit Course | 40 | 60 | 3 – 0 - 0 | - |
| C | PR | Internship | 50 | 50 | - | 3 |
| D | PR | Research project Phase I | 100 | - | 0 – 0 - 17 | 11 |
| **Total** | | | **190** | **110** | **20** | **16** |

**Teaching Assistance: 6 hours**

*MOOC must be successfully completed before the commencement of fourth semester. This course can be carried out at any time from M1 to M3.

## Semester IV (M4)

| Slot | Course Type | Course | Marks | | Hours L - T - P | Credits |
|---|---|---|---|---|---|---|
| | | | CIA | ESE | | |
| **TRACK 1** | | | | | | |
| D | PR | Dissertation Phase II | 100 | 100 | 0 – 0 - 24 | 16 |
| **TRACK 2** | | | | | | |
| D | PR | Research project Phase II | 100 | 100 | 0 – 0 - 24 | 16 |
| **Total** | | | **100** | **100** | **24** | **16** |

**Teaching Assistance: 5 hours**

## List of Program Elective courses

| Category Code | Course Number | Course Name | L | T | P | Credit |
|---|---|---|---|---|---|---|
| PEC | 22EC262A | Flexible and Wearable Sensors | 3 | 0 | 0 | 3 |
| | 22EC262B | Micro and Nano Fluidics | 3 | 0 | 0 | 3 |
| | 22EC262C | Machine Learning | 3 | 0 | 0 | 3 |
| | 22EC262D | Automotive Sensors and in-Vehicle Networking | 2 | 0 | 2 | 3 |
| | 22EC262E | Cloud and Fog Computing | 3 | 0 | 0 | 3 |
| | 22EC262F | IoT Security and Trust | 3 | 0 | 0 | 3 |

Passed in BoS Meetings held on 11/08/2022 Approved in AC Meetings held on 29/08/2022,21/11/2022

| | | | | | | |
|---|---|---|---|---|---|---|
| | 22EC262G | Biomedical sensors | 3 | 0 | 0 | 3 |
| | 22EC262H | Principles of Sensors and Signal Conditioning | 2 | 0 | 2 | 3 |
| | 22EC262I | RF MEMS | 3 | 0 | 0 | 3 |
| | 22EC262J | Wireless Sensor Networks and IoT | 3 | 0 | 0 | 3 |
| | 22EC262K | IoT Applications and Web development | 3 | 0 | 0 | 3 |
| | 22EC262L | Chemical and Environmental Sensor | 3 | 0 | 0 | 3 |
| | 22EC262M | Nano Sensors | 3 | 0 | 0 | 3 |
| | 22EC262N | Deep Learning | 2 | 0 | 2 | 3 |
| | 22EC262O | Embedded Systems Design | 2 | 0 | 2 | 3 |
| | 22EC262P | RF and Microwave Sensors | 3 | 0 | 0 | 3 |
| | 22EC262Q | Micro Systems and Hybrid Technology | 3 | 0 | 0 | 3 |
| | 22EC262R | Digital VLSI Design | 3 | 0 | 0 | 3 |
| | 22EC262S | Fiber optic Sensors | 3 | 0 | 0 | 3 |

**INTERDISCIPLINARY COURSES (to be offered by the department)**

| Category Code | Course Number | Course Name | L | T | P | Credit |
|---|---|---|---|---|---|---|

Passed in BoS Meetings held on 11/08/2022 Approved in AC Meetings held on 29/08/2022,21/11/2022

| | | | | | | |
|---|---|---|---|---|---|---|
| IEC | 22EC065A | Soft Computing | 3 | 0 | 0 | 3 |
| | 22EC065B | Optimization Techniques | 3 | 0 | 0 | 3 |

**INDUSTRY ELECTIVE COURSES**

| Category Code | Course Number | Course Name | L | T | P | Credit |
|---|---|---|---|---|---|---|
| IEC | 22EC166A | Automotive Electronics(ACSIA Technologies) | 3 | 0 | 0 | 3 |

# SYLLABUS

## SEMESTER I

Passed in BoS Meetings held on 11/08/2022

Approved in AC Meetings held on 29/08/2022,21/11/2022

| Course Code | Course Name | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| **22EC060A** | Random Process and Applications | DCC | 3 | 0 | 0 | 3 | 2022 |

**1) Course Objectives**

The goal of this course is to familiarize the student with the theory and applications of probability theory, and thereby aid in understanding phenomena which evolve with respect to time in a probabilistic manner.

**2) Course Outcomes**

After the completion of the course the student will be able to:

| # | Description | Level |
|---|---|---|
| CO1 | Apply the fundamental knowledge of basic probability concepts. | Apply |
| CO2 | Apply probability distributions for various applications. | Apply |
| CO3 | Analyze various random processes. | Analyze |
| CO4 | Explain the various applications of probability theory. | Understand |

**3) Syllabus**

Probability theory, Random variables, Probability Density function, Conditional and Joint Distributions and densities, Functions of Random Variables, Expectation, Conditional Expectation.

Moments, Random Vector, Random Processes, WSS Processes, Power spectral density, Inequalities, Central limit theorem.

Random Sequences, Ergodicity, Karhunen-Leove Expansion, Representation of Band limited and periodic Processes

**4) References**

1. Henry Stark and John W. Woods, *Probability and Random Processes with Applications to Signal Processing*, Pearson Education, 3/e, 2002.
2. Athanasios Papoulis and S. Unnikrishna Pillai, *Probability, Random Variables and Stochastic Processes*, TMH, 4/e, 2002.

3. Oliver C. Ibe., *Fundamentals of Applied Probability and Random Process*, Elsevier, 2005
4. Gray, R. M. and Davisson L. D., *An Introduction to Statistical Signal Processing*, Cambridge University Press, 2004 (Available at: http://www.ee.stanford.edu/~gray/sp.pdf)
5. Gardner, W. A., *Introduction to Random Processes with applications to Signals and Systems*, 2nd edition, McGraw-Hill, Inc., 1990

**5) Course Plan**

| Module | Contents | Hours |
|---|---|---|
| **I** | **Introduction**: Sets, Fields and Events, Definition of probability, Joint, Conditional and Total Probability, Bayes' Theorem and applications.<br>**Random Variable**:- Definition, Probability Distribution Function, Probability Density function, Common density functions, Continuous, Discrete and Mixed random Variables. | **9** |
| **II** | **Conditional and Joint Distributions** and densities, independence of random variables.<br>**Functions of Random Variables**: One function of one random variable, One function of two random variables, two functions of two random variables<br>**Expectation**: Fundamental Theorem of expectation, Conditional Expectation | **9** |
| **III** | **Moments**, Joint moments, Moment Generating functions, Characteristic functions, Correlation and Covariance, Jointly Gaussian Random Variables.<br>**Random Vector**: - Definition, Joint statistics, Covariance matrix and its properties.<br>**Random Processes**: -Basic Definitions, Poisson Process, Wiener Process | **9** |
| **IV** | **Markov Process**, Birth-Death Markov Chains, Markov Chains, Chapman-Kolgomorov equations<br>**Stationarity**, WSS Processes and LTI systems, Power spectral density, White Noise.<br>**Chebyshev and Schwarz Inequalities**, Chernoff bound, Central Limit Theorem | **9** |
| **V** | **Random Sequences**: Basic Concepts, WSS sequences and linear systems, Markov Random sequences, | **9** |

| | | |
|---|---|---|
| | Convergence of Random Sequences: Definitions, Laws of large numbers.<br>**Advanced Topics**: Ergodicity, Karhunen-Leove Expansion, Representation of Bandlimited and periodic Processes | |
| **Total hours** | | **45** |

| Course Code | Course Name | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| **22EC261A** | **IoT Fundamentals and Architecture** | PCC | 3 | 0 | 0 | 3 | 2022 |

**1) Course Objectives**

To introduce the concept of Internet of Things (IoT), reference layer and various protocols and software. To make the students capable to build IoT systems using sensors, single board computers and open source IoT platforms.

**2) Course Outcomes**

After the completion of the course the student will be able to:

| Course Outcomes | Description | Level |
|---|---|---|
| CO 1 | Identify the IoT networking components with respect to OSI layer. | Apply |
| CO 2 | Select IoT protocols and software. | Analyze |
| CO 3 | Evaluate the wireless technologies for IoT | Apply |
| CO 4 | Explain the need for IoT Trust and variants of IoT. | Understand |

**3) Syllabus**

Evolution of IoT, IoT Reference layers and architecture, Characteristics of sensor nodes, IoT Protocols and standards, IoT protocol architecture, wireless

technologies related to IoT, Cloud Computation, Big Data Analytics, Open source IoT platforms, IoT threat and security aspects, Web of things, Industrial IoT, Industry 4.0 standards.

**4) References**


1. Alessandro Bassi, Martin Bauer, Martin Fiedler, Thorsten Kramp, Rob van Kranenburg, Sebastian Lange, Stefan Meissner, “Enabling things to talk – Designing IoT solutions with the IoT Architecture Reference Model”, Springer Open, 2016
2. Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Avesand, David Boyle, “From Machine to Machine to Internet of Things”, Elsevier Publications, 2014.
3. Vijay Madisetti , Arshdeep Bahga, Adrian McEwen (Author), Hakim Cassimally “Internet of Things A Hands-on-Approach” Arshdeep Bahga & Vijay Madisetti, 2014.
4. Barrie Sosinsky, “Cloud Computing Bible”, Wiley-India, 2010.

## 5) Course Plan

| Module | Contents | No. of hours |
|---|---|---|
| I | Evolution of IoT, IPv4 with Network Address Translation, IPV6 addressing, IoT architecture reference layer. Introduction to IoT components, Characteristics IoT sensor nodes, Edge computer, cloud and peripheral cloud, single board computers, open source hardware, Examples of IoT infrastructure. | 8 |
| II | IoT protocols and softwares MQTT, UDP, MQTT brokers, publish subscribe modes, HTTP, COAP,XMPP and gateway protocols. | 9 |
| III | IoT point to point communication technologies IoT Communication Pattern, IoT protocol Architecture, Selection of Wireless technologies ( 6LoWPAN, Zigbee, WIFI, BLE,NFC, LORA, Li-Fi, Widi) | 8 |
| IV | Introduction to Cloud computation and Big data analytics, Evolution of Cloud Computation, Commercial clouds and their features, open source IoT platforms, cloud dashboards, Introduction to big data analytics and Hadoop. | 10 |
| V | IoT security - Need for encryption, standard encryption protocol, light weight cryptography, Quadruple Trust Model for IoT-A – Threat Analysis and model for IoT-A, Cloud security, M2M, Web of things, Cellular IoT, Industrial IoT, Industry 4.0,IoT standards | 10 |
| | **Total hours** | 45 |

| Course Code | Course Name | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| **22EC261B** | **Signal Processing and Data Analytics** | PCC | 3 | 0 | 0 | 3 | 2022 |

**1) Course Objectives**

1. To introduce the concepts of discrete time signal processing and the characterization of random signals.
2. To present the basic theory of modeling the signals and the methods of estimating the unknowns using prediction filters.
3. To provide a comprehensive understanding on applying FFT, DCT, and wavelet techniques for extracting the signal features.
4. To provide an overview of analyzing big data using intelligent techniques and an in-depth introduction to two main areas of Machine Learning: supervised and unsupervised.

**2) Course Outcomes**

After the completion of the course the student will be able to:

| Course Outcomes | Description | Level |
|---|---|---|
| CO 1 | Develop algorithms that can be used to analyze the real-world univariate and multivariate time series data. | Analyze |
| CO 2 | Design an approach to leverage data using the steps in the machine learning process. | Apply |
| CO 3 | Apply both supervised and unsupervised classification methods to detect and characterize patterns in real-world data. | Apply |
| CO 4 | Estimate the signal parameters and identify the model using ARMA models and prediction filters. | Analyze |
| CO 5 | Apply different methods of visualization and analysis of big data. | Apply |

**3) Syllabus**

Random Processes, Gaussian Process- Multi variate Gausssian Process, Stationary process, Autocorrelation, Auto Covariance, Ergodicity, White noise, Power Spectrum, Filtering of Random Process. ARMA, AR, MA Models. Wiener filter, Linear prediction, Kalman Filter. FFT, DCT, filter banks, Wavelet, Wavelet Packets, Cepstrum. Univariate, Multivariate and non-stationary time series analysis. Bayesian decision, Linear discrimination, Principal Component analysis, SVD, Independent Component Analysis.
Supervised learning, generative algorithms, Support Vector machines, Unsupervised learning, K means clustering, Neural network (SOM, ART), Expectation maximization.
Introduction to Big data analytics, visualization and data exploration, basic and intermediate analysis, linear and logistic regression, decision tree.

**4) References**

1. J. G. Proakis, DG. Manolakis and D. Sharma, “Digital signal processing principles, algorithms and applications”, 2012, 4th ed., Person education, USA
2. Sophocles J. Orfanidis, “Introduction to signal Processing” 2010, 2nd ed., Prentice Hall, New Delhi India.
3. Oppenhiem V. A.V and Schaffer R. W, “Discrete- time signal Processing”, 2014, 3rd ed., Prentice Hall,. New Delhi, India
4. Thomas A. Runkler, "Data Analytics: Models and Algorithms for Intelligent Data Analysis", 2016, 2nd ed., Springer Verlag, UK
5. Kevin P. Murphy, "Machine Learning: A Probabilistic Perspective" 2012, 1st ed., MIT Press, USA

**5) Course Plan**

| Module | Contents | No. of hours |
|---|---|---|
| I | Random Processes, Ensemble Average, Gaussian Process, Multi variate Gaussian Process, Stationary process, Autocorrelation, Auto Covariance, Ergodicity, White noise, Power Spectrum, Filtering of Random Process. ARMA, AR, MA Models. Wiener filter, Linear prediction, Kalman Filter. | 9 |
| II | FFT, Power spectrum, DCT, filter banks, Wavelet, Wavelet Packets, Cepstrum.<br>Basic analysis, Univariate time series analysis, Multivariate time series analysis, non-stationary time series. | 9 |
| III | Bayesian decision, Linear discrimination, Principal Component analysis, SVD, Independent Component Analysis. | 9 |
| IV | Supervised learning, generative algorithms, Support Vector machines, Unsupervised learning, K means clustering, Neural network (SOM, ART) and Expectation maximization. | 9 |
| V | Introduction Big data analytics, visualization and data exploration, basic and intermediate analysis, linear and logistic regression, decision tree. | 9 |
| | **Total hours** | 45 |

*Case Study on IoT based applications related to 4th and 5th module.

| Course Code | Course Name | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| 22MC061A | Research Methodology & IPR | RM | 2 | 0 | 0 | 2 | 2022 |

**1) Course Objectives**

This course is intended to prepare the M. Tech students to carry out their dissertation/ research project work effectively, with a research bias. The student will be able to formulate a viable research problem, do a critical

analysis of publications in the area of research, and identify a research method suitable for the work. The student will achieve the capability to write a technical paper based on his/her dissertation/ research project.

## 2) Course Outcomes

After the completion of the course the student will be able to:

| # | Description | Level |
|---|---|---|
| CO1 | Explain research ethics, Citation, Impact factor and Plagiarism. | Apply |
| CO2 | Formulate a research problem, make a suitable research design, and identify the data collection methods. | Apply |
| CO3 | Analyse the collected data. | Analyze |
| CO4 | Explain the role of IPR and Patent law in fostering research work, leading to creation of improved products, thus supporting economic growth and social benefits. | Apply |
| CO5 | Write a technical paper for publication. | Apply |

## 3) Syllabus

Introduction to Research Methodology- motivation for research, types of research, ethical issues. Identifying a research area and collecting related literature. Research problem- scope-objectives, literature review, identifying research gaps, and formulate the research problem. Research design and methods, data collection and analysis. Copy right – royalty - IPR and patent law. Process of patenting and development, Procedure for grant of patents. Copy left- open access, citation, plagiarism, Impact factor. Writing a technical paper.

## 4) References

1. Stuart Melville and Wayne Goddard, *Research methodology: an introduction for science & engineering students.*
2. Ranjit Kumar, 2nd Edition, *Research Methodology: A Step by Step Guide for beginners.*
3. Ramappa T., *Intellectual Property Rights Under WTO*, S. Chand, 2008.

4. Robert P. Merges, Peter S. Menell, Mark A. Lemley, *Intellectual Property in New Technological Age*, 2016.
5. Mayall, *Industrial Design*, McGraw Hill, 1992. Niebel, "Product Design", McGraw Hill, 1974.

**5) Course Plan**

| Module | Contents | Hours |
|---|---|---|
| **I** | Introduction to Research Methodology: Motivation towards research, Types of research.<br>Professional ethics in research: Ethical issues, ethical committees.<br>Identification of major conferences and important journals in a chosen area of interest. Collection of at least 10 published papers on a research problem in the chosen area. | **6** |
| **II** | Defining and formulating the research problem: Literature Survey, Analyzing the collected papers to understand how the authors have identified the research gaps, arrived at their objectives, and formulated their research problem. Understanding how their research work is different from the previous works in the chosen area. | **6** |
| **III** | Research design and methods: Analyzing the collected papers to understand how the authors have formulated the research methods, both analytical methods and experimental methods.<br>Data Collection and analysis: Analyzing the collected papers to understand the methods of data collection, data processing, analysis strategies, and tools used for analyzing the data. | **6** |
| **IV** | Copy right - royalty - Intellectual property rights and patent law – Process of Patenting and Development, Procedure for grant of patents.<br>Reproduction of published material: Copy left-Open access, Citation and acknowledgement. Plagiarism, Impact factor. | **6** |

| | | |
|---|---|---|
| **V** | Technical writing - Structure and components of a typical technical paper, abstract and conclusion, illustrations and tables, bibliography, referencing and footnotes.<br>Writing a technical paper – based on the identified research problem, and using the collected papers, Literature survey, Problem formulation, and Research design, and a hypothetical result. | **6** |
| **Total hours** | | **30** |

| **Course Code** | **Course Name** | **Category** | **L** | **T** | **P** | **Credit** | **Year of Introduction** |
|---|---|---|---|---|---|---|---|
| **22EC269A** | IoT Data Acquisition and Analysis Lab | LBC | 0 | 0 | 2 | 1 | 2022 |

**1) Course Objectives**

To explore the fundamentals of data acquisition using sensors and to enable students to
measure, generate, and synchronize data acquisition tasks and analyze the data in MATLAB/ LabVIEW. To perform data acquisition using Arduino.

**2) Course Outcomes**

After the completion of the course the student will be able to:

| **Course Outcome** | **Description** | **Level** |
|---|---|---|
| CO 1 | Develop PC-based data acquisition and signal conditioning. | Apply |
| CO 2 | Implement techniques to control the analog input, analog output, counter/timer, and digital I/O subsystems of a DAQ device | Apply |
| CO 3 | Perform different types of data acquisition and identify the correct sensor for their measurements. | Apply |
| CO 4 | Acquire data from sensors and analyse the results | Apply |

**3) Course Plan**

| Sl.No | Experiment | No. of hours |
|---|---|---|
| 1 | Familiarization of data Acquisition toolbox in Matlab. | 2 |
| 2 | Acquire and characterise analog and digital signals | 4 |
| 3 | Measure frequency, pulse width and count pulses | 3 |
| 4 | Generate Pulse Width Modulated signal | 3 |
| 5 | Acquire and characterise audio signals | 4 |
| 6 | Simultaneous and synchronized data acquisition | 4 |
| 7 | Simulink data acquisition | 4 |
| 8 | Arduino based multi-channel data acquisition | 6 |
| | **Total hours** | **30** |

# SEMESTER II

| Course Code | Course Name | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| 22EC060B | Estimation and Detection Theory | DCC | 3 | 0 | 0 | 3 | 2022 |

**Pre-requisites:** Random Processes and Applications

## 1) Course Objectives

Familiarize the basic concepts of detection theory, decision theory and elementary hypothesis testing. Also to acquire knowledge about parameter estimation, and linear signal waveform estimation and to get a broad overview of applications of detection and estimation

## 2) Course Outcomes

After the completion of the course the student will be able to:

| # | Description | Level |
|---|---|---|
| CO1 | Analyse signal detection in the presence of noise | Apply |
| CO2 | Analyse various estimation methods | Analyse |
| CO3 | Apply the concepts of estimation and detection in various signal processing applications | Apply |
| CO4 | Explain Linear Signal Waveform Estimation methods | Apply |

## 3) Syllabus

Detection theory, Hypothesis testing, Detection with unknown signal parameters, Non-parametric detection, Parameter estimation, Cramer-Rao lower bound, Linear Signal Waveform Estimation, Levinson Durbin and innovation algorithms, Applications of detection and estimation

## 4) References

1. S.M. Kay, Fundamentals of Statistical Signal Processing: Detection Theory, Prentice Hall, 1998

2. S.M. Kay, Fundamentals of Statistical Signal Processing: Estimation Theory, Prentice Hall, 1993
3. H.L. Van Trees, Detection, Estimation and Modulation Theory, Part I, Wiley, 1968
4. H.V. Poor, An Introduction to Signal Detection and Estimation, 2nd edition, Springer, 1994.
5. L.L. Scharf, Statistical Signal Processing, Detection and Estimation Theory, Addison-Wesley:1990

**5) Course Plan**

| Module | Contents | Hours |
|---|---|---|
| **I** | Detection Theory, Decision Theory, and Hypothesis Testing: Elementary hypothesis testing, Neyman Pearson Theorem, Minimum probability of error, Bayes risk, Multiple hypothesis testing | **9** |
| **II** | Matched filter, Composite hypothesis testing: Generalized likelihood-ratio test. Detection of Signals with unknown Amplitude, Chernoff bound | **8** |
| **III** | Parameter Estimation: Minimum Variance Unbiased Estimator, Cramer-Rao lower bound, Fisher information matrix, Linear Models, Best Linear Unbiased Estimator. Case Study: Applications of Estimation and detection in communication. | **8** |
| **IV** | Maximum Likelihood Estimation, Invariance principle, Least Square Estimation, Non-linear least square estimation, Minimum mean square estimation, Minimum mean absolute error, Maximum A Posteriori Estimators.<br>Case Study: Applications of Estimation and detection in system identification. | **8** |
| **V** | Linear Signal Waveform Estimation: Wiener Filter, Kalman Filter, Choosing an estimator | **9** |
| **Total hours** | | **45** |

| Course Code | Course Name | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| **22EC261D** | Microcontrollers for IoT | PCC | 3 | 0 | 0 | 3 | 2022 |

**1) Course Objectives**

1. Introduce low power microcontrollers and to develop the skill set of programming low power sensing applications.
2. Impart the knowledge of various peripheral related to sensing and communication using wired or wireless means.
3. Upgrade the students by introducing them Advanced ARM Cortex microcontrollers
4. Develop The Skill Set of Students to Build IoT Systems and Sensor Interfacing

**2) Course Outcomes**

After the completion of the course the student will be able to:

| Course Outcomes | Description | Level |
|---|---|---|
| CO 1 | Explain the architecture of MSP 430 microcontroller. | Apply |
| CO 2 | Develop simple embedded programs for MSP 430 micro controller. | Apply |
| CO 3 | Explain the architecture of ARM Cortex Mmicrocontroller. | Apply |
| CO 4 | Design IoT systems. | Apply |
| CO 5 | Explain the architecture of VEGA THEJAS32 Microcontroller. | Apply |

**3) Syllabus**

Passed in BoS Meetings held on 11/08/2022 Approved in AC Meetings held on 29/08/2022,21/11/2022

Introduction to Embedded system, Microcontroller Vs Microprocessor

**MSP430 Microcontrollers**: Functional Block diagram, Addressing modes, Instruction Set, Examples, Reflections on the CPU and Instruction Set, Exceptions, Clock system. **Development:** Development Environment, Access to the Microcontroller for Programming and Debugging, Demonstration Boards, Examples. **Functions, Interrupts, and Low-Power Modes.** Functions and Subroutines, Interrupts, ISR, Low-Power Modes of Operation **ARM Cortex M**: Architecture, operating modes, software development process. **Assembly language**: syntax, addressing modes and operands instruction set, logical and arithmetic operations, stack, functions and control flow, Assembler directives, Examples. **Introduction to input/output** : TI micro controller input/output pins, Texas Instruments TM4C123 LaunchPad I/O pins, Basic concept of input output pins, PLL.

**Sensors interfacing: Sensors** interfacing techniques- Port Programming, ADC, SPI thermometer, I2C thermometer, PWM generation and demodulation, DTH11**Cloud interfacing :**Interfacing and data logging with cloud: Thing speak.

**VEGA THEJAS32 Microcontroller :** RISC-V Instruction Set Architecture, Registers, Operating Modes, Programmers' Model for Base Integer ISA, Base Instruction Formats, Exceptions, Traps, and Interrupts, Machine-Level CSRs**THEJAS32 Microcontroller:** Functional Bock diagram, CPU, Memory Mapped input output and Interrupts

**4) References**


1. John H. Davies, "MSP430 Microcontroller Basics", 2011, 2nd ed., Newnes publishing, New York
2. Jonathan W Valvano, "Introduction to ARM Cortex –M3 Microcontrollers", 2012, 5th ed., Create Space publishing, New York.
3. Muhammad Ali Mazidi, Shujen Chen, SarmadNaimi, SepehrNaimi, "TI ARM Peripherals Programming and Interfacing: Using C Language", 2015, 2nd ed., Mazidi and Naimi publishing, New York.
4. Sergey Y. Yurish,"Digital Sensors and Sensor Systems: Practical Design", 2011, 1st ed., IFSA publishing, New York
5. Jacob Fraden, "Hand Book of Modern Sensors: physics, Designs and Applications", 2014, 4th ed., Springer, New York.
6. RISC_V ISA Manual, "Volume 1, Unprivileged Spec v. 20191213 "
7. THEJAS32 Datasheet


**5) Course Plan**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Introduction**: Embedded system, Microcontrollers vs Microprocessor, Anatomy of a Microcontroller.<br><br>**MSP430 Microcontrollers**: Functional Block diagram, Memory, CPU, addressing modes, Constant Generator and Emulated Instructions, Instruction Set, Examples, Reflections on the CPU and Instruction Set, Exceptions: interrupt and Resets, Clock system. | **9** |
| II | **Development:** Development Environment, Access to the Microcontroller for Programming and Debugging, Demonstration Boards, Examples: Light LEDs in C, Read Input from a Switch.<br>**Functions, Interrupts, and Low-Power Modes.** Functions and Subroutines, Interrupts, ISR, Low-Power Modes of Operation. | **9** |
| III | **ARM Cortex M**: Architecture, register, memory, operating modes, software development process.<br>**Assembly language**: syntax, addressing modes and operands, memory access instructions, logical operation, Arithmetic operation, stack, functions and control flow, Assembler directives, Examples, Simplified machine language execution. | **9** |
| IV | **Introduction to input/output**: TI micro controller input/output pins, Texas Instruments TM4C123 Launch Pad I/O pins, Basic concept of input output pins,PLL, Standard I/O driver and printf function, Debugging.<br>**Sensors interfacing: Sensors** interfacing techniques-Port Programming, ADC, SPI thermometer, I2C thermometer, PWM generation and demodulation, DTH11.<br>**Cloud interfacing :**Interfacing and data logging with cloud: Thing speak | **9** |
| V | **VEGA THEJAS32 Microcontroller:** RISC-V Instruction Set Architecture, Registers – General Purpose Registers, Control and Status Registers, Operating Modes, | **9** |

| | | |
|---|---|---|
| | Programmers' Model for Base Integer ISA, Base Instruction Formats, Exceptions, Traps, and Interrupts, Machine-Level CSRs misa, mhartid, mstatus, mtvec medeleg and mideleg, mip and mie, mepc, mcause, mtval.<br>**THEJAS32 Microcontroller:** Functional Bock diagram, CPU, Memory Mapped input output and Interrupts, Demonstration Boards- ARIES V2.0 | |
| | **Total hours** | **45** |

| Course Code | Course Name | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| 22EC067A | Mini Project | PR | 0 | 0 | 4 | 2 | 2022 |

**1) Course Objectives**

Goal of this course is to enable students to take up small problems in their field of study as mini project and collect the recent publications related to the topic and present the observations and findings related to the project work.

**2) Course Outcomes**

After the completion of the course, the student will be able to:

| Course Outcomes | Description | Level |
|---|---|---|
| CO 1 | Implement a designed system or application by identifying and solving problems in the field of study. | Apply |
| CO 2 | Test the designed system or application. | Evaluate |
| CO 3 | Develop effective written and oral communication | Create |
| CO 4 | Explore domains of interest so as to pursue the course project. | Analyse |

**3) Approach**

1) Students should identify a topic of interest in consultation with PG Programme Coordinator that should lead to their dissertation/research project.
2) Students shall make a presentation for 20-25 minutes based on the detailed study on the project and submit a report of the study.
3) Demonstrate the novelty of the project through the results and outputs
4) The progress of the mini project is evaluated based on three reviews, two interim reviews and a final review.

| Course Code | Course Name | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| **22EC269B** | IoT and Sensor Systems Lab | LBC | 0 | 0 | 2 | 1 | 2022 |

**1) Course Objectives**

The main objective of this course is to know the different real time sensors which could be used for real time automation and to understand the connectivity and configuration of various modules used in IOT.

**2) Course Outcomes**

After the completion of the course the student will be able to:

| Course Outcomes | Description | Level |
|---|---|---|
| CO 1 | Explore ideas to carry out research / investigation independently to solve practical problems through real time automation. | Apply |
| CO 2 | Programming using Arduino and Raspberry-Pi modules. | Apply |
| CO 3 | Programming of Arduino modules with the integration of various peripherals for real time automation. | Apply |
| CO 4 | Programming of Raspberry-Pi modules with the integration of various peripherals for real time automation. | Apply |

**3) List Of Experiments**

| Sl.No | Experiments |
|---|---|
| 1 | Familiarization with the concept of IoT, Raspberry Pi and perform necessary software installation. |
| 2 | Study of different operating systems for Raspberry Pi Understanding the process of OS installation on Raspberry – Pi |
| 3 | Interfacing Raspberry-Pi with basic peripherals. |
| 4 | Interfacing Raspberry-Pi with temperature sensor and LED array. |
| 5 | Interfacing Raspberry-Pi with IR and ultrasonic sensors. |
| 6 | Interfacing Raspberry-Pi with PiCam. |
| 7 | Study of connectivity of Raspberry-Pi circuit to control the operation of a stepper motor. |
| 8 | Setup a cloud platform to log data using Raspberry PI and upload to the cloud platform. |
| 9 | Design an IoT based system for industrial applications. |

## ELECTIVES

| Course Code | Course Name | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| 22EC262A | Flexible and Wearable Sensors | PEC | 3 | 0 | 0 | 3 | 2022 |

**1) Course Objectives**

To impart the importance of flexible electronics and wearable sensors to provide a brief overview of wearable technology and its impact on social life.

**2) Course Outcomes**

After the completion of the course the student will be able to:

| **Course Outcomes** | **Description** | **Level** |
|---|---|---|
| CO 1 | Explain the processing steps involved in the fabrication of flexible electronic circuits. | Understand |
| CO 2 | Describe the fabrication techniques of thin film transistor | Understand |
| CO 3 | Compare various types of wearable haptics,bio and chemical sensors | Apply |
| CO 4 | Interpret the parameters obtained from various body-worn sensors. | Apply |
| CO 5 | Design low power circuits for implementing wearable biopotential sensor systems. | Apply |

**3) Syllabus**

Materials for Flexible Electronics, Thin-film Deposition and Processing Methods for Flexible Devices

Thin Film Transistors: materials and technologies, review of semiconductors employed in flexible electronics.

Wearable Haptics, Wearable Bio and chemical sensors,Wearable inertial sensors, Measurement of energy expenditure by body-worn devices, Low power analog/digital integrated circuit design techniques for wearable biopotential sensors

**4) References**

1. Edward Sazonov and Michael R. Neuman, “Wearable Sensors - Fundamentals, Implementation and Applications”, Elsevier Inc., 2014.
2. William S. Wong, Alberto Salleo, Flexible Electronics: Materials and Applications, 2011, 1st Edition, Springer, New York.
3. “Wearable and Autonomous Biomedical Devices and Systems for Smart Environment”, by Aimé Lay-Ekuakille and Subhas Chandra Mukhopadhyay, Springer 2010.
4. Seamless Healthcare Monitoring”, Toshiyo Tamura and Wenxi Chen, Springer 2018.
5. Guozhen Shen, Zhiyong Fan, “Flexible Electronics: From Materials to Devices”, 2015, 1st Edition, World Scientific Publishing Co, Singapore.

## 5) Course Plan

| Module | Contents | No. of hours |
|---|---|---|
| I | Overview of Flexible Electronics Technology:<br>Materials for Flexible Electronics :Nanowire and nanoparticle synthesis, transition metal oxides, amorphous thin films, polymeric semiconductors, structure and property relationships<br>Thin-film Deposition and Processing Methods for Flexible Devices CVD, PECVD, PVD, etching, photolithography, low-temperature process integration. | 9 |
| II | Thin Film Transistors: materials and technologies, review of semiconductors employed in flexible electronics, thin film transistors based on a-IGZO, plastic electronics for smart textiles. | 8 |
| III | World of Wearable(WOW):The emergence of wearable computing and wearable electronics, Attributes of wearable's, types of wearable sensors: Invasive, Non-invasive; intelligent clothing, Industry sector's overview-sports, healthcare, fashion and entertainment, military, environment monitoring, mining industry, public sector and safety;Wearable Haptics: The need for wearable haptic devices, categories of wearable haptic and tactile display; Wearable Bio and chemical sensors: system design, challenges in chemical biochemical sensing, application areas. | 10 |
| IV | Wearable inertial sensors and their applications, parameters obtained from inertial sensors, Practical considerations for wearable inertial sensor applications in clinical practice; Measurement of energy expenditure by body-worn devices, design considerations | 9 |

| | | |
|---|---|---|
| **V** | Biopotential signals and their characteristics, electrode-body interface and electrode noise; Measurement of energy expenditure by body-worn devices, design considerations ;Low power analog/digital integrated circuit design techniques for wearable bio potential sensors; Architectural design for low-power bio potential acquisition. Practical considerations. | **9** |
| | **Total hours** | **45** |

| **Course Code** | **Course Name** | **Category** | **L** | **T** | **P** | **Credit** | **Year of Introduction** |
|---|---|---|---|---|---|---|---|
| **22EC262B** | MICRO AND NANO FLUIDICS | PEC | 3 | 0 | 0 | 3 | 2022 |

**1) Course Objectives**

Discuss the fundamental physics of micro and nano scale fluids and their hydrodynamics.

**2) Course Outcomes**

After the completion of the course the student will be able to:

| Course Outcomes | Description | Level |
|---|---|---|
| CO 1 | Apply the fundamental physics of micro and nano scale fluids. | Apply |
| CO 2 | Explain the hydrodynamic of micro and nano scale fluids. | Understand |
| CO 3 | Discuss the fabrication techniques of microfluidics devices. | Understand |
| CO 4 | Interpret the working principle of various existing microfluidic devices. | Apply |
| CO 5 | Develop various microfluidic lab-on-chip applications. | Apply |

**3) Syllabus**

Fluids and non-fluids, properties of fluids, classification of fluids, Newtonian and Non Newtonian fluids, pressure driven flow, Reynolds number , Electrokinetic phenomena, Electric double layer, Debye length, coupling species transport and fluid mechanics, Micro channel Resistance, Shear stress, capillary flow, flow through porous media, Diffusion, surface tension, contact angle and wetting. Introduction to surface, surface charge, surface energy, Thermodynamics of surfaces, Fluids in Electrical fields, The Navier Strokes equation, Boundary and Initial conditions problems.
Patterning, Photolithography, Micromachining, Micromolding, Soft lithography, PDMS properties, Fabrication of microfludics channels. Droplet Microfluids, Active Flow control, Microvalves, Electrically actuated microvalves, Micromixers, Combinational Mixers, Elastomeric Micromixers. Microfluidic for Flow cytometry, cell sorting, cell trapping, Cell culture in microenvironment.Enzyme assay and inhibition, Chemical synthesis in microreactors, Sequential reaction and Parallel reaction in micro reactors, chemical separation, liquid chromatography

**4) References**

1. Clement Kleinstreuer, "Micro fluidics and Nanofluidics: Theory and Selected Applications",2013, 1st ed., John Wiley & Sons, New Jersey

2. Shaurya Prakash, JunghoonYeom, "Nanofluidics and Microfluidics: Systems and Applications",2014, 1st ed., William Andrew; Norwich, New York.
3. Albert Folch, "Introduction to BioMEMS", 2012, 1st ed., CRC Press, United Kingdom.
4. Patrick Tabeling, "Introduction to Microfluidics", 2011, Reprint ed., Oxford University Press, Great Britain.
5. Xiujun James Li, Yu Zhou, "Microfluidic Devices for Biomedical Applications", 2013, 1st ed., Wood head Publishing, Cambridge.
6. Terrence Conlisk. A, "Essentials of Micro- and Nanofluidics: With Applications to the Biological and Chemical Sciences", 2012, 1st ed., Cambridge University Press, New York.

## 5) Course Plan

| Module | Contents | No. of hours |
|---|---|---|
| I | **Fundamentals for Microscale and Nanoscale Flow**<br>Fluids and non-fluids, properties of fluids, classification of fluids, Newtonian and Non-Newtonian fluids, pressure driven flow, Reynolds number , Electro kinetic phenomena, Electric double layer, Debye length, coupling species transport and fluid mechanics, Micro channel Resistance, Shear stress, capillary flow, flow through porous media, Diffusion, surface tension, contact angle and wetting. | **10** |
| II | **Hydrodynamics**<br>Introduction to surface, surface charge, surface energy, Thermodynamics of surfaces, Fluids in Electrical fields, The Navier Strokes equation, Boundary and Initial conditions problems | **8** |
| III | **Fabrication methods and techniques**<br>Patterning, Photolithography, Micromachining, Micromolding, Soft lithography, PDMS properties, Fabrication of microfludics channels | **9** |
| IV | **Microfluidic Devices**<br>Droplet Microfluids, Active Flow control, Microvalves, Electrically actuated microvalves, Micromixers, Combinational Mixers, Elastomeric Micromixers | **9** |
| V | **Microfluidics Lab on Chip**<br>Microfluidic for Flow cytometry, cell sorting, cell trapping, Cell culture in microenvironment<br>**Bioreactors on Microchips**<br>Enzyme assay and inhibition, Chemical synthesis in microreactors, Sequential reaction and Parallel reaction in micro reactors, chemical separation, liquid chromatography | **9** |
| | **Total hours** | **45** |

Passed in BoS Meetings held on 11/08/2022 Approved in AC Meetings held on 29/08/2022,21/11/2022

| Course Code | Course Name | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| **22EC262C** | **Machine Learning** | PEC | 3 | 0 | 0 | 3 | 2022 |

**1) Course Objectives**

To enable analyzing data using intelligent techniques and to provide an in-depth introduction to machine learning algorithms.

**2) Course Outcomes**

After the completion of the course the student will be able to:

| Course Outcomes | Description | Level |
|---|---|---|
| CO 1 | Apply various learning approaches to interpret the concepts of supervised and unsupervised learning techniques. | Apply |
| CO 2 | Compare various evaluation parameters of a neural network based classifier. | Apply |
| CO 3 | Apply theoretical foundations of decision trees to identify best split and Bayesian classifier to label data points. | Apply |
| CO 4 | Illustrate the working of classifier models like SVM, Neural Networks and identify classifier model for typical machine learning applications. | Apply |
| CO 5 | Illustrate various clustering algorithms and identify its applicability in real life problems | Apply |

**3) Syllabus**

Introduction to Machine learning, Learning in Artificial Neural Networks, Classification and regression – decision trees, Baye's theorem, MLE, etc., Feedforward networks, Back propagation algorithms, Kernel machines,

Discrete Markov Processes, Model combination schemes, clustering algorithms and other Supervised and Unsupervised learning methods.

**4) References**

1. Christopher M. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2006.
2. EthemAlpaydın, “Introduction to Machine Learning (Adaptive Computation and Machine Learning)”, MIT Press, 2004.
3. Margaret H. Dunham. “Data Mining: introductory and Advanced Topics”, Pearson, 2006.
4. Mitchell. T, “Machine Learning”, McGraw Hill.
5. Ryszard S. Michalski, Jaime G. Carbonell, and Tom M. Mitchell, “Machine Learning : An Artificial Intelligence Approach”, Tioga Publishing Company.

**5) Course Plan**

| Module | Contents | No. of hours |
|---|---|---|
| I | Introduction to Machine Learning, Supervised and unsupervised learning, parametric vs non-parametric models, parametric models for classification and regression- Linear Regression, Logistic Regression, Review of probability/Linear Algebra, Gradient Descent Algorithm(mathematical interpretation) | 8 |
| II | Classification- Cross validation and re-sampling methods- K-fold cross validation, Boot strapping, Measuring classifier performance- Precision, recall, ROC curves. Baye's Theorem, Bayesian classifier, Maximum Likelihood estimation, Density functions, Regression.<br>Decision Trees- Entropy, Information Gain, Tree construction, ID3, Issues in Decision Tree learning- Avoiding Over-fitting, Reduced Error Pruning | 10 |
| III | Feedforward neural networks- shallow model- single layer perceptron, multi-layer perceptron as complex decision classifier- learning XOR-Gradient based learning. Backpropagation algorithm, risk minimization, loss function, regularization, heuristics for faster training and avoiding local minima. Backpropagation algorithm, risk minimization, loss function, regularization | 10 |
| IV | Kernel Machines- Support Vector Machine- Optimal Separating hyper plane, Soft-margin hyperplane, Kernel trick, Kernel functions. Discrete Markov Processes, Hidden Markov models, three basic problems of HMMs- Evaluation problem, finding state sequence, Learning model parameters. Combining multiple learners,Model combination schemes, Voting, Bagging, and Boosting. | 9 |

| | | |
|---|---|---|
| **V** | Clustering- distance based- K-means, density based, association rule mining,Eigen values, Eigen vectors, Orthogonality- challenges motivating deep learning. Case Study -Application of Machine learning in different Engineering Sectors. | **8** |
| | **Total hours** | **45** |

| **Course Code** | **Course Name** | **Category** | **L** | **T** | **P** | **Credit** | **Year of Introduction** |
|---|---|---|---|---|---|---|---|
| **22EC262D** | Automotive Sensors And In-Vehicle Networking | PEC | 2 | 0 | 2 | 3 | 2022 |

**1) Course Objectives**

The objective of this course is

**a)** Acquaint with the basic automotive parts and the need for sensor integration in different automotive systems

**b)** Discuss the basics of various Powertrain sensors and associated systems for proper vehicle dynamics and stability in automotive systems.

**c)** Comprehend various sensors for vehicle body management and discuss various sensors and technologies for passenger convenience, safety and security systems

**d)** Acquaint various communication standards and protocols followed within the automotive systems

**2) Course Outcomes**

After the completion of the course the student will be able to:

| Course Outcomes | Description | Level |
|---|---|---|
| CO 1 | Identify the basic automotive parts and the requirement of sensors and their integration in different automotive systems. | Apply |
| CO 2 | Identify the basics of various Powertrain sensors. | Apply |
| CO 3 | Comprehend and analyse various systems like ABS, ESP, TCS, etc. for understanding vehicle dynamics and stability. | Analyse |
| CO 4 | Comprehend the various sensors for vehicle body management, convenience & security systems. | Analyse |
| CO 5 | Identify various technologies developed for passenger convenience, Air Bag deployment and Seat Belt Tensioner System, etc. with the students | Apply |
| CO6 | Recognize various communication standards and protocols followed within the automotive systems. | Apply |

### 3) Syllabus

Introduction to Automotive Engineering, Automotive Management systems, Powertrain Sensors and Sensors for Chassis management, Sensors for vehicle body management, Sensors for automotive vehicle convenience and security systems, Air Bag and Seat Belt Pre tensioner Systems, Passenger Convenience Systems, Modern Trends and Technical Solutions.

### 4) References

1. Automotive Electrics, Automotive Electronics: Systems & Components, 2014, 5th Edition, BOSCH.
2. John Turner, Automotive Sensors, 2010, 1st Edition, Momentum Press, New York.
3. Automotive Sensors Handbook, 8th Edition, 2011, BOSCH.
4. Jiri Marek, Hans-Peter Trah, Yasutoshi Suzuki, IwaoYokomori, Sensors for Automotive Technology, 2010, 4th Edition, Wiley, New York.

5. Ernest O. Doebelin, “Measurement Systems – Application and Design”, 2017, 6th Edition, McGraw-Hill, New Delhi.

**5) Course Plan**

| Module | Contents | No.of hours |
|---|---|---|
| I | **Introduction to Automotive Engineering, Automotive Management systems** : Powertrain, Combustion Engines, Transmission, Differential Gear, Braking Systems, Introduction to Modern Automotive Systems and need for electronics in Automobiles, Application areas of electronics in the automobiles, Possibilities and challenges in the automotive industry, Enabling technologies and Industry trends | **8** |
| II | **Powertrain Sensors and Sensors for Chassis management:** λ sensors, exhaust temperature sensor, NOx sensor, PM sensor, fuel quality sensor, level sensor, torque sensor, speed sensor, mass flow sensor, manifold pressure sensor.<br>Wheel speed sensors/direction sensors, steering position sensor (multi turn), acceleration sensor (inertia measurement), brake pneumatic pressure sensor, ABS sensor, electronic stability sensor. | **10** |
| III | **Sensors for vehicle body management, Sensors for automotive vehicle convenience and security systems:** Gas sensors (CO2), Temperature/humidity sensor, air bag sensor, keyless entering sensor, radar sensors. Tire pressure monitoring systems, Two wheeler and Four wheeler security systems, parking guide systems, anti-lock braking system, future safety technologies, Vehicle diagnostics and health monitoring, Safety and Reliability, Traction Control, Vehicle dynamics control, Accelerators and tilt sensors for sensing skidding and anti-collision, Anti-collision techniques using ultrasonic Doppler sensors. | **9** |

| | | |
|---|---|---|
| **IV** | **Air Bag and Seat Belt Pre tensioner Systems, Passenger Convenience Systems:** Principal Sensor Functions, Distributed Front AirBag sensing systems, Single-Point Sensing systems, Side-Impact Sensing, and Future Occupant Protection systems. Electromechanical Seat, Seat Belt Height, Steering Wheel, and Mirror Adjustments, Central Locking Systems, Tire Pressure Control Systems, Electromechanical Window Drives, etc. | **9** |
| **V** | **Modern Trends and Technical Solutions:** Enabling Connectivity by Networking:-In vehicle communication standards (CAN & LIN), Telematics solutions, Portable or embedded connectivity- Endorsing Dependability in Drive-by- wire systems:- Terminology and concepts , Why by-wire, FLEXRAY, Requirements on cost and dependability, Drive-by-wire case studies- prototype development-future of In vehicle communication. | **9** |
| | **Total hours** | **45** |

Hands-on session will be included

| Course Code | Course Name | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| **22EC262E** | Cloud and Fog Computing | PEC | 3 | 0 | 0 | 3 | 2022 |

**1) Course Objectives**

- To introduce the concepts and security issues of the cloud paradigm.
- To give awareness about the public cloud platforms.
- To understand the fundamentals of fog computing.

**2) Course Outcomes**

After the completion of the course the student will be able to:

| Course Outcomes | Description | Level |
|---|---|---|
| CO 1 | Interpret the various cloud computing models and services | Apply |
| CO 2 | Compare the various public cloud platforms and software environments. | Apply |
| CO 3 | Discuss the need of security mechanisms in cloud. | Apply |
| CO 4 | Explain the concepts of fog computing. | Understand |
| CO 5 | Illustrate the various applications using cloud and fog computing. | Apply |

**3) Syllabus**

**Introduction to Cloud Computing:** Basics of cloud computing-concepts and models, -cloud architecture standards - Cloud types- Benefits and challenges of cloud computing, role of virtualization in enabling the cloud.

**Cloud Architecture and Resource Management:** Architectural Design of Compute and Storage Clouds – Public Cloud Platforms: Emerging Cloud Software Environments - Extended Cloud Computing Services.

**Security in the Cloud:** Security Overview – Cloud Security Challenges –Risk Management -Security Monitoring – Security Architecture Design – Data Security -Application Security – Virtual machine Security.

**Introduction to fog computing:** Fog Computing and Internet of Things-Pros and Cons - Need and Reasons for Fog Computing- Fog Computing and Edge Computing

**Recent Trends in cloud computing – Case study**

**4) References**

1. Kai Hwang, Geoffrey C Fox, Jack J Dongarra: *Distributed and Cloud Computing- From Parallel Processing to the Internet of things*, Morgan kaufmann Publishers -2012.

2. B. Sosinsky, *Cloud Computing Bible,* Wiley India, 2011.
3. R. Buyya, C. Vecchiola and S. T. Selvi, *Mastering Cloud Computing*, McGraw Hill, 2013.
4. Ivan Stojmenovic, Sheng Wen ,*"The Fog Computing Paradigm: Scenarios and Security Issues"* Proceedings of the 2014 Federated Conference on Computer Science and Information Systems pp. 1–8
5. Rajkumar Buyya, Satish Narayana Srirama, *Fog and Edge Computing: Principles and Paradigms,*Wiley, 2019.

**5) Course Plan**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Introduction to Cloud Computing**<br>Basics of cloud computing-Need for clouds- concepts and models,-cloud architecture standards and interoperability- Cloud types- IaaS, PaaS, SaaS. Benefits and challenges of cloud computing, public, private clouds community cloud, role of virtualization in enabling the cloud. | 9 |
| II | **Cloud Architecture and Resource Management**<br>Architectural Design of Compute and Storage Clouds – Public Cloud Platforms: GAE- AWS -Azure- Emerging Cloud Software Environments -Eucalyptus- Nimbus - Open Stack – Extended Cloud Computing Services – Resource Provisioning and platform Deployment- Virtual machine Creation and management. | 10 |
| III | **Security in the Cloud**<br>Security Overview – Cloud Security Challenges – Security as a Service – Security Governance – Risk Management -Security Monitoring – Security Architecture Design – Data Security -Application Security – Virtual machine Security. | 8 |
| IV | **Introduction to fog computing**<br>Fog Computing-Definition-Characteristics-Application Scenarios - Issues -Fog Computing and Internet of Things-Pros and Cons-Myths of Fog Computing -Need and Reasons for Fog Computing Fog Computing and Edge Computing-IoT , FOG, Cloud Benefits. | 9 |
| V | **Recent Trends in cloud computing**<br>**Case study:**<br>Smart Traffic Light System, Wearable Sensing Devices, Wearable Event Device, Wearable System, Demonstrations, Post Application Example. Event Applications Example, Big Data Analytics for Healthcare Applications, Big Data Analytics for Social Media Applications,Serveless infrastructures, Edge cloud, CloudAI | 9 |

| | | |
|---|---|---|
| | **Total hours** | **45** |

| Course Code | Course Name | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| 22EC262F | IoT Security and Trust | PEC | 3 | 0 | 0 | 3 | 2022 |

**1) Course Objectives**

This course aims to impart the knowledge and technical skills in designing secured and trustable IoT systems.

**2) Course Outcomes**

After the completion of the course the student will be able to:

| Course Outcomes | Description | Level |
|---|---|---|
| CO 1 | Design and implement cryptography algorithms using C programs. | Analyze |
| CO 2 | Solve network security problems in various networks. | Analyze |
| CO 3 | Build security systems using elementary block | Analyze |
| CO 4 | Build Trustable cloud based IoT systems and solve IoT security problems. | Analyze |
| CO 5 | Appreciate the need for cyber security laws and methods. | Analyze |

**3) Syllabus**

Fundamentals of encryption for cyber security, IoT security framework, Elementary blocks of IoT Security & Models for Identity Management, Identity Management and Trust Establishment, Access Control in IoT, Security and Digital Identity in Cloud Computing, Cyber Crimes, Hackers and Forensics.

## 4) References

1) John R. Vacca, “Computer and Information Security Handbook”, Elsevier, 2013. Parikshit Narendra Mahalle , Poonam N. Railkar, “Identity Management for Internet of Things”, River Publishers, 2015.

2) William Stallings, “Cryptography and Network security: Principles and Practice”, 5th Edition, 2014, Pearson Education, India.

3) Maryline Laurent, SamiaBouzefrane, “Digital Identity Management”, Elsevier, 2015.

4) Joseph Migga Kizza, “Computer Network Security”, Springer, 2005.

## 5) Course Plan

| Module | Contents | No. of hours |
|---|---|---|
| **I** | Cryptography – Need and the Mathematical basics- History of cryptography, symmetric ciphers, block ciphers, DES – AES. Public-key cryptography: RSA, Diffie-Hellman Algorithm, Elliptic Curve Cryptosystems, Algebraic structure, Triple Data Encryption Algorithm (TDEA) Block cipher. | 8 |
| **II** | IIOT security frame work, Security in hardware, Boot process, OS & Kernel, application, run time environment and containers. Need and methods of Edge Security, Network Security: Internet, Intranet, LAN, Wireless Networks, Wireless cellular networks, Cellular Networks and VOIP. | 8 |
| **III** | Vulnerability of IoT and elementary blocks of IoT Security, Threat modelling – Key elements. Identity management Models and Identity management in IoT, Approaches using User-centric, Device-centric and Hybrid, Side channel analysis. | 10 |
| **IV** | Trust management lifecycle, Identity and Trust, Web of trust models. Establishment: Cryptosystems – Mutual establishment phases – Comparison on security analysis. Identity management framework. Capability-based access control schemes, Concepts, identity-based and identity-driven, Light weight cryptography, need and methods. | 9 |
| **V** | Cloud security, Digital identity management in cloud, Classical solutions, alternative solutions, Management of privacy and personal data in Cloud. Cyber Crimes and Laws – Hackers – Dealing with the rise tide of Cyber Crimes – Cyber Forensics and incident Response – Network Forensics. | 10 |
| | **Total Hours** | **45** |

| Course Code | Course Name | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| 22EC262G | Biomedical Sensors | PEC | 3 | 0 | 0 | 3 | 2022 |

## 1) Course Objectives

This course aims at introducing the student to sensors used in different biomedical applications.

## 2) Course Outcomes

After the completion of the course the student will be able to:

| Course Outcomes | Description | Level |
|---|---|---|
| CO 1 | Explain the requirements, calibration, characteristics and parameters of biomedical sensors. | Understand |
| CO 2 | Discuss the operating principle and applications of resistive, reactance and electromagnetic sensors. | Understand |
| CO 3 | Compare the different parameters and models of various self-generating sensors. | Apply |
| CO 4 | Apply the knowledge of the features of optical and ultrasound sensors for various biomedical applications. | Apply |
| CO 5 | Use the knowledge of the types of Biosensors and Intelligent sensors to select appropriate sensors for different biomedical applications. | Apply |

**3) Syllabus**

Introduction to Biomedical Sensors: Sensor classification and calibration, static and dynamic characteristics, errors and uncertainty.

Resistive Sensors, Reactance Variation and Electromagnetic Sensors: Thermistors, light-dependent resistors, Capacitive sensors, Inductive sensors, Electromagnetic sensors

Self-Generating Sensors: Thermoelectric sensors, Piezoelectric sensors, Electrochemical sensors, Signal conditioning for self-generating sensors.

Optical and Ultrasound Sensors: Optical techniques, General principles of optical sensing, Fiber-optic sensor technologies and applications. Ultrasonic-based sensing methods and applications.

Biosensors and Intelligent Sensors: Operating principle, biological elements in biosensors, applications. Intelligent Sensors: Definition, parameters, features, operating principle, main building blocks and applications.

**4) References**

1) Yang, V. C., and Ngo, T. T., (2000), Biosensors and their Applications, Kluwer Academic/Plenum Publisher, New York.
2) Hall, E. A., (1990), Biosensors, Open University Press, Milton Keynes
3) Mehrotra, Parikha. “Biosensors and their applications - A review.” Journal of oral biology and craniofacial research vol. 6,2 (2016)
4) Naresh V, Lee N. A Review on Biosensors and Recent Development of Nanostructured Materials-Enabled Biosensors. Sensors. 2021; 21(4)
5) Harsanyi, G , (2000), Sensors in Biomedical Applications: Fundamentals, Technology and Applications, Technomic Publishing Company.

**5) Course Plan**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Introduction to Biomedical Sensors:** Sensor classification and calibration, static and dynamic characteristics, errors and uncertainty. | 8 |
| II | **Resistive Sensors, Reactance Variation and Electromagnetic**<br><br>**Sensors**: Thermistors, light-dependent resistors, Capacitive sensors, Inductive sensors, Electromagnetic sensors. | 9 |
| III | **Self-Generating Sensors:** Thermoelectric sensors, Piezoelectric sensors, Electrochemical sensors, Signal conditioning for self-generating sensors.<br><br>**Case studies** on self-generating sensors. | 9 |
| IV | **Optical and Ultrasound Sensors:** Optical techniques, General principles of optical sensing, Fiber-optic sensor technologies and applications. Ultrasonic-based sensing methods and applications.<br><br>**Case studies** on optical and ultrasound sensors. | 9 |
| V | **Biosensors and Intelligent Sensors**: Operating principle, biological elements in biosensors, applications. Intelligent Sensors: Definition, parameters, features, operating principle, main building blocks and applications.<br><br>**Case study:** Lab-on-a–chip. | 10 |
| | **Total hours** | 45 |

| Course Code | Course Name | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| 22EC262H | Principles Of Sensors And Signal Conditioning | PEC | 2 | 0 | 2 | 3 | 2022 |

**1) Course Objectives**

1. To provide in depth knowledge in physical principles applied in sensing, measurement and a comprehensive understanding on how measurement systems are designed, calibrated, characterized, and analyzed.

2. To provide in-depth understanding of the principle of measurement and theory of instruments and sensors for measuring velocity and acceleration

3. To give a fundamental knowledge on the basic laws and phenomena on which operation of sensor transformation of energy is based.

4. To impart a reasonable level of competence in the design, construction, and execution of mechanical measurements strain, force, torque and pressure

**2) Course Outcomes**

After the completion of the course the student will be able to:

| Course Outcomes | Description | Level |
|---|---|---|
| CO 1 | Apply concepts in common methods for converting a physical parameter into an electrical quantity | Apply |
| CO 2 | Analyze the performance characteristics of Intensity Polarization and Interferometric Sensors | Analyze |
| CO 3 | Compare the performance of various sensors used in real life applications | Apply |
| CO 4 | Design sensor interface circuits for various s microsystems | Analyze |
| CO 5 | Explain the concepts of Flow, Temperature and Acoustic sensors | Understand |

**3) Syllabus**

Sensor Classification, Performance and Types, Error Analysis characteristics, optical detectors, intensity sensors,microbending concepts, Interferometers, Mach Zehnder, Michelson, Fabry Perot and Sagnac, Phase detection, Polarization maintaining fibers. Different types of Strain, Force, Torque and Pressure sensors. Concepts of LVDT, RVDT, eddy current, transverse inductive, Hall effect, Position, Direction, Displacement and Level sensors. Pressure gradient technique, thermal transport, ultrasonic, electromagnetic and Laser anemometer. Flow, Temperature and Acoustic sensors

**4) References**


1. Jacob Fraden, “Hand Book of Modern Sensors: physics, Designs and Applications”, 2015, 3rd edition, Springer, New York.
2. Jon. S. Wilson, “Sensor Technology Hand Book”, 2011, 1st edition, Elsevier, Netherland.
3. GerdKeiser, “OpticalFiber Communications”, 2017, 5th edition, McGraw-Hill Science, Delhi.
4. John G Webster, “Measurement, Instrumentation and sensor Handbook”, 2017, 2nd edition,CRC Press, Florida.
5. Eric Udd and W.B. Spillman, “Fiber optic sensors: An introduction for engineers andscientists”, 2013, 2nd edition, Wiley, New Jersey.

6. Bahaa E. A. Saleh and Malvin Carl Teich, “Fundamentals of photonics”, 2012, 1st edition,John Wiley, New York.

**5) Course Plan**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Sensor fundamentals and characteristics** Sensor Classification, Performance and Types, Error Analysis characteristics Fiber optic sensors, Thermal detectors, Photo multipliers, photoconductive detectors, Photo diodes, Avalanche photodiodes, CCDs. | 8 |
| II | **Intensity Polarization and Interferometric Sensors** Intensity sensor, Microbending concept, Interferometers, Mach Zehnder, Michelson, Fabry- Perot and Sagnac, Phase sensor: Phase detection, Polarization maintaining fibers. | 9 |
| III | **Strain, Force, Torque and Pressure sensors-**Strain gages, strain gage beam force sensor, piezoelectric force sensor, load cell, torque sensor, Piezo-resistive and capacitive pressure sensor, optoelectronic pressure sensors, vacuum sensors. Design of signal conditioning circuits for strain gauges, piezo, capacitance and optoelectronics sensors. | 9 |
| IV | **Position, Direction, Displacement,Level and Velocity Sensors** Potentiometric and capacitive sensors, Inductive and magnetic sensor, LVDT, RVDT, eddy current, transverse inductive, Hall effect, magneto resistive, magnetostrictive sensors. Fiber optic liquid level sensing, Fabry Perot sensor, ultrasonic sensor, capacitive liquid level sensor. Signal condition circuits for reactive and self-generating sensors.<br><br>Electromagnetic velocity sensor, Doppler with sound, light, Accelerometer characteristics, capacitive, piezo-resistive, piezoelectric accelerometer, thermal accelerometer, monolithic and optical gyroscopes, piezoelectric accelerometer, thermal accelerometer, rotor, monolithic and optical gyroscopes. | 9 |

| | | |
|---|---|---|
| **V** | **Flow, Temperature and Acoustic sensors**<br>Flow sensors: pressure gradient technique, thermal transport, ultrasonic, electromagnetic and Laser anemometer. Microflow sensor, coriolis mass flow and drag flow sensor.<br>Temperature sensors- thermo resistive, thermoelectric, semiconductor and optical. Piezoelectric temperature sensor. Acoustic sensors- microphones-resistive, capacitive, piezoelectric, fiber optic, solid state - electrect microphone. | **10** |
| | **Total hours** | **45** |

***Hands-on session will be included**

| **Course Code** | **Course Name** | **Category** | **L** | **T** | **P** | **Credit** | **Year of Introduction** |
|---|---|---|---|---|---|---|---|
| 22EC262I | RF MEMS | PEC | 3 | 0 | 0 | 3 | 2022 |

**1) Course Objectives**

The goal of this course is to provide an insight to the students on the fundamentals of RF MEMS circuit elements, MEMS based circuit design.

**2) Course Outcomes**

After the completion of the course the student will be able to:

| Course Outcomes | Description | Level |
|---|---|---|
| CO 1 | Analyse the different MEMS technologies and the need for packaging. | Apply |
| CO 2 | Analyse the various actuation mechanisms and design consideration for RF MEMS switches. | Apply |
| CO 3 | Explain the operation of inductors and capacitors. | Understand |
| CO 4 | Describe the working of RF MEMS Phase Shifters, Filters, Oscillators | Understand |
| CO 5 | Discuss the concepts of micro machined antennas. | Understand |

**3) Syllabus**

Introduction to RF MEMS- application.

Introduction to Micro fabrication Technique-Material properties, Bulk and surface micromachining,Wet and dry etching, Thin-film depositions, design and testing.

Actuation Mechanisms in MEMS, RF MEMS switches and applications, Introduction to MEMS switch design and its analysis.

Integration and biasing issues for RF switches, Example of RF MEMS switches and applications, Mechanical design, Electromagnetic modelling.

Micro machined inductors, variable inductors, polymer-based inductors, gap-tuning and area tuning capacitors, dielectric tuneable capacitors.

Resonators – applications in oscillators and filters- Modelling of mechanical filters. Introduction to Micromachined antennas, design parameters and RF NEMS, Integration and Packaging. packaging materials and reliability issues.

**4) References**

1. RF MEMS and Their Applications", Vijay Varadan, K. J. Vinoy, K. A. Jose, Wiley, 2003.
2. Tai-Ran Hsu, MEMS and Microsystems Design and Manufacture, TMH, 2017.
3. Chang Liu, Foundations of MEMS, Pearson 2012
4. "RF MEMS: Theory, Design, and Technology", Gabriel M. Rebeiz, Wiley, 2003

5. "RF MEMS Circuit Design for Wireless Applications", Hector J. De Los Santos, Artech House, 2002

**5) Course Plan**

| Module | Contents | No. of hours |
|---|---|---|
| I | Introduction to RF MEMS, application in wireless communications; Overview of RF MEMS fabrication. Introduction to Micro fabrication Techniques- Materials properties, Bulk and surface micromachining,Wet and dry etching, Thin-film depositions, design and testing. | 9 |
| II | Actuation Mechanisms in MEMS- Piezoelectric, Electrostatic, Thermal, Magnetic.RF MEMS switches and applications- Integration and biasing issues for RF switches. MEMS switch design, Example of RF MEMS switches and applications, Mechanical design, Electromagnetic modelling (Capacitance, Loss, Isolation modelling and analysis- Electromechanical finite element analysis, RF design. | 9 |
| III | Inductors and capacitors - micro machined inductors, variable inductors, polymer-based inductors, gap-tuning and area tuning capacitors, two plate and three plate configuration, dielectric tuneable capacitors. | 9 |
| IV | Resonators –applications in oscillators and filters- Modelling of mechanical filters. Electrostatic comb drive.<br>Micromechanical filters using comb drives. Electrostatic coupled beam structures, Surface Acoustic Wave Filters, Film bulk acoustic wave resonators. | 9 |
| V | Micro machined antennas – design parameters. Micromachining to improve performance. Reconfigurable antennas. RF NEMS-overview.<br>Integration and Packaging: Role of MEMS packages, types of MEMS packages, module packaging, packaging materials and reliability issues. | 9 |
| | **Total hours** | **45** |

Passed in BoS Meetings held on 11/08/2022 Approved in AC Meetings held on 29/08/2022,21/11/2022

| Course Code | Course Name | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| 22EC262J | Wireless Sensor Networks and IoT | PCC | 3 | 0 | 0 | 3 | 2022 |

**1) Course Objectives**

This course aims to expose the students to the central elements in the design of communication protocols for the WSNs and design knowledge in analyzing the specific requirements for applications in WSNs. It also aims to design simple IoT systems comprising sensors, edge devices, wireless network connections, data analytics capabilities and cloud storage.

**2) Course Outcomes**

After the completion of the course the student will be able to:

| Course Outcomes | Description | Level |
|---|---|---|
| CO 1 | Explain the basics concepts of Wireless Sensor Network architecture and its principles. | Understand |
| CO 2 | Explain the various communication protocols in WSN stack. | Understand |
| CO 3 | Apply the concepts of localization and time synchronization. | Apply |
| CO 4 | Use open source tools for the implementation of WSN. | Apply |
| CO 5 | Design simple IoT systems comprising sensors, edge devices, wireless network connections, data analytics capabilities and cloud storage. | Apply |

**3) Syllabus**

Comparison of sensor network with ad hoc network, Single node architecture, Network architecture, Physical layer and transceiver design consideration in wireless sensor networks, Fundamentals of wireless MAC protocols, Routing protocols, Localization and positioning, Time

synchronization problem, Tiny Operating System, Contiki OS, Event-Driven Programming, Building blocks of an IoT device, interfacing using any Embedded target boards, Cloud Support, Web server, Data Analytics for IoT.

**4) References**


1. Holger Karl, Andreas Willig, “Protocols and Architectures for Wireless Sensor Networks” 2011, 1st ed., John Wiley & Sons, New Jersey.
2. Fei Hu and Xiaojun Cao, “Wireless Sensor Networks Principles and Practice”, CRC Press,2010.
3. Feng Zhao and Leonidas Guibas, “Wireless Sensor Networks: an Information Processing Approach”, Elsevier Publication, 2004.
4. Honbo Zhou, "The Internet of Things in the Cloud : A Middleware Perspective", CRC Press, 2012.
5. ArshdeepBahga and Vijay Madisetti, "Internet of Things: A Hands-on Approach", Universities Press, 2014.
6. Matt Richardson & Shawn Wallace, “Getting Started with Raspberry Pi”, O'Reilly Media Press, 1st Edition, 2012.
7. AgusKuniawa, "Getting started with Intel IoT and Intel Galileo", Kindle Edition, 2015.
8. Sitharama Iyengar S, Nandan Parmeshwaran, Balkrishnan N and Chuka D, “Fundamentals of Sensor Network Programming, Applications and Technology”, John Wiley & Sons, 2011.


**5) Course Plan**

| Module | Contents | No. of hours |
|---|---|---|
| I | Challenges for wireless sensor networks, Comparison of sensor network with ad hoc network, Single node architecture, Hardware components, Energy consumption of sensor nodes, Network architecture: Sensor network scenarios, Optimization Goals and Design principles. Physical layer and transceiver design consideration in wireless sensor networks | 9 |
| II | Fundamentals of wireless MAC protocols, low duty cycle protocols and wakeup concepts, contention-based protocols, Schedule-based protocols. ROUTING PROTOCOLS - Gossiping and agent-based unicast forwarding, Energy-efficient unicast, Broadcast and multicast, geographic routing, Data centric routing, Data aggregation. | 10 |
| III | Localization and positioning: Possible approaches, single hop localization, positioning in multi-hop environments. Time synchronization: Time synchronization problem, protocols based on sender to receiver and receiver to receiver synchronization in WSN. | 8 |
| IV | Programming Challenges in Wireless Sensor Networks, Tiny Operating System, Contiki OS, Event-Driven Programming, Techniques for Protocol Programming. | 9 |
| V | Building blocks of an IoT device - Programming Inputs and outputs, Serial, SPI and I2C - Sensors and sensor Node and interfacing using any Embedded target boards (Raspberry Pi / Intel Galileo/ARM Cortex/ Arduino)*. Cloud Support: Cloud Storage models and communication APIs. Web server - Web server for IoT - Cloud for IoT - Designing a RESTful web API - Amazon Web services for IoT - Data Analytics for IoT: Apache Hadoop - Using map reduce for batch data analytics. | 9 |
| | **Total hours** | 45 |

Passed in BoS Meetings held on 11/08/2022 Approved in AC Meetings held on 29/08/2022,21/11/2022

| Course Code | Course Name | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| 22EC262K | IoT Applications and Web development | PEC | 3 | 0 | 0 | 3 | 2022 |

**Prerequisite:** IoT fundamentals and Architecture

**1) Course Overview**:

Goal of this course is to acquire specific scripting knowledge to develop interactive applications and to understand the basics of android application development. Also to apply the programming skills in developing application pertaining to Industrial, medical, agricultural, etc.

**2) Course Outcomes:**

After the completion of the course, the student will be able to:

| Course Outcomes | Description | Level |
|---|---|---|
| CO 1 | Apply HTML and CSS for developing web forms to acquire and process user & sensor data. | Apply |
| CO 2 | Apply interactive forms using Java Script | Apply |
| CO 3 | Implement mobile application using android SDK | Apply |
| CO 4 | Explain the need for smart systems in a distributed environment | Understand |
| CO 5 | Implement multidisciplinary case to case modelling and execute wide range of application | Apply |

**3) Syllabus**

Introduction to Mark-up language, HTML document structure, HTML forms, Style (CSS),

Multiple CSS stylesheets, DHTML. Introduction to JavaScript, Functions, DOM, Forms, and Event Handlers, Object Handlers, input validation, J2ME, application design using J2ME. Mobile app development: Android Development environment, Simple UI Layouts and layout properties, GUI

objects, Event Driven Programming, opening and closing a Database. IIoT Fundamentals and Components, Industrial Manufacturing, Monitoring, Control, Optimization and Autonomy, Introduction to Hadoop and big data analytics, Applications in agriculture, IoT enabled Smart Cities and health care

**4) Reference**


1. John Dean, Web Programming with HTML5, CSS and JavaScript, 2018, Jones and Bartlett Publishers Inc., ISBN-10: 9781284091793
2. DiMarzio J. F., Beginning Android Programming with Android Studio, 2016, 4th ed., Wiley, ISBN-10: 9788126565580
3. Fadi Al-Turjman, Intelligence in IoT- enabled Smart Cities, 2019, 1st edition, CRC Press, ISBN-10: 1138316849
4. Giacomo Veneri, and Antonio Capasso, Hands-on Industrial Internet of Things: Create a powerful industrial IoT infrastructure using Industry 4.0, 2018, Packt Publishing.
5. Wiely,F Hasan, Internet Of Things A To Z: Technologies And Applications,IEEE press.
6. Subhas Chandra Mukhopadhyay, Smart Sensing Technology for Agriculture and Environmental Monitoring, 2012, Springer, ISBN-10: 3642276377
7. Vankamamidi S. Naresh1,Suryateja S. Pericherla,Pilla Sita Rama Murty,SivaranjaniReddi, Internet of Things in Healthcare: Architecture, Applications, Challenges, and Solutions,International Journal of Computer Systems Science &Engineering,vol 35 no 6 November 2020


**5) course plan**

| Module | Contents | No. of hours |
|---|---|---|
| I | Introduction to Markup language, HTML document structure, HTML forms, Style (CSS), Multiple CSS style sheets, DHTML, Tools for image creation and manipulation, User experience design, IoT development using charts. | 9 |
| II | Introduction to JavaScript, Functions, DOM, Forms, and Event Handlers, Object Handlers, Input validation, J2ME, application design using J2ME. | 9 |
| III | Mobile app development: Android Development environment, Simple UI Layouts and layout properties, GUI objects, Event Driven Programming, opening and closing a Database. | 9 |
| IV | IIoT Fundamentals and Components, Industrial Manufacturing, Monitoring, Control, Optimization and Autonomy, Introduction to Hadoop and big data analytics | 7 |
| V | Smart Farming: Weather monitoring, Precision farming, Smart Greenhouse, Drones for pesticides.<br>Energy Consumption Monitoring, Smart Energy Meters, Home automation, Smart Grid and Solar Energy Harvesting, Intelligent Parking, Data lake services scenarios.<br>Architecture of IoT for Healthcare Applications | 11 |
| | **Total hours** | **45** |

| Course Code | Course Name | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| **22EC262L** | Chemical and Environmental Sensor | PEC | 3 | 0 | 0 | 3 | 2022 |

**1) Course Objectives**

The goal of this course is to extend engineering principles to electrochemical sensor development with a clear understanding of oxidation and reduction of an electrolytic cell, propound the conception of ion selective and enzyme stabilized electrodes for the detection of chemical

and biomolecules. It also provides expedient in applying specific interaction methods in the recognition of ion selective gases using metal oxide based sensors and to analyze the modes of vibration and develop the suitable mass and thermal sensitive sensors.

**2) Course Outcomes**

After the completion of the course the student will be able to:

| **Course Outcomes** | **Description** | **Level** |
|---|---|---|
| 1 | Analyze potential developed in any electrochemical cell. | Analyze |
| 2 | Explain with a wide range of chemical sensing methods and material characteristics to be applied in biosensors. | Understand |
| 3 | Design gas sensors for commercial and industrial applications. | Apply |
| 4 | Build knowledge of nanomaterials for biological and medical applications. | Apply |
| 5 | Develop site specific antigen-antibody sensors design for most common diseases like metabolic disorders. | Apply |
| 6 | Evaluate process design criteria for gas treatment and air quality analysis. | Apply |

**3) Syllabus**

**Electrochemistry-**Thermodynamics, , Enthalpy, Entropy, Gibbs free Energy, Law of Mass Action, simple Galvanic Cells, Electrode – Electrolyte Interface, Fluid Electrolytes, Dissociation of Salt, Solubility Product, Ion Product, pH Value, Ionic Conductivity, Ionic Mobility, Phase Diagrams.

**Transduction Elements**-Electrochemical Transducers-Introduction Potentiometry and Ion- Selective Electrodes: The Nernst Equation Voltametry and amperometry, conductivity, FET, Modified Electrodes, Thin-Film Electrodes and Screen-Printed electrodes, photometric sensors.

**Chemical Sensing Elements-** Ionic recognition, molecular recognition-chemical recognition agent, spectroscopic recognition, biological recognition agents. Immobilization of biological components, performance factors of Urea Biosensors, Amino Acid Biosensors, Glucose Biosensors and Uric Acid, factors affecting the performance of sensors.

**Potentiometric and Amperometric Sensors-**Potentiometric- Ion selective electrodes- pH linked, Ammonia linked, CO2 linked, Silversulfide linked, Iodine selective, amperometric -bio sensors and gas sensors, Amperometric enzyme electrodes: substrate and enzyme activity, Detection mode and transduction method, mediated and modified electrodes, pH glass and ion selective electrodes, solid state and redox electrodes.

**Optical Biosensor and Immunosensor Biosensor**-Fibre optic biosensor, Fluorophore and chromophore based biosensor, Bioluminescence and chemiluminescence based biosensors, Non labelled and labelled immune sensors, Microbial Biosensors: electrochemical, photo microbial , microbial thermistor, Application of microbial biosensors in glucose, ammonia, acetic acid, alcohol, BOD, methane sensing.

**Sensors in exhaust gas treatment**-Engine combustion process, Catalytic exhaust after treatment, Emission limits, Exhaust sensors and Engine control, Emission test cycles, On-board diagnose (OBD): Diagnose Strategies, Exhaust sensors for OBD, Control Sensors: Hydro-Carbon Sensors, NOx-Sensors, Temperature Sensors, Oxygen Sensors.

**Measurement techniques for air quality -** Measurement techniques for particulate matter in air. Specific gaseous pollutants analysis and control-Measurement of oxides of sulphur, oxides of nitrogen unburnt hydrocarbons, carbon- monoxide, dust mist and fog.

**4) References:**


1. Janata, Jiri,"Principles of Chemical sensors", 2014, 2nd edition, Springer, New York.
2. Brian R Eggins, “Chemical Sensors and Biosensors”, (Part of AnTS Series), 2010, 1st edition, John Wiley Sons Ltd, New York.
3. Peter Grundler, "Chemical Sensors: Introduction for Scientists and Engineers", 2011, 1st edition, Springer, New York.
4. R.G.Jackson, "Novel Sensors and Sensing", 2012, 1st edition, Philadelphia Institute of Physics.
5. 5.Florinel-Gabriel Banica “Chemical Sensors and Biosensors:Fundamentals and Applications” 2012, 1st edition, Wiley-Blackwell, New Jersey.
6. M.Campbell,"Sensor Systems for Environmental Monitoring:VolumeTwo: Environmental Monitoring", 2011, 1st Edition, Springer, New York.


**5) Course Plan**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Electrochemistry**-Thermodynamics, , Enthalpy, Entropy, Gibbs free Energy, Law of Mass Action, simple GalvanicCells, Electrode – Electrolyte Interface, Fluid Electrolytes, Dissociation of Salt, Solubility Product, Ion Product, pH Value, Ionic Conductivity, Ionic Mobility, Phase Diagrams. **Transduction Elements**-Electrochemical Transducers-IntroductionPotentiometry and Ion-Selective Electrodes: The Nernst Equation Voltametry and amperometry, conductivity, FET, Modified Electrodes, Thin-Film Electrodes and Screen-Printed electrodes, photometric sensors. | 9 |
| II | **Chemical Sensing Elements-** Ionic recognition, molecular recognition-chemical recognition agent, spectroscopic recognition, biological recognition agents. Immobilization of biological components, performance factors of Urea Biosensors, Amino Acid Biosensors, Glucose Biosensors and Uric Acid, factors affecting the performance of sensors. **Potentiometric and Amperometric Sensors-** Potentiometric- Ion selective electrodes- pH linked, Ammonia linked, CO2 linked, Silversulfide linked, Iodine selective, amperometric -bio sensors and gas sensors, Amperometric enzyme electrodes: substrate and enzyme activity, Detection mode and transduction method, mediated and modified electrodes, pH glass and ion selective electrodes, solid state and redox electrodes. | 9 |
| III | **Optical Biosensor and Immunosensor Biosensor** - Fiber optic biosensor, Fluorophore and chromophore based biosensor, Bioluminescence and chemiluminescence based biosensors, Non labelled and labelled immune sensors, MicrobialBiosensors: electrochemical, photomicrobial, Microbial thermistor. Application of microbial biosensors in glucose, ammonia, acetic acid, alcohol, BOD, methane sensing. | 9 |

| | | |
|---|---|---|
| **IV** | **Sensors in exhaust gas treatment**-Engine combustion process, Catalytic exhaust after treatment, Emission limits, Exhaust sensors and Engine control, Emission test cycles, On-board diagnose (OBD): Diagnose Strategies, Exhaust sensors for OBD, Control Sensors: Hydro-Carbon Sensors, NOx-Sensors, Temperature Sensors, Oxygen Sensors. | **9** |
| **V** | **Measurement techniques for air quality** - Measurement techniques for particulate matter in air. Specific gaseous pollutants analysis and control- Measurement of oxides of sulphur, oxides of nitrogen unburnt hydrocarbons, carbon-monoxide, dust mist and fog. | **9** |
| | **Total hours** | **45** |

| **Course Code** | **Course Name** | **Category** | **L** | **T** | **P** | **Credit** | **Year of Introduction** |
|---|---|---|---|---|---|---|---|
| 22EC262M | Nanosensors | PEC | 3 | 0 | 0 | 3 | 2022 |

**1) Course Objectives**

To provide an overview of nanosensors and nanodevices for various potential applications.

**2) Course Outcomes**

After the completion of the course the student will be able to:

| Course Outcomes | Description | Level |
|---|---|---|
| CO 1 | Interpret the physical effects involved in signal transduction. | Apply |
| CO 2 | Describe the materials used for nanosensors and the related packaging technologies | Understand |
| CO 3 | Analyse the different types of inorganic biosensors and its applications. | Analyse |
| CO 4 | Design nanosensors and bioelectronics sensors. | Apply |
| CO 5 | Design Sensors for aerospace and defence applications | Apply |

**3) Syllabus**

Sensor Characteristics: Active and Passive sensors – Static characteristic - Accuracy, offset and linearity, Dynamic characteristics - First and second order sensors. Physical effects involved in signal transduction - Photoelectric effect, Photo dielectric effect, Photoluminescence effect, Electroluminescence effect, Hall effect, thermoelectric effect, Peizoresistive effect, Piezoelectric effect, Pyroelectric effect. Materials for Nanosensors: Shape and size Dependence of Properties at Nanoscale, Surface Energy of a Solid, Core/Shell-Structured Nanoparticles, Metallic Nanoparticles and Plasmons Optical Properties of Bulk Metals and Metallic Nanoparticles, Quantum Dots, Carbon Nanotubes, Inorganic Nanowires, Nanoporous Materials: Nano Based Inorganic Sensors, One dimensional gas sensors:- gas sensing with nanostructured thin films, absorption on surfaces, metal oxide modifications by additives, surface modifications, nano optical sensors, nano mechanical sensors, plasmon resonance sensors with nano particles, AMR. Organic / Biosensors: Role of protein in nanotechnology, using protein in nanodevices, antibodies in sensing, enzymes in sensing, enzyme nanoparticle hybrid sensors, Motor proteins in sensing, transmembrane sensors Nanosensors based on Nucleotides and DNA, DNA decoders and microarrays, DNA protein conjugate based sensors, Bioelectronic sensors.NanoSensors: Temperature Sensors, Smoke Sensors, Sensors for aerospace and defence: Accelerometer, Pressure Sensor, Night Vision System, Nano tweezers, nano-cutting tools

## 4) References

1. KouroshKalantar – Zadeh, Benjamin Fry, “Nanotechnology- Enabled Sensors”, Springer
2. H.Rosemary Taylor, “Data acquisition for sensor systems”, Chapman & Hall, 1997.
3. Jerome Schultz, Milan Mrksich, Sangeeta N. Bhatia, David J. Brady, Antonio J. Ricco, David
4 R. Walt, Charles L. Wilkins, “Biosensing: International Research and Development”, Springer
5. Ramon Pallas-Areny, John G. Webster, “Sensors and signal conditioning” John Wiley & Sons, 2001. 6. Peter Hauptmann and Tim Pownall, Sensors: Principles and Applications , Prentice Hall, 2003
7. Vinod Kumar Khanna, Nanosensors: Physical, Chemical, and Biological, CRC, 2012

## 5) Course Plan

| Module | Contents | No. of hours |
|---|---|---|
| I | **Sensor Characteristics**: Active and Passive sensors – Static characteristic - Accuracy, offset and linearity, Dynamic characteristics - First and second order sensors.<br>**Physical effects involved in signal transduction** - Photoelectric effect, Photo dielectric effect, Photoluminescence effect, Electroluminescence effect, Hall effect, Thermoelectric effect, Peizoresistive effect, Piezoelectric effect, Pyroelectric effect | 9 |
| II | **Materials for Nanosensors**<br>Shape and size Dependence of Properties at Nanoscale, Surface Energy of a Solid, Core/Shell-Structured Nanoparticles, Metallic Nanoparticles and Plasmons Optical Properties of Bulk Metals and Metallic Nanoparticles, Quantum Dots, Carbon Nanotubes, Inorganic Nanowires, Nanoporous Materials | 9 |
| III | **Nano Based Inorganic Sensors**<br>One dimensional gas sensors:- gas sensing with nanostructured thin films, absorption on surfaces, metal oxide modifications by additives, surface modifications, nanooptical sensors, nano mechanical sensors, plasmon resonance sensors with nano particles, AMR | 9 |
| IV | **Organic / Biosensors**<br>Role of protein in nanotechnology, using protein in nanodevices, antibodies in sensing, enzymes in sensing, enzyme nanoparticle hybrid sensors, Motor proteins in sensing, transmembrane sensors Nanosensors based on Nucleotides and DNA, DNA decoders and microarrays, DNA protein conjugate based sensors, Bioelectronic sensors. | 9 |
| V | **Nano Sensors**<br>Temperature Sensors, Smoke Sensors, Sensors for aerospace and defense: Accelerometer, Pressure Sensor, Night Vision System, Nano tweezers, nano-cutting tools | 9 |

Passed in BoS Meetings held on 11/08/2022 Approved in AC Meetings held on 29/08/2022,21/11/2022

| | | |
|---|---|---|
| | **Total hours** | **45** |

| Course Code | Course Name | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| 22EC262N | Deep Learning | PEC | 2 | 0 | 2 | 3 | 2022 |

**1) Course Objectives**

The purpose of the course is to introduce the fundamental concepts of deep learning frameworks. The course covers the basic theoretical concepts of deep learning for solving engineering problems and provides a comprehensive foundation to artificial neural networks, neuro-modeling, and their applications. This course will help learners to explore the supervised and unsupervised learning paradigms and shallow/deep neural networks.

**2) Course Outcomes**

After the completion of the course the student will be able to:

| Course Outcomes | Description | Level |
|---|---|---|
| CO 1 | Compare shallow neural networks and deep neural networks for supervised and unsupervised learning. | Apply |
| CO 2 | Develop neural networks for classification, regression and clustering. | Apply |
| CO 3 | Explain the foundations of neural networks, how to build neural networks and learn how to lead successful deep learning projects. | Understand |
| CO 4 | Identify the deep neural network more appropriate for various types of learning tasks in various domains. | Apply |
| CO 5 | Implement deep learning algorithms to solve real world problems. | Apply |

**3) Syllabus**

Introduction to deep learning, difference between conventional neural network and deep neural network, Convolutional Neural Network, Transfer learning, Recurrent neural network, Deep Learning tools and applications.

**4) References**


1. Bengio, Yoshua, Ian J. Goodfellow, and Aaron Courville. "Deep learning" 2015, MIT Press.
2. Josh Patterson and Adam Gibson, “Deep Learning- A Practitioner’s Approach” O’Reilly Media Inc., 2017, USA.
3. Bishop, C. ,M., Pattern Recognition and Machine Learning, Springer, 2011.
4. Bengio, Yoshua. "Learning deep architectures for AI- Foundations and trends in Machine Learning, 2(1)- 2009.
5. Rich E and Knight K, “Artificial Intelligence”, 2011, 2 nd ed., TMH, New Delhi

## 5) Course Plan

| Module | Contents | No. of hours |
|---|---|---|
| I | **Deep Feed Forward Neural Networks-**Feed forward neural networks- deep model- output units and hidden units, training deep models- hyper parameters and validation sets-cross validation, capacity, overfitting and under fitting, bias vs variance trade off, cross validation - vanishing gradient problem, new optimization methods (adagrad, adadelta, rmsprop, adam), regularization methods (dropout, batch normalization, dataset augmentation), early stopping. | **8** |
| II | **Convolutional Neural Networks-**Convolution operation- kernel and feature map, sparse connectivity, equi-variance through parameter sharing, pooling function for invariant representation, convolution and pooling as strong prior, convolution with stride, effect of zero padding. | **10** |
| III | **ConvNet and Transfer learning-**Single-channel and multi-channel data types used in ConvNet, variants of basic convolution- locally connected, tiled ConvNet- spatial separable and depthwise separable convolutions, fully connected layers, ConvNet architecture- layer patterns, layer sizing parameters,case studies- LeNet, AlexNet. Transfer learning – fully and partially. | **10** |
| IV | **Recurrent Neural Networks-**Sequence learning with neural nets, unrolling the recurrence, training RNN- Backpropagation through time (BPTT), vanishing gradient problem, Gated recurrent unit (GRU), Long short term memory (LSTM), Bidirectional LSTMs, bidirectional RNNs. | **8** |

| | | |
|---|---|---|
| **V** | **Deep Learning Tools and Applications**-Tools: Keras,Tensor Flow and Deep Learning packages like Numpy, Pandas Applications: Object detection with RCNN, YOLO, SSD, 3D-CNN. Speech recognition with RNN. | **9** |
| | **Total hours** | **45** |

Computer based simulations using MATLAB/Python to be given

| **Course Code** | **Course Name** | **Category** | **L** | **T** | **P** | **Credit** | **Year of Introduction** |
|---|---|---|---|---|---|---|---|
| 22EC262O | Embedded Systems Design | PEC | 2 | 0 | 2 | 3 | 2022 |

**1) Course Objectives**

This course introduces the role of different hardware, software, and firmware components involved in the design and development of embedded systems. This course aims to introduce the practical concepts of programming a microcontroller, interfacing of external peripherals to microcontroller and debugging of microcontroller based embedded electronic systems.

**2) Course Outcomes**

After the completion of the course the student will be able to:

| Course Outcomes | Description | Level |
|---|---|---|
| CO 1 | Identify the components of embedded systems and various steps in embedded system design process. | Apply |
| CO 2 | Describe the different standard communication protocols used in embedded systems. | Apply |
| CO 3 | Explain the architecture and programming model of ARM Cortex M3 processor. | Apply |
| CO 4 | Develop programs to interface ARM cortex M3 processor with peripherals. | Apply |
| CO 5 | Design an embedded system application using ARM cortex M3 processor. | Apply |

**3) Syllabus**

Introduction to Embedded Systems - Overview of Communication Buses and protocols- Designing Embedded Systems with ARM Cortex M3 Processor- Interfacing ARM Cortex M3 to peripheral devices- Embedded System Industry Case Studies and Applications.

**4) References:**


1. Joseph Yiu, "The Definitive Guide to the ARM Cortex M3", Second Edition, Elsevier Inc., 2010.
2. K.V. Shibu, *Introduction to Embedded Systems*, 2e, McGraw Hill Education India, 2016.
3. Wayne wolf, *Computers as Components: Principles of Embedded Computing System Design*,Morgan Kaufmann; 2 ed,2008.
4. Lyla B. Das, , 1/e, Lyla B. Das, Embedded Systems, 2012 *Embedded Systems: An Integrated Approach*
5. J.R.Gibson, *ARM Assembly Language –An Introduction*, Lulu Press, 2010


**5) Course Plan**

| Module | Contents | No. of hours |
|---|---|---|
| I | Introduction to Embedded Systems:<br>General purpose computers vs Embedded System-Characteristics of embedded systems, Classification of embedded systems<br>Components of embedded system hardware– Software embedded into the system<br>Embedded system design process – Typical applications<br>Embedded Product Development Life Cycle (EDLC) – Different Phases of EDLC- EDLC Approaches<br>Challenges in Embedded system design | 8 |
| II | Overview of Communication Buses and protocols:<br>Serial Bus Communication Protocols, Parallel Bus Protocols, Internet Embedded Systems, Network Protocols, Wireless and Mobile System Protocols. | 10 |
| III | Designing Embedded Systems with ARM Cortex M3 Processor:<br>Evolution of ARM architecture, ARM Design Philosophy & RISC Architecture, programming model, Cortex M3 Processor architecture, registers and flags, operation modes, memory map, Nested Vector Interrupt Controller, power management.<br>Developing programs with ARM Cortex microcontrollers - Simulating programs on Keil IDE | 10 |
| IV | Interfacing ARM Cortex M3 to peripheral devices:<br>Introduction to external peripherals - Interfacing IO devices – LEDs, Switches, Buzzer, Seven Segment Display, LCD, Keypad (4*4), DC Motor, Stepper Motor. | 8 |

| | | |
|---|---|---|
| **V** | Embedded System Industry Case Studies and Applications:<br>Interfacing Sensors -IR sensor, Ultrasonic Sensor, Temperature and Humidity sensor, Soil Moisture Sensor, PIR sensor etc.<br>Consumer applications, Industrial Automation, Biomedical applications, Gaming, IoT etc. | **9** |
| | Total hours | **45** |

**Embedded Systems Programming Lab**

1. Write a program to interface LEDs and buzzer.
2. Write a program to interface switch.
3. Write a Program to design up counter/down counter using seven segment display.
4. Write a program to display characters on Alphanumeric LCD.
5. Write a program to interface keypad and LCD.
6. Write a program to interface stepper motor.
7. Write a program to identify the presence of a person in a room using a PIR sensor.
8. Write a program to find the distance of an object using ultrasonic sensor.
9. Design a burglar alarm system capable of detecting and warning about the presence of an intruder.
10. Design a weather station using temperature and humidity sensor.
11. Write a program to build I2C communication between two microcontrollers.
12. Write a program to build SPI communication between two microcontrollers.

| **Course Code** | **Course Name** | **Category** | **L** | **T** | **P** | **Credit** | **Year of Introduction** |
|---|---|---|---|---|---|---|---|
| **22EC262P** | RF And Microwave Sensors | PEC | 3 | 0 | 0 | 3 | 2022 |

**1) Course Objectives**

The objective of this course is

a) To introduce the students with different RF and Microwave sensors,
b) To familiarize antenna design with a good understanding of their parameters and applications.
c) To introduce comprehensive knowledge of wearable antennas.
d) To explore and understand basics of RFID technology

**2) Course Outcomes**

After the completion of the course the student will be able to:

| **Course Outcomes** | **Description** | **Level** |
|---|---|---|
| CO 1 | Select a proper antenna design to be used in the RF spectral region . | Apply |
| CO 2 | Model specific radiation pattern and evaluate them in different domains | Analyse |
| CO 3 | Correlate the principle behind different radar systems and determine various applications based on the radar systems. | Apply |
| CO 4 | Apply the basic knowledge in the measurement of RF radiation. | Apply |
| CO 5 | Gain knowledge about the RFID technology | Apply |

**3) Syllabus**

Basics of Antenna Theory, Antenna for personal area communication, Radio Channel Characterization and Effect of Wearable Antennas Radar Systems, Applications of Radar, defense factors affecting the performance of RADAR, Radiometers, Microwave power Sensors, Thermocouple Sensors, RFID Sensors and technology.

**4) References**

1. Finkenzeuer Klaus, “RFID Handbook”, 2011, 3rd edition, John Wiley and Sons, New Jersey.
2. Constantine A. Balanis, “Antenna Theory Analysis and Design”, 2016, 4th edition, John Wiley and Sons, New Jersey

3. B. Hoffman - Wellenhof, H.Lichtenegger and J.Collins, "GPS: Theory and Practice ", 5th edition, Springer, New York, 2012.
4. Lillesand & Kiefer, “Remote Sensing and Image Interpretation”, 2011, 6th edition, John Wiley and Sons, New Jersey.

**5) Course Plan**

| Module | Contents | No.of hours |
|---|---|---|
| I | **Antenna for personal area communication**: Microwave Antenna-Introduction, types of Antenna, fundamental parameters of antennas, radiation mechanism, Fresnel and Fraunhofer regions. Antenna for communication and Antenna for sensing, radiometer and radar.<br>Concepts of Printed Antennas, Broadband Microstrip Patch Antennas, Antennas for Wearable Devices, Design Requirements, Modeling and Characterization of Wearable Antennas, WBAN Radio Channel Characterization and Effect of Wearable Antennas, Domains of Operation, Sources on the Human Body, Compact Wearable Antenna for different applications. | 10 |
| II | **Radar, Applications of Radar:** Introduction to RADAR, RADAR range equation, MTI and pulse Doppler RADAR, Tracking RADAR, SAR pulse RADAR, CW RADAR.<br>Automotive, remote sensing, agriculture, medicine, detection of buried objects, NDT, defense factors affecting the performance of RADAR, RADAR transmitters, Receivers | 9 |
| III | **Radiometers:** Radiative transfer theory, SMMR, Types of radiometers - and Bolometers, Applications in automotive, agriculture, medicine, weather forecasting | 9 |
| IV | **Microwave power Sensors**: Diode Sensors, Diode detector principles, dynamic range average power sensors, signal waveform effects on the measurement uncertainty of diode sensors. Thermocouple Sensors: Principles of Thermocouple sensor, power meters for thermocouple sensors. | 8 |
| V | **RFID Sensors**: Introduction, Components of RFID systems, hardware and software components, RFID standards, RFID applications | 9 |

Passed in BoS Meetings held on 11/08/2022 Approved in AC Meetings held on 29/08/2022,21/11/2022

| | | |
|---|---|---|
| | **Total hours** | **45** |

| Course Code | Course Name | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| **22EC262Q** | Microsystems And Hybrid Technology | PEC | 3 | 0 | 0 | 3 | 2022 |

**1) Course Objectives**:

1. To introduce the fundamental concepts of MEMS based sensors and actuators.
2. To acquaint the students with various materials and material properties for Microsystem designing.
3. To provide comprehensive understanding of various micromachining techniques and expose the students to design, simulation and analysis software.
4. Enhancing the basics of thick film and hybrid technologies for sensor development.

**2) Course Outcomes**

After the completion of the course the student will be able to:

| Course Outcomes | Description | Level |
|---|---|---|
| CO1 | Apply fundamental concepts of MEMS and Microsystems | Apply |
| CO2 | Apply the concepts of various sensors and actuators. | Apply |
| CO3 | Compare the scaling effects in miniaturizing devices. | Apply |
| CO4 | Interpret various micromachining techniques and design, analysis and applications of various MEMS devices micromachining tools and techniques | Apply |
| CO5 | Acquainted with thick film and hybrid technologies for sensor development. | Apply |
| CO6 | Incorporate simulation and micro-fabrication knowledge for developing various MEMS devices. | Analyze |

**3) Syllabus**

Introduction to MEMS, Microsystems, Sensors and Actuators, Materials for Microsystems, Scaling Effects in Microsystems, Micromachining Technologies, MEMS and micro systems applications, Hybrid Technology.

**4) References**


1. G.K.Ananthasuresh, K J Vinoy, S Gopalakrishnan, KN Bhatt, V K Aatre," Micro and smart systems", 2012, 1st ed., Wiley, New York.
2. Tai-Ran Hsu, “MEMS & Microsystem, Design and Manufacture”, 2017, 1st ed., McGraw Hill India, New Delhi.
3. Mahalick NP, "MEMS", 2017, 1st ed., Tata McGraw Hill, New Delhi
4. Wolfgang Menz, Jürgen Mohr, Oliver Paul, "Microsystem Technology", 2011, 2nd ed., Wiley, New York.
5. Banks H.T. Smith R.C. and Wang Y.Smart, ‘Material Structures – Modeling, Estimation and Control’, 2011, 1st ed., John Wiley & Sons, NewYork.
6. MassoodTabib – Arar, ‘Microactuators – Electrical, Magnetic Thermal, Optical, Mechanical, Chemical and Smart structures’, 2014, 1st ed., Kluwer Academic publishers, New York .


**5) Course Plan**

| Module | Contents | No. of hours |
|---|---|---|
| I | MEMS and Microsystems, Miniaturization, Benefits of Microsystems, Typical MEMS and Microsystems products, Evolution of Micro fabrication and Applications.<br>Various domains and classification of transducers: electrostatic, piezoelectric, thermal.<br>Sensing principles: electrostatic, resistive, chemical etc. SAW devices. Micro actuators, Design of Micro accelerometers, Engineering Science for Microsystem design and fabrication. | 9 |
| II | Silicon, Silicon compounds, Silicon Piezo resistors, Gallium Arsenide, Quartz, Piezoelectric materials, Polymers, Shape Memory Alloys, ferroelectric and rheological materials. | 9 |
| III | Introduction to Scaling, Scaling laws, Scaling in Geometry, Scaling in Rigid body dynamics, Scaling in Electromagnetic, Electrostatic, magnetic, optical and Thermal domains. Scaling in Fluid mechanics. | 9 |
| IV | Overview of silicon processes techniques, Photolithography, Ion Implantation, and Diffusion, Chemical Vapor Deposition, Physical vapor Deposition, Epitaxy, Etching, Bulk micromachining, Surface Micromachining, LIGA and other techniques. | 9 |
| V | Details of application in actual systems, introduction to RF- MEMS, MOEMS, future of smart structures and MEMS leading to NEMS. Packaging, test and calibration of MEMS.<br>Thick-film and hybrid technology in sensor production. Basic materials, components, manufacturing Screen manufacturing, Screen printing, Parameters, Comparison: thick- vs. Thinfilm technology Structure dimensions, Assembly and packaging Surface mount technology (SMT) Active and passive devices (SMD), Connection technologies, Packaging. | 9 |
| | **Total hours** | **45** |

Passed in BoS Meetings held on 11/08/2022 Approved in AC Meetings held on 29/08/2022,21/11/2022

| Course Code | Course Name | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| **22EC262R** | Digital VLSI Design | PEC | 3 | 0 | 0 | 3 | 2022 |

**1) Course Objectives**

The course helps the students to analyse the performance of various VLSI circuits and design digital VLSI circuits using different logic styles.

**2) Course Outcomes**

After the completion of the course the student will be able to:

| Course Outcomes | Description | Level |
|---|---|---|
| CO 1 | Analyse the performance of CMOS inverter | Apply |
| CO 2 | Design logic circuits using different logic styles | Apply |
| CO 3 | Design arithmetic circuits such as adders and multipliers | Apply |
| CO 4 | Design memory arrays like RAM, ROM, CAM etc. | Apply |
| CO 5 | Discuss the power reduction techniques in VLSI circuits | Understand |

**3) Syllabus**

**CMOS Inverter**: Static and Dynamic Behaviour, Performance, Power, Energy, Delay, CMOS Circuit, Logic Design.

**Advanced techniques in CMOS Logic Circuits**: Mirror circuits, Pseudo NMOS, Tri-state circuits, Dynamic CMOS Logic circuits.

**Arithmetic Circuits in CMOS VLSI:** Bit Adder Circuits, Ripple Carry Adder, Carry Look Ahead Adders, High speed adders, Multipliers.

**Memory Arrays:** Memory classification, ROM, Read Write Memories. Content - Addressable or Associative Memories, Memory Peripheral Circuits.

**Low power design**: Scaling Versus Power consumption, Various Power reduction techniques.

## 4) References


1. John P. Uyemura, *Introduction to VLSI Circuits and Systems*, Wiley Student Edition 2006.
2. Jan M Rabaey, *Digital Integrated Circuits - A Design Perspective*, Pearson Education, 2nd Edition, 2016.
3. Neil H. E. Weste and David Harris, *Principles of CMOS VLSI Design*, 4th Edition, Pearson, 2010.
4. Sung-Mo Kang & Yusuf Leblebici, *CMOS Digital Integrated Circuits - Analysis & Design*, McGraw-Hill Education, 4th Edition, 2014.


## 5) Course Plan

| Module | Contents | No. of hours |
|---|---|---|
| I | **CMOS Inverter:** Static Behaviour, Performance of CMOS Inverter - Dynamic Behaviour, Power, Energy and Energy-Delay, Designing Logic gates using CMOS logic – Complementary CMOS logic, Ratioed Logic and Pass Transistor Logic. | **8** |
| II | **Advanced techniques in CMOS Logic Circuits:** Mirror circuits, Pseudo NMOS, Tri-state circuits, Clocked CMOS, Dynamic CMOS Logic circuits, Dual Rail Logic Networks. | **8** |
| III | **Arithmetic Circuits in CMOS VLSI:** Bit Adder Circuits, Ripple Carry Adder, Carry Look Ahead Adders, Other Highspeed adders, Multipliers - Parallel multiplier, Wallace Tree and Dadda multiplier. | **10** |
| IV | **Memory Arrays:** Memory classification, Memory Core - Read Only Memories, Non-volatile Read Write Memories. Content - Addressable or Associative Memories, Memory Peripheral Circuits - Address Decoders, Sense Amplifiers. | **10** |
| V | **Low power design:** Scaling Versus Power consumption, Power reduction techniques: Clock gating, Dynamic power reduction, Static power reduction, Power gating, Sleep transistors. | **9** |
| | **Total hours** | **45** |

| Course Code | Course Name | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| 22EC262S | Fiber Optic Sensors | PEC | 3 | 0 | 0 | 3 | 2022 |

**1) Course Objectives**

The course introduces the different aspects of fiber optic sensors and its application.

**2) Course Outcomes**

After the completion of the course the student will be able to:

| Course Outcomes | Description | Level |
|---|---|---|
| CO 1 | Describe the concept of a basic optical fiber technology | Understand |
| CO 2 | Model fiber grating sensors and Fabry-Perot Interferometer Sensors | Apply |
| CO 3 | Analysis of Polarimetric Sensors | Analyse |
| CO 4 | Explain passive, active detection schemes and multiplexing techniques | Understand |
| CO 5 | Developfiber optic sensors for various applications | Apply |

**3) Syllabus**

Review of optical fibre technology, Introduction to fiber optic sensors, Fiber Bragg grating sensors, Fabry-Perot Interferometer Sensors, Interrogation Techniques Passive and active detection schemes,multiplexing techniques, applications of Fiber Optic Sensors

**4) References**

1. Shizhuo Yin, Paul B Ruffin, Francis T. S. Yu " Fiber Optic Sensors", CRC

Press, Taylor & Francis group, 2nd edition, 2008
2. Wojtek J Bock, Israel Gannot, Stoyan Tanev " Optical waveguide sensing and Imaging, Springer, 2006

**5) Course Plan**

| Module | Contents | No. of hours |
|---|---|---|
| I | Review of optical fibre technology: optical fiber, sources,amplifiers and detectors;Introduction to fiber optic sensors, classification: - based on sensing location, operating principle & applications. | 9 |
| II | Fiber Bragg gratings, long period gratings and their applications. Modelling of fiber grating sensors, multi-parameter sensitivity problem. Fabry-Perot Interferometer Sensors: Fabry-Perot Interferometer - theory and sensor configurations. Embedded sensors. | 9 |
| III | Polarimetric Sensors Polarization, Jones Matrix calculations, Birefringent Optical fiber, Polarimetric sensors, Temperature sensing, Coherence, Impact detection.<br>Optical current measurement, Optical voltage sensor, Optical network instability diagnosis. | 9 |
| IV | Interrogation Techniques Passive detection schemes: - The use of linearly dependent devices, Power detection, CCD spectrometer interrogator.<br>Active detection schemes: -Acousto optic tunable filter interrogator, matched fiber Bragg grating pair interrogator. Michelson Interferometer interrogator<br>Multiplexing techniques | 9 |
| V | Applications of Fiber Optic Sensors Applications to large composite and concrete structures- Mines, Dams, Aircraft etc. Applications to electric power industry- load monitoring of power transmission lines, winding temperature measurement, electric current measurement. Applications to medicine- Temperature, ultrasound. Chemical sensing. Applications to oil and gas industry | 9 |
| | **Total hours** | **45** |

## ASSESSMENT PATTERN

### (i) CORE COURSES

Evaluation shall include application, analysis and design based questions (for both continuous internal evaluation and end semester examination).

**Continuous Internal Evaluation: 40 marks**

Micro project/ Course based project: 20 marks

Course based task/ Seminar/ Quiz : 10 marks

Continuous assessment Test (CAT), 1 No. : 10 marks
(CAT shall include minimum 80% of the Syllabus)

The project shall be done individually. Group projects not permitted.

**End Semester Examination (ESE): 60 marks**

### (ii) ELECTIVE COURSES

Evaluation shall include application, analysis and design based questions (for both continuous internal evaluation and end semester examination).

**Continuous Internal Evaluation: 40 marks**

Preparing a review article based on peer reviewed Original publications (Minimum 10 publications shall be referred) : 15 marks

Course based task/ Seminar/ Data collection and interpretation: 15 marks

Continuous assessment Test (CAT), 1 No. : 10 marks
(CAT shall include minimum 80% of the Syllabus)

**End Semester Examination: 60 marks**

### (iii) RESEARCH METHODOLOGY & IPR/AUDIT COURSE

**Continuous Internal Evaluation: 40 marks**

Course based task : 15 marks

Seminar/ Quiz : 15 marks

Continuous assessment Test (CAT), 1 No. : 10 marks
(CAT shall include minimum 80% of the Syllabus)

**End Semester Examination: 60 marks**

**(iv) INTERNSHIP**

**Continuous Internal Evaluation: 50 marks**

Student's diary/ Daily Log: 25 Marks
Evaluation done by the Industry: 25 Marks

**End Semester Evaluation (External Evaluation): 50 Marks**

Internship Report - 25 Marks

Comprehensive Viva Voce - 25 Marks

**(v) LABORATORY COURSES**

The laboratory courses will be having only Continuous Internal Assessment and carries 100 marks.

**(vi) INDUSTRY BASED ELECTIVES/ INTERDISCIPLINARY ELECTIVES**

**Assessment pattern for Interdisciplinary electives:**

**Continuous Internal Evaluation: 40 marks**

Preparing a review article based on peer reviewed Original publications (Minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Continuous assessment Test (CAT), 1 No. : 10 marks
(CAT shall include minimum 80% of the Syllabus)

**End Semester Examination: 60 marks**

**Assessment pattern for Industry based electives:**

**Continuous Internal Evaluation: 40 marks**

The continuous internal evaluation will be done by the expert in the Industry/course faculty handling the course.

Micro project/Course based project: 20 marks

Course based task/ Seminar/ Quiz: 10 marks

Continuous assessment Test (CAT), 1 No. : 10 marks
(CAT shall include minimum 80% of the Syllabus)

The project shall be done individually.

**End Semester Examination: 60 marks**

**(vii) MOOC COURSES**

MOOC Course to be successfully completed before the commencement of fourth semester (starting from semester 1) and the certificate is to be duly produced for verification. A credit of 2 will be awarded to all students who ever successfully complete the MOOC course as per the evaluation pattern of the respective agency conducting the MOOC.

**(viii) MINIPROJECT**

**Interim evaluation:**

40 marks (20 marks for each review)

**Final evaluation**

Evaluation by a Committee: 35 marks

The committee will evaluate the level of completion and demonstration of functionality/specifications, clarity of presentation, oral examination, work knowledge and involvement).

Report: 15 marks

The committee will evaluate the technical content, adequacy of References, templates followed and permitted plagiarism level is not more than 25%).

Supervisor/ Guide: 10 marks

**(ix) RESEARCH PROJECT/DISSERTATION**

**Research Project:**

Students choosing track 2 shall carry out the research project only in the college, under the guidance of a supervisor assigned by the DLAC.

**Dissertation:**

All categories of students in track 1 are to carry out the dissertation in the college or can work either in any CSIR/ industrial R&D organization/ any other reputed Institute which have facilities for dissertation work in the area proposed.

**Marks distribution:**

Phase I: Total marks: 100 marks, CIA = 100 marks

Phase II: Total marks: 200 marks, CIA = 100 marks, ESE = 100 marks

**(x) TEACHING ASSISTANCESHIP (TA)**

All M.Tech students irrespective of their category of admission shall undertake TA duties for a minimum duration as per the curriculum. Being a TA, the student will get an excellent opportunity to improve their expertise in the technical content of the course, enhance communication skills, obtain a hands-on experience in handling the experiments in the laboratory and improve peer interactions.