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HINDUSTAN

INSTITUTE OF TECHNOLOGY & SCIENCE

(DEEMED TO BE UNIVERSITY)

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

CURRICULUM AND SYLLABUS

Under CBCS

(Applicable for Students admitted from Academic Year 2020-21)

M. Tech. ELECTRICAL AND ELECTRONICS ENGINEERING

(Specialization in IoT & Embedded systems)

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

SCHOOL OF ELECTRICAL SCIENCES

HINDUSTAN INSTITUTE OF TECHNOLOGY & SCIENCE
VISION AND MISSION

Motto

To Make Every Man A Success And No Man A Failure

Vision

To be an International Institute of Excellence, providing a conducive environment for education with a strong emphasis on innovation, quality, research and strategic partnership blended with values and commitment to society.

Mission

- To create an ecosystem for learning and world class research.
- To nurture a sense of creativity and innovation.
- To instill highest ethical standards and values with a sense of professionalism.
- To take up activities for the development of Society.
- To develop national and international collaboration and strategic partnership with industry and institutes of excellence.
- To enable graduates to become future leaders and innovators.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
VISION AND MISSION

Vision of the Department

To educate the students in the recent developments of emerging fields in Electrical and Electronics Engineering, to encourage research activities, innovative techniques and to develop managerial abilities so as to make them excel globally with ethical values.

Mission of the Department

M1: To empower students with state-of-art Knowledge and Technological skills in Electrical and Electronics Engineering.
M2: To upgrade curriculum continuously to meet the Emerging Industrial Requirement.
M3: To mould students for Research, Innovation and Entrepreneurship.
M4: To inculcate Managerial and Professional capabilities with Ethics and Human values.

M. Tech. Electrical and Electronics Engineering
Specialization in IoT and Embedded systems

PROGRAMME EDUCATIONAL OBJECTIVES (PEO)

The program is expected to enable the students to

PEO I Design and develop innovative products and services in the field of IoT and embedded systems

PEO II keeps abreast with the latest technology and toolset.

PEO III Communicate effectively to propagate ideas and promote teamwork

PEO IV Attain intellectual leadership skills to cater to the changing needs of power industry, academia, society and environment

PROGRAM OUTCOMES (PO)

At the end of this program, graduates will be able to

1. **A knowledge base for engineering:** Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.
2. **Problem analysis:** An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions
3. **Investigation:** An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data and synthesis of information in order to reach valid conclusions.
4. **Design:** An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.
5. **Use of engineering tools:** An ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.
6. **Individual and teamwork:** An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.
7. **Communication skills:** An ability to communicate complex engineering concepts within the profession and with society at large. Such ability includes reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.
8. **Professionalism:** An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.
9. **Impact of engineering on society and the environment:** An ability to analyze social and

environmental aspects of engineering activities. Such ability includes an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society, the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.

10. **Ethics and equity:** An ability to apply professional ethics, accountability, and equity.
11. **Economics and project management:** An ability to appropriately incorporate economics and business practices including project, risk, and change management into the practice of engineering and to understand their limitations.
12. **Life-long learning:** An ability to identify and to address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge

PROGRAM SPECIFIC OUTCOMES (PSO)

PSO1: An ability to design and develop environmental friendly IoT enabled embedded devices.

PSO2: To introduce application of embedded systems for conversion, control and automation.

PSO3: Apply appropriate techniques and modern Engineering hardware and software tools in IoT enabled embedded devices to engage in life- long learning and to successfully adapt in multi-disciplinary environments.

PSO4: Understand the impact of Professional Engineering solutions in societal and environmental context, commit to professional ethics and communicate effectively.

M.TECH – EEE -Specialization in IoT & Embedded systems									
(65 CREDIT STRUCTURE)									
SEMESTER - I									
SL. NO	COURSE CATEGORY	COURSE CODE	NAME OF THE COURSE	L	T	P	C	S	TCH
THEORY									
1	PC	MAA3705	Advanced Mathematics for Electrical Engineers	2	2	0	**3**	1	4
2	PC	EED1701	Advanced Embedded Controllers$	3	0	0	**3**	1	3
3	PC	EED1702	PYTHON for IoT	3	0	0	**3**	1	3
4	DE		Department Elective – I	3	0	0	**3**	1	3
5	DE		Department Elective- II	3	0	0	**3**	1	3
6	PC	ZZZ3715	Research Methodology & IPR	2	0	0	**2**	1	2
PRACTICALS									
7	PC	EED3791	Embedded systems Laboratory	0	0	3	**2**	0	3
8		EED3780	Mini project	0	0	0	**2**	1	
Total				16	2	3	**21**	5	21
SEMESTER – II									
SL. NO	COURSE CATEGORY	COURSE CODE	NAME OF THE COURSE	L	T	P	C	S	TCH
THEORY									
1	PC	EED1703	Internet of Things	3	0	0	**3**	1	3
2	PC	EED1704	Communication Protocols for IoT	3	0	0	**3**	1	3
3	PC	EED1705	Embedded system design	3	0	0	**3**	1	3
4	DE		Department Elective – III	3	0	0	**3**	1	3
5	NE		Non Department Elective - I	3	0	0	**3**	1	3
PRACTICALS									
6	PC	EED3792	IoT enabled embedded devices Laboratory	0	0	3	**2**	0	3
7	PC	EED3796	Seminar	0	0	3	**2**	2	3
Total				18	0	9	**19**	10	21

M.TECH – EEE -Specialization in IoT & Embedded systems									
(65 CREDIT STRUCTURE)									
SEMESTER – III									
SL. NO	COURSE CATEGORY	COURSE CODE	NAME OF THE COURSE	L	T	P	C	S	TCH
THEORY									
1	DE		Department Elective – IV	3	0	0	**3**	1	3
PRACTICALS									
1	PC	EED3797	Internship	0	0	3	**2**	2	3
2	PC	EED3798	Project Phase –I	0	0	16	**8**	2	16
Total				0	0	19	**13**	4	21
SEMESTER – IV									
SL. NO	COURSE CATEGORY	COURSE CODE	NAME OF THE COURSE	L	T	P	C	S	TCH
1	PC	EED3799	Project Phase –II	0	0	24	**12**	2	24
Total				0	0	24	**12**	2	24

Sl. No	Course Code	Course Title	L	T	P	C	TCH
DEPARTMENT ELECTIVE I							
1	EED3721	Sensor-Concepts and Techniques$	3	0	0	3	3
2	EED3722	Micro Electro Mechanical Systems	3	0	0	3	3
3	EED3723	Sensor networks & IoT	3	0	0	3	3
4	EED3724	Machine Learning	3	0	0	3	3
DEPARTMENT ELECTIVE II							
1	EED3725	Real Time Operating System$	3	0	0	3	3
2	EED3726	Electric and Hybrid Vehicles#	3	0	0	3	3
3	EED3727	Embedded IoT$	3	0	0	3	3
4	EED3728	Smart Grid Technologies & IOT#	3	0	0	3	3
DEPARTMENT ELECTIVE III							
1	EED3729	Embedded system for Electric and Hybrid Vehicles#	3	0	0	3	3
2	EED3730	Artificial intelligence in electrical drives#	3	0	0	3	3
3	EED3731	Smart Systems$	3	0	0	3	3
4	EED3732	Energy Storage Systems#	3	0	0	3	3
DEPARTMENT ELECTIVE IV							
1	EED3733	**INDUSTRY 4.0 and INDUSTRIAL INTERNET OF THINGS**	3	0	0	3	3
2	EED3734	Energy Harvesting Technologies and Power Management for IoT Devices	3	0	0	3	3
3	EED3735	Embedded Systems in Biomedical Applications	3	0	0	3	3
4	EED3736	Embedded Systems in Robotics	3	0	0	3	3

LIST OF NON DEPARTMENTAL ELECTIVES OFFERED BY ELECTRICAL DEPARTMENT									
SEM	**COURSE CATEGORY**	**COURSE CODE**	**NAME OF THE COURSE**	**L**	**T**	**P**	**C**	**S**	**TCH**
2	NE	EEA3741	Photovoltaic and fuel cell systems#	3	0	0	3	1	3
2	NE	EEA3742	Wind and hydro energy systems#	3	0	0	3	1	3
2	NE	EEA3743	Biomass energy systems#	3	0	0	3	1	3

Credit summary

SEM	Credit
I	21
II	19
III	13
IV	12
Total	**65**

SEMESTER – I

COURSE TITLE	**ADVANCED MATHEMATICS FOR ELECTRICAL ENGINEERS**			**CREDITS**	**3**
Course Code	**MAA3705**	**Course Category**	**PC**	**L-T-P-S**	**3- 0- 0- 1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL-3**				

CO	**COURSE OUTCOMES**	**PO**
Prerequisites: Nil		

MODULE 1 – ADVANCEDMATRIXTHEORY(9L)

Matrixnorms–Jordancanonicalform–Generalizedeigenvectors–Singularvalue decomposition – Pseudo inverse – Least square approximations – QR algorithm

MODULE 2 – NUMERICAL SOLUTION OFALGEBRAICEQUATIONS(9L)

Solutions of large systems of equations using Gauss Elimination method; principle behind sparsity and optimal ordering; relevance of the solution technique for engineering applications.

MODULE 3 – NUMERICAL SOLUTION OF ORDINARYDIFFERENTIALEQUATIONS (9L)

Single and multi – step methods – explicit and implicit methods – advantages of implicit methods – solution of differential algebraic methods encountered in power engineering.

MODULE 4 – LINEARPROGRAMMING (9L)

Basic concepts – Graphical and Simplex methods –Transportation problem – Assignment problem.

MODULE 5 – DYNAMICPROGRAMMING(9L)

Elements of the dynamic programming model – optimality principle – Examples of dynamic programming models and their solutions.

REFERENCE BOOKS

1	Lewis.D.W., "Matrix Theory", Allied Publishers,Chennai1995.
2	Bronson,R, "Matrix Operations", Schaums outline Series ,McGraw Hill ,Newyork.1989.
3	L.O.Chua, P.M.Lin, "Computer-Aided Analsis of Electronic Circuits", Prentice Hall, Englewood Cliffs, New Jersey,1978.
4	Taha, H.A., "Operations research - An Introduction ", Mac Millan publishing Co.,(1982).
5	Gupta, P.K.and Hira, D.S., "Operations Research", S.Chand& Co., NewDelhi,1999.

E BOOKS

1	https://nptel.ac.in/downloads/111105035/
2	https://www.elsevier.com/books/mathematics-for-electrical-engineering-and-computing/attenborough/978-0-7506-5855-3

MOOC

1	https://nptel.ac.in/courses/111105035/
2	http://www.nptelvideos.in/2012/11/mathematics.html
3	https://www.coursera.org/learn/seo-strategies

<table>
<tr><td>COURSE TITLE</td><td colspan="3">ADVANCED EMBEDDED CONTROLLERS</td><td>CREDITS</td><td>3</td></tr>
<tr><td>COURSE CODE</td><td>EED1701</td><td>COURSE CATEGORY</td><td>PC</td><td>L-T-P-S</td><td>3-0-0-0</td></tr>
<tr><td>CIA</td><td colspan="3">50%</td><td>ESE</td><td>50%</td></tr>
<tr><td>LEARNING LEVEL</td><td colspan="3">BTL3</td><td>ASSESSMENT MODEL</td><td>ESE</td></tr>
<tr><td colspan="6">MODULE 1 –OVERVIEW OF MIXED SIGNAL PROCESSOR(9)</td></tr>
<tr><td colspan="6">Introduction to 16-bit Mixed Signal Controller- Important aspects of Mixed Signal Controller’s Hardware – CPU – Functional Block Diagram - Memory Mapping – Clock System - Addressing Modes - Register Mode – Indexed Mode – Introduction to functions – Interrupts - Low Power Modes - Development Environment - Programming and Debugging</td></tr>
<tr><td colspan="6">MODULE 2 – PERIPERALS OF MIXED SIGNAL PROCESSOR (9)</td></tr>
<tr><td colspan="6">Parallel ports - Digital Inputs/ Outputs – Timers - Watchdog Timer- Capture/Compare module – Generation of Periodic Signal – Generation of PWM Signal - Operation of the ADC Peripheral (ADC10) - Internal Temperature Sensor – Serial Communication Protocols</td></tr>
<tr><td colspan="6">MODULE 3 –ARCHITECTURE OF ARM CORTEX – M4 (9)</td></tr>
<tr><td colspan="6">ARM Cortex-M4 Processor Core overview - Programmers Model - Memory Model - Exception and Fault Handling - Power Management - Instruction Set Summary - CMSIS Functions - Hardware-Software Synchronization - Interrupt Synchronization - Multithreading - Register Map - System Timer - Nested Vectored Interrupt Controller - Floating Point Unit (FPU)-Optional Memory Protection Unit.</td></tr>
<tr><td colspan="6">MODULE 4 –PERIPHERALS OF ARM CORTEX – M4 CONTROLLER (9)</td></tr>
<tr><td colspan="6">Cortex-M4 Peripherals - Parallel I/O Ports - Timer Interfacing - Pulse Width Modulation - Frequency Measurement - Binary Actuators - Integral Control of a DC Motor – DAC - ADC -Serial Communication Protocols.</td></tr>
<tr><td colspan="6">MODULE 5 –PROCESSOR AND CONTROLLER</td></tr>
<tr><td colspan="6">Design And Development Of Embedded Systems Using Msp430 Processor And Arm Cortex Controllers.</td></tr>
<tr><td colspan="6">TEXT BOOKS</td></tr>
<tr><td>1</td><td colspan="5">Steven F.Barret, Daniel J Pack, ―Microcontroller Programming and Interfacing: Texas Instruments MSP430‖ , Morgan & Claypool Publishers, ISBN: 9781608457137</td></tr>
<tr><td>2</td><td colspan="5">John H. Davies, ―MSP430 Microcontroller Basics‖, First Edition, Newnes Publication , ISBN: 978-93-80501-85-7, 2010.</td></tr>
<tr><td>3</td><td colspan="5">C.P.Ravikumar. ―MSP430 Microcontroller in Embedded System Project‖, First Edition, Elite Publishing House Private Ltd, Dec , ISBN:978-81-88901-46-3, 2011</td></tr>
<tr><td>4</td><td colspan="5">J. W. Valvano, ―Embedded Systems: Introduction to ARM Cortex -M Microcontrollers‖, Fourth edition, Volume 1, ISBN: 978-1477508992, 2013</td></tr>
<tr><td>5</td><td colspan="5">J. W. Valvano, ―Embedded Systems: Real-Time Interfacing ARM Cortex –Microcontrollers‖, Fourth edition, Volume 2, ISBN: 978-1477508992, 2014</td></tr>
<tr><td>6</td><td colspan="5">Cortex-M4 Devices, Generic User Guide By ARM.</td></tr>
</table>

COURSE TITLE	PYTHON FOR IOT			CREDITS	3
Course Code	EED1702	Course Category	PC	L-T-P-S	3- 0- 0- 1
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				
Prerequisites : Nil					

MODULE 1 – PythonConcepts, Data Structures, Classes(9L)

Interpreter – Program Execution – Statements – Expressions – Flow Controls – Functions - Numeric Types – Sequences - Strings, Tuples, Lists and - Class Definition – Constructors – Inheritance – Overloading – Text & Binary Files - Reading and Writing.

MODULE 2 – Data Wrangling(9L)

Combining and Merging DataSets – Reshaping and Pivoting – Data Transformation – String Manipulation, RegularExpressions.

MODULE 3 – Data Aggregation, Group Operations, Time series & Web Scrapping (9L)

GoupBy Mechanics – Data Aggregation – GroupWise Operations and Transformations – Pivot Tables and CrossTabulations – Date and Time Date Type tools – Time Series Basics – Data Ranges, Frequencies and Shifting.

Data Acquisition by Scraping web applications –Submitting a form - Fetching web pages – Downloading web pagesthrough form submission – CSS Selectors.

MODULE 4 – Visualization in Python (9L)

Matplot lib package – Plotting Graphs – Controlling Graph – Adding Text – More Graph Types – Getting and setting values – Patches.

MODULE 5 – Implementation using Raspberry Pi (9L)

Working with Raspberry Pi 3 Model - Installing OS and Designing Systems using Raspberry pi - Configuring Raspberry Pi for VNC Connection - Getting introduced to Linux OS

Basic Linux commands and uses - Getting Started with Python - Interface sensor and Actuator with Raspberry Pi

REFERENCE BOOKS

1	Mark Lutz, “Learning Python”, O'Reilly Media, 5th Edition, 2016.
2	White, “Hadoop: The Definitive Guide”, Third Edition - O’Reilly, 2012.
3	Brandon Rhodes and John Goerzen, “Foundations of Python Network Programming: The ComprehensiveGuide to Building Network Applications with Python”, Apress, Second Edition, 2016.

COURSE TITLE	**RESEARCH METHODOLOGY & IPR**			**CREDITS**	**3**
COURSE CODE	**ZZZ3715**	**COURSE CATEGORY**	**PC**	**L-T-P-S**	**3-0-0-1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL-5**				

CO	COURSE OUTCOMES	PO
1.	Understand research problem formulation.	1,2,3
2.	Understand that Computer, Information Technology, controls today's world but tomorrow world will be ruled by ideas, concept, and creativity.	1,2,3
3.	Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.	1,2,3,5
4.	Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.	1,2,3,5
5.	Analyze research related information and to follow research ethics	1,2,3,12

Prerequisites: Nil

MODULE 1 – RESEARCH PROBLEM FORMULATION (9L)

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

MODULE 2 –RESEARCH PROPOSAL AND ETHICS (9L)

Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

MODULE 3 - DATA ANALYSIS AND INTERPRETATION (9L)

Classification of Data, Methods of Data Collection, Sampling, Sampling techniques procedure and methods, Ethical considerations in research Data analysis, Statistical techniques and choosing an appropriate statistical technique, Hypothesis, Hypothesis testing, Data processing software (e.g. SPSS etc.), statistical inference, Interpretation of results.

MODULE 4 - NATURE OF INTELLECTUAL PROPERTY (9L)

Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

MODULE 5 –PATENT RIGHTS AND NEW DEVELOPMENTS IN IPR (9L)

Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

REFERENCE BOOKS

1	Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students',
2	Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3	Ranjit Kumar, 2 nd Edition, "Research Methodology: A Step by Step Guide for beginners"

4	Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
5	Mayall , “Industrial Design”, McGraw Hill, 1992.
6	Niebel , “Product Design”, McGraw Hill, 1974.
7	Asimov, “Introduction to Design”, Prentice Hall, 1962.
8	Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”, 2016.
9	T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008
10	C.R. Kothari, Gaurav Garg, Research Methodology Methods and Techniques , New Age International publishers, Third Edition
11	Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, 2nd Edition, SAGE, 2005
12	Business Research Methods – Donald Cooper & Pamela Schindler, TMGH, 9th edition
13	Creswell, John W. Research design: Qualitative, quantitative, and mixed methods, approaches. Sage publications, 2013.

Course Title	**EMBEDDED SYSTEMS LABORATORY**				**2**
Course Code	**EEA3791**	**Course Category**	**PC**	**L-T-P-S**	**0-0-3-0**
CIA	**60%**		**ESE**	**40%**	
LEARNING LEVEL	**BTL-4**				

Prerequisites: -: Microcontroller programming

Practical: **(45)**

1. Programming practice on assembler and simulator tools.
2. Basic experiments with Atmega: - Blink, Digital Read Serial, Fade, and Read Analog Voltage.
3. Experiments with Atmega -Digital: - Button, Digital Input Pullup, Blink Without Delay.
4. Experiments with Atmega -Analog: - Analog In Out Serial, Sensors: - LM35, Display: - LCD, LED and Communication:-Bluetooth, Zigbee and Wi Fi.
5. Intel Atom Processor:- Linux Shell commands
6. Experiments with Intel Atom Processor:- temperature sensor Interface ,Capacitive touch pad and Accelerometer using analog board
7. Experiments with Intel Atom Processor:- Blinking LED and Controlling the motor using GPIO board
8. Introduction to ARM7- Cortex processor Instruction set.
9. Programming in Integrated Development Environment
10. Experiments with ARM7- Cortex (STM 32F4 Discovery):-Interfacing with Audio card, MEMS Sensor and Accelerometer.
11. Experiments with ARM7- Cortex (ST Nucleo-F401RE):- Interfacing with MEMS and Bluetooth, Working with SPI and I2C sensors including accelerometers

COURSE TITLE	MINI PROJECT				2
COURSE CODE	EEA3780	COURSE CATEGORY	PC	L-T-P-S	0-0-3-0
CIA	60%		ESE	40%	
LEARNING LEVEL	BTL-6				

CO	COURSE OUTOMES	PO
1	Able to develop simple electrical and electronic models based on the knowledge gained.	1,3,4,5,12
2	Able to propose a project and defend its advantages.	1,3,4,5,12
3	Able to implement a real time system as proposed.	1,3,4,5,12

Prerequisites: - Basic Electrical and Electronics Engineering subjects.

MINI PROJECT

To carry out a mini project and simple prototype in the area of interest based on the knowledge gained in Electrical and Electronics Engineering from undergraduate and first semester

The students will carry out a project in one of the following Electrical and Electronics Engineering areas but with substantial multidisciplinary components:

- Power Electronics, Control system
- Transmission and Distribution, Power system
- Electrical Machines, Solid State Drives etc. . .

Every individual student will be assigned a faculty to guide them. There will be three major reviews which will be carried out as listed below.

Review #	Requirement	Mark Weightage	
		Internal	External
0	Area / Title selection	-	-
1	Literature review / Proposal for the Project	10%	-
2	Mathematical modelling/Circuit Design	20%	-
3	Final simulation / Hardware presentation	20%	-
End Semester Exam	Final Viva-Voce and project demonstration	-	50%

SEMESTER – II

COURSE TITLE	INTERNET OF THINGS				CREDITS	3
COURSE CODE	EED1703	COURSE CATEGORY	PC	L-T-P-S	3-0-0-1	
CIA	50%			ESE	50%	
LEARNING LEVEL	BTL 3					
Prerequisites: Nil						
MODULE 1 –INTRODUCTION(9L)						
Internet of Things Promises–Definition– Scope–Sensors for IoT Applications–Structureof IoT– IoT Map Device						
MODULE 2 –IOT SENSORS(9L)						
Industrial sensors – Description & Characteristics–First Generation – Description &Characteristics–Advanced Generation – Description & Characteristics–Integrated IoTSensors – Description & Characteristics–Polytronics Systems – Description &Characteristics–Sensors' Swarm – Description & Characteristics–Printed Electronics –Description & Characteristics–IoT Generation Roadmap						
MODULE 3 -TECHNOLOGICAL ANALYSIS(9L)						
Wireless Sensor Structure–Energy Storage Module–Power Management Module–RF Module–Sensing Module						
MODULE 4 - IOT DEVELOPMENT EXAMPLES(9L)						
ACOEM Eagle – EnOcean Push Button – NEST Sensor – Ninja Blocks -Focus onWearable Electronics						
MODULE 5 –IOT PROJECTS (9L)						
Creating the sensor project - Preparing Raspberry Pi/ ARM Cortex - Clayster libraries - Hardware- Interacting with the hardware - Interfacing the hardware- Internal representation ofsensor values - Persisting data - External representation of sensor values – Exportingsensor data - Creating the actuator project- Hardware - Interfacing the hardware -Creating a controller - Representing sensor values - Parsing sensor data – Calculatingcontrol states - Creating a camera - Hardware -Accessing the serial port on RaspberryPi/ ARM Cortex - Interfacing the hardware - Creating persistent default settings – Addingconfigurable properties - Persisting the settings - Working with the current settings -Initializing the camera						

REFERENCE BOOKS	
1	Dr. Guillaume Girardin , Antoine Bonnabel, Dr. Eric Mounier, 'Technologies Sensors for the Internet of Things Businesses & Market Trends 2014 -2024',Yole Development Copyrights ,2014
2	Peter Waher, 'Learning Internet of Things', Packt Publishing, 2015
3	Editors OvidiuVermesan Peter Friess,'Internet of Things – From Research andInnovation to Market
4	N. Ida, Sensors, Actuators and Their Interfaces, Scitech Publishers, 2014.

<table>
<tr><td>COURSE TITLE</td><td colspan="4">COMMUNICATION PROTOCOLS FOR IoT</td><td>CREDITS</td><td>3</td></tr>
<tr><td>COURSE CODE</td><td>EED1704</td><td>COURSE CATEGORY</td><td>PC</td><td>L-T-P-S</td><td colspan="2">3-0-0-1</td></tr>
<tr><td>CIA</td><td colspan="3">50%</td><td>ESE</td><td colspan="2">50%</td></tr>
<tr><td>LEARNING LEVEL</td><td colspan="6">BTL 3</td></tr>
<tr><td colspan="7">Prerequisites:Nil</td></tr>
<tr><td colspan="7">MODULE 1 –INTRODUCTION (9L)</td></tr>
<tr><td colspan="7">IoT architecture outline, standards - IoT Technology Fundamentals- Devices and gateways, Local and wide areanetworking, Data management, Business processes in IoT, Everything as aService(XaaS), M2M and IoT Analytics</td></tr>
<tr><td colspan="7">MODULE 2 –IOT REFERENCE ARCHITECTURE (9L)</td></tr>
<tr><td colspan="7">Introduction,Functional View, Information View, Deployment and Operational View, Other Relevant architectural views. Real-World Design Constraints- Introduction, Technical Designconstraints</td></tr>
<tr><td colspan="7">MODULE 3 –IoT DATA LINK LAYER & NETWORK LAYER PROTOCOLS(9L)</td></tr>
<tr><td colspan="7">PHY/MAC Layer(3GPP MTC, IEEE 802.11, IEEE 802.15), WirelessHART,ZWave,Bluetooth Low Energy, Zigbee Smart Energy, DASH7 - Network Layer-IPv4,IPv6, 6LoWPAN, 6TiSCH,ND, DHCP, ICMP, RPL, CORPL, CARP</td></tr>
<tr><td colspan="7">MODULE 4 - IoT TRANSPORT & SESSION LAYER PROTOCOLS(9L)</td></tr>
<tr><td colspan="7">Transport Layer (TCP, MPTCP, UDP, DCCP, SCTP)-(TLS, DTLS) – Session Layer-HTTP, CoAP, XMPP, AMQP, MQTT</td></tr>
<tr><td colspan="7">MODULE 5 – IoT SERVICE LAYER PROTOCOLS & SECURITY PROTOCOLS(9L)</td></tr>
<tr><td colspan="7">Service Layer -oneM2M, ETSI M2M, OMA, BBF – Security in IoT Protocols – MAC802.15.4 , 6LoWPAN, RPL, Application Layer</td></tr>
<tr><td colspan="7">REFERENCE BOOKS</td></tr>
<tr><td>1</td><td colspan="6">Daniel Minoli, “Building the Internet of Things with IPv6 and MIPv6: The EvolvingWorld of M2M Communications”, ISBN: 978-1-118-47347-4, Willy Publications ,2016</td></tr>
<tr><td>2</td><td colspan="6">Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stefan Avesand,StamatisKarnouskos, David Boyle, “From Machine-to-Machine to the Internet ofThings: Introduction to a New Age of Intelligence”, 1st Edition, Academic Press, 2015</td></tr>
<tr><td>3</td><td colspan="6">Bernd Scholz-Reiter, Florian Michahelles, “Architecting the Internet of Things”,ISBN 978-3-642-19156-5 e-ISBN 978-3-642-19157-2, Springer, 2016</td></tr>
<tr><td>4</td><td colspan="6">N. Ida, Sensors, Actuators and Their Interfaces, Scitech Publishers, 2014.</td></tr>
</table>

COURSE TITLE	EMBEDDED SYSTEM DESIGN			CREDITS	3
Course Code	EED1705	Course Category	PC	L-T-P-S	3- 0- 0- 1
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

MODULE 1 – INTRODUCTION TO EMBEDDED CONCEPTS(9L)

Introduction to embedded systems, Application Areas, Categories of embeddedsystems, Overview of embedded system architecture, Specialties of embedded systems, recent trends in embedded systems, Architecture of embedded systems, Hardware architecture, Software architecture, Application Software, Communication Software.

MODULE 2 – OVERVIEW OF ARM AND CORTEX-M39L)

Background of ARM Architecture, Architecture Versions, Processor Naming,Instruction Set Development, Thumb-2 and Instruction Set Architecture. Cortex-M3 Basics: Registers, General Purpose Registers, StackPointer, Link Register, Program Counter, Special Registers, Operation Mode, Exceptions and Interrupts, Vector Tables, Stack Memory Operations, Reset Sequence. Cortex-M3Instruction Sets: Assembly Basics, Instruction List, Instruction Descriptions.Cortex-M3 Implementation Overview: Pipeline, Block Diagram, Bus. Interfaces on Cortex-M3, I-Code Bus, D Code Bus, System Bus, External PPB and DAP Bus

MODULE 3 – CORTEX EXCEPTION HANDLING AND INTERRUPTS(9L)

Exceptions: Exception Types, Priority, Vector Tables, Interrupt Inputs and Pending Behavior, Fault Exceptions, Supervisor Call and Pendable Service Call. NVIC: Nested Vectored Interrupt Controller Overview, Basic Interrupt Configuration, Software Interrupts and SYSTICK Timer. Interrupt Behavior: Interrupt/Exception Sequences, Exception Exits, Nested Interrupts, Tail-Chaining Interrupts, Late Arrivals and Interrupt Latency.

MODULE 4 – CORTEX-M3/M4 PROGRAMMING (9L)

Cortex-M3/M4 Programming: Overview, Typical Development Flow, Using C, CMSIS (Cortex Microcontroller Software Interface Standard), Using Assembly. Exception Programming: Using Interrupts, Exception/Interrupt Handlers, Software Interrupts, Vector Table Relocation. Memory Protection Unit and other Cortex-M3 features: MPU Registers, Setting Up the MPU, Power Management, Multiprocessor Communication.

MODULE 5 – CORTEX-M3/M4 DEVELOPMENT AND DEBUGGING TOOLS (9L)

STM32L15xxx ARM Cortex M3/M4 Microcontroller: Memory and Bus Architecture, Power Control, Reset and Clock Control. STM32L15xxx Peripherals: GPIOs, System Configuration Controller, NVIC, ADC, Comparators, GP Timers, USART. Development and Debugging Tools: Software and Hardware tools like Cross Assembler, Compiler, Debugger, Simulator, In-Circuit Emulator (ICE), Logic Analyzer etc.

REFERENCE BOOKS

1	Joseph Yiu,” The Definitive Guide to the ARM Cortex-M3”, Second Edition, Elsevier Inc. 2010.
2	Andrew N Sloss, Dominic Symes, Chris Wright, “ARM System Developer'sGuide Designing and Optimizing System Software”, Elsevier Publications,2006

3	Steve Furber, "ARM System-on-Chip Architecture", 2nd Edition, Pearson Education, India ISBN: 9788131708408, 8131708403 , 2015
4	STM32L152xx ARM Cortex M3 Microcontroller Reference Manual 5/97
5	ARM Company Ltd. "ARM Architecture Reference Manual– ARM DDI 0100E"

Course Title	**IOT ENABLED EMBEDDED DEVICES LABORATORY**				**2**
Course Code	**EED3792**	**Course Category**	**PC**	**L-T-P-S**	**0-0-3-0**
CIA	**60%**		**ESE**	**40%**	
LEARNING LEVEL	**BTL-4**				
Prerequisites: -: Microcontroller programming					
Practical:					**(45)**

1.Node MCU/ESP 32 - Temperature Sensor Interfacing (LM35) - Bluetooth Interfacing (HC05)- Motor driver Interfacing (L298) -LCD Interfacing (HD44780)

2.IMPLEMENTATION OF IoT using BLYNK/CAYENNE - –Installation and Activation - Blinking an LED -Reading Analog Voltage - LCD Interfacing (HD44780) -Project

3. IMPLEMENTATION OF IoT using Google Assistant – Arest server - Creating own server – Project

4. IMPLEMENTATION OF IoT using Raspberry Pi & Python Programming: - LCD Interfacing (HD44780) - Motor driver Interfacing (L298) – Camera interface

COURSE TITLE	**SEMINAR**				**2**
COURSE CODE	**EED3796**	**COURSE CATEGORY**	**PC**	**L-T-P-S**	**0-0-3-0**
CIA	**60%**		**ESE**	**40%**	
LEARNING LEVEL	**BTL-6**				

CO	**COURSE OUTOMES**	**PO**
1	Able to develop simple electrical and electronic models based on the knowledge gained.	1,3,4,5,12
2	Able to propose a project and defend its advantages.	1,3,4,5,12
3	Able to implement a real time system as proposed.	1,3,4,5,12

Prerequisites: - Basic Electrical and Electronics Engineering subjects.

SEMINAR

Seminar should be taken on state of the art topic of student's own choice based on relevant specializationapproved by an Department incharge. The student shall submit the duly certified seminar report in standard format, for satisfactory completion of the work by the concerned Guide and head of the department/institute.

DEPARTMENT ELECTIVE I

COURSE TITLE	**SENSOR-CONCEPTS AND TECHNIQUES**			**CREDITS**	**3**
COURSE CODE	**EED3721**	**COURSE CATEGORY**	**PC**	**L-T-P-S**	**3-0-0-0**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL2**			**ASSESSMENT MODEL**	

MODULE 1 –SENSORS / TRANSDUCERS	**(9)**
Principles – Classification – Parameters – Characteristics – Environmental Parameters (EP) – Characterization. -Inductive Sensors: Sensitivity and Linearity of the Sensor –Types-Capacitive Sensors:– Electrostatic Transducer– Force/Stress Sensors Using Quartz Resonators – Ultrasonic Sensors.	
MODULE 2 – THERMAL AND MAGNETIC SENSORS	**(9)**
Introduction – Gas thermometric Sensors – Thermal Expansion Type Thermometric Sensors – Acoustic Temperature Sensor – Dielectric Constant and Refractive Index thermosensors – Helium Low Temperature Thermometer – Nuclear Thermometer – Magnetic Thermometer – Resistance Change Sensors and the Principles Behind – Magneto-resistive Sensors – Anisotropic Magneto resistive Sensing – Semiconductor Magnetoresistors– Hall Effect and Sensors – Inductance and Eddy Current Sensors– Angular/Rotary Movement Transducers – Synchros – Synchroresolvers - Eddy Current Sensors – Electromagnetic Flowmeter – Switching Magnetic Sensors SQUID Sensors	
MODULE 3 –RADIATION AND ELECTRO ANALYTICAL SENSORS	**(9)**
Introduction – Basic Characteristics – Types of Photosensistors/Photo detectors– Xray and Nuclear Radiation Sensors– Fiber Optic Sensors, the Electrochemical Cell – The Cell Potential – Standard Hydrogen Electrode (SHE) – Liquid Junction and Other Potentials – Polarization – Concentration Polarization– Reference Electrodes - Sensor Electrodes – Electro ceramics in Gas Media.	
MODULE 4 –SMART SENSORS	**(9)**
Introduction – Primary Sensors – Excitation – Amplification – Filters – Converters – Compensation– Information Coding/Processing - Data Communication – Standards for Smart Sensor Interface– The Automation.	
MODULE 5 –ACTUATORS	**(9)**
Pneumatic and Hydraulic Actuation Systems- Actuation systems – Pneumatic and hydraulic systems - Directional Control valves – Presure control valves – Cylinders - Servo and proportional control valves – Process control valves – Rotary actuators.	

TEXT BOOKS	
1	D. Patranabis – “Sensors and Transducers” –PHI Learning Private Limited.
2	W. Bolton – “Mechatronics” –Pearson Education Limited.
3	Sensors and Actuators – D. Patranabis – 2nd Ed., PHI, 2013.

<table>
<tr><td>COURSE TITLE</td><td colspan="3">MICRO ELECTRO-MECHANICAL SYSTEMS - MEMS</td><td>CREDITS</td><td>3</td></tr>
<tr><td>Course Code</td><td>EED3722</td><td>Course Category</td><td>PC</td><td>L-T-P-S</td><td>3- 0- 0- 1</td></tr>
<tr><td>CIA</td><td colspan="3">50%</td><td>ESE</td><td>50%</td></tr>
<tr><td>LEARNING LEVEL</td><td colspan="5">BTL-3</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">MODULE 1 – INTRODUCTION TO MEMS (9L)</td></tr>
<tr><td colspan="6">Microsystems versus MEMS, Micro fabrication, Smart Materials, Structures and Systems, Integrated Microsystems, Applications of Smart Materials and Microsystems</td></tr>
<tr><td colspan="6">MODULE 2 – MICRO SENSORS, ACTUATORS, SYSTEMS AND SMART MATERIALS(9L)</td></tr>
<tr><td colspan="6">Silicon Capacitive Accelerometer, Piezo-resistive Pressure Sensor, Conductometric Gas Sensor, An Electrostatic Comb-Drive, A Magnetic Micro relay, Portable Blood Analyzer, Piezoelectric Inkjet Print Head, Micro-mirror Array for Video ProjectionSmart Materials and Systems</td></tr>
<tr><td colspan="6">MODULE 3 – MICRO FABRICATION TECHNIQUE (9L)</td></tr>
<tr><td colspan="6">Silicon as a Material for Micromachining, Thin-Film Deposition, Lithography, Etching, Silicon Micromachining Specialized Materials for Microsystems, Advanced Processes for Micro fabrication</td></tr>
<tr><td colspan="6">MODULE 4 – MODELING OF SOLIDS IN MICROSYSTEMS (9L)</td></tr>
<tr><td colspan="6">The Simplest Deformable Element: A Bar, Transversely Deformable Element: A beam, Energy Methods for Elastic Bodies, Heterogeneous Layered Beams, Bimorph Effect, Residual Stresses and Stress Gradients, Poisson Effect and the Anticlastic Curvature of Beams, Torsion of Beams and Shear Stresses, Dealing with Large Displacements, In-Plane Stresses</td></tr>
<tr><td colspan="6">MODULE 5 - FINITE ELEMENT METHOD (9L)</td></tr>
<tr><td colspan="6">Need for Numerical Methods for Solution of Equations - Variational Principles, Finite Element Method, Finite Element Model for Structures with Piezoelectric Sensors and Actuators, Analysis of a Piezoelectric Bimorph Cantilever Beam</td></tr>
<tr><td colspan="6">REFERENCE BOOKS</td></tr>
<tr><td>1</td><td colspan="5">Micro and Smart Systemsby G.K. Ananthasuresh, K.J. Vinoy,S.Gopalakrishnan,K.N.Bhat,V.K. Aatre : Wiley, India (2016).</td></tr>
<tr><td>2</td><td colspan="5">Smart Material Systems and MEMS: Design and Development Methodologies: Vijay K., 2017</td></tr>
<tr><td>3</td><td colspan="5">The MEMS Handbook: Edited by Mohamed Gad-el-Hak, University of NotreDame, CRC Press LLC, 2015</td></tr>
</table>

COURSE TITLE	SENSOR NETWORKS & IoT			CREDITS	3
COURSE CODE	EED3723	COURSE CATEGORY	PE	L-T-P-S	3- 0- 0- 0
CIA	50%			ESE	50%
LEARNING LEVEL	BTL – 3 (APPLY)				
Prerequisite :					
MODULE 1:INTRODUCTION (9)					
Introduction to Sensor networks in smart transportation, smart cities, smart living, smart energy, smart health, and smart learning.					
MODULE 2:SENSOR NETWORK SYSTEMS(9)					
Cyber Physical Systems, Systems of Systems, Software Architectures and Connectors, Software Interoperability, Big Data and Big Data Mining, Privacy and Security IoT Reference Architecture Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views. Real-World Design Constraints- Introduction, Technical Design constraints, hardware, Data representation and visualization, Interaction and remote control.					
MODULE 3:IOT PHYSICAL DEVICES & ENDPOINTS (9)					
Exemplary Device Board, Linux on Raspberry, Interface and Programming & IOT Device. Hardware Platforms and Energy Consumption, Operating Systems, Time Synchronization, Positioning and Localization, Medium Access Control, Topology and Coverage Control, Routing: Transport Protocols, Network Security, Middleware, Databases					
MODULE : INDUSTRIAL AUTOMATION& IoT(9)					
Industrial Automation-Service-oriented architecture-based device integration, SOCRADES: realizing the enterprise integrated Web of Things, IMC-AESOP: from the Web of Things to the Cloud of Things, Commercial Building Automation					
MODULE 5: CASE STUDY – IoT Implementations (9)					
Case study: Smart Grid &IoT, Commercial building automation using IoT, Recent trends in sensor network and IOT architecture, Automation in Industrial aspect of IOT.					

TEXT BOOKS	
1	Mandler, B., Barja, J., MitreCampista, M.E., Cagáová, D., Chaouchi, H., Zeadally, S., Badra, M., Giordano, S., Fazio, M., Somov, A., Vieriu, R.-L., Internet of Things. IoT Infrastructures, Springer International Publication
2.	Internet of Things: A Hands-On Approach Paperback – 2015, by ArsheepBahga (Author), Vijay Madisetti (Author)
REFERENCE BOOKS	
1	IoT Fundamentals: Networking Technologies, Protocols and Use Cases for the Internet of Things by Pearson Paperback – 16 Aug 2017 ,by Hanes David (Author), Salgueiro Gonzalo (Author), Grossetete Patrick (Author), Barton Rob (Author

COURSE TITLE	MACHINE LEARNING			CREDITS	3
COURSE CODE	EED3724	COURSE CATEGORY	PC	L-T-P-S	2- 0- 2- 2
CIA	60%			ESE	40%
LEARNING LEVEL	BTL-4 - ANALYZE				

CO	OUTCOMES	PO
1	Apply multilayer perceptron using simple machine learning techniques.	1,2,3
2	Use decision trees and statistics models	1,2,3
3	Use data analysis for machine learning	1,2,3
4	Use Genetic algorithm and reinforced learning for appropriate applications	1,2,3
5	Use the Python programming for machine learning.	1,2,3,5

Prerequisites : NIL

MODULE 1: Introduction (6+6)

Learning - Types of machine learning - Supervised learning - The brain and the neurons, Linear Discriminants -Perceptron - Linear Separability -Linear Regression - Multilayer perceptron - Examples of using MLP - Back propagation of error.

Suggested Activities: Design a Multilayer Perceptron for Rain Forecasting system

Suggested sources: Enrico C, Simon W, Jay R, Machine Learning Techniques for Space Weather, Elsevier, 2018

MODULE 2: Classification Algorithms (6+6)

Decision trees - Constructing decision trees - Classification of regression trees - Regression example - Probability and Learning: Turning data into probabilities - Some basic statistics - Gaussian mixture models - Nearest Neighbor methods.

Suggested Activities: Explore the Regression Examples in Machine Learning

Suggested sources: Norman Matlof, "Statistical Regression and Classification: From Linear Models to Machine Learning", CRC Press, 2017.

MODULE 3: Analysis (6+6)

The k-Means algorithm - Vector Quantization's - Linear Discriminant Analysis - Principal component analysis - Factor Analysis - Independent component analysis - Locally Linear embedding – Isomap - Least squares optimization - Simulated annealing.

Suggested Activities: Simulated annealing / Modelling on any data science application.

Suggested sources: L.M. Rasdi, Simulated Annealing Algorithm for Deep Learning, Procedia Computer Science, Volume: 72, 2015.

MODULE 4: Optimization Techniques (6+6)	
The Genetic algorithm - Genetic operators - Genetic programming - Combining sampling with genetic programming - Markov Decision Process - Markov Chain Monte Carlo methods: sampling - Monte carlo - Proposal distribution. **Suggested Activities:** Design an Encryption algorithm using Genetic algorithm Suggested sources:**Harsh Bhasin, Application of Genetic Algorithms in Machine learning,, International Journal of Computer Science and Information Technologies, Vol. 2 (5), 2011.**	
MODULE 5: Python for Machine Learning (6+6)	
Baysean Networks - Markov Random moFields - Hidden Markov Models -Tracking methods. Python: Installation - Python for MATLAB AND R users - Code Basics - Using NumPy and MatPolitB. **Suggested Activities**: Design a simple application using NumPy and MatPolitB. **Suggested sources:** Rakshith Vasudev, Introduction to Numpy -1 : An absolute beginners guide to Machine Learning and Data science., 2017.	
TEXT BOOKS	
1	Kevin P. Murphy, “Machine Learning – A probabilistic Perspective”, MIT Pres, 2016.
2	Randal S, “Python Machine Learning, PACKT Publishing, 2016.
REFERENCE BOOKS	
1	Ethem Alpaydin, "Machine Learning: The New AI”, MIT Press, 2016.
2	Shai Shalev-Shwartz, Shai Ben-David, "Understanding Machine Learning: From Theory to Algorithms”, Cambridge University Press, 2014.
3	Sebastian Raschka, “Python Machine Learning”, Packt Publishing Ltd, 2015.
E BOOKS	
1	http://www.cs.huji.ac.il/~shais/UnderstandingMachineLearning/index.html
2	http://www.mlyearning.org/
MOOC	
1	https://www.coursera.org/learn/practical-machine-learning
2	https://www.coursera.org/learn/python-machine-learning

DEPARTMENT ELECTIVE II

<table>
<tr><td>COURSE TITLE</td><td colspan="3">REAL TIME OPERATING SYSTEM</td><td>CREDITS</td><td>3</td></tr>
<tr><td>COURSE CODE</td><td>EED3725</td><td>COURSE CATEGORY</td><td>PC</td><td>L-T-P-S</td><td>3-0-0-0</td></tr>
<tr><td>CIA</td><td colspan="3">50</td><td>ESE</td><td>50</td></tr>
<tr><td>LEARNING LEVEL</td><td colspan="3">BTL2</td><td>ASSESSMENT MODEL</td><td></td></tr>
<tr><td colspan="6">MODULE 1 –REAL TIME SYSTEMS (9)</td></tr>
<tr><td colspan="6">Introduction- Issues in real time computing- Structure of a real time system- Task classes- Performance measures for real time systems- Task assignment and scheduling algorithms - Mode changes- Fault tolerant scheduling - Real Time Models.</td></tr>
<tr><td colspan="6">MODULE 2 – µC/OS- II RTOS CONCEPTS (9)</td></tr>
<tr><td colspan="6">Foreground/Background process- Resources - Tasks - Multitasking -Priorities - Schedulers -Kernel - Exclusion - Inter task communication-Interrupts - Clock ticks - µC/OS- II Kernel structure - µC/OS- II Initialisation - Starting µC/OS- II.</td></tr>
<tr><td colspan="6">MODULE 3 –µC/OS- II RTOS FUNCTIONS (9)</td></tr>
<tr><td colspan="6">Task Management - Time management - Semaphore management - Mutual exclusion semaphore - Event Management –Message management - Memory management - Porting µC/OS- II – Comparison and Study of Various RTOS like QNX- VX Works-PSOS.</td></tr>
<tr><td colspan="6">MODULE 4 –EMBEDDED LINUX (9)</td></tr>
<tr><td colspan="6">- Features - Embedded Linux Distributions - Architecture of Embedded Linux - Linux Kernel Architecture – User Space -Root File System - Linux Start-Up Sequence - GNU Cross Platform Tool chain - Porting Traditional RTOS Applications to Linux.</td></tr>
<tr><td colspan="6">MODULE 5 – REAL-TIME LINUX (9)</td></tr>
<tr><td colspan="6">Linux and Real-Time - Real-Time Programming in Linux - Hard Real-Time Linux - Building and Debugging - Building the Kernel- Integrated Development Environment - Kernel Debuggers - Embedded Drivers - Board support packages - Introduction to C linux.</td></tr>
<tr><td colspan="6">TEXT BOOKS</td></tr>
<tr><td>1</td><td colspan="5">Krishna C.M., Kang G. Shin, "Real Time Systems", Tata McGraw-Hill Edition, 2010.</td></tr>
<tr><td>2</td><td colspan="5">Philip A.Laplante, "Real Time Systems Design and Analysis-An Engineers Handbook", II Edition-IEEE Press, IEEE ComputerSociety Press, 2001</td></tr>
<tr><td>3</td><td colspan="5">Jean J Labrosse, "MicroC/OS-II The Real Time Kernel" II Edition,CMP Books, 2002.</td></tr>
<tr><td>4</td><td colspan="5">P. Raghavan,Amol Lad, SriramNeelakandan, "Embedded LinuxSystem Design and Development", Auerbach Publications, Taylor& Francis Group, 2006.</td></tr>
<tr><td>5</td><td colspan="5">Christopher Hallinan, "Embedded Linux Primer, A Practical, Real-World Approach", II Edition Pearson Education, Inc., 2011.</td></tr>
</table>

<table>
<tr><td>COURSE TITLE</td><td colspan="3">ELECTRIC AND HYBRID VEHICLES</td><td>CREDITS</td><td>3</td></tr>
<tr><td>COURSE CODE</td><td>EED3726</td><td>COURSE CATEGORY</td><td>DE</td><td>L-T-P-S</td><td>3- 0- 0- 1</td></tr>
<tr><td>CIA</td><td colspan="3">50%</td><td>ESE</td><td>50%</td></tr>
<tr><td>LEARNING LEVEL</td><td colspan="5">BTL- 4</td></tr>
<tr><td>CO</td><td colspan="4">COURSE OUTCOMES</td><td>PO</td></tr>
<tr><td>1</td><td colspan="4">Understand mathematical models, performance and characteristics of hybrid and electric vehicles.</td><td>2,3,4</td></tr>
<tr><td>2</td><td colspan="4">Analyze the concepts, topologies and power flow control of electric traction systems.</td><td>2,3,4</td></tr>
<tr><td>3</td><td colspan="4">Appraise the configuration and control of various hybrid electric motor drives</td><td>2,3,4,5</td></tr>
<tr><td>4</td><td colspan="4">Plan and design appropriate vehicle management system.</td><td>2,3,4,5,12</td></tr>
<tr><td colspan="6">Prerequisites : power electronics</td></tr>
<tr><td colspan="6">MODULE 1 – INTRODUCTION HYBRID AND ELECTRIC VEHICLES (9L)</td></tr>
<tr><td colspan="6">History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.
Suggested Reading: Future prospectus of hybrid and electric vehicles
Applications: Modern hybrid vehicles</td></tr>
<tr><td colspan="6">MODULE 2 – ELECTRIC TRACTION SYSTEMS(9L)</td></tr>
<tr><td colspan="6">Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. Basic concepts of electric traction, introduction to various electric drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.
Suggested Reading: https://link.springer.com/chapter/10.1007/978-3-642-30281-7_2 (Railway traction system)</td></tr>
<tr><td colspan="6">MODULE 3 – HYBRID ELECTRIC MOTOR DRIVES(9L)</td></tr>
<tr><td colspan="6">Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Introduction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.
Suggested Reading: Modern Electric Hybrid Electric & Fuel Cell Vehicles by Mehrdad Ehsani (http://ceb.ac.in/knowledge-center)</td></tr>
<tr><td colspan="6">MODULE 4 –ELECTRICAL MACHINES AND INTERNAL COMBUSTION ENGINE(9L)</td></tr>
<tr><td colspan="6">Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems.
Suggested Reading: Selection of ICE and Electrical machines</td></tr>
<tr><td colspan="6">MODULE 5 – VEHICLE MANAGEMENT SYSTEM(9L)</td></tr>
<tr><td colspan="6">Introduction to energy management strategies used in hybrid and electric vehicle, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy strategies.
Suggested Reading: Advanced Vehicle Management System</td></tr>
<tr><td colspan="6">LAB / MINI PROJECT/FIELD WORK</td></tr>
<tr><td colspan="6"></td></tr>
</table>

TEXT BOOKS	
1	Sira -Ramirez, R. Silva Ortigoza, 'Control Design Techniques in Power Electronics Devices', Springer, 2006
2	Siew-Chong Tan, Yuk-Ming Lai, Chi Kong Tse, 'Sliding mode control of switching Power Converters', CRC Press, 2011
REFERENCE BOOKS	
1	Bimal Bose, 'Power electronics and motor drives', Elsevier, 2006
2	Ion Boldea and S.A Nasar, 'Electric drives', CRC Press, 2005
E BOOKS	
1	https://www.elsevier.com/books/electric-and-hybrid-vehicles/pistoia/978-0-444-53565-8 (**eBook ISBN:** 9780444535665)
2	https://onlinelibrary.wiley.com/doi/book/10.1002/9781119998914 Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives
MOOC	
1	https://www.edx.org/course/electric-cars-introduction
2	https://www.edx.org/course/hybrid-vehicles

COURSE TITLE	**EMBEDDED IOT**			**CREDITS**	**3**
COURSE CODE	**EED3727**	**COURSE CATEGORY**	**PC**	**L-T-P-S**	**3-0-0-0**
CIA	**50**			**ESE**	**50**
LEARNING LEVEL	**BTL 2**			**ASSESSMENT MODEL**	**ESE**

MODULE 1 –FUNDAMENTALS AND APPLICATIONS OF IoT (9)	
Introduction to Internet of Things (IoT)– Functional Characteristics – Recent Trends in the Adoption of IoT – Societal Benefits of IoT, Health Care –– Machine to Machine (M2M) - Smart Transportation – Smart Living – Smart Cities- Smart Grid	
MODULE 2 – IoT ARCHITECTURE (9)	
Functional Requirements - Components of IoT: Sensors – Actuators – Embedded Computation Units – Communication Interfaces – Software Development	
MODULE 3 –COMMUNICATION PRINCIPLES (9)	
RFID – ZigBEE – Bluetooth – Internet Communication- IP Addresses - MAC Addresses - TCP and UDP – IEEE 802 Family of Protocols – Cellular-Introduction to EtherCAT.	
MODULE 4 –COMMUNICATION INTERFACE IN IoT (9)	
IEEE 802.11 Wireless Networks Attacks: Basic Types, WEP Key Recovery Attacks, Keystream Recovery Attacks against WEP – RFID Security – Security Issues in ZigBEE: Eavesdropping Attacks, Encryption Attacks – Bluetooth Security: Threats to Bluetooth Devices and Networks.	
MODULE 5 –CLOUD SECURITYCONCEPTS (9)	
Confidentiality, privacy, integrity, authentication, non-repudiation, availability, access control, defence in depth, least privilege, how these concepts apply in the cloud, what these concepts mean and their importance in PAAS, IAAS and SAAS. e.g. User authentication in the cloud; Cryptographic Systems- Symmetric cryptography, stream ciphers, block ciphers, modes of operation, public-key cryptography, hashing, digital signatures, public-key infrastructures, key management, X.509 certificates, OpenSSL.	
TEXT BOOKS	
1	Adrian McEwen and Hakim Cassimally, —Designing the Internet of Things‖, John Wiley and Sons Ltd, UK, 2014.
2	Olivier Hersent, David Boswarthick and Omar Elloumi, —The Internet of Things: Key Applications and Protocols‖, John Wiley and Sons Ltd., UK 2012.
3	Dieter Uckelmann, Mark Harrison, Florian Michahelles, —Architecting the Internet of Things‖, Springer, New York, 2011.
4	Johnny Cache, Joshua Wright and Vincent Liu, —Hacking Exposed Wireless: Wireless Security Secrets and Solutions‖, Tata McGraw Hill, New Delhi, 2010
5	Himanshu Dwivedi, Chris Clark and David Thiel, —Mobile Application Security‖, Tata McGraw Hill, Nw Delhi, 2010.
6	Vijay Madisetti, Arshdeep Bahga, —Internet of Things (A Hands-on Approach), Universities Press, 2015.
7	Tim Mather, Subra Kumaraswamy, ShahedLatif, “Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance” O'Reilly Media; 1 edition [ISBN: 0596802765], 2009

COURSE TITLE	SMART GRID TECHNOLOGIES & IOT			CREDITS	3
COURSE CODE	EED3728	COURSE CATEGORY	DE	L-T-P-S	3- 0- 0- 1
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-4				

CO	COURSE OUTCOMES	PO
1	Get acquainted with different smart devices and smart meters	2,3,4,5,12
2	Describe how modern power distribution system functions	2,3,4,5,12
3	Identify suitable communication networks for Smart Grid applications	2,3,4,5,12

Prerequisites : Fundamentals of Power Distribution System, Transmission and Distribution, Power system Operation and Control, Communication Networks

MODULE 1 – INTRODUCTION TO SMART GRID (9L)

Introduction - Evolution of Electric Grid, Smart Grid Concept - Definitions and Need for Smart Grid – Functions – Opportunities – Benefits and challenges, Difference between conventional & Smart Grid, Technology Drivers

MODULE 2 – ENERGY MANAGEMENT SYSTEM (9L)

Energy Management System (EMS) - Smart substations - Substation Automation - Feeder Automation, SCADA – Remote Terminal Unit – Intelligent Electronic Devices – Protocols, Phasor Measurement Unit – Wide area monitoring protection and control, Smart integration of energy resources – Renewable, intermittent power sources – Energy Storage.

MODULE 3 – DISTRIBUTION MANAGEMENT SYSTEM (9L)

Distribution Management System (DMS) – Volt / VAR control – Fault Detection, Isolation and Service Restoration, Network Reconfiguration, Outage management System, Customer Information System, Geographical Information System, Effect of Plug in Hybrid Electric Vehicles

MODULE 4 – SMART METERS (9L)

Introduction to Smart Meters – Advanced Metering infrastructure (AMI), AMI protocols – Standards and initiatives, Demand side management and demand response programs, Demand pricing and Time of Use, Real Time Pricing, Peak Time Pricing.

MODULE 5 – COMMUNICATION NETWORKS & IOT (9L)

Elements of communication and networking – architectures, standards, PLC, Zigbee, GSM, BPL, Local Area Network (LAN) - House Area Network (HAN) - Wide Area Network (WAN) - Broadband over Power line (BPL) - IP based Protocols - Basics of Web Service and CLOUD Computing, Cyber Security for Smart Grid.

LAB / MINI PROJECT/FIELD WORK

FIELD WORK

TEXT BOOKS

1	Stuart Borlase ‘Smart Grid: Infrastructure, Technology and Solutions’, CRC Press 2012.
2	JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, ‘Smart Grid: Technology and Applications’, Wiley, 2012

REFERENCE BOOKS

1	Mini S. Thomas, John D McDonald, ‘Power System SCADA and Smart Grids’, CRC Press, 2015
2	Kenneth C.Budka, Jayant G. Deshpande, Marina Thottan, ‘Communication Networks for Smart Grids’, Springer, 2014.

E BOOKS

1	https://books.google.co.in/books?isbn=1119969093
2	https://books.google.co.in/books?isbn=135123093X

MOOC	
1	https://www.mooc-list.com/course/smart-grids-electricity-future-edx
2	https://www.mooc-list.com/course/distributed-energy-smart-grid-resources-future-edx

DEPARTMENT ELECTIVE III

<table>
<tr><td>COURSE TITLE</td><td colspan="3">EMBEDDED SYSTEMS FOR ELECTRIC AND HYBRID VEHICLES</td><td>CREDITS</td><td>3</td></tr>
<tr><td>COURSE CODE</td><td>EED3729</td><td>COURSE CATEGORY</td><td>DE</td><td>L-T-P-S</td><td>3- 0- 0- 1</td></tr>
<tr><td>CIA</td><td colspan="3">50%</td><td>ESE</td><td>50%</td></tr>
<tr><td>LEARNING LEVEL</td><td colspan="5">BTL- 4</td></tr>
<tr><td>CO</td><td colspan="4">COURSE OUTCOMES</td><td>PO</td></tr>
<tr><td>1</td><td colspan="4">Understand performance and characteristics of hybrid and electric vehicles.</td><td>2,3,4</td></tr>
<tr><td>2</td><td colspan="4">Analyze the concepts, topologies and power flow control of electric traction systems.</td><td>2,3,4</td></tr>
<tr><td>3</td><td colspan="4">Appraise the configuration and control of various hybrid electric motor drives</td><td>2,3,4,5</td></tr>
<tr><td>4</td><td colspan="4">Plan and design appropriate vehicle management system.</td><td>2,3,4,5,12</td></tr>
<tr><td colspan="6">Prerequisites : power electronics</td></tr>
<tr><td colspan="6">MODULE 1 – INTRODUCTION HYBRID AND ELECTRIC VEHICLES (9L)</td></tr>
<tr><td colspan="6">History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.
Suggested Reading: Future prospectus of hybrid and electric vehicles
Applications: Modern hybrid vehicles</td></tr>
<tr><td colspan="6">MODULE 2 – ELECTRIC TRACTION SYSTEMS(9L)</td></tr>
<tr><td colspan="6">Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. Basic concepts of electric traction, introduction to various electric drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.
Suggested Reading: https://link.springer.com/chapter/10.1007/978-3-642-30281-7_2 (Railway traction system)</td></tr>
<tr><td colspan="6">MODULE 3 – HYBRID ELECTRIC MOTOR DRIVES(9L)</td></tr>
<tr><td colspan="6">Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Introduction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.</td></tr>
<tr><td colspan="6">MODULE 4 – AUTOMOTIVE POWERTRAIN ELECTRONIC SYSTEMS & CHASSIS CONTROL SYSTEMS (9L)</td></tr>
<tr><td colspan="6">Power train electronic systems: sensors and actuators- electronic control units-engine management-electronic ignition systems-engine management systems for diesel and petrol injection systems. Transmission systems: sensors, actuators & control-chassis and body electronic systems: sensors and actuators for chassis and body systems. Comfort and control systems: HVAC-engine cooling-vehicle security-driver comfort and assistance-signalling and vision- safety system</td></tr>
</table>

Chassis control systems: ABS-ESP-TCS-ACC-active suspension system. Automatic transmission- X–by–wire systems – automotive alarm systems - vehicle immobilization & deactivation - driver information systems - parking systems - central locking system and electric windows. Occupants and driver safety systems: Seat belt lighteners and air–bags- fault tolerant schemes.ADAS andAutonomous Vehicles.	
MODULE 5 – VEHICULAR NETWORKS (9L)	
Controller Area Networks (CAN) - field of application- physical layer and bit coding-frame types and format-Bit stuffing and synchronization- error management. Overview of other communication protocols: LIN-Flex ray .	
TEXT BOOKS	
1	Sira -Ramirez, R. Silva Ortigoza, 'Control Design Techniques in Power Electronics Devices', Springer, 2006
2	Siew-Chong Tan, Yuk-Ming Lai, Chi Kong Tse, 'Sliding mode control of switching Power Converters', CRC Press, 2011
3	William Ribbens, "Understanding Automotive Electronics – An Engineering Perspective", Eighth Edition, Butterworth Heinemann, 2017.
4	Tom Denton, "Automobile Electrical and Electronic Systems", Fourth Edition, Routledge, 2012
REFERENCE BOOKS	
1	Bimal Bose, 'Power electronics and motor drives', Elsevier, 2006
2	Ion Boldea and S.A Nasar, 'Electric drives', CRC Press, 2005
3	Dominique Paret, "Multiplexed Networks for Embedded Systems: CAN, LIN, FlexRay, Safe–by–Wire", Wiley, First Edition, 20
E BOOKS	
1	https://www.elsevier.com/books/electric-and-hybrid-vehicles/pistoia/978-0-444-53565-8 (**eBook ISBN:** 9780444535665)
2	https://onlinelibrary.wiley.com/doi/book/10.1002/9781119998914 Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives
MOOC	
1	https://www.edx.org/course/electric-cars-introduction
2	https://www.edx.org/course/hybrid-vehicles

COURSE TITLE	ARTIFICIAL INTELLIGENCE IN ELECTRICAL DRIVES			CREDITS	3
COURSE CODE	EED3730	COURSE CATEGORY	DE	L-T-P-S	3- 0- 0- 1
CIA	50%			ESE	50%
LEARNING LEVEL	BTL- 4				

CO	COURSE OUTCOMES	PO
1.	Able to understand fundamentals of various AI based techniques	2,3,4,5,12
2.	Able to analyse various AI techniques presented for electrical machines and drives	2,3,4,5,12
3.	Able to analyse various evolution techniques	3,4,5,12

Prerequisites : power electronics

MODULE 1 – ARTIFICIAL INTELLIGENT BASED SYSTEMS (9L)

Natural language system – perception system for vision speech and touch - expert or knowledge based system – knowledge acquisition – knowledge of representation – inference strategy – expert controller.

Suggested Reading: Artificial Intelligence basics

MODULE 2 – ARTIFICIAL INTELLIGENCE(9L)

Definition, problem solving methods, searching techniques, knowledge representation, reasoning methods, predicate logic, predicate calculus, multivalue logic.

Suggested Reading: Paradigms of Artificial Intelligence Programming

Applications: Renewable Energy

MODULE 3 – FUZZY LOGIC(9L)

Concepts, fuzzy relations, membership functions, matrix representation, de-fuzzification methods **Suggested Reading: fuzzy logic with engineering application**

Applications: Renewable Energy

MODULE 4 – ARTIFICIAL NEURAL NETWORK (9L)

Introduction, multi-layer feed forward networks, back propagation algorithms, radial basis function and recurrent networks.

Applications: Domestic and Commercialapplications

MODULE 5 – EVOLUTIONARY TECHNIQUES(9L)

Introduction and concepts of genetic algorithms and evolutionary programming Hybrid Systems: Introduction and Algorithms for Neuro-Fuzzy, Neuro-Genetic, Genetic-Fuzzy systems.

Suggested Reading: Modern evolutionary techniques

Applications: Renewable Energy Conversion

LAB / MINI PROJECT/FIELD WORK

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TEXT BOOKS

1	Rajasekaran S. and Pai G.A.V., "Neural Networks, Fuzzy Logic and Genetic Algorithm Synthesis and applications, PHI New Delhi, 2017
2	Lin C. and Lee G., "Neural Fuzzy Systems", Prentice Hall International Inc. 1996

REFERENCE BOOKS

1	Goldberg D.E. “Genetic Algorithms in Search Optimization & Machine Learning”, Wesley Co., New York. 2000
2	Kosko B., "Neural Networks & Fuzzy Systems A dynamical systems approach to machine intelligence, Prentice Hall of India. 2008
E BOOKS	
1	https://www.kobo.com/us/en/ebooks/artificial-intelligence
2	https://courses.csail.mit.edu/6.034f/ai3/rest.pdf
MOOC	
1	https://nptel.ac.in/courses/106105077/
2	https://onlinecourses.nptel.ac.in/noc18_cs51/

COURSE TITLE	**SMART SYSTEMS**			**CREDITS**	**3**
COURSE CODE	**EED3731**	**COURSE CATEGORY**	**PC**	**L-T-P-S**	**3-0-0-0**
CIA				**ESE**	
LEARNING LEVEL				**ASSESSMENT MODEL**	
MODULE 1 –INTRODUCTION TO SENSOR DEVICES (9)					
Piezoresistive pressure sensor- Piezoresistive Accelerometer - Capacitive Sensing- Accelerometer and Microphone - Resonant Sensor and Vibratory Gyroscope - Low-Power, Low Voltage Sensors- Micro Electro Mechanical Systems Analysis and Design of MEMS Devices- Nano Sensors.					
MODULE 2 – INTERFACING SENSOR INFORMATION AND MCU (9)					
Amplification and Signal Conditioning- Integrated Signal Conditioning- Digital conversion- MCU Control-MCUs for Sensor Interface- Techniques and System Considerations- Sensor Integration.					
MODULE 3 –CONTROL TECHNIQUES AND STANDARDS (9)					
Control of Sensors using - State Machines, Fuzzy Logic, Neural Networks, Adaptive Control. Control Application using - CISC, RISC, DSP Control and IEEE 1451 Standards.					
MODULE 4 –COMMUNICATION FOR SMART SENSORS (9)					
Wireless Data Communications- RF Sensing- Telemetry- Automotive Protocols- Industrial Networks-Home Automation- MCU Protocols.					
MODULE 5 –PACKAGING, TESTING AND RELIABILITY IMPLICATIONS OF SMART SENSORS (9)					
Semiconductor Packaging- Hybrid Packaging- Packaging for Monolithic Sensors- Reliability Implications-Testing Smart Sensors- HVAC Sensor Chip.					
TEXT BOOKS					
1	Randy Frank, "Understanding Smart Sensors", Artech House, Second Edition, 2011Boston,				
2	Minhang Bao, "Analysis and design principles of MEMS devices", Elsevier Publications, 2005,USA.				
3	Nadim Maluf and Kirt Williams, "An Introduction to Micro Electro Mechanical Systems Engineering", Second Edition, Artech House Publishers, June 2004, USA.				
4	Gabriel M. Rebeiz, "RF MEMS: Theory, Design, and Technology", Wiley-Interscience; 1st edition, 2002,UK				
5	John A. Pelesko and David H. Bernstein, " Modeling MEMS and NEMS", CRC Press, 2002,UK				
6	Rai-choudhury, "MEMS and MOEMS Technology and Applications",PHI, 2010.				
7	Ananthasuresh, "Micro and Smart Systems" Wiley Publishers,2013.				

COURSE TITLE	**ENERGY STORAGE SYSTEMS**			**CREDITS**	**3**
COURSE CODE	**EED3732**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3- 0- 0- 1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL- 4**				

CO	**COURSE OUTCOMES**	**PO**
1	Recognize various issues related to energy market, its growth and its structural implications in India.	2,3
2	Analyze the performance of different battery storage systems.	2,3,
3	Employ different thermoelectric measurement techniques appropriately.	2,3,4
4	Interpret the applications of super capacitors for appropriate storage systems.	2,3,4,5,12
5	Understand and differentiate different types of fuel cells.	3,4,5,12

Prerequisites : Fundamental Chemistry and Material Science.

MODULE 1 – INTRODUCTION (9L)

Prospect for both traditional and renewable energy sources - detailed analysis of Indian energy market and future need through 2020 - energy, economic growth and the environment, implications of the Kyoto Protocol, and structural change in the electricity supply industry

Suggested Reading: Present and Future Energy Scenario in India

MODULE 2 – STORAGE SYSTEMS (9L)

Batteries - performance, charging and discharging, storage density, energy density, and safety issues, classical batteries - Lead Acid, Nickel-Cadmium, Zinc Manganese dioxide, and modern batteries -Zinc-Air, Nickel Hydride, Lithium Battery.

Suggested Reading : Storage Battery Maintenance and Principles

MODULE 3 – THERMOELECTRIC (9L)

Thermoelectric - electron conductor and phonon glass, classical thermoelectric materials (i) four-proberesistivity measurement, Seebeck coefficient measurement, and thermal conductivity measurement.

Suggested Reading:

Applications:

MODULE 4 – SUPER CAPACITORS (9L)

Super capacitors - types of electrodes and some electrolytes, Electrode materials - high surface area activated carbons, metal oxide, and conducting polymers, Electrolyte - aqueous or organic, disadvantages and advantages of super capacitors - compared to battery systems, applications - transport vehicles, private vehicles, and consumer electronics - energy density, power density, price, and market.

Suggested Reading: Linden's Handbook of Batteries, Fourth Edition by by: Thomas B. Reddy

MODULE 5 – FUEL CELLS (9L)

Fuel cells - direct energy conversion - maximum intrinsic efficiency of an electrochemical converter, physical interpretation - carnot efficiency factor in electrochemical energy convertors, types of fuel cells -hydrogen oxygen cells, hydrogen air cell, alkaline fuel cell, and phosphoric fuel cell.

Suggested Reading: fuel cells and its application

TEXT BOOKS

1. Tetsuya Osaka, MadhavDatta, 'Energy Storage Systems in Electronics', Gordon and Breach Science Publishers, 2000.

2	R. M. Dell, D.A.J. Rand, 'Understanding Batteries', RSC Publications, 2001.
REFERENCE BOOKS	
1	James Larminie, Andrew Dick, 'Fuel Cell System Explained', J. Wiley, 2003.
2	D.M. Rowe, 'Thermoelectrics Handbook: Macro to Nano', CRC Press, 2006.
E BOOKS	
1	https://ocw.tudelft.nl/wp-content/uploads/Sustainable-hydrogen-and-electrical-energy-storage-lecture1.pdf
MOOC	
1	https://ocw.tudelft.nl/course-lectures/introduction-energy-storage/
2	https://ocw.tudelft.nl/courses/sustainable-hydrogen-electrical-energy-storage/

DEPARTMENT ELECTIVE IV

COURSE TITLE	**INDUSTRY 4.0 and INDUSTRIAL INTERNET OF THINGS**			**CREDITS**	**3**
COURSE CODE	**EED3733**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3- 0- 0- 1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL- 4**				
CO	**COURSE OUTCOMES**				**PO**
Prerequisites : Basics of Internet of Things (IoT)					
MODULE 1 – INDUSTRY 4.0(9L)					
Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality, Artifical Intelligence, Big Data and Advanced Analysis					
MODULE 2 – INDUSTRIAL IoT (9L)					
IIoT-Introduction, Industrial IoT: Business Model and Referece Architerture: IIoT-Business Models, Industrial IoT- Layers: IIoT Sensing, IIoT Processing, IIoT Communication, IIoT Networking					
MODULE 3 – IIoT ANALYTICS(9L)					
Big Data Analytics and Software Defined Networks, Machine Learning and Data Science, Julia Programming, Data Management with Hadoop.					
MODULE 4 – IoT SECURITY(9L)					
Industrial IoT: Security and Fog Computing - Cloud Computing in IIoT, Fog Computing in IIoT, Security in IIoT					
MODULE 5 – CASE STUDY (9L)					
Industrial IoT- Application Domains: Oil, chemical and pharmaceutical industry, Applications of UAVs in Industries, Real case studies : Milk Processing and Packaging Industries, Manufacturing Industries					
TEXT BOOKS					
1	Industry 4.0: The Industrial Internet of Things", by Alasdair Gilchrist (Apress), 2017				
2	"Industrial Internet of Things: Cybermanufacturing Systems"by Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat (Springer), 2017				
REFERENCE BOOKS					

1	Hands-On Industrial Internet of Things: Create a powerful Industrial IoT by Giacomo Veneri, Antonio Capasso, Packt, 2018

COURSE TITLE	**ENERGY HARVESTING TECHNOLOGIES AND POWER MANAGEMENT FOR IoT DEVICES**			**CREDITS**	**3**
COURSE CODE	**EED3734**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3- 0- 0- 1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL- 4**				
CO	**COURSE OUTCOMES**				**PO**
Prerequisites : Nil					
MODULE 1 – ENERGY HARVESTING SYSTEMS(9L)					
Introduction – Energy sources – energy harvesting based sensor networks –photovoltaic cell technologies – generation of electric power in semiconductor PV cells– types					
MODULE 2 – PIEZO-ELECTRIC ENERGY HARVESTING AND ELECTROMECHANICAL MODELING(9L)					
Piezoelectric materials – transducers – harvesters – microgenerators – strategies forenhancing the performance of energy harvesters. Electromechanical modeling ofLumped parameter model and coupled distributed parameter models and closed-formsolutions					
MODULE 3 – ELECTROMAGNETIC ENERGY HARVESTING ANDNON-LINEAR TECHNIQUES(9L)					
Basic principles – micro fabricated coils and magnetic materials – scaling – powermaximations – micro and macro scale implementations. Non-linear techniques –vibration control & steady state cases					
MODULE 4 – ENERGY HARVESTING WIRELESS SENSORS (9L)					
Power sources for WSN – Power generation – conversion – examples – case studies.Harvesting micro electronic circuits – power conditioning and losses					
MODULE 5 – CASE STUDY (9L)					
Case studies for Implanted medical devices – Bio-MEMS based applications –harvesting for RF sensors and ID tags – powering wireless SHM sensor nodes					
TEXT BOOKS					
1	Carlos Manuel Ferreira Carvalho, Nuno Filipe Silva VeríssimoPaulino, “CMOSIndoor Light Energy Harvesting System for Wireless Sensing Applications”,springer, 2016				
REFERENCE BOOKS					
1	Danick Briand, Eric Yeatman, Shad Roundy ,“Micro Energy Harvesting”, 2015				

COURSE TITLE	**EMBEDDED SYSTEMS FOR BIOMEDICAL APPLICATIONS**			**CREDITS**	**3**
COURSE CODE	**EED3735**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3- 0- 0- 1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL- 4**				

CO	**COURSE OUTCOMES**	**PO**
Prerequisites :		

MODULE 1 – OVERVIEW OF BIOMEDICAL DEVICES(9L)

bio potentials –bio potential electrodes –bio potential amplifiers, System Theory for Physiological Signals: Filters

MODULE 2 – EMBEDDEDSYSTEMS IN PATIENT MONITORING (9L)

ECG, EEG, EMG, Blood pressure, respiration, pulse oxymeters, diagnostic devices.

MODULE 3 – EMBEDDED SYSTEMS FOR NON INVASIVE MEASUREMENT (9L)

Noninvasive Diagnosis Using Sounds from Within the Body, Noninvasive Measurement of Blood Pressure, Measurement of Electrical Potentials and Magnetic Fields from the Body Surface and Plethysmography.

MODULE 4 – HEALTHCARE AND THE WIRELESS SENSOR NETWORK, (9L)

Smart m-Health Sensing, m-Health and Mobile Communication Systems, Data Collection and Decision Making.m-Health Computing m-Health2.0,Social Networks, Health Apps, Cloud and Big Health Data

MODULE 5 – CASE STUDY (9L)

m-Health and Global Healthcare and the Future of m-Health –case study

.

TEXT BOOKS

1	John G. webster, “Medical Instrumentation -Application and Design”, Fourth Edition, JohnWiley and Sons, 2010
2	Subhas Chandra Mukhopadhyay and Aime Lay-Ekuakille, “Advances in BiomedicalSensing, Measurements, Instrumentation and Systems”, Springer, 201
3	Aime Lay-Ekuakille and Subhas Chandra Mukhopadhyay, “Wearable andAutonomousBiomedical Devices and Systems for Smart Environment -Issues andCharacterization”, Springer, 2010
4	Robert B. Northrop, “Noninvasive Instrumentation and Measurement in Medical Diagnosis”, CRC Press, 2002

REFERENCE BOOKS

1	Roberts. H. Istepanian and Bryan Woodward, “m-Health Fundamentals and Applications”, Wiley, 2017

<table>
<tr><td>COURSE TITLE</td><td colspan="3">EMBEDDED SYSTEMS FOR ROBOTICS</td><td>CREDITS</td><td>3</td></tr>
<tr><td>COURSE CODE</td><td>EED3736</td><td>COURSE CATEGORY</td><td>DE</td><td>L-T-P-S</td><td>3- 0- 0- 1</td></tr>
<tr><td>CIA</td><td colspan="3">50%</td><td>ESE</td><td>50%</td></tr>
<tr><td>LEARNING LEVEL</td><td colspan="5">BTL- 4</td></tr>
<tr><td>CO</td><td colspan="4">COURSE OUTCOMES</td><td>PO</td></tr>
<tr><td colspan="6">Prerequisites :</td></tr>
<tr><td colspan="6">MODULE 1 – INTRODUCTION TO SENSORS FOR ROBOTIC APPLICATIONS (9L)</td></tr>
<tr><td colspan="6">Sensor Categories, Binary Sensor, Analog versus Digital Sensors, Shaft Encoder; A/D Converter, Position Sensitive Device; Compass, Gyroscope, Accelerometer, Inclinometer, Digital Camera</td></tr>
<tr><td colspan="6">MODULE 2 – ROBOTICS CONTROL ELEMENTS (9L)</td></tr>
<tr><td colspan="6">Actuators - DC Motors, H-Bridge, Pulse Width Modulation, Stepper Motors, Servos. Control - On-Off Control, PID Control, Velocity Control and Position Control -</td></tr>
<tr><td colspan="6">MODULE 3 – EMBEDDED CONTROLLERS FOR ROBOTS(9L)</td></tr>
<tr><td colspan="6">Embedded Controllers, Interfaces, Operating System - Industrial Robots</td></tr>
<tr><td colspan="6">MODULE 4 – ROBOT KINEMATICS(9L)</td></tr>
<tr><td colspan="6">Evolution of robotics, Robot anatomy, Design and control issues, Manipulation and Control. Direct Kinematic Model - Denavit-Hartenberg Notation, Kinematic Relationship between adjacent links, Manipulator Transformation Matrix; Inverse Kinematic Model</td></tr>
<tr><td colspan="6">MODULE 5 – MOBILE ROBOTS (9L)</td></tr>
<tr><td colspan="6">Concepts of Localization and path planning - Autonomous robots - Robot Operating System.</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">TEXT BOOKS</td></tr>
<tr><td>1</td><td colspan="5">AnisKoubaa, "Robot Operating System (ROS) The Complete Reference”, First Volume, Springer, 2016</td></tr>
<tr><td>2</td><td colspan="5">Thomas Bräunl, “Embedded Robotics: Mobile Robot Design and Applications with Embedded Systems”, Third Edition, Springer-Verlag Berlin Heidelberg, 2008.</td></tr>
<tr><td>3</td><td colspan="5">R.K.Mittal and I.J.Nagrath, “Robotics and Control”, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2003</td></tr>
<tr><td colspan="6">REFERENCE BOOKS</td></tr>
<tr><td>1</td><td colspan="5">K.S. Fu, R.C. Gonzalez and C.S.G. Lee, “Robotics: Control, Sensing, Vision, and Intelligence”, McGraw-Hill, New York, 1987.</td></tr>
</table>

NON-DEPARTMENTAL ELECTIVES

COURSE TITLE	PHOTOVOLTAIC AND FUEL CELL SYSTEMS			CREDITS	3
COURSE CODE	EEC3741	COURSE CATEGORY	OE	L-T-P-S	3- 0- 0- 1
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-5				

CO	COURSE OUTCOMES	PO
1	Understand and analyse the fundamental concepts of solar PV systems	2,3,4,5,12
2	Design a solar PV power plants and its components	2,3,4,5,12
3	Understand and analyse the fundamental concepts of fuel cells	2,3,4,5,12

Prerequisites : Nil

MODULE 1 - SOLAR PV SYSTEMS (L12)

Fundamentals of solar cell, semiconductors as basis for solar cells materials and properties, P-N junction, sources of losses and prevention, estimating power and energy demand, site selection, land requirements, choice of modules, economic comparison, balance of systems, off grid systems, grid interface, Supporting structures, mounting and installation, battery storage, power condition unit, selection of cables and balance of systems, planning with software, maintenance and schedule, Monitoring, Data Management, Performance Analysis and Financial Analysis

MODULE 2 - SOLAR PV POWER PLANTS (L12)

Array design, inverter types and characteristics, Power conditioning system: working algorithms, performance analysis; design of standalone, hybrid and grid interactive plants, commissioning of solar PV plant

MODULE 3 - FUEL CELLS (L12)

Thermodynamics of fuel cells; free energy change and cell potentials; effects of temperature and pressure on cell potential; energy conversion efficiency; factors affecting conversion efficiency; polarization losses; important types of fuel cells (hydrogen-oxygen, organic compounds-oxygen, carbon or carbon monoxide-air, nitrogen compounds-air); electrode types; electrolytes for fuel cells; applications.

TEXT BOOKS

1	Chetan Singh Solanki, Solar Photovoltaic Technology And Systems: A Manual For Technicians, Trainers And Engineers PHI Learning Pvt. Ltd..,New Delhi 110092, 2013
2	A. K. Mukerjee, Nivedita Thakur, Photovoltaic Systems: Analysis And Design, Phi Learning Pvt. Ltd..,New Delhi 110001, 2011
3	Shripad T. Revankar, Pradip Majumdar, Fuel Cells: Principles, Design, And Analysis, CRC Press, 2014
4	N.K. Bansal, Non-Conventional Energy Resources, Vikas Publishing House Pvt Ltd, New Delhi , 2014

REFERENCE BOOKS

1	Roger A. Messenger, Amir Abtahi, Photovoltaic Systems Engineering ,4th Edition, CRC Press, 2017 (ISBN 9781498772778 - CAT# K29524)

2	Michael Boxwell , Solar Electricity Handbook - 2015 Edition: A simple, practical guide to solar energy - designing and installing solar PV systems.Green Stream Publishing, United Kingdom,2015
3	B. Viswanathan, M. Aulice Scibioh, **Fuel Cells**: **Principles and Applications**, Taylor & Francis Group, 2007
E BOOKS	
1	https://courses.edx.org/c4x/DelftX/ET.3034TU/asset/solar_energy_v1.1.pdf
2	http://unesdoc.unesco.org/images/0013/001332/133249e.pdf
MOOC	
1	https://online.stanford.edu/courses/matsci256-solar-cells-fuel-cells-and-batteries-materials-energy-solution
2	https://www.mooc-list.com/course/solar-energy-photovoltaic-pv-systems-edx
3	https://www.coursera.org/lecture/energy-environment-life/fuel-cells-and-hydrogen-economy-c0VKy

COURSE TITLE	**WIND AND HYDRO ENERGY SYSTEMS**			**CREDITS**	**3**
COURSE CODE	**EEC3742**	**COURSE CATEGORY**	**OE**	**L-T-P-S**	**3- 0- 0- 1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL-4**				

CO	**COURSE OUTCOMES**	**PO**
1	Understand and analyse the fundamental concepts wind energy power generation	2,3,4,5,12
2	Understand and analyse the operation and control of wind energy converter	2,3,4,5,12
3	Understand and analyse the concepts and components of hydro power generation	2,3,4,5,12

Prerequisites : Nil

MODULE 1 - WIND ENERGY (12L)

Basics :Status, Advantages and disadvantages of wind energy systems, Advantages and disadvantages, Types of wind energy converters, local Effects on wind, site selection: roughness length, wind shear, Wind Speed Variability, Obstacles to wind flow,

Working principles of wind energy: Energy content in wind, Energy Conversion at the Blade, Wind variations: Weibull distribution.

MODULE 2 - COMPONENTS , OPERATION AND CONTROL OF A WIND ENERGY CONVERTER (12L)

Components of a wind energy converter: Rotor Blades, Gearboxes, Synchronous or Asynchronous Generators, Towers, Miscellaneous components, Turbine Selection

Operation and Control of Wind Energy Converters: grid requirements, Issue of Noise and Its Control, Power Curve and Capacity Factor, Pitch control, Stall Control, Yaw Control

MODULE 3 - HYDRO POWER (12L)

Hydropower basics: Water Cycle in Nature, Classification of Hydropower Plants, Status of Hydropower Worldwide, Advantages and Disadvantages of Hydropower, Operational Terminology, Legal Requirements

Working principles: Locating a Hydropower Plant, Basics of Fluid Mechanics for hydro power, single and multiple reservoir system, cascaded power plants

Important Parts of Hydropower Station: Turbine, Electric Generator, Transformer and Power House, Structural parts: Dam and Spillway, Surge Chambers, Stilling Basins, Penstock and Spiral Casing, Tailrace, Pressure Pipes, Caverns, auxilliary parts. Hydraulic turbines: Classification of Hydraulic Turbines, Theory of Hydro Turbines: Francis, Kaplan, Pelton turbines, efficiency and selection of turbine	
TEXT BOOKS	
1	Nag P K. Power Plant Engineering, 3rd Edition, Tata McGraw Hill, 2008
2	Jain P. Wind Energy Engineering. McGraw-Hill 2011
3	Wagner H. Mathur J. Introduction to Hydro energy Systems : Basics, Technology and Operation, Springer, 2011
4	Bansal RK. A textbook of fluid mechanics and hydraulic machines. Laxmi Publications, 2005, New Delhi
REFERENCE BOOKS	
1	Johnson GL. Wind Energy Systems, (Electronic Edition), Prentice Hall Inc, 2006
2	Mathew S. Wind Energy: Fundamentals, Resource Analysis and Economics. Springer, 2006
3	Hussian Z. Abdullah MZ. Alimuddin Z. Basic Fluid Mechanics and Hydraulic Machines. CRC Press, 2009.
E BOOKS	
1	https://nptel.ac.in/courses/108105058/24
2	https://nptel.ac.in/courses/108108078/6
3	https://www.nrel.gov/docs/fy13osti/54909.pdf
4	https://www.usbr.gov/power/edu/pamphlet.pdf
5	https://ieeexplore.ieee.org/document/6533416
MOOC	
1	http://www1.rmit.edu.au/courses/045838
2	https://www.coursera.org/lecture/electric-utilities/1-7-renewables-hydroelectric-and-wind-B3YMk

COURSE TITLE	BIOMASS ENERGY SYSTEMS			CREDITS	3
COURSE CODE	EEC3743	COURSE CATEGORY	OE	L-T-P-S	3- 0- 0- 1
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-4				

CO	COURSE OUTCOMES	PO
1	Understand the fundamental concepts of Biomass	1,2,3,4,5,12
2	analyse the operation and control of biomass and biogas	1,2,3,4,5,12
3	Understand and analyse the industrial and power generation aspects of biomass	1,2,3,4,5,12
Prerequisites : Nil		
MODULE 1 - BIOMASS RESOURCE		**(L12)**
Characteristics of Biomass fuel, technologies for using biomass, comparison of direct combustion with other technologies		
MODULE 2 - BIOMASS GASIFIERS AND INDUSTRIAL USE OF BIOMASS (L12)		

Biomass Gasifiers: Basics of Gasification and types of Gasifiers, Thermodynamic Analysis Biogas Technology, Sizing/Selection and design of Gasifiers, Industrial use of biomass: Industrial Boilers, biomass as fuel, co-firing and co-generation, Economic analysis, Testing and Performance Evaluation of Gasifiers, Use of biomass for liquid fuel, Biomass policy		
MODULE 3 - BIOGAS		**(L12)**
Types of biogas plants, design and performance analysis, application of biomass		
TEXT BOOKS		
1	Biomass Assessment Handbook - Bioenergy for a sustainable environment, Edited by Frank Rosillo-Calle, Sarah Hemstock, Peter de Groot and Jeremy Woods, Earthscan November 2006	
2	Success & Visions for Bioenergy: Thermal processing of biomass for bioenergy, biofuels and bioproducts, Edited by A V Bridgwater, CPL Press September 2007.	
REFERENCE BOOKS		
1	Alternate Energy: Assessment & Implementation Reference Book, James J Winebrake, Springer January 2007.	
2	Biofuels - Securing the Planet's Future Energy Needs, Edited by A Demirbas Springer 2009.	
3	Energy Technology and Directions for the Future, John R. Fanchi, Elsevier Science February 2004	
E BOOKS		
1	https://nptel.ac.in/courses/108108078/7	
2	https://nptel.ac.in/downloads/108108078/	
3	http://www.cigr.org/documents/CIGRHandbookVol5.pdf	
4	https://www.crcpress.com/Principles-of-Sustainable-Energy-Systems-Third-Edition/Kutscher-Milford-Kreith/p/book/9781498788922	
5	https://link.springer.com/referencework/10.1007/978-1-4614-5820-3	
MOOC		
1	https://www.edx.org/course/sustainable-energy-design-a-renewable-future	