Curriculum Structure & Detailed Syllabus

Master of Science (Embedded Electronics & IIoT)

(Two-Year Post-Graduate Program)

Silicon University, Odisha

Silicon Hills, Patia, Bhubaneswar - 751024

https://silicon.ac.in

Effective From Academic Year 2024-25

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Approval History

ACM#	Date	Resolutions
SU-1	27/04/2024	The curriculum structure of M.Sc. (Embedded Electronics & IIoT) was approved in principle by the Academic Council.
SU-2	17/08/2024	The curriculum structure and detailed syllabus of M.Sc.(Embedded Electronics & IIoT) was approved by the Academic Council.

Program Outcomes

Graduates Attributes (GAs) form a set of individually assessable outcomes that are the components indicative of the graduate's potential to acquire competence to practice at the appropriate level.

PO1. Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.

PO2. Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.

PO3. Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.

PO4. Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.

PO5. Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.

PO6. Function effectively as an individual or as a member of a multidisciplinary team with professional and managerial skills.

PO7. Work in a professional context with intellectual integrity, ethics, and social responsibility.

PO8. Communicate effectively and present technical information in oral and written reports supported by diagrams and models for easy visualization.

PO9. Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.

PO10. Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Program Specific Outcomes (PSOs)

PSO1. Understand & learn the concepts of embedded system design, industrial automation, and Internet of Things (IoT) to develop innovative solutions for various real-world applications.

PSO2. Develop and integrate embedded systems as well as IoT for real-life & industrial applications, and optimize their performance using appropriate tools.

PSO3. Use cutting-edge tools, platforms, and technology to build a rewarding career profile and a passion for entrepreneurship, higher education, or research.

Program Educational Objectives (PEOs)

PEO1. Build a successful career based on concepts of electronics and design principles of embedded & IIoT systems using various electronics technologies and tools.

PEO2. Work independently or in a diverse team with effective communication in an interdisciplinary environment, and demonstrate leadership in industry and academia.

PEO3. Engage in lifelong learning and career development through analysis, discussion, professional studies, literature study, and continued research.

Course Categories & Definitions

L	Lecture
T	Tutorial
P	Practical / Laboratory / Sessional
WCH	Weekly Contact Hours
UCR	University Core Course
UMC	University Mandatory Course (0-Credit)
PCR	Program Core Course
PEL	Program Elective Course
OEL	Open Elective Course
HNS	Honours (Choice-based) Course
MNR	Minor (Choice-based) Course
OOC	Open Online Course (on NPTEL / Swayam / Other)
INT	Summer Internship
PSI	Practice School / Industry Internship
PRJ	Project Work
SEC	Skill Enhancement Course
VAC	Value Addition Course

Contents

Part I

Curriculum Structure

Curriculum Structure

Semester I								
Category	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
PCR	MT5008	Mathematical Methods for Electronics	3	0	0	3	0	0
PCR	EC5036	Electronic Circuits	3	1	0	3	1	0
PCR	EC5037	Embedded C Applications	3	0	0	3	0	0
PCR	EC5038	Microcontrollers & Applications	3	0	0	3	0	0
PCR	EC5022	Signals & Systems	3	0	0	3	0	0
PRACTICAL								
PCR	EC5039	Electronic Circuits Lab	0	0	2	0	0	1
PCR	EC5040	Embedded C Applications Lab	0	0	4	0	0	2
PCR	EC5041	Microcontrollers & Applications Lab	0	0	2	0	0	1
UCR	HS5003	Communication & Soft Skills	0	0	4	0	0	2
		SUB-TOTAL	**15**	**1**	**10**	**15**	**1**	**5**
		TOTAL	**26**			**21**		

Semester II								
Category	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
PCR	EC5042	Sensors & Control Systems	3	0	0	3	0	0
PCR	EC5043	Embedded Systems & Design	3	1	0	3	1	0
PCR	EC5044	M2M & Internet of Things	3	1	0	3	1	0
PEL		Program Elective - I	3	0	0	3	0	0
PEL		Program Elective - II	3	0	0	3	0	0
PRACTICAL								
PCR	EC5045	Sensors & Control Systems Lab	0	0	2	0	0	1
PCR	EC5046	Embedded Systems & Design Lab	0	0	4	0	0	2
PCR	EC5047	M2M & Internet of Things Lab	0	0	2	0	0	1
PCR	EC5048	Embedded Applications Research Lab	0	0	2	0	0	1
		SUB-TOTAL	**15**	**2**	**10**	**15**	**2**	**5**
		TOTAL	**27**			**22**		

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Semester III								
Category	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
PCR	EC6021	Digital System Design	3	0	0	3	0	0
PCR	EC6022	Industrial Automation & IIoT	3	1	0	3	1	0
PEL		Program Elective - III	3	0	0	3	0	0
PEL		Program Elective - IV	3	0	0	3	0	0
PRACTICAL								
PCR	EC6023	Industrial Automation & IIoT Lab	0	0	2	0	0	1
SEC	EC6024	Emerging Technologies Lab	0	0	4	0	0	2
PRJ	IP4003	Capstone Project	0	0	10	0	0	5
INT	IP4001	Summer Internship	0	0	0	0	0	1
		SUB-TOTAL	**12**	**1**	**16**	**12**	**1**	**9**
		TOTAL	**29**			**22**		

Semester IV								
Category	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY								
OOC	EC6010	MOOC	0	0	0	3	0	0
PRACTICAL								
PRJ/PSI	IP4002	Project Work / Industry Internship	0	0	24	0	0	12
VAC	VA0001	Yoga / NCC / NSS	0	0	2	0	0	0
		SUB-TOTAL	**0**	**0**	**26**	**3**	**0**	**12**
		TOTAL	**26**			**15**		

		GRAND TOTAL (4 SEMESTERS)	**108**	**80**

Note:
1. Courses offered under each elective are given in “List of Electives” on Page 4.
2. MOOC - Massive Open Online Course (on NPTEL / Swayam / Other).
3. Approved list of courses for MOOC (self study) shall be published by the department. Students are advised to complete the same before the end of 4th semester.
4. Students opting for Project Work shall undergo the same under the guidance of a faculty member.
5. Students selected for Industry Internship shall be attached to a faculty member as mentor.
6. The Value Addition Course (Yoga / NSS / NCC) may be assigned in a different semester depending on available capacity.

List of Electives

Code	Elective # and Subjects
	Program Elective-I
EC5049	AI Technologies & Soft-Computing
EC5050	Embedded System Applications
EC5051	Mechatronics in Manufacturing Practices
	Program Elective-II
EC5052	Machine Learning & IIoT
EC5053	Reconfigurable Hardware Design
EC5054	Virtual Instrumentation & DAQ
	Program Elective-III
CS6028	Web Technology & Cloud Computing
EC6026	Embedded OS & LINUX
EC6027	Machine Vision & Intelligent Automation
	Program Elective-IV
CS6026	Data Security & Privacy
EC6028	Advanced Embedded Systems
EC6029	PLC, SCADA, VFD & DCS

Note:
1. The department shall offer subjects under each program elective depending on available capacity.
2. Unless adequate number of students choose an elective subject offered by the department, the subject shall not be offered and the students shall be assigned with a different elective subject.

Part II

Detailed Syllabus

Category	Code	Mathematical Methods for Electronics	L-T-P	Credits	Marks
PCR	MT5008		3-0-0	3	100

Objectives	The objective of this course is to learn different mathematical techniques and methods of optimization & stochastic processes to create the fundamental foundation for various domains in electronics.
Pre-Requisites	Calculus of single variable & ordinary differential equations, basic concepts on system of linear equations & matrices and elementary probability.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Root finding problems, Bisection method, Fixed point iteration, Secant method, Newton-Raphson method, Numerical solution of ordinary differential equation, Euler's method, Improved Euler Method, Runge-Kutta method of fourth order.	**8 Hours**
Module-2	Linear programming, Graphical method, Simplex method, Big-M method, Two phase method, Duality and prime dual relationship, Dual simplex method, Sensitivity & post optimal analysis.	**10 Hours**
Module-3	Graph & Networks, Minimum spanning tree problem, Shortest path problem (Dijkstra's algorithm, Floyd's algorithm), Maximum flow problem.	**7 Hours**
Module-4	Stochastic Process, Discrete time Markov chain, Transition Probability matrix, Chapman-Kolmogorov equations, state classification, Steady state probabilities, First Passage Times, Absorbing State, Continuous time Markov Chain.	**9 Hours**
Module-5	Genetic Algorithm, Working principles, Coding, Fitness function, GA operators, Generation of mating pool, Cross-over, Mutation, Testing and reproduction, Solving optimization problems using GA.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. E. Kreyszig, ***Advanced Engineering Mathematics***, 9th Edition, Wiley India, 2006.
T2. F. S. Hiller and G. J. Lieberman, ***Introduction to Operations Research***, 7th Edition, McGraw-Hill Education, 2001.
T3. H. A. Taha, ***Operations Research: An Introduction***, 8th Edition, Pearson Education, 2007.
T4. K. Dev, ***Optimization for Engineering Design Algorithms and Examples***, 2nd Edition, PHI Learning, 2012.

Reference Books:

R1. M. K. Jain, S. R. K. Iyengar, and R. K. Jain, ***Numerical Methods for Scientific and Engineering Computation***, 3rd Edition, New Age International Publishers, 2020.
R2. D. B.West, ***Introduction to Graph Theory***, 2nd Edition, Pearson Education, 2001.

R3. A. Ravindran, D. Phillips, and J. J. Solberg, ***Operations Research: Principle and Practice***, 2nd Edition, Wiley India,2010.

Online Resources:

1. https://nptel.ac.in/courses/111101165: by Prof. S. Baskar, IIT Bombay
2. https://nptel.ac.in/courses/111102012: by Dr. A. Mehra, IIT Delhi
3. https://nptel.ac.in/courses/111102096: by Dr. S. Dharmaraja, IIT Delhi
4. https://nptel.ac.in/courses/106108056: by Dr. S. K. Shevade, IISc Bangalore
5. https://nptel.ac.in/courses/112105235: by Prof. D. K. Pratihar, IIT Kharagpur

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Apply numerical methods to solve algebraic, transcendental and ordinary differential equations.
CO2	Model and solve linear programming problems by appropriate methods.
CO3	Model and solve optimization problems of a network.
CO4	Model and apply Markov Models to solve real life engineering problems.
CO5	Apply Genetic Algorithm to solve real life optimization problems.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	2	1	1	1					1	2	1	1
CO2	3	2	2	1	1					1	1	2	1
CO3	3	3	2	2	1					1	2	2	2
CO4	3	2	2	2	1					1	2	1	2
CO5	3	3	2	2	2					1	2	2	2

Category	Code	Electronic Circuits	L-T-P	Credits	Marks
PCR	EC5036		3-1-0	4	100

Objectives	The objective of this course is to study analog & digital electronic circuits, various electronic components and their applications.
Pre-Requisites	Basic UG level knowledge on electronics and circuits is required.
Teaching Scheme	Regular classroom lectures with the use of ICT as and when required and interactive sessions with a focus on problem-solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**P-N Junction Diodes**: Semiconductor Diode, Diode Equivalent Circuits; Rectifiers, Clippers, Clampers; **Bipolar Junction Transistor (BJT)**: Construction, Operation, Configurations (CB, CE, CC), Operating Point; **BJT DC Analysis**: BJT DC Biasing, Different Biasing Circuits.	**12 Hours**
Module-2	**BJT AC Analysis**: BJT Small Signal Models (r_e and h-models of different configurations), Small Signal Models of Different Biasing Circuits, Effect of R_S and R_L; **MOSFET**: Construction, Different Types of MOSFETs (Depletion and Enhancement).	**12 Hours**
Module-3	**MOSFET DC Analysis**: DC Biasing, Different MOSFET Biasing Circuits (Depletion type & Enhancement type), **Operational Amplifiers**: Introduction to OP-AMP, Applications – Summing Amplifier, Buffer, Differentiator and Integrator, Instrumentation Amplifier.	**11 Hours**
Module-4	**Digital Electronics**: Introduction, Analog to Digital Conversion, Basic Digital Circuits, Logic Gates and their Operations, Universal Logic Gates; **Number Systems and Codes**: Binary Number System, Signed Binary Numbers, Binary Arithmetic, 1's and 2's Complement Arithmetic, Gray Codes, Binary to Gray & Gray to Binary Code Conversion; Boolean Algebra and Identities, Algebraic Reduction and Realization using Logic Gates and Universal Logic Gates.	**10 Hours**
Module-5	**Logic Function Minimization & Combinational Circuits**: Standard Representation for Logic Functions – Sum-of-Products (SOP) and Product-of-Sums (POS) Forms, Canonical SOP and POS Forms; K-map Representation and Simplification of Logic Functions using K-map, Minimization of 2, 3, and higher variable logical functions; Don't Care Conditions; Design of Adder, Subtractor, and Multiplier circuits.	**11 Hours**
	Total	**56 Hours**

Text Books:

T1. R. L. Boylestad and L. Nashelsky, ***Electronic Devices and Circuit Theory***, 11th Edition, Pearson Education, 2015.

T2. M. M. Mano and M. D. Ciletti, ***Digital Design: With an Introduction to Verilog HDL***, 5th Edition, Pearson Education, 2013.

Reference Books:
R1. A. S. Sedra and K. C. Smith, ***Microelectronic Circuits***, 7th Edition, Oxford University Press, 2014.
R2. J. Millman and C. C. Halkias, ***Integrated Electronics: Analog and Digital Circuits and Systems***, 2nd Edition, TMH Publications, 2017.
R3. P. Horowitz and W. Hill, ***The Art of Electronics***, 2nd Edition, Cambridge University Press, 1989.
R4. A. Agarwal and J. Lang, ***Foundations of Analog and Digital Electronic Circuits***, 1st Edition, Elsevier, 2005.

Online Resources:
1. https://nptel.ac.in/courses/117101106/: by Prof. A.N. Chandorkar, IIT Bombay
2. https://nptel.ac.in/courses/108102095/: by Prof. S.C. Dutta Roy, IIT Delhi
3. https://nptel.ac.in/courses/117106086/: by Prof. S. Srinivasan, IIT Madras
4. https://nptel.ac.in/courses/117103064/: by Prof. A. Mahanta & Prof. R. P. Palanthinkal, IIT Guwahati
5. http://www.allaboutcircuits.com
6. https://www.electronics-tutorials.ws/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain PN-Junction diode, BJT and its DC analysis, and their applications.
CO2	Explain AC analysis of BJT and working principle of MOSFET.
CO3	Design various circuits using OP-AMP and perform DC analysis of MOSFET.
CO4	Describe the fundamental concepts of digital electronics and different number systems.
CO5	Explore digital circuit design using logic function minimization techniques.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	1	1	2	2							1		
CO2	2	2		1						1		1	1
CO3	3	1	3	2	3						3		
CO4	1		2	1						1		1	2
CO5	2	2	3	3	3					2	3	2	2

Category	Code	Embedded C Applications	L-T-P	Credits	Marks
PCR	EC5037		3-0-0	3	100

Objectives	The objective of this course is to learn the in-depth concepts of embedded C programming techniques, GPIO, peripheral operations, and serial communication standards by leveraging industry standard MCUs.
Pre-Requisites	Knowledge of computer programming and basic electronics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on design & programming activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**C Programming**: Names, Types, and Type declarations, Storage classes, Linkage and Scope, Character constants, Arrays, Other types, Operators and Expressions, Increment and Decrement operators, Precedence and Associativity, Program Flow and Control, Functions, Recursion, Demonstration and practice.	**8 Hours**
Module-2	**Advanced Topics in C**: Pointers, Multidimensional arrays, Structures, Input and Output, Memory Management, Miscellaneous functions, Demonstration and practice.	**9 Hours**
Module-3	**Introduction to STM MCU**: Principal MCU components, Bit Serial Ports, S/W for MCU programming, STM project development, Memory-Mapped peripherals, Core memory addresses, Peripheral memory addresses; HAL_GPIO module – GPIO pin hardware, LED Test demonstration, Enabling multiple outputs, Push-Button test; Clock speed – Setting the PIN clock speed, Demonstration and practice.	**9 Hours**
Module-4	**Interrupts, Timer and UART**: NVIC specifications; Interrupt Process – External Interrupts; STM timer peripherals, Timer configurations, LED test programs; UART & USARTs – Transmit and Receive programming, Demonstration and practice.	**8 Hours**
Module-5	**ADC and PWM**: ADC Functions – ADC module with HAL, Conversion modes, Channels, Groups, and Ranks, Demonstrations; General purpose timer PWM signal generation, Timer H/W architecture, PWM signals with HAL; Introduction to I2C, SPI, Demonstration and practice.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. P.S. Deshpande and O. G. Kakde, ***C and Data Structures***, 1st Edition, Dreamtech Press, 2003.
T2. E. Balagurusamy, ***Programming in ANSI C***, 7th Edition, McGraw-Hill Education, 2017.
T3. C. Noviello, ***Mastering STM32***, 2nd Edition, Leanpub, 2022.

Reference Books:

R1. K. R. Venugopal and S. R. Prasad, ***Mastering C***, 3rd Edition, McGraw-Hill Education, 2017.
R2. T. V. Sickle, ***Programming Microcontrollers in C***, 2nd Edition, LLH Publishing, 2001.

R3. M. A. Mazidi, S. Chen, and E. Ghaemi, ***STM32 Arm Programming for Embedded Systems (Using C Language with STM32 Nucleo)***, 1st Edition, Microdigitaled, 2018.

Online Resources:
1. https://nptel.ac.in/courses/106104128: By Prof. S. Nandakumar, IIT Kanpur
2. https://nptel.ac.in/courses/106105171: By Prof. A. Basu, IIT Kharagpur
3. https://nptel.ac.in/courses/106105193: By Prof. I. Sengupta and Prof. K. Datta, IIT Kharagpur
4. https://nptel.ac.in/courses/108105102: By Prof. Santanu Chattopadhyay, IIT Kharagpur
5. https://www.st.com/content/st_com/en/support/learning/stm32-education.html

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain the concepts of C programming required to program any MCU.
CO2	Develop advanced C programming skills for embedded system applications.
CO3	Program an Industry standard MCU using embedded C programming.
CO4	Describe interrupts, timers, and UART operations for real-time applications.
CO5	Analyze the ADC and PWM operations using embedded C programming techniques.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO9	Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	1	1	1	1						2	2	2
CO2	2	2	2	1	1						2	2	2
CO3	3	3	3	3	3				2	2	3	3	3
CO4	3	3	3	3	3				2	2	3	3	3
CO5	3	3	3	3	3				2	2	3	3	3

Category	Code	Microcontrollers & Applications	L-T-P	Credits	Marks
PCR	EC5038		3-0-0	3	100

Objectives	The objective of this course is to study the concepts & architecture of microcontroller systems including 8051, PIC and interfacing architecture, modeling embedded solutions, and applications of microcontrollers.
Pre-Requisites	Knowledge of digital electronics, operating systems, and basics of microprocessor programming is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on examples, case-studies, and latest trends.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Microprocessor Vs Microcontroller, Embedded Systems, Embedded Microcontrollers, 8051 Architecture- Registers, Pin diagram, I/O ports functions, Internal Memory organization. External Memory (ROM & RAM) interfacing.	**10 Hours**
Module-2	**Basic Microcontroller Programming**: 8051 Instruction set, Interrupts, Addressing modes, Data transfer instructions, Arithmetic instructions, Logical instructions, Branch instructions, Bit manipulation instructions, Assembly language program examples using these instructions.	**8 Hours**
Module-3	**Advanced Microcontroller Programming**: Programming 8051 timers, Counters programming, Serial Communication, 8051 connection to RS232, 8051 serial communication programming, Programming timer interrupts, external hardware interrupts, and serial communication interrupts.	**8 Hours**
Module-4	**Microcontroller Interfacing**: Memory interfacing, I/O interfacing, Interfacing an LCD to the 8051, 8051 interfacing to ADC, Sensors, Interfacing a stepper motor, 8051 interfacing to the keyboard, Interfacing a DAC to the 8051, Serial data transfer scheme, Onboard Communication Interfaces - I2C Bus, SPI Bus, UART, External Communication Interfaces - RS232, USB.	**8 Hours**
Module-5	**PIC Controllers**: Overview of PIC18 family, Internal Bus Architecture, Block Diagram, Memory Organization, General purpose and Special purpose registers, Pipelining operation.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. M. A. Mazidi, J. G. Mazidi, R. McKinlay, ***The 8051 Microcontroller and Embedded Systems: Using Assembly and C***, 2nd Edition, Pearson Education, 2011.

T2. A. K. Ray and K. M. Bhurchandani, ***Advanced Microprocessors and Peripherals***, 2nd Edition, McGraw Hill Education, 2006.

T3. D. A. Patterson and J. H. Hennessy, ***Computer Organization and Design: The Hardware/Software Interface***, 5th Edition, Morgan Kaufman Publishers, 2013.

Reference Books:

R1. K. Kant, ***Microprocessors and Microcontrollers: Architecture, Programming and System Design 8085, 8086, 8051, 8096***, 2nd Edition, Prentice Hall India, 2013.
R2. D. Hall, ***Microprocessors and Interfacing***, 3rd Edition, McGraw-Hill Education, 2017.

Online Resources:

1. https://nptel.ac.in/courses/108107029/: by Dr. P. Agarwal, IIT Roorkee
2. https://nptel.ac.in/courses/106108100/: by Prof. K. Kumar, IISc Bangalore
3. http://www.electrical4u.com/circuit-analysis.htm
4. http://www.allaboutcircuits.com
5. https://www.electronics-tutorials.ws/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe the architecture & functionality of 8051 microcontrollers.
CO2	Write assembly language programs for 8051 microcontrollers using its instruction set.
CO3	Develop advanced programs involving timer, counter, communication, and interrupts for the 8051 microcontroller.
CO4	Interface microcontrollers with other devices & peripherals for real life applications.
CO5	Explore the architecture, programming & memory interfacing of PIC microcontrollers.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO6	Function effectively as an individual or as a member of a multidisciplinary team with professional and managerial skills.
PO9	Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	2			2	2	3		1
CO2	3	3	2	2	3	1			3	3	3		2
CO3	3	3	3	2	3	2			3	3	3		2
CO4	3	3	3	3	3	2			3	2	3		3
CO5	3	3	3	3	2	2			2	2	3		3

Category	Code	Signals & Systems	L-T-P	Credits	Marks
PCR	EC5022		3-0-0	3	100

Objectives	The objective of this course is to study the characteristics of different signals and systems in time and frequency domains, and to analyze different signals and systems using Fourier, Laplace and Z-Transform.
Pre-Requisites	Fundamental knowledge of basic mathematics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Signals**: Introduction, Classification: continuous/discrete-time, commonly used continuous-time signals and discrete-time Signals, Periodic/Aperiodic, Even/Odd, Energy/Power, Operations on Continuous-time and Discrete-time Signals: Addition, Multiplication, Differentiation/Difference, Integration/Accumulation, Shifting, Scaling, Folding.	**8 Hours**
Module-2	**Systems and LTI/LSI Systems**: Introduction, Classification of continuous-time and discrete-time - Linear/Non-linear, Time varying/Time invariant, Causal/Non-causal, Dynamic/Static, Stable/Unstable, Difference equations, Response of LSI system convolution Sum.	**8 Hours**
Module-3	**Analysis by Fourier Series and Fourier Transform**: Fourier series, Convergence of the Fourier series, Trigonometric Fourier series and Exponential Fourier series, Continuous time Fourier Transform, Fourier transform of some useful signals, Properties of the Fourier transform.	**9 Hours**
Module-4	**Analysis by Laplace Transform**: Introduction, Region of Convergence for Laplace transform, and properties of ROC, Laplace transform of some useful signals, Properties of the Laplace transform, The inverse Laplace transform and its properties.	**9 Hours**
Module-5	**Analysis by Z-Transform**: Discrete-time system analysis using the Z-transform, The Region of Convergence, Z-transform of some useful sequences, Properties of Z-transform, Inverse Z-transform.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. A. V. Oppenheim, A. S. Willsky, and S. H. Nawab, ***Signals and Systems***, 2nd Edition, Prentice Hall India, 1992.
T2. S. Haykin and B. V. Veen, ***Signals and Systems***, 2nd Edition, John Wiley & Sons, 2002.
T3. B. P. Lathi, ***Principles of Signal Processing and Linear Systems***, 2nd Edition, Oxford Univ. Press, 2009.

Reference Books:

R1. H. P. Hsu, ***Signal and System - Schaum's Outlines***, 2nd Edition, McGraw Hill, 2011.
R2. A. N. Kani, ***Signals and Systems***, 2nd Edition, McGraw Hill Education, 2010.

R3. M. J. Roberts, ***Signals and Systems - Analysis using Transform Methods and MATLAB***, 2nd Edition, McGraw hill, 2003.

Online Resources:
1. https://nptel.ac.in/courses/117104074/: by Prof. K.S. Venkatesh, IIT Kanpur
2. https://nptel.ac.in/courses/108105065/: by Prof. T.K. Basu, IIT Kharagpur
3. https://nptel.ac.in/courses/108104100/: by Prof. A. K. Jagannatham, IIT Kanpur
4. https://nptel.ac.in/courses/108105059/: by Prof. S. Mukhopadhyay, IIT Kharagpur
5. https://ocw.mit.edu/resources/res-6-007-signals-and-systems-spring-2011/lecture-notes/
6. https://engineering.purdue.edu/~mikedz/ee301/ee301.html
7. https://stanford.edu/~boyd/ee102/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe different types of signals and systems.
CO2	Analyse various types of LSI systems responses.
CO3	Explain continuous and discrete systems in time & frequency domains using different transforms.
CO4	Describe the system stability and causality using Laplace Transform.
CO5	Analyse discrete time signals and systems using Z-transform.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO6	Function effectively as an individual or as a member of a multidisciplinary team with professional and managerial skills.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	1	1	1	2	1					2	2	
CO2	2	2	2	2	1	1					1		1
CO3	1	1	1	1	1	2				1	2	1	1
CO4	2	2	1	1	3	1				1	2		
CO5	1	1	2	1	1	2				1	2	1	1

Category	Code	Electronic Circuits Lab	L-T-P	Credits	Marks
PCR	EC5039		0-0-2	1	100

Objectives	The objective of this course is to study PN junction diode, BJT, MOSFET, OPAMP and different digital electronic circuits through hands-on experiments.
Pre-Requisites	Basic knowledge on electronics and topics taught in theory class are required
Teaching Scheme	Regular laboratory experiments to be conducted under supervision of the faculty with use of ICT as and when required, sessions are planned to be interactive with focus on implementation in hardware/software tools.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
Experiments on Analog Electronics (Any Six)	
1	Familiarization with electronic components and devices (Testing of semiconductor diodes and transistors using digital multi-meter).
2	Study and use of Oscilloscope, signal generator to view waveforms and measure amplitude and frequency of a given waveform.
3	Study of V-I characteristics of PN junction diode and determining its DC and AC resistances.
4	Design and implementation of Rectifier (HWR & FWR) circuits.
5	Design and implementation of Clipper & Clamper circuits.
6	Study of static characteristics of BJT in CE configuration.
7	Design, simulate and realize the BJT bias circuits and compare the results.
8	Design, simulate and realize the MOSFET bias circuits and compare the results.
9	Design, simulate and realize the BJT common-emitter amplifier circuit and perform its AC analysis.
10	Design and study the operation of Op-Amp as inverting amplifier, non-inverting amplifier, and summing amplifier.
11	Design and study the operation of Op-Amp as differentiator, integrator, and square wave generator.
Experiments on Digital Electronics (Any Four)	
12	Study the pin diagram and investigate logic behavior of AND, OR, NAND, NOR, EX OR, EX-NOR, NOT and Buffer gates.
13	Design and realization of Code Converters: Gray to Binary and Binary to Gray.
14	Design and realization of a given Boolean function with universal logic (i) NAND Gates only (ii) NOR Gates only (iii) Minimum number of Gates.
15	Design and realization of a half adder and full adder circuit.
16	Design and realization of a half subtractor and full subtractor circuit.

P.T.O

Text Books:

T1. R. L. Boylestad and L. Nashelsky, ***Electronic Devices and Circuit Theory***, 11th Edition, Pearson Education, 2015.

T2. M. M. Mano and M. D. Ciletti, ***Digital Design: With an Introduction to Verilog HDL***, 5th Edition, Pearson Education, 2013.

Reference Books:

R1. A. S. Sedra and K. C. Smith, ***Microelectronic Circuits***, 7th Edition, Oxford University Press, 2014.

R2. J. Millman and C. C. Halkias, ***Integrated Electronics: Analog and Digital Circuits and Systems***, 2nd Edition, TMH Publications, 2017.

R3. P. Horowitz and W. Hill, ***The Art of Electronics***, 2nd Edition, Cambridge University Press, 1989.

R4. A. Agarwal and J. Lang, ***Foundations of Analog and Digital Electronic Circuits***, 1st Edition, Elsevier, 2005.

Online Resources:

1. https://nptel.ac.in/courses/117101106/: by Prof. A.N. Chandorkar, IIT Bombay
2. https://nptel.ac.in/courses/108102095/: by Prof. S.C. Dutta Roy, IIT Delhi
3. https://nptel.ac.in/courses/117106086/: by Prof. S. Srinivasan, IIT Madras
4. https://nptel.ac.in/courses/117103064/: by Prof. A. Mahanta, IIT Guwahati

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Design electronic circuits like rectifiers, clippers, and clampers using PN-junction diodes.
CO2	Design & analyze amplifier circuits using BJT and MOSFET with different types of biasing.
CO3	Design and implement OPAMP circuits for various applications.
CO4	Explore the use of logic gates in design of various digital circuits and systems.
CO5	Apply logic function minimization techniques for designing digital electronic circuits.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO6	Function effectively as an individual or as a member of a multidisciplinary team with professional and managerial skills.
PO7	Work in a professional context with intellectual integrity, ethics, and social responsibility.
PO9	Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	1	1	1		1							1
CO2	1	1	3	1	1	1	1					1	
CO3	3	2	3	2	2	1	1			1	2		
CO4	1	2	1	1	2	1			1			1	1
CO5	2	3	3	3	2	1	1		1	1	3		1

Category	Code	Embedded C Applications Lab	L-T-P	Credits	Marks
PCR	EC5040		0-0-4	2	100

Objectives	The objective of the laboratory course is to implement embedded C programming on 16/32-Bit microcontrollers through interfacing, experimental analysis, and hands-on practice.
Pre-Requisites	Knowledge of basic C programming and microcontroller is required.
Teaching Scheme	Regular laboratory experiments to be conducted under supervision of the faculty with use of ICT as and when required, sessions are planned to be interactive with focus on implementation in hardware/software tools.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
	GPIO Programming (Any three)
1	Acquaintance with equipment and components required to make the system operational through a demonstration
2	Understand the PIN configurations and port registers of ARM-based microcontroller through laboratory practice
3	Implement LCD interfacing with an ARM-based microcontroller and analyze Buzzer interfacing with a time delay approach
4	Display pressed a key on LCD and extend the interconnection with LED as well as Buzzer
5	Learn the concept of Menu operation using Keypad and LCD using an ARM-based microcontroller
6	Experimental Assignment - 1
7	Experimental Assignment - 2
	Interrupt programming (Any one)
8	Implement interfacing of a TSOP with remote to control LED & BUZZER using ARM-based microcontroller
9	Implement interrupt programming to display the pressed key on LCD using an ARM-based microcontroller
10	Interfacing different Switch with ARM-based microcontroller
11	Experimental Assignment - 3
12	Experimental Assignment - 4
	UART Programming (Any two)
13	Interface a GSM modem with an ARM microcontroller and LCD through R/W operations
14	Interface a GPS with an ARM microcontroller and threw latitude/longitude information in LCD
15	Display RFID code in LCD using ARM-based microcontroller

Cont'd...

Experiment-#	Assignment/Experiment
16	Implement remote server for attendance record using Wifi and ARM-based microcontroller
17	Experimental Assignment - 5
18	Experimental Assignment - 6
PWM, I2C, ADC Programming (Any two)	
19	Implement DC motor drive using PWM signals
20	Analyze Real-Time Clock (RTC) operations and perform ALARM snoozing, termination, etc.
21	Implement EEPROM R/W operations using selected microcontroller
22	Understand ADC operations and sensor interfacing for the monitoring of laboratory temperature
23	Experimental Assignment - 7
24	Experimental Assignment - 8
Laboratory Project (Any one) – Compulsory	
25	Project on Home Automation (Interfacing all the required external modules with the ARM microcontroller)
26	Project on Smart Irrigation System (Interfacing all the required external modules with the ARM microcontroller)
27	Project on Object Tracking System (Interfacing all the required external modules with the ARM microcontroller)
28	Project on Vending Machine (Interfacing all the required external modules with the ARM microcontroller)

Text Books:

T1. P.S. Deshpande and O. G. Kakde, ***C and Data Structures***, 1st Edition, Dreamtech Press, 2003.
T2. E. Balagurusamy, ***Programming in ANSI C***, 7th Edition, McGraw-Hill Education, 2017.
T3. C. Noviello, ***Mastering STM32***, 2nd Edition, Leanpub, 2022.

Reference Books:

R1. K. R. Venugopal and S. R. Prasad, ***Mastering C***, 3rd Edition, McGraw-Hill Education, 2017.
R2. T. V. Sickle, ***Programming Microcontrollers in C***, 2nd Edition, LLH Publishing, 2001.
R3. M. A. Mazidi, S. Chen, and E. Ghaemi, ***STM32 Arm Programming for Embedded Systems (Using C Language with STM32 Nucleo)***, 1st Edition, Microdigitaled, 2018.

Online Resources:

1. https://nptel.ac.in/courses/106104128: By Prof. S. Nandakumar, IIT Kanpur
2. https://nptel.ac.in/courses/106105171: By Prof. A. Basu, IIT Kharagpur
3. https://nptel.ac.in/courses/106105193: By Prof. I. Sengupta and Prof. K. Datta, IIT Kharagpur
4. https://www.st.com/content/st_com/en/support/learning/stm32-education.html
5. https://nptel.ac.in/courses/108105102: By Prof. Santanu Chattopadhyay, IIT Kharagpur

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe, explain and practice GPIO programming of a selected microcontroller.
CO2	Design and analyze the interrupt programming concepts by interfacing external modules.
CO3	Explore UART interfacing and programming concepts of a selected microcontroller.
CO4	Implement PWM, I2C, and ADC programming through a real-time approach.
CO5	Design and analyze various interfacing concepts through industry-standard projects.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO6	Function effectively as an individual or as a member of a multidisciplinary team with professional and managerial skills.
PO9	Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	2	1	2						2	2	2
CO2	3	3	3	2	3						3	2	3
CO3	3	3	3	2	3						3	3	3
CO4	3	3	3	2	3						3	3	3
CO5	3	3	3	3	3	3			3	3	3	3	3

Category	Code	Microcontrollers & Applications Lab	L-T-P	Credits	Marks
PCR	EC5041		0-0-2	1	100

Objectives	The objective of this course is to provide practical experience on modeling embedded solutions by programming microcontrollers such as 8051, PIC and their interfacing with other devices & peripherals.
Pre-Requisites	Knowledge of digital electronics, operating systems, and topics taught in the theory class is required.
Teaching Scheme	Regular laboratory experiments to be conducted under supervision of the faculty with use of ICT as and when required, sessions are planned to be interactive with focus on programming and simulation.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
ASM Programming (8/16-bit Microcontrollers)	
1	Write and execute assembly language programs based on Data Transfer Instructions
2	Develop assembly language programs based on Arithmetic Instructions (e.g., 8-bit Addition, Subtraction, Multiplication, Division).
3	Develop assembly language programs using Logical Instructions (AND, OR, etc.).
4	Develop assembly language programs using Branch Instructions.
5	Develop assembly language programs using Looping, Counting, and Indexing.
Embedded C Programming (8/16-bit microcontroller).	
6	Perform an I/O operation on a microcontroller.
7	Develop a program to interface a Stepper Motor with a microcontroller.
8	Develop a program to interface an LCD with a microcontroller.
9	Develop a program to perform ADC operation on a microcontroller.
10	Develop a program to perform RS232/RS485 operation using a microcontroller.
11	Develop a program to perform I2C communication using a microcontroller.
12	Develop a program to perform SPI communication using a microcontroller.
13	Develop a program to interface a touch sensor using a microcontroller.
Assignment & Project (Compulsory)	
14	Assignment on hardware and software co-simulation using embedded assembly code inside a C routine.
15	Project Work: Selected project on Microcontroller-based applications.

Text Books:

T1. M. A. Mazidi, J. G. Mazidi, R. McKinlay, ***The 8051 Microcontroller and Embedded Systems: Using Assembly and C***, 2nd Edition, Pearson Education, 2011.

T2. A. K. Ray and K. M. Bhurchandani, ***Advanced Microprocessors and Peripherals***, 2nd Edition, McGraw Hill Education, 2006.

T3. D. A. Patterson and J. H. Hennessy, ***Computer Organization and Design: The Hardware/Software Interface***, 5^{th} Edition, Morgan Kaufman Publishers, 2013.

Reference Books:

R1. K. Kant, ***Microprocessors and Microcontrollers: Architecture, Programming and System Design 8085, 8086, 8051, 8096***, 2^{nd} Edition, Prentice Hall India, 2013.
R2. D. Hall, ***Microprocessors and Interfacing***, 3^{rd} Edition, McGraw-Hill Education, 2017.
R3. K. J. Ayala, ***The 8051 Microcontroller***, 3^{rd} Edition, Cengage Learning, 2007.

Online Resources:

1. https://nptel.ac.in/courses/108107029/: by Dr. P. Agarwal, IIT Roorkee
2. https://nptel.ac.in/courses/106108100/: by Prof. K. Kumar IISc Bangalore
3. http://www.electrical4u.com/circuit-analysis.htm
4. http://www.allaboutcircuits.com
5. https://www.electronics-tutorials.ws/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Write simple microcontroller programs using data transfer & arithmetic instructions.
CO2	Write and execute advanced programs for 8051 microcontrollers using its instruction set.
CO3	Develop programs to perform I/O operations on microcontrollers.
CO4	Develop programs to interface microcontrollers with various other devices & peripherals.
CO5	Develop microcontroller-based embedded solutions with hardware/software co-simulation.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO6	Function effectively as an individual or as a member of a multidisciplinary team with professional and managerial skills.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	1		1	1		1							1
CO2	1	1				1						1	
CO3	3	1	3	2	3	1				1	2		
CO4	1	2	1			1						1	1
CO5	2	1	3	3	2	1				1	3		1

Category	Code	Communication & Soft Skills	L-T-P	Credits	Marks
UCR	HS5003		0-0-2	1	100

Objectives	The objectives of this laboratory course are to develop effective communication and soft skills, such as negotiation, assertiveness, teamwork, leadership, presentation, writing e-mails, business letters, and reports, etc.
Pre-Requisites	Knowledge of English and basic communication skills is required.
Teaching Scheme	Regular laboratory classes pair through and/or team activities with regular assessments, presentations, discussions, role-playing, audio-visual supplements, writing activities, business writing practices and vocabulary enhancement.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Introduction to the course and diagnostic test
2	Personality development and soft skills for professionals
3	Group Discussion (GD): Mock GD 1
4	Group Discussion (GD): Mock GD 2
5	Verbal Ability
6	Writing a compelling resume and cover letter
7	Personal Interview FAQs
8	Mock Personal Interview (PI)
9	Assertive communication and negotiation skills
10	Teamwork and leadership skills
11	Powerpoint Presentation 1
12	Powerpoint Presentation 2
13	Writing business letters, email etiquette
14	Preparing Analytical Reports

Text Books:

T1. M. A. Rizvi, ***Effective Technical Communication***, 2nd Edition, Tata McGraw-Hill, 2017.
T2. M. Raman and S. Sharma, ***Technical Communication: Principles and Practice***, 3rd Edition, Oxford University Press, 2015.

Reference Books:

R1. S. John, ***The Oxford Guide to Writing and Speaking***, 3rd Edition, Oxford University Press, 2013.
R2. S. Kumar and P. Lata, ***Communication Skills***, 2nd Edition, Oxford University Press, 2015.
R3. B. K. Das, K. Samantray, R. Nayak, S. Pani, and S. Mohanty, ***An Introduction to Professional English and Soft Skills***, 2nd Edition, Cambridge University Press, 2012.

Online Resources:

1. https://nptel.ac.in/courses/109/106/109106094/: By Prof. A. Iqbal, IIT Madras
2. https://nptel.ac.in/courses/109/104/109104031/: By Dr. T. Ravichandran, IIT Kanpur

3. https://www.coursera.org/specializations/business-english
4. https://ocw.mit.edu/courses/comparative-media-studies-writing/21w-732-5-introduction-to-technical-communication-explorations-in-scientific-and-technical-writing-fall-2006/download-course-materials/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Communicate assertively and make successful negotiations in business situations.
CO2	Improve skills like verbal ability, GD, PI & writing resumes for career success.
CO3	Develop effective team work abilities and take leadership in real-life situations.
CO4	Demonstrate & apply various techniques of effective oral presentation.
CO5	Compose effective business correspondences such as e-mail, business letters, and reports.

Program Outcomes Relevant to the Course:

PO6	Function effectively as an individual or as a member of a multidisciplinary team with professional and managerial skills.
PO7	Work in a professional context with intellectual integrity, ethics, and social responsibility.
PO8	Communicate effectively and present technical information in oral and written reports supported by diagrams and models for easy visualization.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1						2	1	1		1			1
CO2						1	1	1			1		1
CO3						3	1	1		1	1		1
CO4						3	1	3		1	1		1
CO5						1	2	1		1	1	1	1

Category	Code	Sensors & Control Systems	L-T-P	Credits	Marks
PCR	EC5042		3-0-0	3	100

Objectives	The objective of this course is to study the principles & applications of various sensors for measuring electrical and non electrical parameters, conditioning their outputs, and allied control systems for control of the same in a control loop.
Pre-Requisites	Knowledge of mathematics for electronics & electronics circuits is required.
Teaching Scheme	Regular classroom lectures with the use of ICT as and when required and interactive sessions with a focus on problem-solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction: Principles of Measurement systems, Static characteristics & dynamic characteristics; Resistive Transducers: Resistive potentiometers, Strain gauges; Inductive Transducers: Variable reluctance displacement sensor, LVDT, Hall effect sensors; Capacitive Transducers: Variable separation, Area & dielectric displacement transducer, Pressure, Humidity and Level measurement; Translational & Rotational Velocity Measurement: Moving coil moving magnet pickups, Eddy current magnetic & photoelectric pulse counting.	**9 Hours**
Module-2	Temperature Measurement: RTDs, Thermistor, Thermocouples, IC type temperature sensor, Pyrometers: Radiation Pyrometer, Optical Pyrometer; Force measurement: Load cell; Flow Measurement: Turbine flow meter, Electromagnetic flow meter, Ultrasonic flow meter; Acceleration measurement; Encoder and Telemetry for distributed monitoring.	**8 Hours**
Module-3	Measurement System: Dynamic characteristics, Open-Loop/Closed-loop system, Feedback, Transfer function, Block diagram, Signal flow graphs, Mason's Gain formula, Mathematical modelling of dynamical systems using transfer function; Time Response Analysis: Standard Test Signals, Time response of first order & second order systems.	**9 Hours**
Module-4	Temperature Control: Fundamentals of temperature, Thermal control system, Thermodynamic transfer, Thermal energy source, Temperature measurements & indicating devices, Electronic sensors; Flow Control: Introduction, System concept, Flow units of measurement, Solid and fluid flow measurement, Electronic sensors, Flow meter placement, Section of flow meter.	**8 Hours**
Module-5	Level Control: Level control system, Methods of measurement, Level measurement methods, Electronic sensors, Selecting a level sensor; Analytical Control Instruments: pH measurement and control, Conductivity applications and control, Combustion analysers and control, Humidity control.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. P. Bentley, ***Principles of Measurement Systems***, 4^{th} Edition, Pearson Education, 2005.
T2. T. Bartelt, ***Industrial Control Electronics***, 3^{rd} Edition, Delmar Cengage Learning, 2005.

Reference Books:

R1. A. K. Ghosh, ***Introduction to Measurement and Instrumentation***, 3rd Edition, PHI Learning, 2009.
R2. E. O. Doeblin, ***Measurement Systems, Applications and Design***, 4th Edition, McGraw Hill, 2007.
R3. C. Rangan, G. Sarma, and V. S. V. Mani, ***Instrumentation : Devices and Systems***, 2nd Edition, McGraw Hill, 2017.
R4. D. Patranabis, ***Sensors and Transducers***, 2nd Edition, PHI Learning, 2010.

Online Resources:

1. https://nptel.ac.in/courses/108/108/108108147/: by Prof. H. J. Pandya, IISc Bangalore
2. https://nptel.ac.in/courses/115107122/: by Prof. S. K. Srivastava, IIT Roorkee
3. https://nptel.ac.in/courses/108/105/108105062/: by Prof. S. Sen and Prof. S. Mukhopadhyay, IIT Kharagpur
4. https://nptel.ac.in/courses/108/105/108105064/: by Prof. A. Barua, IIT Kharagpur

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Articulate the use of resistance, inductance and capacitance principles for transducers.
CO2	Analyze various sensors used for temperature, force, flow, and acceleration.
CO3	Explain various signal conditioning circuits, signal processing elements & data acquisition systems and evaluate their performance.
CO4	Understand and analyze the control concept in temperature and flow control systems.
CO5	Analyse the concepts of control in measurement of level, pH, conductivity and humidity.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO6	Function effectively as an individual or as a member of a multidisciplinary team with professional and managerial skills.
PO9	Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	2			3	3	3	2	3
CO2	3	3	3	2	1	1			2	2	3	2	3
CO3	3	3	3	3	2	2			3	3	3	3	2
CO4	3	3	3	3	3	2			3	3	3	3	2
CO5	3	3	3	3	3	2			3	2	3	2	2

Category	Code	Embedded Systems & Design	L-T-P	Credits	Marks
PCR	EC5043		3-1-0	4	100

Objectives	The objective of this course is to study the components, programming, integration, and life cycle management of hardware & firmware to design and develop embedded systems for real-world applications.
Pre-Requisites	Basic knowledge of MPMC and digital electronics is required.
Teaching Scheme	Regular classroom lectures with the use of ICT as needed and interactive sessions with a focus on problem-solving activities, and discussion on research articles wherever appropriate.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Embedded Systems**: Introduction, Definition, Embedded Systems vs General Computing Systems, History and Classification, Major Application Areas, Purpose of Embedded Systems; Typical Embedded Systems – Core of the Embedded System, Memory, Sensors and Actuators, Communication Interface, Embedded Firmware, PCB, and Passive Components.	**12 Hours**
Module-2	**Characteristics and Quality Attributes**: Characteristics and Quality Attributes of Embedded Systems; Hardware-Software Co-Design and Program Modeling – Fundamental Issues, Computational Models in Embedded Design, Introduction to UML, Hardware Software Trade-offs.	**12 Hours**
Module-3	**Hardware Design and Development**: Analog and Digital Components, VLSI and IC Design, EDA Tools; Embedded Firmware Design and Development – Embedded Firmware Design Approaches, Embedded Firmware Development Languages; Trends in the Embedded Industry – Processor Trends, Embedded OS Trends, Development Language Trends, Bottlenecks, Development Platform Trends.	**11 Hours**
Module-4	**RTOS based Design**: Operating system basics, Types of operating systems, Tasks, Processes & Threads, Multiprocessing & Multitasking, Task Scheduling, Threads, Processes, and Scheduling, Putting them Altogether, Task Communication, Task Synchronization, Device Drivers, How to Choose an RTOS; Resource Sharing, Other features of RTOS, Commercial RTOSs – General purpose OS, Windows CE, LynxOS, VxWorks, Jbed, pSOS.	**11 Hours**
Module-5	**Integration & Testing**: Integration of Hardware & Firmware, Board Bring up; Development Environment – Integrated Development Environment (IDE), Types of files generated on cross-compilation, Disassembler/Decompiler, Simulators, Emulators & Debugging, Target Hardware Debugging; Product Enclosure Design & Development – Tools, Development Techniques, Embedded Product Development Life Cycle (EDLC) – Definition, Objectives, Phases, Approaches (Modeling the EDLC).	**10 Hours**
	Total	**56 Hours**

Text Books:

T1. K. V. Shibu, ***Introduction to Embedded Systems***, 2nd Edition, McGraw-Hill Education, 2017.
T2. R. Kamal, ***Embedded Systems : Architecture, Programming and Design***, 12th Reprint, Tata McGraw-Hill, 2007.
T3. S. Chattopadhyay, ***Embedded System Design***, 2nd Edition, Prentice Hall India, 2013.

Reference Books:

R1. D. E. Simon, ***An Embedded Software Primer***, Addison Wesley, 1999.
R2. J. Ganssle, ***The Art of Designing Embedded Systems***, 2nd Edition, Elsevier, 2008.
R3. K. Short, ***Embedded Microprocessor System Design***, 1st Edition, Prentice Hall, 1998.
R4. C. Baron, J. Geffroy, and G. Motet (Eds), ***Embedded System Applications***, Springer, 1997.

Online Resources:

1. https://nptel.ac.in/courses/106105159/: by Prof. A. Basu, IIT Kharagpur
2. https://nptel.ac.in/courses/108102045/: by Prof. S. Chaudhary, IIT Delhi
3. https://archive.nptel.ac.in/courses/108/102/10810216/: by Prof. D. V. Gadre, NSUT New Delhi

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe the fundamental building blocks of a typical embedded system.
CO2	Explain the attributes of embedded systems and hardware & firmware co-design approach.
CO3	Design hardware for embedded systems using appropriate design and development steps.
CO4	Explain the concept of Operating System and RTOS-based embedded firmware design.
CO5	Assemble, manage, and test an embedded system through its development life cycle.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO9	Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	1							1	3		
CO2	3	3	1		1					2	3		2
CO3	3	3	1	2	2					3	3		2
CO4	2	2	1	2	3				2	3	3		3
CO5	3	3	1		3				2	3	3		3

Category	Code	M2M & Internet of Things	L-T-P	Credits	Marks
PCR	EC5044		3-1-0	4	100

Objectives	The objective of this course is to study the principles of design and implementation of Machine-to-Machine (M2M) and Internet of Things (IoT), including their management procedures, networking, and security measures.
Pre-Requisites	Knowledge of sensors, transducers, actuators, analog & digital electronics, concepts of internet technologies, and computer programming is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on design, programming, and case studies.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: M2M and Internet of Things (IoT), Physical & Logical Design of IoT, IoT Enabling Technologies, IoT Levels & Deployments, M2M, Difference between IoT and M2M, NFV, Need for IoT Systems Management, SNMP, Network Operator Requirements.	**11 Hours**
Module-2	**Domain Specific IoTs**: Home Automation - Smart Lighting, Smart Appliances, Intrusion Detection, Smoke/Gas Detection; Smart Cities - Smart Parking, Smart Lighting, SHM, Surveillance, and Emergency Response; Retail - Inventory Management, Smart payments, and vending machines; Agriculture - Smart Irrigation, Greenhouse/Poly house control; Industry - Machine Diagnosis and Prognosis, Indoor Air Quality Monitoring; Healthcare - Wearable Devices, Health & Fitness; Review of a selected research article.	**12 Hours**
Module-3	**Python Programming**: Data Types, Control Flow, Functions, Modules, Packages, File Handling, Date/Time Operation, Classes; **IoT using Raspberry Pi**: Introduction to Raspberry Pi, Linux on Raspberry Pi, Implementation of IoT with Raspberry Pi, Raspberry Pi Interfaces: Serial, SPI, I2C, Interfacing of LED, Switches.	**11 Hours**
Module-4	**IoT Strategies**: Networking Technology, Communication Technology, Adaptive and Event Driven Processes, Virtual Sensors, Security, Privacy & Trust, Low power communication, Energy harvesting, IoT-related standardization, IoT Protocols: MQTT, CoAP, AMQP, JMS, DDS, REST, XMPP; Discussion on a selected research article.	**11 Hours**
Module-5	**Data Analytics for IoT**: Introduction, Apache Hadoop, YARN, Oozie, Spark, Storm, Using Apache Storm for Real-time Data Analysis; Case studies on data analytics for IoT; Class demonstration, Discussion on a selected research article.	**11 Hours**
	Total	**56 Hours**

Text Books:

T1. A. Bahga and V. Madisetti, ***Internet of Things: A Hands-on-Approach***, University Press, 2014.

T2. O. Vermesan and P. Friess, ***Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems***, River Publishers, 2013.

T3. M. Schwartz, ***Internet of Things with Arduino Cookbook***, Packt Publishing, 2016.

Reference Books:

R1. D. Hanes, G. Salgueiro, P. Grossetete, R. Barton, and J. Henry, ***IoT Fundamentals : Networking Technologies, Protocols, and Use Cases for the Internet of Things***, 1st Edition, Pearson Education, 2017.
R2. D. Kellmereit and D. Obodovski, ***The Silent Intelligence : The Internet of Things***, 1st Edition, Lightning Source Inc., 2014.
R3. A. McEwen and H. Cassimally, ***Designing the Internet of Things***, Wiley Publishers, 2013.

Online Resources:

1. https://nptel.ac.in/courses/106/105/106105195/: by Prof. S. Misra, IIT Kharagpur.
2. https://nptel.ac.in/courses/108/108/108108098/: by Prof. T. V. Prabhakar, IISc Bangalore
3. https://nptel.ac.in/courses/106/105/106105166/: by Prof. S. Misra, IIT Kharagpur
4. https://nptel.ac.in/courses/108/105/108105064/: by Prof. A. Barua, IIT Kharagpur
5. https://nptel.ac.in/courses/106/106/106106182/: by Prof. S. Iyengar, IIT Madras
6. https://nptel.ac.in/courses/115/104/115104095/: by Prof. M. Verma, IIT Kanpur
7. https://nptel.ac.in/courses/106/104/106104189/: by Dr. R. Misra, IIT Patna

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe and explain M2M, IoT, design techniques, and network management concepts.
CO2	Explore the specialties of domain-specific IoTs in various real-world applications.
CO3	Write python programs for device-level implementations using an open-source platform.
CO4	Articulate IoT deployment strategies and communication protocols.
CO5	Perform data analytics on collected and real-time data in different IoT applications.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO9	Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	2	2	2					1	2	3	2	
CO2	3	3	3	2	1				3	3	3	3	
CO3	3	2	3	3	3				3	3	3	3	3
CO4	3	1	2	3	2					3	3	3	3
CO5	3	1	2	2	2				2	3	3	3	3

Category	Code	AI Technologies & Soft Computing	L-T-P	Credits	Marks
PEL	EC5049		3-0-0	3	100

Objectives	The objective of the course is to study the goals, methods & techniques of AI and Soft Computing to build intelligent systems with perception, reasoning, and learning abilities and find solutions to complex real-life problems.
Pre-Requisites	Knowledge of basic mathematics, algorithms & data structures is required.
Teaching Scheme	Regular classroom lectures with the use of ICT as required, sessions are planned to be interactive with a focus on examples, case studies, and latest trends.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Artificial Intelligence**: Introduction and Applications; Intelligent Agents – Agents and Environment, PEAS description; Searching – Uninformed Search Strategies (BFS, DFS, UCS), Informed Search, Heuristic Functions, A* Search Algorithm, Local Search Algorithms & Hill Climbing Search; Adversarial Search – Game Playing, Minimax Algorithm, Alpha-Beta Pruning; Knowledge & Reasoning – Knowledge-Based Agents, The Wumpus World Problem.	**9 Hours**
Module-2	**Logic**: Propositional Logic, First-Order Predicate Logic, Syntax and Semantics; Planning – The Planning Problem, Partial-Order Planning, Planning Graphs; Uncertain Knowledge & Reasoning – Bayes Rule and its use; Probabilistic Reasoning, Bayesian Networks; Learning – Forms of Learning, Supervised (Classification) and Unsupervised (Clustering) Learning, Inductive Learning, Decision Trees, Neural Networks.	**8 Hours**
Module-3	**Artificial Neural Networks**: Biological Neurons and their Working, Simulation of Biological Neurons for Problem Solving, Different ANNs Architectures, Training Techniques for ANNs, Applications of ANNs to Solve Some Real-life Problems. Multilayer Perceptron – Back-propagation Algorithm, Logic Gate Problem.	**9 Hours**
Module-4	**Fuzzy Logic**: Definition and Terminology of Fuzzy Set, Set Theoretic Operations, T-norm, T-conorm, Membership Function Formulation and Parameterization, Extension Principle, Fuzzy Relations, Linguistic Variables, Fuzzy if-then Rules, Compositional Rule of Inference, Fuzzy Reasoning, Fuzzy Inference Systems, Mamdani Fuzzy Models, Defuzzification, Sugeno and Tsukamoto Fuzzy Models.	**9 Hours**
Module-5	**Genetic Algorithm**: Introduction, Working Cycle of a GA, Binary Coded GA, GA-parameter Setting, Constraint Handling GA, Advantages and Disadvantages; Hybrid Systems – Combination of Genetic Algorithms with Fuzzy Logic or Neural Networks, Combination of Neural Network and Fuzzy Logic.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. S. Russell and P. Norvig, ***Artificial Intelligence - A Modern Approach***, 3rd Edition, Pearson, 2016.

T2. J. S. R. Jang, C. T. Sun, and E. Mizutani, ***Neuro Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence***, 1st Edition, Pearson Education, 2015.
T3. S. Rajasekaran and G. A. Vijayalakshami, ***Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis and Applications***, 2nd Edition, PHI Learning, 2017.

Reference Books:

R1. D. W. Patterson, ***Introduction to Artificial Intelligence & Expert Systems***, 1st Edition, Pearson Education, 2015.
R2. S. Haykin, ***Neural Networks : A Comprehensive Foundation***, 2nd Edition, Pearson Education,1997.

Online Resources:

1. https://nptel.ac.in/courses/106102220/: by Prof. Mausam, IIT Delhi
2. https://nptel.ac.in/courses/112103280/: by Prof. S. M. Hazarika, IIT Guwahati
3. https://nptel.ac.in/courses/127105006/: by Prof. D. K. Pratihar, IIT Kharagpur
4. https://nptel.ac.in/courses/106105173/: by Prof. D. Samanta, IIT Kharagpur

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explore agents, environments, and perform uninformed search in a state space.
CO2	Apply planning and reasoning to handle uncertainty in real life problems.
CO3	Analyze different types of problems to apply neural network techniques.
CO4	Explain fuzzy logic techniques and their applications.
CO5	Envisage the need of hybridization and develop hybrid models for solving complex problems.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO9	Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	3	3					1	1	2	1	1
CO2	2	3	2	2					1	1	3	1	2
CO3	3	3	3	2					2	1	3	1	2
CO4	3	3	3	2					2	2	3	1	2
CO5	3	3	3	1	2				2	2	3	1	3

Category	Code	Embedded System Applications	L-T-P	Credits	Marks
PEL	EC5050		3-0-0	3	100

Objectives	The objective of this course is to study real-world applications of embedded systems in the real world, including requirement specifications, design and implementation, focusing on real-time applications.
Pre-Requisites	Knowledge of digital electronics, operating systems, and microcontroller programming is required.
Teaching Scheme	Regular classroom lectures with the use of ICT as required, sessions are planned to be interactive with a focus on examples, case studies, and a project to develop an embedded system based on a single-chip microcontroller.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Automotive Applications**: Fundamentals, Vehicle functional domains and requirements, Electrical subsystems, The systems approach to control and instrumentation, Sensors and Actuators in various vehicle domains; Systems in Power Train Electronics, Engine management systems in chassis control - ABS, ESP, TCS, Active suspension systems.	**8 Hours**
Module-2	**Cruise Control Systems**: Mechanism & installation of adaptive cruise control, Body electronic systems, Automotive safety systems, HVAC, Electric hybrid vehicles and their configurations, Drive-by-wire systems, Autonomous and connected vehicles and their challenges, Embedded Automotive Protocols - CAN, LIN, Flex-Ray, MOST-AUTOSAR standard and its applications, OSEK VDX.	**8 Hours**
Module-3	**Embedded Systems for Robotics**: Robots and embedded systems, Sensors, Microcontrollers and actuators in robots, Recent Trends in Robotics - Milli/Micro/Nano Robots; Industrial Robots - Evolution of robotics, Robot anatomy, Manipulation and Control; Direct Kinematic Model - Relationship between adjacent links, Manipulator transformation matrix; Inverse Kinematic Model - Manipulator workspace, Solvability, Solution techniques; Mobile robots, Localization and path planning.	**9 Hours**
Module-4	**Biomedical Applications**: Overview of biomedical devices, Bio-potential electrodes & amplifiers; Embedded systems in patient monitoring - ECG, EEG, EMG, Blood pressure, Respiration, Pulse oximeters, Diagnostic devices; Non-invasive diagnosis using sounds, Measurement of electrical potentials and magnetic fields from the body surface.	**9 Hours**
Module-5	**Smart Healthcare**: Smart healthcare and wireless sensor network, Smart m-Health sensing, m-Health and mobile communication systems, Data collection and decision making, m-Health computing, m-Health 2.0, Social networks, Health apps, Cloud and big health data, m-Health and global healthcare, Future of m-Health, Case studies.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. W. B. Ribbens, ***Understanding Automotive Electronics – An Engineering Perspective***, 8th Edition, Elsevier, 2017.

T2. T. Bräunl, ***Embedded Robotics: Mobile Robot Design and Applications with Embedded Systems***, 3rd Edition, Springer-Verlag, 2008.

T3. J. G. Webster and A. J. Nimunkar, ***Medical Instrumentation - Application and Design***, 5th Edition, John Wiley & Sons, 2020.

Reference Books:

R1. R. Bosch GmbH, ***Bosch Automotive Electrics and Automotive Electronics - Systems and Components, Networking and Hybrid Drive***, 5th Edition, Springer Vieweg, 2007.

R2. J. J. Craig, ***Introduction to Robotics: Mechanics and Control***, 4th Edition, Pearson Education, 2018.

R3. S. C. Mukhopadhyay and A. Lay-Ekuakille (Ed.), ***Advances in Biomedical Sensing, Measurements, Instrumentation and Systems***, Springer, 2010.

R4. V. A. W. Hillier and D. R. Rogers, ***Hilliers Fundamentals of Motor Vehicle Technology: Chassis and Body Electronics***, 5th Edition, Oxford University Press, 2007.

Online Resources:

1. https://www.elprocus.com/embedded-systems-real-time-applications/
2. https://www.elprocus.com/basics-of-embedded-system-and-applications/
3. https://www.theengineeringprojects.com

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe the systems approach of embedded systems in automotive applications.
CO2	Visualize drive-by-wire, and connected vehicle technologies in hybrid vehicles.
CO3	Explore real-world applications of embedded systems in robotics and robot control systems.
CO4	Correlate real-world applications of embedded systems in biomedical applications.
CO5	Explore real world applications of embedded systems in smart healthcare.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO9	Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	3	3	2				2	2	2	2	2
CO2	3	3	3	3	3				2	2	2	3	2
CO3	3	3	2	2	3				2	1	2	3	2
CO4	3	3	3	3	3				2	2	2	2	2
CO5	3	3	3	3	3				2	2	3	2	2

Category	Code	Mechatronics in Manufacturing	L-T-P	Credits	Marks
PEL	EC5051		3-0-0	3	100

Objectives	The objective of this course is to study various aspects of mechatronics such as programmable logic devices, hydraulic and pneumatic systems, drives and mechanisms, and applications of mechatronics in the manufacturing industry.
Pre-Requisites	Knowledge of basic mathematics and programming is required.
Teaching Scheme	Regular classroom lectures with the use of ICT as required, sessions are planned to be interactive with a focus on examples, case studies, and the latest trends.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Mechatronics**: Introduction, Examples of mechatronic systems, Embedded systems, The design process, Traditional and mechatronic designs, Systems – Modelling systems, Connected systems, Measurement systems, Control systems, Feedback, Basic elements of a closed-loop system; Analogue and digital control systems, Sequential controllers.	**8 Hours**
Module-2	**Hydraulic & Pneumatic Systems**: Actuation systems, Hydraulic Systems, Pneumatic Systems -Flapper nozzle system and its characteristics, I/P converter, Valves, Directional control valves, Valve symbols, Pilot operated valves, Directional valves, Pressure control valves, Cylinders, Cylinder sequencing, Servo and proportional control valves, Process control valves, Valve bodies and plugs, Control valve sizing.	**8 Hours**
Module-3	**Electrical Drives**: Electrical Systems, Mechanical Switches, Relays, Solid-state switches, Diodes, Thyristors and TRIACs, Bipolar Transistors, MOSFETs, Solenoids, DC motors (Brush type & brush-less), AC motors, Stepper motors, Stepper motor specifications, Stepper motor control and selection, DC Servomotors, Motor Selection.	**9 Hours**
Module-4	**Mechanisms**: Mechanical Systems, Types of motion, Freedom and Constraints, Loading, Kinematic chains (Four bar, slider-crank), Cams, Gears, Gear trains, Rotational to translational motion, Ratchet and pawl, Belt and chain drives, Bearings, Electromechanical linear actuators.	**9 Hours**
Module-5	**System Models**: Mathematical models, Mechanical system building blocks, Rotational systems, Building up a mechanical system, Electrical system building blocks, Electrical and mechanical analogies, Fluid system building blocks, Building up a model for a fluid system, Thermal system building blocks, Building up a model for a thermal system.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. W. Bolton, ***Mechatronics***, 4th Edition, Pearson Education, 2010.
T2. C. W. De Silva, ***Mechatronics: An Integrated Approach***, 1st Edition, CRC Press,2005.

Reference Books:

R1. D. Shetty, ***Mechatronics: Systems Design***, 2nd Edition, CI-Engineering, 2010.
R2. C. D. Johnson, ***Process Control Instrumentation Technology***, 8th Edition, Pearson Education, 2015.

Online Resources:

1. https://nptel.ac.in/courses/112107298: by Prof. P. M. Pathak, IIT Roorkee
2. https://nptel.ac.in/courses/112101304: by Prof. P. Gandhi, IIT Bombay
3. https://nptel.ac.in/courses/112103174: by Dr. S. N. Joshi, IIT Guwahati

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe the basics of mechatronics systems with real-world examples.
CO2	Explain various aspects of hydraulic and pneumatic systems.
CO3	Explain the working principles and control of various electrical drives.
CO4	Articulate the principles of mechanical actuation systems.
CO5	Develop mathematical models for mechanical, electrical, fluid and thermal systems.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO9	Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	2	3	1	3				2	3	2		2
CO2	3	2	3	1	3				1	2	2		2
CO3	2	2	3	1	3				1	2	2		2
CO4	3	2	3	3	3				1	2	3	2	2
CO5	3	2	3	2	3				3	3	2	2	2

Category	Code	Machine Learning & IIoT	L-T-P	Credits	Marks
PEL	EC5052		3-0-0	3	100

Objectives	The objective of this course is to study various supervised and unsupervised algorithms to discover patterns in data and make predictions based on the patterns for solving business problems in IoT and IIoT applications.
Pre-Requisites	Knowledge of mathematics, statistics, and internet technologies is required.
Teaching Scheme	Regular classroom lectures with the use of ICT as required, sessions are planned to be interactive with a focus on problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Machine learning, Definition of learning systems, Goals and applications of machine learning, Role of machine intelligence in IoT; Supervised Learning – Regression Models, Dimensionality and structured models, Model selection and bias-variance tradeoff, Simple linear regression, Hypothesis testing and confidence intervals, Multiple linear regression, Classification Problems, Logistic Regression.	**9 Hours**
Module-2	**Linear Model Selection & Regularization**: Validation and cross-validation (K-fold cross-validation), Shrinkage methods - Ridge regression and lasso regression; Generative model for discrete data - Bayesian concept learning, Naïve Bayes classifier, Tree-based methods, Classification trees, Bagging and random forests, Boosting.	**9 Hours**
Module-3	**Unsupervised Learning**: Clustering (K-means, Spectral clustering), Feature extraction - Principal Component Analysis (PCA), Independent Component Analysis (IDA); **Internet of Things**: Data analytics, IoT analytics challenges, IoT data acquisition, Data exploration and pre-processing, IoT technologies, Architecture and networking protocols, IoT communication technologies, Devices and gateways.	**8 Hours**
Module-4	**IoT Application Framework**: Fog computing, Edge computing, Cloud computing, Characteristics of cloud Computing, Driving factors towards cloud, Architecture, Role of networks in cloud computing, Protocols, Role of web services, Service models, Cloud clients, Deployment models - Public clouds, Community clouds, Hybrid cloud, Private cloud, Issues in cloud computing, Applications, Distributed computing.	**9 Hours**
Module-5	**Industrial IoT**: Use cases - Smart energy, Smart mobility, Smart citizens, Urban planning, Smart city data characteristics, Applied machine learning algorithms in IoT use cases.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. T. Hastie, R. Tibshirani, and J. Friedman, ***The Elements of Statistical Learning - Data Mining, Inference, and Prediction***, 2nd Edition, Springer, 2017.

T2. A. Bahga and V. Madisetti, ***Internet of Things: A Hands-on-Approach***, 1st Edition, University Press,

2014.

T3. A. Minteer, ***Analytics for the Internet of Things (IoT): Intelligent Analytics for Your Intelligent Devices***, Packt Publishing, 2017.

Reference Books:

R1. Y. G. James, D. Witten, T. Hastie, and R. Tibshirani, ***An Introduction to Statistical Learning with Applications in R***, 2nd Edition, Springer, 2017.

R2. T. M. Mitchell, ***Machine Learning***, 1st Edition, McGraw-Hill Education, 2017.

R3. R. Kamal, ***Internet of Things: Architecture and Design Principles***, 1st Edition, McGraw-Hill Education, 2017.

R4. C. Pfister, ***Getting Started with the Internet of Things***, 1st Edition, O'Reilly, 2011.

Online Resources:

1. https://nptel.ac.in/courses/106106139/: by Dr. B. Ravindran, IIT Madras.
2. https://nptel.ac.in/courses/106105152/: by Prof. S. Sarkar, IIT Kharagpur.
3. https://nptel.ac.in/courses/106105166/: by Prof. S. Misra, IIT Kharagpur

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Apply supervised machine learning models to solve real life problems.
CO2	Analyze and select appropriate supervised learning models for solving real life problems.
CO3	Apply classification and regression models and decision tree based models.
CO4	Design, build and integrate IoT platforms incorporating different machine learning methods.
CO5	Explore various industrial IoT use cases to apply machine learning algorithms.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO9	Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	3	3	3	3				1	1	2	2	2
CO2	2	3	3	3	3				1	1	2	2	1
CO3	3	3	2	2	3				2	2	2	3	2
CO4	3	3	3	3	2				3	2	3	2	2
CO5	3	3	3	3	2				3	2	3	1	1

Category	Code	Reconfigurable Hardware Design	L-T-P	Credits	Marks
PEL	EC5053		3-0-0	3	100

Objectives	The objective of this course is to study the concepts of architecture, management, and programing of reconfigurable systems and their applications.
Pre-Requisites	Knowledge on basic electronics, digital electronics, microcontrollers & embedded system design is required.
Teaching Scheme	Regular classroom lectures with the use of ICT as and when required and interactive sessions with a focus on problem-solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Device Architecture**: Logic, The Array and Interconnect, Extending Logic, Configuration, Case Studies; **Reconfigurable Computing Architectures**: Reconfigurable Processing Fabric Architectures – Fine-grained, Coarse-grained, RPF Integration into Traditional Computing Systems - Independent Reconfigurable Coprocessor Architectures, Processor + RPF Architectures.	**8 Hours**
Module-2	**Reconfigurable Computing Systems**: Early Systems, PAM, VCC, and Splash, Small-scale Reconfigurable Systems - PRISM, CAL and XC6200, Cloning, Circuit Emulation, Accelerating Technology, Teramac, Reconfigurable Supercomputing: Cray, SRC, and Silicon Graphics, The CMX-2X, Non-FPGA Research, Other System Issues, The Future of Reconfigurable Systems	**9 Hours**
Module-3	**Reconfiguration Management**: Reconfiguration, Configuration Architectures: Single-context, Multi-context, Partially Reconfigurable, Relocation and Defragmentation, Pipeline Reconfigurable, Block Reconfigurable, Managing the Reconfiguration Process: Configuration Grouping, Configuration Caching, Configuration Scheduling, Software-based Relocation and Defragmentation, Context Switching.	**9 Hours**
Module-4	**Programming Reconfigurable Systems**: Compute Models: Challenges, Common Primitives, Dataflow, Sequential Control, Data Parallel, Data-centric, Multi-threaded, Other Compute Models, System Architectures: Streaming Dataflow, Sequential Control, Bulk Synchronous Parallelism, Data Parallel, Cellular Automata, Multi-threaded, Hierarchical Composition.	**8 Hours**
Module-5	**Programming FPGA Applications in Verilog**: Different modeling styles in Verilog, Data types and objects, Dataflow, Behavioral and Structural Modeling, Synthesis and Simulation, Verilog constructs and codes for combinational and sequential circuits.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. Hauck and A. Dehon, ***Reconfigurable Computing***, 1st Edition, Elsevier, 2011.

T2. J. Cardoso and M. Hubner, ***Reconfigurable Computing: From FPGAs to Hardware/Software Codesign***, Springer, 2011.

Reference Books:

R1. N. Jari, ***Processor Design System-On-Chip Computing for ASICs and FPGAs***, Springer, 2007.

R2. P. E. Gaillardon, ***Reconfigurable Logic: Architecture, Tools, and Applications***, 1st Edition, CRC Press, 2015.

R3. C. Maxfield, ***The Design Warrior's Guide to FPGAs***, Newnes, 2004.

R4. S. Palnitkar, ***Verilog HDL A Guide to Digital Design and Synthesis***, 4th Edition, SunSoft Press, 1996.

Online Resources:

1. https://archive.nptel.ac.in/courses/108/105/108105118/
2. https://nptel.ac.in/courses/117108040

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain the basic device architecture and reconfigurable computing architecture.
CO2	Design and analyze Reconfigurable Computing Systems.
CO3	Describe Reconfiguration Management and its significance in various scenarios.
CO4	Design systems for different applications using programming of reconfigurable systems.
CO5	Implement various application programs using Verilog on FPGA board.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO6	Function effectively as an individual or as a member of a multidisciplinary team with professional and managerial skills.
PO9	Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	1	1	1					1		2	1	
CO2		2	3	2	2						1	1	1
CO3	2	1	1	1							2	1	
CO4	1	1	2	3	3					1	2	3	2
CO5	1	2	3	2	2	1			1	2	1		

Category	Code	Virtual Instrumentation & DAQ	L-T-P	Credits	Marks
PEL	EC5054		3-0-0	3	100

Objectives	The objective of this course is to learn the principles, programming methodologies, Data Acquisition (DAQ) systems, communication buses, and various other components to design and construct virtual instrumentation systems for diverse applications.
Pre-Requisites	Knowledge of sensors, transducers, actuators, analog & digital electronics, and computer programming is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on design & programming activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Historical perspectives, Advantages, Block diagram & architecture of a virtual instrument, Conventional instruments vs. Traditional instruments, Data-flow techniques, Graphical programming in data-flow, Comparison with conventional programming, Distributed system using LabVIEW.	**6 Hours**
Module-2	**VI Programming**: Structures in LabVIEW, Loop behavior & inter-loop communication, Local & Global variables, Shift registers, Feedback, Auto-indexing, Loop timing, Timed loop; Other Structures - Sequence structures, Case structures, Formula node, Event structure; Arrays & Clusters, Graphs & Charts, File Input/Output, String Handling.	**9 Hours**
Module-3	**Data Acquisition (DAQ)**: Introduction, Classification of Signals, Analog interfacing: Sampling Theorem, Over-sampling, and Inter-channel Delay, ADCs, DACs Connecting signals to the DAQ: DI, RSE, NRSE, Bridge Signal Sources; PC Buses: Local busses - PCI, RS232, RS422, RS485; Interface Buses: USB, PCMCIA, VXI, SCXI, PXI.	**9 Hours**
Module-4	**Machine Vision**: Basics of IMAQ vision: Digital Images, Display; Image analysis, Image processing techniques, Particle Analysis: Thresholding, Binary Morphology, Particle Measurement; Measurements: Edge Detection, Pattern Matching, Geometric Matching, Dimensional Measurement, Color Inspection, OCR; Machine Vision Hardware and Software; Discussion on a selected research article.	**9 Hours**
Module-5	**Motion Control**: Motors: Servomotors, Brushless Servomotors, Stepper Motors, Linear Stepper Motors; Calculation of trajectory, Selecting the right motion controller; Move Types: Single-Axis, Point-to-Point Motion, Coordinated Multi-Axis Motion, Electronic Gearing; Motor Amplifiers and Drivers: Simple Servo Amplifiers, Stepper Motor Amplifiers, AC Servo Amplifiers, DC Servo Amplifiers; Discussion on a selected research article.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. G. Johnson, ***LabVIEW Graphical Programming***, 4th Edition, McGraw Hill, 2006.
T2. S. Gupta and J. John, ***Virtual Instrumentation using LabVIEW***, 2nd Edition, McGraw-Hill, 2010.
T3. J. Jerome, ***Virtual Instrumentation using LabVIEW***, 1st Edition, PHI Learning, 2010.

Reference Books:

R1. K. James, ***PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control***, 1st Edition, Newnes, 2000.
R2. G. W. Johnson and R. Jeninngs, ***LabVIEW Graphical Programming***, 4th Edition, McGraw-Hill Education, 2019.
R3. P. A. Blume, ***The LabVIEW Style Book***, 1st Edition, Prentice Hall, 2017.

Online Resources:

1. http://www.nitttrchd.ac.in/sitenew1/nctel/electrical.php
2. http://iota.ee.tuiasi.ro/~master/Signals%20&%20DAQ.pdf
3. http://www.setsunan.ac.jp/~shikama/LabVIEW_Elvis_Multisim/060803_Introduction_to_LabVIEW_8_in_6_Hours.pdf
4. http://www.ece.mtu.edu/labs/EElabs/EE3010/Lecture%20Notes/Chapter%2009.pdf
5. http://ece-research.unm.edu/jimp/415/labview/LV_Intro_Six_Hours.pdf

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe the foundations for the design and development of Virtual Instruments (VIs).
CO2	Utilize the programming skills to develop a system for virtual instrumentation.
CO3	Correlate data acquisition & communication for the design of indigenous VIs to solve various engineering problems.
CO4	Recognize the applications of machine vision using virtual instrumentation techniques.
CO5	Utilize virtual instrumentation for specific industrial applications to understand the operation and driving of various motors and gears.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO8	Communicate effectively and present technical information in oral and written reports supported by diagrams and models for easy visualization.
PO9	Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

P.T.O

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	1		1					1	2	1	2
CO2	3	2	2	1	3			1		3	3	3	3
CO3	3	2	2		2			2		2	3	1	2
CO4	3	3	3	2	3			1	3	3	3	3	3
CO5	3	3	3	2	3			1	3	3	3	3	3

Category	Code	Sensors & Control Systems Lab	L-T-P	Credits	Marks
PCR	EC5045		0-0-2	1	100

Objectives	The objective of the course is to study the design and implementation of different sensors and signal conditioning devices through hands-on practical experience.
Pre-Requisites	Knowledge of mathematics and electronics circuits are required.
Teaching Scheme	Regular laboratory experiments to be conducted under supervision of the faculty with use of ICT as and when required, sessions are planned to be interactive with focus on implementation in hardware/software tools.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
Sensor based implementations	
1	Temperature measurement by RTD /Thermistor and Thermocouple.
2	Measurement of force using strain gauge.
3	Displacement measurement using LVDT.
4	Level measurement using capacitive transducer & its calibration.
5	Flow measurement using turbine-type flow sensor
6	Pressure measurement using Bourdon tube and diaphragm type sensor.
7	Experiments on air velocity sensor and its associated signal conditioning circuit.
8	Design of Instrumentation amplifier.
9	Design of active 2nd order low pass filter.
10	Design of a D/A converter circuit.
11	Mini Project on temperature/flow/level/humidity control applications.

Text Books:

T1. J. P. Bentley, ***Principles of Measurement Systems***, 4th Edition, Pearson Education, 2005.
T2. A. K. Ghosh, ***Introduction to Measurement and Instrumentation***, 3rd Edition, PHI Learning, 2009.
T3. I. J. Nagrath and M. Gopal, ***Control Systems Engineering***, 6th Edition, New Age International, 2017.
T4. K. Ogata, ***Modern Control Engineering***, 5th Edition, PHI Learning, 2010.

Reference Books:

R1. D. Patranabis, ***Sensors and Transducers***, 2nd Edition, PHI Learning, 2010.
R2. D. V. S. Murthy, ***Transducers and Instrumentation***, 2nd Edition, PHI Learning, 2008.
R3. E. O. Doeblin, ***Measurement Systems, Applications and Design***, 4th Edition, McGraw Hill, 2007.
R4. B. C. Kuo, ***Automatic Control Systems***, 7th Edition, Prentice Hall India, 2010.
R5. R. C. Dorf and R. H. Bishop, ***Modern Control Systems***, 12th Edition, Pearson Education, 2013.

Online Resources:

1. https://nptel.ac.in/courses/108108147/: by Prof. H. J. Pandya, IISc Bangalore
2. https://www.youtube.com/watch?v=SxWZOsBVBCA
3. https://www.coursera.org/lecture/intelligent-machining/sensors-2w3Am

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Analyze the characteristics of RTD and Thermistor.
CO2	Measure temperature, weight and position using different sensors.
CO3	Explain measurement of flow, level, pressure and velocity using various types of sensors.
CO4	Conceptualize and design of second order active filters.
CO5	Design instrumentation amplifiers and D/A converters.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO6	Function effectively as an individual or as a member of a multidisciplinary team with professional and managerial skills.
PO9	Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	1			3	1	3	3	2
CO2	3	3	3	2	3	1			3	1	3	3	2
CO3	3	3	3	2	3	1			3	1	3	2	2
CO4	3	3	3	2	3	1			2	1	3	1	1
CO5	3	3	3	2	3	1			2	1	3	1	1

Category	Code	Embedded Systems & Design Lab	L-T-P	Credits	Marks
PCR	EC5046		0-0-4	2	100

Objectives	The objective of this laboratory course is to provide hands-on exposure on RTOS-based real-time embedded system design by leveraging the capabilities of cutting-edge microcontrollers for practical applications.
Pre-Requisites	Knowledge of computer programming and embedded system design is required.
Teaching Scheme	Regular laboratory experiments to be conducted under supervision of the faculty with use of ICT as and when required, sessions are planned to be interactive with focus on implementation in hardware/software tools.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Installation and configuration settings of a selected microcontroller board to develop RTOS-based applications.
2	Practice of different types of RTOS and implement a program to toggle an LED.
3	Implementing task scheduling for two different tasks in a selected RTOS and embedded board.
4	Implementing a memory management scheme for two different tasks and passing a message using UART.
5	Implementing software timer in a selected RTOS and embedded board using task delay.
6	Implementing a queue to store and read data using multiple tasks running in parallel.
7	Implementing hardware interrupts and task allocation in a selected embedded board.
8	Project Work: Selected projects on RTOS-based applications.

Text Books:

T1. K. V. Shibu, ***Introduction to Embedded Systems***, 2nd Edition, McGraw-Hill Education, 2017.
T2. R. Kamal, ***Embedded Systems : Architecture, Programming and Design***, 12th Reprint, Tata McGraw-Hill, 2007.
T3. S. Chattopadhyay, ***Embedded System Design***, 2nd Edition, Prentice Hall India, 2013.

Reference Books:

R1. D. E. Simon, ***An Embedded Software Primer***, Addison Wesley, 1999.
R2. J. Ganssle, ***The Art of Designing Embedded Systems***, 2nd Edition, Elsevier, 2008.
R3. K. Short, ***Embedded Microprocessor System Design***, 1st Edition, Prentice Hall, 1998.
R4. C. Baron, J. Geffroy, and G. Motet (Eds), ***Embedded System Applications***, Springer, 1997.

Online Resources:

1. https://nptel.ac.in/courses/106105159/: by Prof. A. Basu, IIT Kharagpur
2. https://nptel.ac.in/courses/108102045/: by Prof. S. Chaudhary, IIT Delhi
3. https://archive.nptel.ac.in/courses/108/102/10810216/: by Prof. D. V. Gadre, NSUT New Delhi

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Install and configure a microcontroller development board for RTOS based applications.
CO2	Implement task scheduling mechanism using a RTOS for various real-time applications.
CO3	Articulate the memory management scheme of multiple tasks in a RTOS environment.
CO4	Analyze and implement software timer-based applications in a selected RTOS.
CO5	Implement queue to store and hardware interrupts for real-time embedded system design.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO6	Function effectively as an individual or as a member of a multidisciplinary team with professional and managerial skills.
PO9	Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	1			2	3	2	2	2
CO2	3	3	3	3	3	1			2	3	2	2	3
CO3	3	3	3	3	3	1			2	3	3	3	3
CO4	3	3	2	3	3				3	3	3	3	3
CO5	2	3	2	3	2	1			3	3	3	3	3

Category	Code	M2M & Internet of Things Lab	L-T-P	Credits	Marks
PCR	EC5047		0-0-2	1	100

Objectives	The objective of this laboratory course is to learn the design and implementation of M2M, the Internet of Things (IoT), its management procedures, and networking through practical hands-on experience.
Pre-Requisites	Knowledge of basic electronics, microcontrollers, computer programming, and the topics taught in the theory class is required.
Teaching Scheme	Regular laboratory experiments conducted under supervision of the teacher. Experiments shall comprise of implementation in hardware/software tools.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
M2M-based implementations (Any five)	
1	Understanding the installation and configuration settings of a selected microcontroller.
2	Interfacing of a temperature sensor (LM35) using a selected microcontroller.
3	Interfacing of an alpha-numeric LCD/OLED with a standard microcontroller.
4	Design and development of a driver circuit for unipolar/bipolar stepper motor control.
5	Development of a motion detector assembly using a sensor and microcontroller.
6	Interfacing two standard microcontrollers using the I2C protocol.
7	Interfacing of a standard SPI-enabled sensor using a selected microcontroller.
IoT-based implementations (Any four)	
8	Design and development of a real-time monitoring system using a digital sensor, microcontroller, and 4G modem.
9	Measurement and analysis of air particles using Raspberry Pi.
10	Implementing sensor data transmission using Bluetooth communication link.
11	Implementation of AI assistant using Raspberry Pi.
12	Implementing sensor data transmission using a Wifi-based communication link.
13	Design and development of a Zigbee mesh network for distributed sensing.
Project (Compulsory)	
14	Project Work: Selected projects on IoT-based applications.

Text Books:

T1. C. Pfister, ***Getting Started with the Internet of Things***, 1st Edition, O'Reilly, 2011.
T2. J. Witts, ***Wearable-Tech Projects with the Raspberry Pi Zero***, Packt Publishing, 2017.
T3. S. Naimi, S. Naimi, and M. A. Mazidi, ***The STM32F103 ARM Microcontroller and Embedded Systems: Using Assembly and C***, 1st Edition, Naimi & Mazidi Books, 2021.

Reference Books:

R1. R. Kamal, ***Internet of Things: Architecture and Design Principles***, 1st Edition, McGraw-Hill Education, 2017.

R2. E. Hagan and J. Culkin, ***Learn Electronics with Arduino: An Illustrated Beginner's Guide to Physical Computing***, 1st Edition, O'Reilly, 2017.

Online Resources:

1. https://nptel.ac.in/courses/108105062/: by Prof. S. Sen and S. Mukhopadhyaya, IIT Kharagpur
2. https://nptel.ac.in/courses/106105166/: by Prof. S. Misra, IIT Kharagpur
3. https://nptel.ac.in/courses/106105159/: by Prof. A. Basu, IIT Kharagpur
4. https://nptel.ac.in/courses/108105064/: by Prof. A. Barua, IIT Kharagpur
5. http://www.eecg.toronto.edu/_kphang/teaching/spice/index.html
6. https://www.electronicshub.org/
7. https://www.elprocus.com/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Interface analog sensors with industry-standard microcontrollers.
CO2	Analyze the interfacing scheme of display devices and motors with a microcontroller.
CO3	Implement M2M communication protocols as per the specifications of a microcontroller.
CO4	Implement IoT-based solutions using standard wireless devices.
CO5	Solve industrial problems using M2M communication and the Internet of Things (IoT).

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO6	Function effectively as an individual or as a member of a multidisciplinary team with professional and managerial skills.
PO9	Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	2			3	3	3	1	2
CO2	3	3	3	3	3	2			3	3	3	2	2
CO3	3	3	3	3	3	2			3	3	3	3	3
CO4	3	3	3	3	2	2			3	3	3	3	3
CO5	3	3	3	3	2	2			3	3	3	3	3

Category	Code	Embedded Applications Research Lab	L-T-P	Credits	Marks
PCR	EC5048		0-0-2	1	100

Objectives	The objective of the course is to develop research temperament by involving the students in experiment design, Root Cause Analysis (RCA), graphs/data representation, oral presentation on scientific materials, scientific computing languages, and software tools.
Pre-Requisites	Knowledge of programming, embedded systems and applications is required.
Teaching Scheme	Regular laboratory experiments to be conducted under supervision of the faculty with use of ICT as and when required, sessions are planned to be interactive with focus on implementation in hardware & software tools.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Experimental data collection by exploring industrial issues and performing a Root Cause Analysis (RCA).
2	Design adequate solution/s to certain problems to operate the system/process without affecting the Standard Operating Procedure (SOP).
3	Design of Penta chart, Gantt chart, and critical path analysis (CPA) to describe a selected project.
4	Design of experiments (DOE) using the concepts of Sampling, Critical thinking, deductive & inductive logic.
5	Analysis of Instrumentation Techniques for developing research outcomes.
6	Data organization & analysis using graphs/data representation (scatterplot, box-plot, 2D intensity, histogram), control chart and fitting methods.
7	Developing a research document by following standard manuscript guidelines, style, editing, clarity, and conciseness.
8-10	Mini Project: Project assignment, implementation, preparation of scientific document, and oral presentation.

Text Books:

T1. K. Srinagesh, ***The Principles of Experimental Research***, 1st Edition, Butterworth-Heinemann, 2006.
T2. C. R. Kothari and G. Garg, ***Research Methodology: Methods and Techniques***, 4th Edition, New Age International Publishers, 2019.
T3. B. Andersen and T. Fagerhaug, ***Root Cause Analysis: Simplified Tools and Techniques***, 2nd Edition, ASQ Quality Press, 2006.

Reference Books:

R1. R. Singh, ***Research Methodology - For Ph.D. Course Work***, 1st Edition, RT Publications, 2021.
R2. A. Sutherland, B. Ariel, and M. P. Bland, ***Experimental Designs: 6 (The SAGE Quantitative Research Kit)***, 1st Edition, SAGE Publications, 2022.

Online Resources:

1. https://www.econstor.eu/bitstream/10419/188371/1/v01-i02-p016_3-139-2-PB.pdf
2. https://www.health.vic.gov.au/quality-safety-service/root-cause-analysis-rca-statements-and-reports
3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1292997/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Realize the procedure for Root Cause Analysis (RCA) by exploiting certain defined problems.
CO2	Design adequate solution/s to certain industrial problems without affecting the SOP.
CO3	Develop skills to describe a research project using standard techniques and DOE.
CO4	Analyze the experimental and instrumentation techniques to describe research outcomes.
CO5	Analyze experimental data using graphs/data representation techniques and formulate a proper scientific report.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO6	Function effectively as an individual or as a member of a multidisciplinary team with professional and managerial skills.
PO9	Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	1			2	3	2	2	2
CO2	3	3	3	3	3	1			2	3	2	2	3
CO3	3	3	3	3	3	1			2	3	3	3	3
CO4	3	3	2	3	3				3	3	3	3	3
CO5	2	3	2	3	2	1			3	3	3	3	3

Category	Code	Digital System Design	L-T-P	Credits	Marks
PCR	EC6021		3-0-0	3	100

Objectives	The objective of this course is to study the principles, design, and applications of various digital systems by utilizing combinational and sequential building blocks, their Verilog simulation, state machine & FSM design and their algorithms.
Pre-Requisites	Knowledge of digital electronics is required.
Teaching Scheme	Regular classroom lectures with the use of ICT as and when required and interactive sessions with a focus on problem-solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Minimization & Design of Combinational Circuits**: Karnaugh Maps, Minimization of Sum of Products and Product of Sums, Design of minimal two level gate networks, Design of multiple output two level gate networks, NAND and NOR implementation of real life digital circuits; Combinational circuit design procedure, Design of Multiplexer and De-multiplexer, Multiplexer based Designs, Decoder, Comparator, Verilog implementation of different combinational circuits.	**8 Hours**
Module-2	**Sequential Circuits**: Design of sequential modules – SR, D, T and J-K Latch/Flip-flops, Triggering of Flip-flops, Concept of Master-Slave, Flip-flop conversions, Counters (Synchronous & Asynchronous), Shift Registers, Verilog implementation of different Sequential circuits.	**8 Hours**
Module-3	**State Machines Design**: The Finite State Model - State Diagram, State Table, State Reduction, State Assignment, Transition and Excitation Table, Synthesis of Synchronous sequential Circuits, circuit design using Mealy and Moore type Model; Design FSMs for Serial Binary adder, Sequence Detector, Counter; Finite State Machine, Capabilities and Limitations of FSMs, Important Definitions and Theorems, Minimization of Completely specified Sequential Machines using Partition Technique.	**11 Hours**
Module-4	**Algorithmic State Machines**: Introduction, components of ASM Chart, Salient Features of ASM Charts, Introductory examples of ASM Charts, ASM Chart for Binary Multiplier, Weighing machines.	**7 Hours**
Module-5	**FSM based Design Examples**: BCD to 7-Segment Display Decoder, BCD Adder, Traffic Light Controller, State Graphs for Control Circuits; **Programmable Logic Devices**: Brief Overview, SPLDs, CPLDs, FPGAs.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. L. K. John and C. H. Roth Jr., ***Digital System Design using VHDL***, 2nd Edition, Cengage Learning, 2012.

T2. M. M. Mano and M. D. Ciletti, ***Digital Design: With an Introduction to Verilog HDL***, 5th Edition, Pearson Education, 2013.

T3. A. A. Kumar, ***Fundamentals of Digital Circuits***, 3rd Edition, PHI Learning, 2014.

Reference Books:
R1. J. F. Wakerly, ***Digital Design: Principles and Practices***, 4th Edition, Pearson Education, 2008.
R2. W. I. Fletcher, ***An Engineering Approach to Digital Design***, 1st Edition, PHI Learning, 1990.
R3. S. Salivahanan and S. Arivazhagan, ***Digital Circuits and Design***, 3rd Edition, VIKAS Publication, 2009.

Online Resources:
1. https://nptel.ac.in/courses/117105080/: by D. Roychoudhury, IIT Kharagpur
2. https://nptel.ac.in/courses/108106177/: by N. Goel, IIT, Ropar
3. https://nptel.ac.in/courses/117108040/: by K. Varghese, IISc Bangalore

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe the building blocks of a combinational circuit and implement using Verilog.
CO2	Explain the attributes of sequential circuits and verify them using Verilog.
CO3	Analyze the principles of design and development steps of Finite State Models.
CO4	Illustrate Algorithmic State Machines and their applications in real world.
CO5	Assemble, manage, and test a digital system applying FSM and ASM algorithms.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO9	Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	3	3	3				2	1	3		2
CO2	3	3	3	3	3				3	2	2		2
CO3	3	3	3	2	2				3	2	3		3
CO4	3	3	3	2	2				2	1	3		3
CO5	3	3	3	2	2				2	2	2		2

Category	Code	Industrial Automation & IIoT	L-T-P	Credits	Marks
PCR	EC6022		3-1-0	4	100

Objectives	The objective of the course is to study the principles, operation, tuning, and configuration of various process control systems in industries. This course also covers the equipment, protocols, and software layers required to manage and implement the Industrial IoT (IIoT) data flow in a complex industrial plant.
Pre-Requisites	Knowledge of computer networks, internet technology, basic analog and digital electronics, and control system is required.
Teaching Scheme	Regular classroom lectures with the use of ICT as required, sessions are planned to be interactive with a focus on examples, case studies, and the latest trends.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Process Control**: Introduction, Process Definition, Feedback Control; Controller Types – Discontinuous, Continuous, and Composite; PID Controller Tuning – Zeigler-Nichols Tuning Method, Process Reaction Curve; Digital PID Controllers – Position and Velocity algorithm.	**11 Hours**
Module-2	**Special Control Structures**: Cascade Control, Feed forward Control, Feed forward-Feedback Control Configuration, Ratio Control, Selective Control and Adaptive Control Configuration.	**9 Hours**
Module-3	**Industrial IoT (IIoT)**: Technical requirements, Background, Key technologies, IIoT, Use-cases of IIoT, IoT and IIoT –- Similarities and differences, IoT analytics and AI, Industry environments and scenarios covered by IIoT; Understanding the Industrial Process – Automation in the industrial process, Control and measurement systems, Types of industrial processes; Discussion on a selected research article.	**12 Hours**
Module-4	**Industrial Process & Devices**: CIM pyramid architecture – Devices and networks; IIoT Data Flow – Industrial IoT data flow in a factory, The edge device, IIoT data flow in the cloud; Industrial Data Flow and Devices – IIoT data flow in the factory, Measurements and the actuator chain, Sensors, Converters, Actuators, Controllers, PLCs, DCS, Industrial protocols, SCADA, Historian, ERP and MES; Discussion on a selected research article.	**12 Hours**
Module-5	**Implementing IIoT Data Flow**: Discovering OPC, OPC Classic, OPC UA, Understanding the IIoT edge, Features of the edge, The edge architecture, Edge implementations, Edge internet protocols; Implementing IIoT data flow – IIoT data sources and data gathering, Edge deployment and data flow scenarios; Discussion on a selected research article.	**12 Hours**
	Total	**56 Hours**

Text Books:

T1. S. Bhanot, ***Process Control: Principles and Applications***, 1st Edition, Oxford University Press, 2011.
T2. J. P. Bentley, ***Principles of Measurement Systems***, 4th Edition, Pearson Education, 2005.
T3. G. Veneri and A. Capasso, ***Hands-On Industrial Internet of Things***, Packt Publishers, 2018.

Reference Books:

R1. J. Stenerson, ***Industrial Automation and Process Control***, 3rd Edition, Prentice Hall of India, 2003.
R2. C. A. Smith and A. B. Corripio, ***Principles and Practice of Automatic Process Control***, 3rd Edition, John Wiley & Sons, 2006.
R3. A. Bahga and V. Madisetti, ***Internet of Things: A Hands-on-Approach***, University Press, 2014.

Online Resources:

1. https://nptel.ac.in/courses/108105062/: by Prof. S. Mukhopadhyay and Prof. S. Sen, IIT Kharagpur
2. https://nptel.ac.in/courses/108105088/: by Prof. S. Mukhopadhyay, IIT Kharagpur
3. https://nptel.ac.in/courses/106105195/: by Prof. Sudip Misra, IIT Kharagpur
4. https://nptel.ac.in/courses/108108179/: by Prof. T V Prabhakar, IISc Bangalore

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe the principles of Industrial Process Control, analog/digital controllers, and tuning procedure.
CO2	Apply special control structures to design a complex process control system.
CO3	Visualize industrial IoT for monitoring & control various industrial processes.
CO4	Envisage the need for industrial process control devices for data monitoring, analysis, and control operations.
CO5	Analyze IIoT data flow techniques and edge architecture in a complex industrial process.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO9	Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	2	2							2	1	1
CO2	2	2	2	2							2	1	2
CO3	3	3	3	2	2				2	2	2	1	3
CO4	3	3	3	3	2				2	2	3	1	3
CO5	3	3	3	3	2				2	2	3	1	3

Category	Code	Web Technology & Cloud Computing	L-T-P	Credits	Marks
PEL	CS6028		3-0-0	3	100

Objectives	The objective of this course is to study development of web applications using HTML, CSS, and JavaScript and fundamentals of cloud computing for building high performance secured cloud applications for IIoT domain.
Pre-Requisites	Knowledge of computer programming and basics of internet is required.
Teaching Scheme	Regular classroom lectures with the use of ICT as required, sessions are planned to be interactive with a focus on programming and cloud concepts.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Internet & HTML**: Internet and WWW, Client-Server model, Browsers, IP Addresses, URLs, MIME types, Internet Protocols, HTTP Request/Response model; Structure of a Web page, HTML Tags, Attributes and Elements, Basic Tags, Text, Lists, Links, Tables, Images, Fonts & Colors, Forms, Multimedia.	**9 Hours**
Module-2	**Cascading Style Sheets**: Introduction, Advantages, Selectors, CSS Rules, Adding CSS to Web Pages, Foreground & Background Colors, Borders, CSS Box Model, Positioning, Display and Float, Pseudo-Class and Elements, CSS3 Features - Shadow and Effects.	**8 Hours**
Module-3	**JavaScript & XML**: Adding JS, Variables, Literals, Operators, Conditional Statements, Arrays, Functions, Built-in & User-defined Objects; HTML DOM, Window & Location objects, Events and Event Handlers, Form Validation, AJAX – Processing Steps, Sending and Retrieving Information, XML – Elements, Attributes, Validation, Display; XML DTD: XML Schema, Using DTD in an XML Document.	**9 Hours**
Module-4	**Cloud Computing**: Introduction, Definition, Characteristics, NIST Model – Service Models, Deployment Models, Cloud Service Examples, Virtualization, Load Balancing, Scalability & Elasticity, Deployment, Replication, Monitoring.	**8 Hours**
Module-5	**Cloud Application Design**: Design Considerations, Reference Architectures, Design Methodologies, Data Storage Approaches, Cloud Application Benchmarking & Tuning, Cloud Security - Introduction, Authentication, Authorization, Identity & Access Management, Data Security, Key Management, Auditing.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. DT Editorial Services, ***HTML5 Black Book***, 2nd Edition, Dreamtech Press, 2016.

T2. A. Bahga and V. Madisetti, ***Cloud Computing: A Hands-On Approach***, 1st Edition, Orient Blackswan, 2014.

T3. A. T. Velte, T. J. Velte, and R. Elsenpeter, ***Cloud Computing: A Practical Approach***, 1st Edition, McGraw-Hill Education, 2017.

Reference Books:

R1. U. K. Roy, ***Web Technologies***, 1st Edition, Oxford University Press, 2016.
R2. K. Hwang, G. C. Fox, and J. J. Dongarra, ***Distributed and Cloud Computing - From Parallel Processing to the Internet of Things***, 1st Edition, Elsevier, 2012.
R3. B. Sosinsky, ***Cloud Computing Bible***, 1st Edition, Wiley-India, 2011.

Online Resources:

1. https://nptel.ac.in/courses/106105084/: by Prof. I. Sengupta, IIT Kharagpur
2. https://www.javatpoint.com/html-tutorial
3. https://www.javatpoint.com/css-tutorial
4. https://www.javatpoint.com/xml-tutorial
5. https://nptel.ac.in/courses/106/105/106105223/: by Prof. S. K. Ghosh, IIT Kharagpur

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe the basics of Internet, World-wide-Web, and design simple web pages using HTML.
CO2	Apply cascading style sheets to create professionally designed web pages.
CO3	Utilize the power of JavaScript, AJAX, and XML to build rich interactive user interfaces.
CO4	Explain the basic concepts and architecture of cloud computing and NIST model.
CO5	Describe the design principles to build high-performance & secured cloud applications.

Program Outcomes Relevant to the Course:

PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO6	Function effectively as an individual or as a member of a multidisciplinary team with professional and managerial skills.
PO8	Communicate effectively and present technical information in oral and written reports supported by diagrams and models for easy visualization.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1					1	1		2		1	1		1
CO2					1	1		2		1	1		1
CO3					2	2		3		2	2	1	2
CO4				1	2	1		2		1	1		1
CO5				2	3	2		3		2	2	2	2

Category	Code	Embedded OS & LINUX	L-T-P	Credits	Marks
PEL	EC6026		3-0-0	3	100

Objectives	The objective of this course is to study embedded Linux operating systems with focus on key concepts such as BSP, power management, storage, drivers, porting applications, bootloader, and embedded networking.
Pre-Requisites	Knowledge of electronic circuits, microcontrollers and microprocessors, embedded systems, and C programming is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving & programming activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: History, Why Embedded Linux?, Embedded Linux vs. Desktop Linux, Distributions, Porting Roadmap, Architecture – Real-Time Executive, Monolithic Kernels, Microkernel; Linux Kernel Architecture, User Space, Linux Start-Up Sequence, GNU Cross-Platform Toolchain.	**8 Hours**
Module-2	**Board Support Package (BSP)**: Inserting BSP in Kernel Build Procedure, The Boot Loader Interface, Memory Map, Interrupt Management, The PCI Subsystem, Timers, UART, Power Management – Hardware and Power Management, Power Management Standards, Supporting Processor's Power-Saving Modes, Unified Driver Framework for Power Management, Power Management Applications.	**9 Hours**
Module-3	**Embedded Storage**: Flash Map, MTD-Memory Technology Device – The MTD Model, Flash Chips, Flash Disks; MTD Architecture, Sample MTD Driver for NOR Flash, The Flash-Mapping Drivers, MTD Block and Character Devices, Mtdutils Package, Embedded File Systems, Optimizing Storage Space, Tuning Kernel Memory.	**9 Hours**
Module-4	**Embedded Drivers**: Linux Serial Driver, Ethernet Driver, I2C Subsystem on Linux, USB Gadgets, Watchdog Timer, Kernel Modules; Porting Applications: Architectural Comparison, Application Porting Roadmap, Programming with Pthreads, Operating System Porting Layer (OSPL), Kernel API Driver.	**8 Hours**
Module-5	**Processor Basics**: Stand-Alone Processors, Integrated Processors – Systems on Chip, Other Architectures, Hardware Platforms; Bootloader – Role of a Bootloader, Bootloader Challenges, Universal Bootloader – Das U-Boot, Porting U-Boot, Device Tree Blob (Flat Device Tree), Other Bootloaders; Embedded Networking – Sockets, A Simple Example, A Remote Thermostat, Embedded Web Servers.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. P. Raghavan, A. Lad, and S. Neelakandan, ***Embedded Linux System Design and Development***, Auerbach Publications, 2006.

T2. C. Hallinan, ***Embedded Linux Primer: A Practical, Real-World Approach***, 2nd Edition, PHI, 2011.

T3. D. Abbott, ***Linux for Embedded and Real-time Applications***, Elsevier, 2003.

Reference Books:

R1. K. C. Wang, ***Embedded and Real-Time Operating Systems***, 1st Edition, Springer, 2017.
R2. C. Simmonds, ***Mastering Embedded Linux Programming***, 2nd Edition, PACKT Publications, 2015.

Online Resources:

1. https://nptel.ac.in/courses/117106113/: by Prof. Anand Iyer, IIT Madras
2. https://nptel.ac.in/courses/117106111/: by Prof. S. Chandramouleeswaran, IIT Madras
3. https://nptel.ac.in/courses/106105193/: Prof. Indranil Sengupta, IIT Kharagpur
4. https://docs.yoctoproject.org/current/ref-manual/index.html
5. https://elinux.org/Main_Page

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe the concepts and architecture of Embedded Linux Operating System.
CO2	Illustrate BSP and process management for hardware devices or hardware platform.
CO3	Explore embedded storage technologies such as MTD, memory management, and tuning.
CO4	Analyze embedded device drivers and porting applications to an embedded Linux platform.
CO5	Examine compatibility, bootloaders and networking on embedded Linux platforms.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO9	Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	3	2					2	2	2		3
CO2	3	3	3	3					3	3	3		2
CO3	3	3	3	3	2				3	3	3		2
CO4	3	3	3	3	2				3	3	3		3
CO5	3	3	3	3	2				3	3	3		3

Category	Code	Machine Vision & Intelligent Automation	L-T-P	Credits	Marks
PEL	EC6027		3-0-0	3	100

Objectives	The objective of this course is to learn the principles, methodologies, and several machine vision components required to design an indigenous computer vision based industrial applications.
Pre-Requisites	Knowledge of sensors, analog & digital electronics, and computer programming is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on design & programming activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Introduction**: Computer and Human Vision System: The Human Eye, Computer Vs Human Vision System, Evolution of Computer Vision, Computer/Machine Vision and Image Processing, Applications of Computer Vision.	**7 Hours**
Module-2	**Digital Images**: Fundamentals, Monochrome and Color Images, Image Brightness and Contrast, 2D-3D-4D Images, Digital Image Representation, Digital Image File Formats, Fundamental Image Operations – Points, Edges, and Vertices, Point Operations, Thresholding, Brightness, Geometric Transformations, Spatial Transformation, Affine Transformation, Image Interpolation – Nearest-Neighbor Interpolation, Bilinear Interpolation, Bicubic Interpolation; Steps in Digital Image Processing.	**10 Hours**
Module-3	**Machine Vision System Components**: Machine Vision system, Machine Vision camera, CCD & CMOS Image sensors, TDI sensor, Camera type, Camera lens, Lenses & their parameters, Machine vision lighting, Filters, Machine vision software, Machine vision automation, Integration of machine vision components, Introduction to 3D Modelling.	**9 Hours**
Module-4	**Digital Image Processing**: Needs of Image Processing for Machine Vision Applications, Preprocessing – Image filtering, Subsampling/scaling, Histogram; Image Segmentation – Threshold-based segmentation, edge-based segmentation, Region-based segmentation, Object recognition.	**8 Hours**
Module-5	**Case studies**: Presence/absence inspection of a 3G switch box, Surface inspection of a rivet, Dimensional measurement of a cage sleeve; General process for building machine vision solutions.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. Anand and L. Priya, ***A Guide for Machine Vision in Quality Control***, 1st Edition, Taylor & Franscis, 2020.
T2. E. R. Davies, ***Computer & Machine Vision***, 4th Edition, Elsevier, 2012.
T3. D. A. Forsyth and J. Ponce, ***Computer Vision: A Modern Approach***, 2nd Edition, Pearson Education, 2015.

Reference Books:

R1. K-S. Kwon and S. Ready, ***Practical Guide to Machine Vision Software: An Introduction with LabVIEW***, 1st Edition, Wiley-VCH, 2014.

R2. M. Sonka, V. Hlavac, and R. Boyle, ***Image Processing, Analysis, and Machine Vision with MindTap***, 4th Edition, Cengage India, 2017.

Online Resources:

1. https://nptel.ac.in/courses/106105216/: by Prof. Jayanta Mukhopadhyay, IIT Kharagpur
2. https://nptel.ac.in/courses/108103174/: by Prof. M. K. Bhuyan, IIT Guwahati
3. https://nptel.ac.in/courses/108106189/: by Prof. A. N. Rajagopalan, IIT Madras
4. https://www.intel.in/content/www/in/en/manufacturing/what-is-machine-vision.html

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe the foundations of human and computer vision systems.
CO2	Apply digital image transformation & interpolation in machine vision applications.
CO3	Visualize integration of different machine vision components in automation systems.
CO4	Apply various image processing techniques in machine vision applications.
CO5	Explore different real-world applications of machine vision techniques.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO9	Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	2	1							2	1	1
CO2	3	3	2	1							3	1	3
CO3	3	3	3	2	2				3	3	3	1	3
CO4	3	3	3	1	2				2	3	3	1	3
CO5	3	3	3	3	2				3	3	3	1	3

Category	Code	Data Security & Privacy	L-T-P	Credits	Marks
PEL	CS6026		3-0-0	3	100

Objectives	The objective of this course is to study the security goals, services and mechanisms from a data science perspective with focus on cryptography techniques on user data stored and communicated through unsecured channels.
Pre-Requisites	Knowledge on computer networks and algorithms is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with problem solving activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to Computer Security Concepts, Security Attacks, Security Services and Mechanisms, Symmetric Cipher model, Cryptography & Cryptanalysis, Substitution Techniques: Caesar cipher, Monoalphabetic cipher, Playfair cipher, Hill Cipher, Vignere cipher, Vernam cipher; One-tme pad; Transposition cipher.	**8 Hours**
Module-2	Integer and Modular Arithmetic, Euclidean and Extended Euclidean Algorithms, Concept of groups, rings, and fields, Difference between GF(p) and GF(2m), Symmetric key Cryptography: Data Encryption Standard (DES), Advanced Encryption Standard (AES).	**9 Hours**
Module-3	Fermat's and Euler's Theorems, Chinese Remainder Theorem, Integer Factorization, Discrete Logarithms; Public Key Cryptography: RSA, El-Gamal, Elliptic Curve Cryptography (ECC): Introduction to elliptic curve, arithmetic, and applications.	**9 Hours**
Module-4	Message Integrity and Authentication, Cryptographic Hash Functions: MD5, SHA, Digital Signature algorithms using RSA, and ECC (ECDSA).	**8 Hours**
Module-5	Key Distribution, Certificate Authority, X.509, Kerberos; Security Protocols: PGP, S/MIME, SSL/TLS, IPSec; Role of Firewall and IDS in security.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. W. Stallings, ***Cryptography and Network Security: Principle and Practice***, 7^{th} Edition, Pearson Education, 2017.

T2. C. P. Pfleeger, S. L. Pfleeger, and J. Margulies, ***Security in Computing***, 5^{th} Edition, Prentice-Hall India, 2015.

Reference Books:

R1. B. A. Forouzan, D. Mukhopadhaya, ***Cryptography and Network Security***, 2^{nd} Edition, McGraw-Hill Education, 2010.

R2. C. Kaufman, R. Perlman, and M. Speciner, ***Network Security: Private Communication in a Public World***, 2^{nd} Edition, Prentice-Hall India, 2002.

R3. A. J. Menezes, P. C. Van Oorschot, and S. A. Vanstone, ***Handbook of Applied Cryptography***, CRC Press, 1996.

Online Resources:
1. https://nptel.ac.in/courses/106105031/: by Dr. D. Mukhopadhyay, IIT Kharagpur
2. https://nptel.ac.in/courses/106105162: by Prof. S. Mukhopadhyay, IIT Kharagpur
3. https://nptel.ac.in/courses/106106221: by Prof. A. Choudhury, IIIT Bangalore
4. https://nptel.ac.in/courses/106104220: by Prof. S. Shukla, IIT Kanpur
5. https://www.cs.bgu.ac.il/~dsec121/wiki.files/j21.pdf: Survey of Web Security
6. www.uky.edu/~dsianita/390/firewall1.pdf: A Simple Guide to Firewalls
7. https://www.cryptool.org/en/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Analyze the performance of traditional symmetric key cryptography techniques.
CO2	Acquire the basis of modern symmetric key cryptography and asymmetric key cryptography and their strength and weaknesses.
CO3	Acquire the basis of asymmetric key cryptography and their strength and weaknesses.
CO4	Apply the public key cryptography and Hash algorithms for data integrity, authentication, and digital signature.
CO5	Analyze various security threats on computer network and web and role of Firewalls and IDS in data security and privacy.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO6	Function effectively as an individual or as a member of a multidisciplinary team with professional and managerial skills.
PO7	Work in a professional context with intellectual integrity, ethics, and social responsibility.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2										1	1	1
CO2	3		2	3	1	1	1				1	1	1
CO3	3		2	3	2	1	1				1	1	1
CO4	1		2	3	2	2	1				1	1	1
CO5	1		3	3	2	2	3				1	1	1

Category	Code	Advanced Embedded Systems	L-T-P	Credits	Marks
PEL	EC6029		3-0-0	3	100

Objectives	The objective of this course is to develop complex embedded systems, improve designs by utilizing ARM-based processors and advanced level system design & development for complex engineering applications.
Pre-Requisites	Knowledge of analog & digital electronics, microcontrollers & microprocessors, and computer programming is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on problem solving & programming activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Processor Design**: Processor architecture and organization, Abstraction, MU0 - a simple processor, Instruction set design, Processor design trade-offs, RISC, Design for low power consumption, Examples; ARM Architecture – Acorn RISC Machine, Architectural inheritance, Programmer's model, Development tools.	**8 Hours**
Module-2	**ARM Assembly Language Programming**: Data processing – Simple register operands, Immediate operands, Shifted register operands, Setting the condition codes, Multiplies; Data transfer – Register-indirect addressing, Address pointer, Single register load and store, Offset addressing, Multiple register data transfers, Stack addressing, Block copy addressing; Control flow – Branching, Conditional execution, Branch and link, Subroutine return, Supervisor calls, Jump tables; Assembly language program exercises.	**9 Hours**
Module-3	**ARM Organization and Implementation**: 3-stage pipeline ARM organization, 5-stage pipeline ARM organization, ARM instruction execution, ARM implementation, The ARM co-processor interface, Examples and exercises, Latest research.	**8 Hours**
Module-4	**The ARM Instruction Set**: Conditional execution, B, BL, BX, BLX, SWI, Data processing, Multiply, CLZ, Signed/unsigned byte data transfer, Half-word and signed byte data transfer, Multiple register transfer, SWP, Status register to/from general register transfer, Co-processor instructions – Data operations/transfer, Register transfers, BRK, Unused instruction space, Memory faults, ARM architecture variants.	**9 Hours**
Module-5	**Architectural Support for High-Level Languages**: Abstraction in software design, Data types & ARM floating-point architecture, Expressions & conditional statements, Loops, Functions and procedures, Use of memory, Run-time environment; The Thumb Instruction Set, Architectural Support for System Development – AMBA, Peripheral specification, Prototyping tools, ARMulator, JTAG boundary scan, ARM debug architecture, Embedded trace, Signal processing support, Latest research.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. Furber, ***ARM System-on-Chip Architecture***, 2nd Edition, Addison-Wesley, 2000.

T2. K. V. K. Prasad, ***Embedded/Real-Time Systems: Concepts, Design and Programming Black Book***, 1st Edition, Dreamtech Press, 2023.

Reference Books:

R1. A. N. Sloss, D. Symes, C. Wright, ***ARM System Developer's Guide: Designing and Optimizing System Software***, Elsevier, 2012.

R2. J. Yiu, ***System-on-Chip Design with ARM Cortex-M Processors***, Arm Education Media, 2019.

Online Resources:

1. https://nptel.ac.in/courses/117106111/: by Prof. S. Chandramouleeswaran, IIT Madras
2. https://nptel.ac.in/courses/106105193/: Prof. I. Sengupta, IIT Kharagpur
3. https://developer.arm.com/documentation/100166/0001/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Articulate the concepts of processor design and ARM architecture.
CO2	Develop ARM assembly language programs using data transfer and control flow instructions.
CO3	Implement ARM programs using concepts of pipelining and co-processor interface.
CO4	Develop advanced programs using the ARM instruction set for complex engineering problems.
CO5	Implement and test high-level ARM applications using various prototyping concepts.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO9	Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	1	1							1	3		2
CO2	3	3	2		2					3	3		3
CO3	3	3	3						2	3	3		3
CO4	3	3	3		2				2	3	3	1	3
CO5	3	3	3	1	2				2	3	3	1	3

Category	Code	PLC, SCADA, VFD & DCS	L-T-P	Credits	Marks
PEL	EC6030		3-0-0	3	100

Objectives	The objective of this course is to study programmable logic controllers, SCADA, VFD and Distributed Control Systems to design & develop instrumentation systems for automation of large scale process industries.
Pre-Requisites	Knowledge of electronic circuits, sensors, control systems, and computer programming is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on design & programming activities.

Evaluation Scheme

Attendance	Teacher's Assessment	Mid-Term	End-Term	Total
10	20	20	50	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Programmable Logic Controller (PLC)**: Definition, Historical background, Parts of a PLC, Principles of operation, PLC size & application, PLC hardware components, Electromagnetic control relays, Contactors, Motor starters, Manually & Mechanically operated switches, Sensors, Output control devices, Seal-in circuits, Electrical interlocking circuits, Converting relay schematics into PLC ladder programs, Ladder Logic Program from a narrative description.	**9 Hours**
Module-2	**PLC Programming**: Introduction, Types of PLC languages, Ladder diagram format, Ladder relay instructions, Ladder relay programming, Timers and counters, Program/Flow control instructions, Math instructions, Data manipulation, Data transfer instructions & special function instructions, Programming by Functional block diagrams, PLC Installation Practices, Editing, and Troubleshooting: PLC enclosures, Electrical noise, Leaky inputs and outputs, Grounding, Voltage variations & surges, Program editing and commissioning, Preventive maintenance, Troubleshooting.	**11 Hours**
Module-3	**SCADA System**: Introduction, definitions and history of Supervisory Control and Data Acquisition, typical SCADA system Architecture, important definitions HMI, MTU, RTU, communication means, Desirable Properties of SCADA system, advantages, disadvantages and applications of SCADA; SCADA Protocols: Open systems interconnection (OSI) Model, TCP/IP protocol, Modbus model, Device Net, Control Net, Ether Net/IP, Process Field bus (Profibus).	**9 Hours**
Module-4	**Variable Frequency Drive (VFD)**: VFD Architecture, Operation, Selection, Parameterization, Commissioning and troubleshooting, Interfacing PLC to VFD.	**6 Hours**
Module-5	**Distributed Control Systems (DCS)**: Introduction, History of DCS, DCS concept, Communication in DCS, Modes of DCS, DCS hardware & software, DCS structure, Architectural feature of DCS, DCS design considerations, Advantages & disadvantages.	**7 Hours**
	Total	**42 Hours**

Text Books:

T1. F. D. Petruzella, ***Programmable Logic Controllers***, 5th Edition, McGraw-Hill Education, 2017.
T2. S. A. Boyer, ***SCADA - Supervisory Control and Data Acquisition***, Inst. Soc. of America, 2004.
T3. S. Bhanot, ***Process Control: Principles and Applications***, 1st Edition, Oxford University Press, 2008.

Reference Books:

R1. L. A. Bryan and E. A Bryan, ***Programmable Controller: Theory and Implementation***, 2nd Edition, Industrial Text Co., 1997.
R2. K. P. Raju and Y. J. Reddy, ***Instrumentation and Control System***, McGraw-Hill Education, 2017.
R3. B. G. Liptak, ***Process Control: Instrument Engineers Handbook***, 4th Edition, The Instrumentation Systems and Automation Society, 2006.

Online Resources:

1. https://nptel.ac.in/courses/108/105/108105063/: by Prof. S. Mukhopadhyay, IIT Kharagpur
2. https://nptel.ac.in/courses/108/105/108105088/: by Prof. S. Mukhopadhyay, IIT Kharagpur
3. https://nptel.ac.in/courses/108/105/108105062/: by Prof. S. Sen, IIT Kharagpur
4. https://www.youtube.com/watch?v=d0UZro2Ajo: by by Mr. P. Raverkar (Siemens)

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain wiring of PLC with various sensors & devices and execute ladder programs.
CO2	Develop programs for PLC based processes and their applications as per requirements.
CO3	Utilize SCADA systems effectively in various industrial sectors.
CO4	Effective use of VFD and its industrial application.
CO5	Design and construct DCS with required hardware and software for industry use.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO9	Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	3	2	3				1		2	1	1
CO2	3	3	3	1	3				1		2		2
CO3	3	3	2	1	3				2	1	1	1	1
CO4	2	2	2	2	2				1	1	2	1	2
CO5	2	2	3	2	3				2		2	2	2

Category	Code	Industrial Automation & IIoT Lab	L-T-P	Credits	Marks
PCR	EC6023		0-0-2	1	100

Objectives	The objective of the course is to provide hands-on exposure on design and analysis of ON-OFF/P/PI/PD/PID, Feed-forward, Cascade Controller, PLC/SCADA/VFD, and Advanced Controllers using industry-standard tools.
Pre-Requisites	Knowledge of mathematics, computer programming, analog and digital electronics is required.
Teaching Scheme	Regular laboratory experiments to be conducted under supervision of the faculty with use of ICT as and when required, sessions are planned to be interactive with focus on implementation in hardware / software tools.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
	Industrial Automation and Control (Any three)
1	Performance analysis of ON-OFF/P/PI/PD/PID controllers for controlling a 1st order process using LABVIEW/SIMULINK.
2	Performance analysis of ON-OFF/P/PI/PD/PID controllers for controlling a 2nd order process using LABVIEW/SIMULINK.
3	PID Control Tuning by Ziegler-Nichols techniques.
4	PID Control Tuning by Process reaction Curve (PRC) method.
5	Design of Feedback, Feed-forward, and Cascade controller by MATLAB or SIMULINK.
	Industrial IoT (Any five)
6	Understand the PLC and various components.
7	Implementation of a PLC ladder logic to control various process control devices (Relay, contactor, valve, pneumatic cylinder).
8	Implementation of a SCADA operation and control of a process using a mobile device.
9	Implementation of a VFD operation and control of a process using a mobile device.
10	HMI configuration and remote-control operation using a mobile device.
11	Implementation of direct digital control algorithm (position) for different process control applications.
12	Implementation of direct digital control algorithm (velocity) for different process control applications.
	Project (Compulsory)
13	Project Work: Selected projects on IIoT-based applications.

Text Books:

T1. S. Bhanot, ***Process Control: Principles and Applications***, 1st Edition, Oxford University Press, 2011.
T2. G. Veneri and A. Capasso, ***Hands-On Industrial Internet of Things***, Packt Publishers, 2018.
T3. F. D. Petruzella, ***Programmable Logic Controllers***, 5th Edition, McGraw-Hill Education, 2017.

Reference Books:

R1. S. A. Boyer, ***SCADA - Supervisory Control and Data Acquisition***, Instrument Society of America, 2004.
R2. B. G. Liptak, ***Process Control: Instrument Engineers Handbook***, 4th Edition, The Instrumentation Systems and Automation Society, 2006.
R3. A. Bahga and V. Madisetti, ***Internet of Things: A Hands-On Approach***, 1st Edition, Orient Blackswan, 2015.

Online Resources:

1. https://nptel.ac.in/courses/108105062/: by Prof. S. Mukhopadhyay and Prof. S. Sen, IIT Kharagpur
2. https://nptel.ac.in/courses/108105088/: by Prof. S. Mukhopadhyay, IIT Kharagpur
3. https://nptel.ac.in/courses/106105195/: by Prof. Sudip Misra, IIT Kharagpur
4. https://nptel.ac.in/courses/108108179/: by Prof. T V Prabhakar, IISc Bangalore

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Analyze the performance of process controllers using industry standard tools.
CO2	Investigate & analyze the tuning of process controllers using mathematical techniques.
CO3	Analyze the performance of different controllers using industry standard tools.
CO4	Implement Industrial IoT by integrating PLC/SCADA/VFD/HMI with mobile devices for remote monitoring and control operations.
CO5	Design & implement digital control algorithms for different process control applications.

Program Outcomes Relevant to the Course:

PO1	Apply knowledge of science, mathematics, electronics, and domain knowledge for analyzing and designing embedded and IoT systems for various industrial applications.
PO2	Develop innovative and cost-effective embedded solutions for the electronics and manufacturing industries by identifying, formulating, and analyzing various problems.
PO3	Design efficient electronic, automation, and IoT-enabled sensor-based embedded systems considering various societal and environmental aspects.
PO4	Apply reasoning & contextual knowledge to assess security & privacy in design, deployment of embedded and IIoT sytems in sensitive applications.
PO5	Integrate and apply appropriate techniques, resources, and modern design software tools for modeling, and developing embedded systems in relevant real-world applications.
PO6	Function effectively as an individual or as a member of a multidisciplinary team with professional and managerial skills.
PO9	Review research literature and conduct independent research in embedded electronics, IIoT, and related fields to develop advanced techniques, sensors, systems, and tools.
PO10	Recognize the need and engage in continuous lifelong learning to enhance the knowledge & skills in the domain of embedded systems and IIoT for real-world applications.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	1	2	1	3	2					2	2	2
CO2	3	2	3	2	3	2					3	2	3
CO3	3	2	3	2	3	2					3	3	3
CO4	2	3	3	3	3	2					3	3	3
CO5	3	3	3	3	3	3			2	3	3	3	3

Category	Code	Emerging Technologies Lab	L-T-P	Credits	Marks
SEC	EC6024		0-0-4	2	100

Objectives	The objective of this laboratory course is to provide practical exposure to the latest & emerging technologies in embedded electronics and IIoT domains to make the students industry ready and adapt to the fast changing world.
Pre-Requisites	Knowledge of subjects taught in previous semesters is required. Additional topics (if any) required to perform the experiments shall be taught in the lab.
Teaching Scheme	Regular laboratory experiments to be conducted under the supervision of the teacher. Demonstration will be given for each experiment.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test / Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
Design and Analysis of Circuits (Any Four)	
1	Design and analysis of a DC power supply circuit with +12V/1A, -12V/1A, +5V/1A,+9V/1A and variable outputs using SPICE simulation software.
2	Design of Printed Circuit Board (PCB) layout using Open-Source software.
3	Fabrication of DC power supply circuit using chemical etching technique.
4	The component placing of the DC power supply circuit using proper soldering/desoldering methodology.
5	Design and development of a signal conditioning circuit.
LabVIEW and DAQ (Any Two)	
7	Design of a temperature measurement system with thermocouple providing cold junction compensation using LabVIEW and DAQ.
8	Design of a signal conditioning and data acquisition for strain gauge type load cell.
9	Design of sound measurement system using LabVIEW and DAQ.
10	Design of a displacement measurement system using LVDT and its signal conditioning circuit.
Soft Computing Techniques using MATLAB (Any Two)	
12	Write a program to generate the following parameterized fuzzy membership functions and visualize them for different parameter values: Triangular MF, Trapezoidal MF,Gaussian MF, Generalized Bell MF, Sigmoidal MF.
13	Design of Fuzzy Logic controller for a specific process.
14	Implement AND, OR, XOR Gate using Artificial Neural Network (ANN).
Assignment and Mini Project (Compulsory)	
15	Assignment on a selected real life problem.
16	Selected Project on Circuit Design/LabVIEW & DAQ/MATLAB.

Text Books:

T1. J. P. Bentley, ***Principles of Measurement Systems***, 4th Edition, Pearson Education, 2005.
T2. D. K. Pratihar, ***Soft Computing***, Revised Edition, Narosa Publishing, 2015.

T3. G. W. Johnson and R. Jeninngs, ***LabVIEW Graphical Programming***, 4th Edition, McGraw-Hill Education, 2019.

Reference Books:

R1. K. James, ***PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control***, 1st Edition, Newnes, 2000.
R2. S. Haykin, ***Neural Networks : A Comprehensive Foundation***, 2nd Edition, Pearson Education,1997.
R3. D. Patranabis, ***Sensors and Transducers***, 2nd Edition, PHI Learning, 2010.

Online Resources:

1. https://nptel.ac.in/courses/108105062/: by Prof. S. Sen and S. Mukhopadhyaya, IIT Kharagpur
2. https://nptel.ac.in/courses/106105159/: by Prof. A. Basu, IIT Kharagpur
3. https://nptel.ac.in/courses/108105064/: by Prof. A. Barua, IIT Kharagpur
4. https://nptel.ac.in/courses/108108147/: by Prof. H. J. Pandya, IISc Bangalore

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Analyze circuits using SPICE tools and implement on PCB using EDA tools.
CO2	Assemble components on circuit boards and troubleshoot for correct grounding & shielding.
CO3	Design and analyze signal conditioning circuits for industrial grade sensors.
CO4	Develop virtual instrumentation systems using various sensors and data acquisition systems.
CO5	Design real life solutions using fuzzy logic and artificial neural networks.

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CO2	3	3	3	2	3	2			1		3	2	3
CO3	3	3	3	2	3	2			3	3	3	3	3
CO4	3	3	3	2	3	3			3	3	3	3	3
CO5	3	3	3	3	3	3					3	3	3

Department of Electronics Engineering
SiliconTech, Bhubaneswar